GLOBAL VALUE CHAIN DEVELOPMENT REPORT 2025

REWIRING GVCs IN A CHANGING GLOBAL ECONOMY

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Contents

Tables, Figures, and Boxes ix
Foreword xv
Publishing Partners xviii
Contributors xix
Acknowledgments xxii
Abbreviations xxiv
Editorial and Advisory Committee xxix
Key Messages and Findings xxxi
Executive Summary xxxviii

Chapter 1: Recent Developments in Global Value Chains 1

1.1 Introduction 1
1.2 Recent Trends in International Trade and Global Value Chains 3
1.3 Structural Shifts in Global Value Chains 14
1.4 Regional Trends 25
1.5 Conclusion 36
References 39
Annex 1.1: Methodological Notes for Chapter 1 43

Chapter 2: Resilience and Reglobalization: Global Value Chain Trends and New Opportunities 44

Overview 44
2.1 Introduction 45
2.2 The Emerging Architecture of Geographic Reglobalization 47
2.3 Latin America and the Caribbean – Positioning for Reconfiguration 54
2.4 LAC's Global Value Chain Preparedness and Capability 57
Technology Readiness 58
Logistics Performance Index 58
Mobile Connectivity Index 58
ICT Capital Goods Imports Index 59
Human Capital – AI Readiness Index 59
Digital Services Trade Restrictiveness Index 60
Digitally Deliverable Services Index 60
Government Promotion of Investments in Emerging Technologies Index 61
Global Cybersecurity Index 61

2.5 Strategic Imperatives for Global Value Chain Upgrading in LAC.....62
2.6 Sustainability Readiness.....63
Low Carbon Intensity Index.....63
Renewable Energy Consumption Index.....63
Trade in Energy Transition Goods Index.....64
Protectionism in Energy Transition Goods Index.....64
Critical Minerals Index.....64
Biodiversity and Habitat – Environmental Performance Index.....64
Exposure and Vulnerability to Natural Disasters Index.....65
2.7 Regional Benchmarking and Strategic Priorities for LAC.....65
2.8 Geopolitics Readiness.....66
Export Structure and China Similarity Index.....67
Exposure to Geopolitical Trade Restrictions Index.....67
Security and Institutional Stability Index.....68
Trade Exposure to Sanctioned Economies Index.....68
Diplomatic Alignment and Nonalignment Index.....69
Social Cohesion and Demographic Readiness Index.....69
2.9 Geopolitical Readiness and Regional Positioning.....69
2.10 Intra-Regional Comparison.....70
2.11 The New Trade Cartography for Africa – From Risk to Route.....73
2.12 Africa in Inter-Regional Perspective – Global Value Chain Readiness Benchmarks.....75
Technological Readiness.....76
Trade and Logistics Capacity Readiness.....78
Sustainability Performance Readiness.....79
Institutional and Geopolitical Resilience Readiness.....82
Financial Readiness.....83
Business Readiness.....84
2.13 Africa's GVC Readiness Index: Intra-Regional Comparisons.....87
Southern Africa.....88
North Africa.....89
West Africa.....89
Central Africa.....90
Institutional Innovators.....90
Broader Implications.....91
2.14 Roadmap for Strategic Global Value Chain Integration – Aligning Africa's Policy Priorities.....91
Harnessing the Digital Technology Transition.....92
Seizing Africa's Green Comparative Advantage.....92

Attracting and De-Risking Global Value Chain-Oriented Investment.... 92
Aligning with Global Industrial Policy and Market Access Regulations.... 93
2.15 Completing the Agenda of Regional Economic Integration..... 95
2.16 Comparative Discussion and Prospects for Successful Integration 99
References..... 103
Annex 2.1: Latin America and the Caribbean (LAC) Readiness Indicators..... 107
Annex 2.2: Indicator Definitions and Source Data (LAC) 116
Annex 2.3: Africa Readiness Indicators..... 122
Annex 2.4: Indicator Definitions and Source Data (Africa)..... 147

Chapter 3: Global Electric Vehicle Value Chains: Paradigm Shifts and New Opportunities for Developing Economies 156
3.1 Introduction..... 156
3.2 Overview of the Electric Vehicle Supply Chain..... 158
3.2.1 The Production and Trade of Electric Vehicles..... 158
3.2.2 The Production and Trade of Electric Vehicle-Related Minerals and Components..... 163
3.3 Structure Change of Value Added Creation and Carbon Emissions Along Global EV and ICEV Supply Chains 169
3.3.1 Value-Added Induced By the Production of EV and ICEV 169
3.3.2 Carbon Emissions Induced by the Production of EVs and ICEVs..... 171
3.3.3 Life Cycle Carbon Emissions of EVs and ICEVs 172
3.4 New Opportunities for a More Inclusive Global EV Supply Chains: A Study Based on Product Space Evolution 175
3.4.1 Product Space Network of EV Supply Chains..... 175
3.4.2 Evolutionary Pattern of the Global EV Supply Chain..... 177
3.4.3 Evolutionary Patterns of Typical Products in the EV Supply Chain..... 180
3.4.4 EV Product Space Network and Its Evolution in Typical Economies 182
3.4.5 Opportunities for Different Economies..... 187
3.5 Conclusion..... 192
References..... 193

Chapter 4: Towards Greener and Inclusive Global Value Chains – Insights From Environmental Policy..... 196
4.1 Introduction..... 196
4.2 Tracing CO_2 Emissions along GVCs..... 199
4.3 How an Emissions Trading System Can Help Decarbonize the Domestic Segments of GVCs..... 202

4.3.1 Challenges in Designing Effective Environmental Policies in China 204
4.3.2 Impacts of Place-Based ETS Design on China's Emission Reduction 206
4.4 Trade-Related Environmental Policies: Impacts on GVCs and Green Innovation 210
4.4.1 Trade-Related Environmental Policies and GVCs 210
4.4.2 Empirical Evidence on the Trade and Innovation Effects of Environmental Policies 213
4.5 Carbon Border Adjustment Mechanisms and Their Impacts on Carbon Leakage in GVCs 215
4.5.1 The Potential Effectiveness of CBAMs in Reducing Cross-Border Carbon Leakage 216
4.5.2 A GVC-based CGE Analysis for CBAMs Considering Firm Heterogeneity 217
4.6 Addressing GVC-Driven Environmental Externalities 223
4.6.1 Environmental Externalities in Manufacturing GVCs 224
4.6.2 Environmental Externalities in Agricultural GVCs 225
4.7 Conclusion and Discussion 226
References 228
Annex 4.1: Updated Accounting for Tracing CO_2 Emissions Along GVCs 236

Chapter 5: Industrial Policy in a Strategically Contested Global Economy 239
5. 1 Introduction – Industrial Policy In An Evolving Global Economy 239
5. 2 Conceptual Background and Analytical Considerations 242
5. 3 Evolving Practices in Industrial Policy: Recent Developments and Key Insights 249
5.4 Economic Impacts: Firm Behaviour, Productivity and Supply Chain Reconfiguration 255
5.5 Strategic Rivalry and the Geography of Adjustment 263
5.6 Governance Gaps and Institutional Responses 269
5.7 Summary Observations and Research Frontiers 274
5.7.1 Where the Evidence Converges 275
5.7.2 Outstanding Questions and Research Gaps 276
5.7.3 What We Can and Cannot Conclude 277
5.7.4 Implications for Future Research 278
References 280

Chapter 6: Foreign Direct Investment, Trade Finance and Global Value Chain Integration 283

6.1 Overview 283

6.2 The Layered Financial Architecture of Global Value Chains 285

6.2.1 Globalization at a Crossroads 285

6.2.2 Global Trade and Trade Finance 287

6.2.3 Trade Finance and Heterogeneity 292

6.2.4 Supply Chain Finance 298

6.2.5 Access to Finance and Trade Opportunities: A Quantitative View 302

6.3 Foreign Direct Investment as a Catalyst for Global Value Chain Assimilation 305

6.3.1 Foreign Direct Investment and Trade: Literature Review 305

6.3.2 Data Sources 307

6.3.3 Network Analysis: The Trade-Investment Ghostbusting 309

6.3.4 Foreign Direct Investment and Global Value Chain Integration: An Econometric Analysis 313

6.3.5 Policy Implications 317

6.4 Concluding Remarks 323

References 326

Annex 6.1: Methodological Notes for Chapter 6 331

Chapter 7: Technology, Productivity and Inclusive Growth Through Global Value Chains 333

7.1 Introduction 333

7.2 Recent Developments in Between-and Within-Economy Inequality 335

7.3 Mechanisms: Global Value Chains, Productivity and Technology Diffusion 340

7.3.1 Cross-Economy Evidence On Global Value Chain-Led Productivity Convergence 343

7.3.2 Micro-Level Mechanisms: How Global Value Chain Participation Transforms Firm Capabilities 346

7.3.3 The Architecture of Knowledge Transfer in Global Value Chains 348

7.3.4 The Convergence-Divergence Paradox 349

7.4. Inequality, Labor Markets Global Value Chains and Technology 350

7.4.1 The Functional Distribution of Income 351

7.4.2 Labor Market Effects 355

7.4.3 Firm Level Heterogeneity 359

7.4.4 Regional Inequality 359

7.4.5 The Next Wave: Artificial Intelligence, Global Value Chains and Labor....359
7.5 Policy Responses – Harnessing Global Value Chains and Technology for Inclusive Growth....362
7.6 Conclusion....364
References....365

Chapter 8: Targeted Trade Deals As a New Form of Global Value Chain Governance....371
8.1 Introduction....371
8.2 Defining Targeted Trade Deals....375
8.3 Mapping Targeted Trade Deals....376
8.3.1 Mapping Methodology....376
8.3.2 Provision Mapping Approach....378
8.3.3 Non-Mappable TTDs....379
8.4 Descriptive Statistics and Empirical Analysis....379
8.4.1 Additional Data Sources....379
8.4.2 Patterns and Trends in TTD....382
8.4.3 TTD Characteristics and Provision Analysis....385
8.4.4 What Drives TTD Formation?....390
8.4.5 TTD Impact: Digital Trade and CRM....396
8.5 Legal and Policy Considerations for TTDs....399
8.5.1 TTDs and the WTO Framework....400
8.5.2 TTDs and Investment....401
8.5.3 Domestic Issues of TTDs....401
8.6 Conclusions....405
References....407
Annexes....409

Appendix
Background Paper and Chapter Authors' Workshop for the Global Value Chain Development Report 2025....416

Tables, Figures, and Boxes

TABLES

1 Global Developments Affecting World Trade, 2017-2024 13
2.1 The LAC Playbook for Reglobalization 71
2.2 LAC Policy Roadmap 72
2.3 Africa's Policy Roadmap 98
2.A.1 Pillar Ranking By Country Technology Readiness 107
2.A.2 Pillar Rankings By Country Sustainability Readiness 110
2.A.3 Pillar rankings By Country Institutional And Geopolitical Resilience 113
2.A.4 Technology Indicators 116
2.A.5 Sustainability Indicators 118
2.A.6 Geopolitical Indicators 120
2.A.7 Pillar Rankings By Country Technology Readiness 123
2.A.8 Pillar Rankings By Country Trade and Investment Readiness 127
2.A.9 Pillar Rankings By Country Sustainability And Energy Readiness 131
2.A.10 Pillar Rankings By Country Institutional and Geopolitical Readiness 135
2.A.11 Pillar Rankings By Country Financial Readiness 139
2.A.12 Pillar Rankings By Country Business Readiness 143
2.A.13 Normalized Indicators Technology, Trade & Investment, Sustainability, Institutional and Geopolitical, Financial and Business Readiness 147
3.1 Simulation Results of Scenario 1 (cleaner energy mix) 174
3.2 Simulation Results of Scenario 2 (more efficient electric driving system) 174
3.3 Simulation Results of Scenario 3 (cleaner energy mix and more efficient electric driving system) 174
4.1 Climate Mitigation Policy Instruments 197
4.2 Firm Size and Ownership 207
4.3 Scenarios under ETS with Different Firm Coverage and Financial Conditions 207
4.4 A CBAM CGE Model Scenario Setting 218
5.1 Harmful Interventions by Country – Economic Impact vs. Reported Numbers 241
5.2 Comparisons of Industrial Policy Cases from Various Studies 246
5.3 Welfare Effects of Industrial Policy 259
5.4 Impact of GVC Participation on Firm Productivity Gap (Baseline Estimates) 259
5.5 Heterogeneous Impacts of GVC Participation Across Productivity Quartiles 260
5.6 The Effect of Subsidies on Quality 260
5.7 Comparative Semiconductor Firm GVC Strategies in Response to US Semiconductor-Related Policies, Based on Wong Et Al. (2024) 261

6.1 Gravity Estimation of Trade and FDI in 2019 303
6.2 FDI and GVC Assimilation in Capital Use 315
6.3 FDI and GVC Assimilation in Intermediate Input Use 316
6.4 FDI and the Margins of GVC Assimilation 317
8.1 Overview of Additional Data and Source 380
8.2 Drivers of TTD Formation (Odds Ratio) 395
8.3 Effect of CRM TTDS on Bilateral CRM Trade Flows (PPML Estimates) ... 398
8.A.1 Determinants of TTD Formation (Odds Ratio, Year FE) 411
8.A.2 Determinants of TTD Formation (Average Marginal Effects, Year FE) 412
8.A.3 Impact of Digital TTDs on Bilateral Digital Trade Flows 413
8.A.4 Impact of CRM TTDs on Bilateral Critical Raw Minerals Trade Flows 414
8.A.5 Impact of Digital TTDs with Binding Language on Bilateral Digital Trade Flows 415

FIGURES

1.1 Decomposition of World Gross Exports, 2007-2024 5
Differences in Volatility Between Constant and Current Price Measures of Global Trade Growth, By Sector and Trade Type, 2007-2024 6
1.2 Trade Growth By Selected Sectors, 2021-2024 7
1.3 Trends in Global Value Chain Participation By Exports Type, 2007-2024 8
1.4 Global Value Chain Production Lengths By Region, 2018-2024 10
1.5 Changes in Extent of Global Value Chain Integration – Relevance and Participation 12
1.6 Herfindahl-Hirschman Indexes of Economies for Global Value Chain-Related Trade, 2019-2024 18
1.7 Percent Change in the Ratio of Foreign to Domestic Value-Added in Domestic Final Demand, Structural Decomposition Analysis, Selected Economies 21
1.8 Ratio of Intra- to Inter-Regional Domestic Value-Added in Intermediates Trade 22
1.9 Value-Added Trade Between the People's Republic of China and the United States 24
1.10 Global Value Chain Participation Rates By Region, 2018 and 2024 26
1.11 Change in the EU's Inter- and Intra-Regional Total Trade and Domestic Value-Added in Intermediates Trade, 2017-2024 28
1.12 Change in Central and West Asia's Inter- and Intra-Regional Total and Domestic Value-Added in Intermediates Trade, 2017-2024 29
1.13 Top 10 Trading Partners of the Russian Federation By Trade Type, 2018-2024 31
1.14 Change in North America's Inter- and Intra-Regional Total Trade and Domestic Value-Added in Intermediates Trade, 2017-2024 32
1.15 Change in South America's Inter- and Intra-Regional Total Trade and Domestic Value-Added in Intermediates Trade, 2017-2024 33

1.16 Change In Southeast Asia's Inter- and Intra-Regional Total Trade and Domestic Value-Added in Intermediates Trade, 2017-2024 35
2.1 Shares of Africa and LAC in World Exports, Excluding Mineral Fuels and Mineral Oil 48
2.2 Index of Geographic Trade Diversification, 2000-2024 49
2.3 Changes in Chinese Indirect Value Added to the US from 2017 to 2024 and Gross Value of Chinese Indirect Value Added to the US in 2024. 50
2.4 Fixed and Mobile Broadband Costs as Percentage of GNI per Capita, Africa vs. Other Regions 51
2.5 Domestic vs. Foreign Firm Contribution to Value Added in Electronics GVCs, Selected Regions 52
2.6 Simulated Productivity Change under North-South Decoupling, By Region 53
2.7 Simulated Unit Labor Cost Differences, By Macro-Region and Scenario 54
2.8 Total GVC Participation Regional Averages, 1995-2011 vs 2011-2022 55
2.9 Country-level shifts in global value chain integration, 1995-2022 56
2.10 Technology Readiness Regional Performance Distributions 62
2.11 Sustainability Readiness Regional Performance Distributions 66
2.12 Institutional and Geopolitical Readiness Regional Performance Distributions 70
2.13 Global Value Chain Readiness Index 2025 75
2.14 Digital Trade Policy Readiness 77
2.15 Technology Readiness Regional Performance Distributions 78
2.16 Trade and Investment Readiness Regional Performance Distributions 80
2.17 Sustainability Readiness Regional Performance Distributions 81
2.18 Institutional and Geopolitical Readiness Regional Performance Distributions 83
2.19 Financial Readiness Regional Performance Distributions 85
2.20 Business Readiness Regional Performance Distributions 86
2.21 GVC Readiness Top 15 and Bottom 15 Economies 88
2.22 Preference Utilization in Africa and LAC 94
2.23 Preference Utilization in Africa and LAC in High FVAX Sectors 95
2.24 Preference Utilization in Africa and LAC in High DVAR Sectors 96
3.2 Top 10 EV firms by Global Sales in 2023 (in thousands) 159
3.1 Production of Electric Vehicles, 2019-2023 159
3.3 Electric Vehicle Trade Network in 2023 161
3.4 Trade Structure of Major Electric Vehicles-Exporting Countries from 2017 to 2023 162
3.5 Diagram of EV and ICEV Supply Chains 163
3.6 Trade of EV-Related Key Minerals in 2023 165
3.7 Distribution of Multinational Enterprises Engaged in the Extraction of Critical Minerals 166

3.8 Regional EV Battery Manufacturing Capacity By Manufacturer Headquarters and Global EV Battery Market Share in 2023....167
3.9 Global EV Electric Motor Market Share in 2022....167
B 3.1.1 The Industrial Chain Distribution of CATL....168
3.10 Value Added Induced By EV and ICEV Production, 2023....170
3.11 Carbon Emissions Induced By EV and ICEV Production, 2023....172
3.12 Life Cycle Carbon Emissions per EV and ICEV....173
3.13 Global EV Supply Chain Product Space, 2017-2023....177
3.14 Schematic Diagram of Evolutionary Patterns....178
3.15 Evolutionary Patterns of 15 Categories in the EV Supply Chain (Typical Economies)....179
3.16 Evolutionary Pattern of Six Typical Products in the EV Supply Chain Across Selected Countries....181
3.17 EV Supply Chain Product Space of the US, Japan and Germany in 2023 and their Evolutionary Patterns....183
3.18 EV Supply Chain Product Space of China and India in 2023, and Their Evolutionary Patterns....185
3.19 EV Supply Chain Product Space of Indonesia and Bolivia, and Their Evolutionary Patterns....186
3.20 The Resource Advantages of Developing Economies....188
4.1 Tracing CO_2 Emissions of Annex B and Non-Annex B Economy Groups, 2000-2023....200
4.2 The Current State of Play in Emissions Trading....203
4.3 Tracing China's Emissions Embodied in Exports from Upstream to Downstream....205
4.4 ETS Scenario Results With Different Firm Coverage and Financial Conditions....208
4.5 Number of Active Environmental Measures in the EDB....211
4.6 Number of Notified Trade-Related Environmental Measures By Economy....211
4.7 Potential Effects of Environmental Policies....212
4.8 Potential Effects of Environmental Policy on Trade....213
4.9 Potential Effects of Environmental Policy on Green Innovation....214
4.10 Simulation Results of an EU CBAM's Impact on CO2 Emissions....218
4.11 Simulation Results of an EU CBAM's Impact on Welfare....220
4.12 Simulation Results of an EU CBAM's Impact on GVCs By Firm Ownership....221
4.13 The Relationship Between Welfare Changes and the Difference in Carbon Prices for Non-EU Economies....221
4.14 Simulation Results of the EU CBAM's Impact on the Length of GVCs....222
4.15 Accounting for Tracing Emissions Along GVCs....236
5.1 The Input-Output Demand Matrices of China in 2007....244
5.2 Welfare Gains from Deep and Shallow Cooperation....245

B 5.1.1 New Industrial Policy Measures (Cumulative, based on announcements since Jan 2023; sample of 75 jurisdictions) 247
B 5.1.2 A General Hierarchy of Trade Restrictive Policies 248
5.3 Trade Distortive Industrial Policy in 2023 by Income Group 250
5.4 The Rise of Industrial Subsidies in China 251
5.5 Industrial Subsidies in Major Chinese industries 251
5.6 Simulated Welfare and Output Effects of Subsidies 253
5.7 Cross-Strait Production Integration and Vulnerability to External Shocks 265
B 5.2.1 Trade Fragmentation the Cold War and Now 266
B 5.2.2 Reallocation of Multinational Activity Across Countries 267
6.1 Global Trade and FDI Indicators (1990–2023) 286
6.2 Trade Finance Rejections in West Africa 294
6.3 Increase of Exports and Imports By Trading Partner, USD Value and Percentage Growth 296
6.4 Applications and Rejections by Firm Type 297
6.5 Selected Economies' Average Annual Growth in GVC Participation, 2010-2020 300
6.6 Trade vs. FDI Centrality – Excluding Tax Havens 310
6.7 Trade vs. FDI Centrality – Full Sample 311
6.8 Evolution of FDI Network Centrality – Top 35 Economies, 2001-2021 312
7.1 Global Value Chains, Technology and the Productivity-Inequality Trade-Off 334
7.2 Developments in Between-Economy Inequality, 1870-2018 336
7.3 Developments in Between-Economy Inequality Since 1990 336
7.4 Heterogeneous Catch-Up by Income Group 337
7.5 Gini Coefficient in 1990 and 2023 338
7.6 Evolution of the Gini Coefficient by Income Group, 1990-2023 339
7.7 Income Convergence Across Economies, 2000-2023 340
7.8 Uneven Catch-Up Dynamics Across Income Groups, 2000-2023 341
7.9 Channels from Global Value Chains/Technology to Uneven Catch-Up Dynamics Across Economies 343
7.10 Conditional Correlation Between Backward Global Value Chain Participation and Within-Industry Productivity Gap 347
7.11 Estimated Relationship Between Global Value Chain Participation and the Level of Productivity 348
7.12 Channels From Global Value Chains/Technology To Within-Economy Inequality 351
7.13 Changes in Labor Shares Between 2000 and 2019 352
7.14 Estimated Relationship Between Global Value Chain Participation and the Change in the Labor Share 354
7.15 Relationship Between Changes in Global Value Chain Participation and Indicators of Income Inequality 357

8.1 Cumulative Adoption of Targeted Trade Deals....382
8.2 Global Spread of TTD Participation Pre- and Post-2020....383
8.3 Presence of Various Digital TTD Provisions....385
8.4 Presence of Various CRM TTDs Provisions....387
8.5 Dates of Validity in TTD Texts....389
8.6 RTA Linkages and the Likelihood of TTD Formation....391
8.7 Shared Regional Bloc Status and Likelihood of TTD Formation....392
8.8 Digital Infrastructure and the Formation of Digital TTDs....393
8.9 CRM Endowments and the Formation of CRM TTDs....394
8.10 Bilateral Trade Around TTD Implementation....397

BOXES

1.1 Using Current Prices in an Inflationary Period....5
1.A.1 Measuring trade partner concentration in global value chains....43
2.1 OECD-TiVA Integration Patterns (1995–2022)....55
2.2 Preference Utilization and GVCS in Africa and LAC....94
3.1 Global Leader in the EV Battery Industry CATL....168
3.2 The View from Global Business....189
5.1 The Rise of New Industrial Policies....247
5.2 What Do We Know About the Impact of Geoeconomic Fragmentation on Third Countries?....266
5.3 The View from Business Competing in the Era of Strategic Subsidies....272
6.1 Trade Finance Instruments at a Glance....288
6.2 Sources of Trade Finance Data....291
6.3 Definition of Supply Chain Finance from the Global Supply Chain Finance Forum....302
6.4 Understanding 'Conduit' and 'Sink' FDI The Hidden Architecture of Global Capital Flows....313
6.5 The View from Business Financing Connectivity in the New Frontier of FDI and Trade Finance....320
6.A.1 Illustrating Trade vs. FDI Centrality with a Simple Example....332
8.1 Government Perspectives on TTDs....384
8.2 The View From Business Navigating Targeted Trade Deals in a Fragmented Global Economy....402

Foreword

The *Global Value Chain Development Report 2025: The Re-wiring of GVCs in a Changing Global Economy* comes at a pivotal moment for the world economy. Over the past decade, international production networks have been tested by the COVID-19 pandemic, intensifying geopolitical frictions, financial uncertainty, and accelerating climate challenges. These overlapping shocks have sparked debates about deglobalization and reshoring. Yet the evidence is clear: global value chains (GVCs) remain resilient and indispensable to the functioning of the world economy. The latest data shows that GVCs are indeed under strain, but that they still account for 46.3% of global trade, not far from the 2022 peak of 48%. Rather than unraveling, GVCs are adapting – becoming more digital, more regional, and increasingly shaped by security concerns with potentially important implications for sustainability and inclusiveness.

This year's report points to the emergence of a new phase in globalization. Referred to by the World Trade Organization as reglobalization, this phase sees firms and governments not retreating from global integration but rather reconfiguring it to meet new economic, political, and social priorities. The report examines what this change implies for the evolution of GVCs. It finds a major reconfiguration of both the physical structure and institutional architecture that govern international production. This re-wiring of GVCs operates simultaneously across multiple dimensions – geographic repositioning through regionalization and nearshoring, technological transformation through digitalization and automation, governance innovation through new industrial policies and new forms of targeted trade agreements, and environmental restructuring through green investment and carbon pricing mechanisms.

Across Latin America and Africa, the report's GVC readiness diagnostics underscore both challenges and opportunities. Digital infrastructure gaps, institutional bottlenecks, limited formal integration agreements, and continuing trade logistics constraints continue to hold back deeper integration. At the same time, green investment, supply chain diversification, and nearshoring offer fresh possibilities that especially Latin America is acting upon by striking a growing number of sector-specific arrangements, many of which are regulation-focused and non-binding. In the electric vehicle sector, economies are leveraging policy to reposition themselves in value chains. The People's Republic of China has emerged as a leader spanning inputs, assembly, and recycling, while African producers are seeking greater value retention from mineral processing.

The report also deepens our understanding of the complex interplay between GVCs, climate, and sustainability. Our analysis traces embodied carbon emissions across borders and evaluates the implications of emission trading schemes, carbon border adjustment mechanisms, green innovation, and new financing instruments. It shows

that achieving climate goals while preserving development opportunities requires more market-oriented and incentive-based green policy instruments, complemented by greater transparency, effective international cooperation and active technology transfer across supply chains. Without these, the risk of carbon leakage and unequal adjustment remains high.

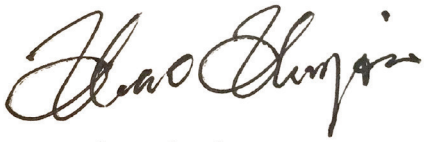
At the same time, foreign direct investment, new technologies like artificial intelligence, and industrial policy are reshaping GVCs. Evidence in this report confirms that foreign direct investment continues to foster technology assimilation and productivity growth but also shows how strategic industrial policies can create spillovers or distortions that extend well beyond national borders. Understanding these cross-border effects is vital for designing policies that enhance resilience while maintaining openness.

Finally, the report turns to governance. As traditional multilateral negotiations remain difficult, sectoral, or otherwise limited, deals – often, not binding or even trade-centered – are emerging as new tools to govern frontier issues such as digital trade or access to critical minerals. The report identifies more than 180 such 'targeted trade deals', most of which were signed between 2021 and 2024. These underscore that international cooperation has evolved toward more flexible, issue-specific frameworks rather than disappeared. Improving the transparency, comparability, and interoperability of such policies will be central to building trust and predictability in this new governance landscape.

An important caveat for the report and its findings is that the data and evidence collected mainly runs through 2024 – and thus pre-dates the substantial tariff increases, and associated uncertainty seen in 2025. And yet, available data at the time of publication in December 2025 suggest that trade growth remained robust, illustrating the resilience of supply chains thanks to firm agility and creative policy approaches to managing disruptions. This reaffirms the report's central insights regarding the adaptability of GVCs, but it undeniable that the past year has put further strains on them.

This fifth edition of the *Global Value Chain Development Report* is the product of even greater collaboration than in previous years. More than 60 scholars and policymakers from leading institutions worldwide contributed to the background papers and chapters. The co-publishing partners – the Asian Development Bank, the Research Institute for Global Value Chains at the University of International Business and Economics, the Institute of Developing Economies-Japan External Trade Organization, the World Trade Organization, and the World Economic Forum – are grateful for their commitment.

We hope the *Global Value Chain Development Report 2025* will help policymakers, researchers, and business leaders better understand how GVCs are reconfiguring under the pressures of our turbulent times. By advancing knowledge and fostering dialogue, this report aims to support the construction of a global trading system that is more inclusive, resilient, and sustainable, and that continues to deliver benefits to people around the world.



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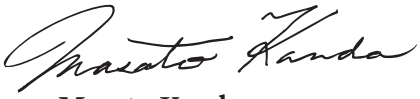

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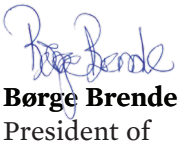

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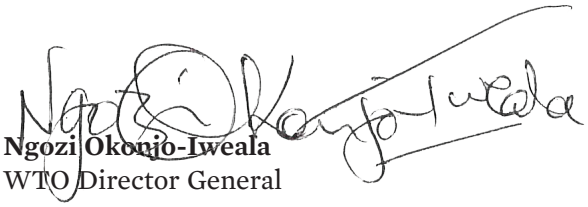

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RIGVC-UIBE is the first research institute to focus on global value chain (GVC) research. The institute is a platform for promoting GVC research by integrating research efforts and resources of universities and other research institutions, government agencies, and firms across the world. It runs training and degree programs on GVCs, and its resources are open to all researchers.

ADB is a leading multilateral development bank supporting inclusive, resilient, and sustainable growth across Asia and the Pacific. Working with its members and partners to solve complex challenges together, ADB harnesses innovative financial tools and strategic partnerships to transform lives, build quality infrastructure, and safeguard our planet. Founded in 1966, ADB is owned by 69 members—50 from the region.

IDE-JETRO is a research institution affiliated with the Japan External Trade Organization (JETRO), an incorporated administrative agency under the Ministry of Economy, Trade, and Industry of Japan. IDE-JETRO aims to make intellectual contributions to the world as a leading center of social science research on developing regions. It accumulates locally grounded knowledge on these areas, clarifies the conditions and issues they face, and disseminates a better understanding of these regions both in Japan and internationally. These activities provide an intellectual foundation for cooperation between Japan and the international community in addressing development challenges.

The World Economic Forum is the international organization for public-private cooperation that brings together leaders from business, government, and civil society with the mission of improving the state of the world. Through its research, platforms, and partnerships, the World Economic Forum plays a key role in analyzing and shaping the future of global value chains – especially in the areas of supply chain resilience, manufacturing and production networks, digitalization, and sustainable trade. By convening multistakeholder dialogue and fostering public-private collaboration, the World Economic Forum convenes stakeholders and provides platforms for public and private discussions that, among many other things, examine global production systems and their ability to be inclusive, adaptive, and sustainable.

The WTO is the only global international organization dealing with the rules of trade. Its main function is to ensure that trade flows as smoothly, predictably, and freely as possible. It also provides a forum for its members to negotiate trade agreements and to resolve the trade problems they face with each other. The overall objective of the WTO is to help its members use trade as a means to raise living standards, create jobs, and improve people's lives.

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Abbreviations

ACEA	European Automobile Manufacturers' Association
ADB	Asian Development Bank
AEO	authorized economic operator
AfCFTA	African Continental Free Trade Area
AfDB	African Development Bank
AI	artificial intelligence
AIPI	International Monetary Fund's Artificial Intelligence Preparedness Index
AML	anti-money laundering
AP	Associated Press
ASEAN	Association of Southeast Asia Nations
ASIF	China's Annual Survey of Industrial Firms
AUC	African Union Commission
BaTiS	WTO-OECD Balanced Trade in Services
BAU	business-as-usual
BEVs	battery electric vehicles
BIS	Bank for International Settlements
BITs	bilateral investment treaties
BO	beneficial ownership
BRI	Belt and Road Initiative
C-TPAT	Customs-Trade Partnership Against Terrorism
CATL	Contemporary Amperex Technology Co. Ltd.
CBAMs	carbon border adjustment mechanisms
CDIS	Coordinated Direct Investment Survey
CEPS	Centre for European Policy Studies
CGE	computable general equilibrium
CMA	UK Competition and Markets Authority
CPTPP	Comprehensive and Progressive Agreement for Trans-Pacific Partnership
CRM	critical raw minerals
CRS	Congressional Research Service
DAVAX2	domestic added value absorbed by importer as intermediate goods
DCI	Digital Infrastructure Capability Index
DDS	digitally deliverable services
DEAs	digital economy agreements
DEFA	ASEAN Digital Economy Framework Agreement
DEPA	Digital Economy Partnership Agreement
DEs	omestic enterprises
DESA	United Nations, Department of Economic and Social Affairs
DGD	USITC Dynamic Gravity Dataset
DOE	U.S. Department of Energy

DPI	digital public infrastructure
DRC	Democratic Republic of the Congo
DSS	downward-sloping supply curve
DSTRI	OECD Digital Services Trade Restrictiveness Index
DTA	Digital Trade for Africa
DVA	domestic value-added
E-ID	electronic-identification
ECOWAS	Economic Community of West African States
EDB	WTO Environmental Database
EDGAR	Emissions Database for Global Atmospheric Research
EMDEs	emerging market and developing economies
ERDI	Economic Research and Development Impact Department
ERI	Electricity Regulatory Index
ESG	environmental, social, and governance
ETGs	energy-transition goods
ETSs	emissions trading systems
EU	European Union
EVs	electric vehicles
FCI	Factoring Chains International
FDI	foreign direct investment
FIEs	foreign-invested enterprises
FTAs	free trade agreements
FTC	US Federal Trade Commission
FVAX	foreign value added at exports
GATT	General Agreement on Tariffs and Trade
GDP	gross domestic product
GFDD	World Bank's Global Financial Development Database
GHG	greenhouse gas
GIPTP	Global Industrial Policy Transparency Platform
GNI	gross national income
GSCFF	Global Supply Chain Finance Forum
GSDB	Global Sanctions Database
GTA	Global Trade Alert
GVCRI	Global Value Chain Readiness Index
GVCs	global value chains
HFDI	horizontal foreign direct investment
HHI	Herfindahl-Hirschman Index
HS	Harmonized System
IBE	Institute of Business and Economics
ICC-DSI	International Chambers of Commerce-Digital Standard Initiative
ICCT	International Council on Clean Transportation
ICEs	internal combustion engines
ICEVs	internal combustion engine vehicles
ICIO	inter-country input-output

ICTs	information and communications technologies
IDE-JETRO	Institute of Developing Economies-Japan External Trade Organization
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IFC	International Finance Corporation
ILO	International Labor Organization
IMF	International Monetary Fund
IO	input-output
IP	industrial policy
IPAs	investment promotion agencies
IRENA	International Renewable Energy Agency
ISDS	investor-state dispute settlement
ISI	import substitution industries
ISO	International Organization for Standardization
IT	information technology
ITU	International Telecommunication Union
IXPs	Internet Exchange Points
KPIs	Key Performance Indicators
LAC	Latin America and the Caribbean
LBD	learning-by-doing
LMICs	low- and middle-income countries
LNG	liquefied natural gas
LPI	World Bank's Logistics Performance Index
MAC	marginal abatement cost
MENA	Middle East and North Africa
MFN	most-favoured nation
MNCs	multinational corporations
MNEs	multinational enterprises
MoCs	memorandums of cooperation
MoUs	memorandums of understanding
MRA	mutual recognition agreement
MRIOTs	multiregional input-output tables
MRV	measurement, reporting, and verification
MSMEs	micro, small, and medium-sized enterprises
MSP	Minerals Security Partnership
NIPO	New Industrial Policy Observatory
NLP	natural language processing
NSW	national single window
NTMs	non-tariff measures
OECD	Organisation for Economic Co-operation and Development
OEM	original equipment manufacturer
OICA	International Organization of Motor Vehicle Manufacturers
OTA	over-the-air

PAPSS	Pan-African Payment and Settlement System
PCS	port community systems
PDR	Lao People's Democratic Republic
PHEVs	plug-in hybrid electric vehicles
PPAs	power-purchase agreements
PPML	Poisson Pseudo-Maximum Likelihood
PPP	public-private-partnership
PPP	purchasing power parities
PRC	The People's Republic of China
PTAs	preferential trade agreements
PUR	preference utilization rate
R&D	research and development
RCA	revealed comparative advantage
RCEP	Regional Comprehensive Economic Partnership
RECs	regional economic communities
RGGI	Regional Greenhouse Gas Initiative
RMI	Rocky Mountain Institute
RoO	rules-of-origin
RTAs	regional trade agreements
RTI	routine task intensity
RVCs	regional value chains
SACU	Southern African Customs Union
SADC	Southern African Development Community
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCF	supply chain finance
SCM	Subsidies and Countervailing Measures
SCMP	South China Morning Post
SDGs	United Nations Sustainable Development Goals
SDV	software-defined vehicle
SEZ	special economic zone
SLAs	service-level agreements
SMEs	small and medium-sized enterprises
SOEs	state-owned enterprises
SPEs	special purpose entities
STEM	science, technology, engineering and mathematics
TAPED	Trade Agreement Provisions on Electronic-commerce and Data
tCO_2e	ton of CO_2 emissions
TEAs	trade executive agreements
TF/SCF	trade and supply chain finance
TiFI	Trade in Factor Income
TiVA	OECD Trade in Value-Added
TTDs	targeted trade deals
TWh	terawatt-hour

UAE	United Arab Emirates
UIBE	University of International Business and Economics
UK	United Kingdom
UNCTAD	United Nations Conference on Trade and Development
UNECA	United Nations Economic Commission for Africa
UNIDO	United Nations Industrial Development Organization
US	United States
USMCA	United States-Mexico-Canada Agreement
VFDI	vertical foreign direct investment
WBES	World Bank Enterprise Surveys
WBG-HBFDI	World Bank's Bilateral FDI dataset
WDI	World Bank's World Development Indicators
WEO	IMF's World Economic Outlook
WGI	World Governance Indicators
WIOD	World Input-Output Database
WITS	World Integrated Trade Solution
WTO	World Trade Organization

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Key Messages and Findings

Chapter 1: Recent Developments in Global Value Chains

Key messages

- Trade proved resilient after successive shocks, but the widening gap since 2022 between traditional and GVC-related trade points to deeper reorganization of production networks.
- Services have overtaken goods in GVC participation, showing greater resilience post-pandemic, especially digitally deliverable services such as finance, telecommunications, and IT. This shift reflects the increasing role of services in global trade and their relative insulation from physical supply chain disruptions.
- The average number of production stages in GVCs has lengthened in many economies since 2020, driven by supply chain disruptions and rerouting of trade, especially in Europe and Central and West Asia.
- Economies with the highest GVC participation still dominate, but their combined share of GVC-related trade dropped from 76% in 2010 to 63.6% in 2025 as low-GVC traders have increased their participation, signaling a modest broadening of globalization.
- Reshoring and regionalization trends are evident in major economies such as China, the US, and the EU, which have reduced their dependence on foreign value-added in domestic consumption, suggesting a shift toward reshoring.
- Gross and direct value-added trade were negatively affected by growing fragmentation along geopolitical lines, while indirect value-added trade was generally unaffected. The Russian Federation's trade pivoted to PRC and India, Central and West Asia rose as a transit hub, and indirect routes between the US and China via connector economies such as Mexico and Viet Nam grew.

Chapter 2: Resilience and Reglobalization GVC Trends and New Opportunities

Key messages

- Globalization is being rewired, not reversed. GVC integration has slowed and consolidated since 2011, with production, trade and investment concentrating on technologically advanced, regionally integrated hubs. Apparent diversification often masks continued dependence on a narrow set of partners and products, especially in Latin America and the Caribbean (LAC) and Africa.
- LAC and the Caribbean and Africa participate in GVCs but struggle to upgrade. New TiVA evidence and firm-level diagnostics show that many economies in both regions remain locked into low-complexity, low-margin tasks, while foreign-controlled firms dominate high-value segments. Participation alone does not guarantee domestic value capture, learning, or resilience.

- Readiness rather than volume is the new basis of competitiveness. A Global Value Chain Readiness Index (GVCRI) across six pillars (technology and connectivity, trade and investment, sustainability and energy, institutional and geopolitical, financial and business readiness) highlights that LAC and Africa lag in digital backbone, logistics reliability, institutional quality and financial depth, even where they hold strengths in renewables, critical minerals, demographics and pragmatic diplomacy.
- Corridor-first, key performance indicator-anchored reforms can convert endowments into reliability-priced opportunities. For both regions, priority actions include strengthening digital and data infrastructure, grid reliability and green power, trade facilitation and preference utilization, and investment de-risking around key corridors. Progress should be tracked through practical metrics – such as corridor uptime, broadband affordability, ETG tariffs, customs clearance times, and SME upgrading – so that reglobalization translates into higher domestic value capture and more resilient, inclusive growth.

Chapter 3: Global EV Value Chains: Paradigm Shifts and New Opportunities for Developing Economies

Key messages

- The rapid rise of electric vehicles (EVs) is reshaping traditional global automotive supply chains. In 2023, China accounted for 76.9% of global EV production, far exceeding the United States, Germany, and Japan. This stands in sharp contrast to the internal combustion engine vehicle (ICEV) era, when global production and trade were long dominated by these three countries. As the core component of EVs, EV batteries rely heavily on minerals. In 2023, global battery manufacturing consumed 85% of lithium, 70% of cobalt, and over 10% of nickel. While this creates new opportunities for resource-rich developing economies to upgrade within the EV supply chain, the extreme concentration of mineral supply, such as cobalt from the Democratic Republic of the Congo and lithium from Chile, also exposes the upstream segment to significant vulnerability. Diversifying sources of critical minerals may therefore emerge as an urgent strategic priority for major battery-and vehicle-producing countries.
- EVs are essential to global transport decarbonization. According to EV-ICIO and life-cycle assessments, EVs emit 2-4 more tons of CO_2 during production than ICEVs due to battery manufacturing yet deliver substantial life-cycle emissions reductions. The carbon payback period varies widely — 1.7 years in the United States, 5.7 years in China, and 7.6 years in Japan. However, the simulation results show that a 15% increase in renewable energy and electric-drive efficiency would shorten the payback period to 1.4, 4.5 and 5.9 years in the United States, China and Japan respectively, underscoring the critical role of policy interventions in accelerating the mitigation benefits of EVs.

- Product-space analysis identifies three evolutionary pathways through which economies develop new advantage products in the EV industry: breakthrough-, cluster-, and chain-type. Developed economies such as the United States and South Korea mainly expand their EV-related capabilities through cluster and chain paths, reflecting strong path dependence. In contrast, large developing economies and resource-rich countries tend to enter and upgrade within the EV industry through breakthrough and chain-type modes, gradually building new competitive strengths.

Chapter 4: Toward Greener and Inclusive Global Value Chains: Insights from Environmental Policy

Key messages

- GVCs are deeply rooted in domestic production systems while simultaneously operating through cross-border production sharing. This duality implies that meaningful climate mitigation requires action across all nodes of the chain.
- Expanding carbon pricing to cover a wider range of firms, including SMEs, and ensuring more equitable green financial access across firms of different sizes and ownership types can improve emissions efficiency while minimizing GDP losses.
- When countries adopt different environmental regulations, this can introduce border adjustment complexities, disrupt economies of scale for firms operating across multiple jurisdictions and create a need for "regulatory hedging" strategies, where firms adjust production to serve specific regulatory markets.
- Trade-related environmental policies shape GVCs by influencing green innovation and technological upgrading. Policies that encourage green innovation – such as R&D supports, intellectual property reforms, and market-based incentives for low-emission technologies – can accelerate the shift of firms and sectors toward the green technological frontier.

Chapter 5: Industrial Policy in a Strategically Contested Global Economy

Key messages

- Industrial policy has re-emerged at unprecedented scale and scope as governments pursue climate, technology, and security objectives. Recent mapping exercises show large, targeted interventions across more than 70 economies, concentrated in GVC-intensive sectors such as semiconductors, clean energy technologies, digital infrastructure, and critical minerals. These measures are no longer occasional exceptions but a core feature of national development and security strategies.
- Modern industrial policies are embedded in fiscal and financial architectures rather than confined to line ministries. Tax credits, production subsidies, targeted credit, green finance, and strategic public procurement are increasingly coordinated

with macro-stabilization and climate investment frameworks, so that industrial policy now functions both as a tool of structural transformation and as an integral component of long-term public investment planning.

- Because production is organized through dense cross-border value chains, policy impacts propagate through upstream and downstream linkages. New empirical work using MRIO and firm-level data finds that indirect spillovers on suppliers, customers, and third-country competitors can rival or exceed the direct domestic effects of support, creating both positive learning externalities and negative displacement or overcapacity risks across borders.
- The effectiveness and welfare consequences of industrial policy remain highly context dependent. Case studies in sectors such as autos, shipbuilding, and clean energy show that outcomes hinge on detailed design and implementation quality, including targeting, competitive neutrality, time consistency, and phase-out strategies. At the same time, the evidence base is still incomplete, so strong global welfare conclusions about industrial policy, in aggregate, are not yet warranted.
- Geoeconomic fragmentation and subsidy competition are reshaping the geography of GVCs. Firms respond to tariffs, sanctions, and subsidies by rerouting trade and investment through "connector" economies such as Viet Nam, Mexico, Türkiye, and parts of ASEAN that can bridge rival blocs. Much of this adjustment reflects re-routing and incremental upgrading rather than wholesale relocation, but it is gradually altering regional industrial structures and the distribution of bargaining power.
- Multilateral rules and monitoring have not kept pace with this surge in policy activism. World Trade Organization (WTO) subsidy disciplines remain formally in place, but notification gaps, weak enforcement, and the broader dispute settlement impasse reduce their constraining power. In response, institutions such as the International Monetary Fund (IMF), the Organisation for Economic Co-operation and Development (OECD), the World Bank and the WTO are experimenting with joint subsidy platforms, sectoral observatories, and modular transparency proposals that can provide a shared factual basis for dialogue even when legal reform is slow.
- For firms, industrial policy has become a strategic operating condition rather than a background parameter. Large multinationals now treat policy regimes as part of their comparative advantage calculus, hedging risks and arbitraging incentives across locations when structuring supply chains and investment. This creates opportunities for anchor economies that can credibly combine incentives with stability, but it also raises the risk of inefficient subsidy races and fiscal strain, especially where transparency and evaluation remain weak.

Chapter 6: Foreign Direct Investment, Trade Finance and Global Value Chain Integration

Key messages

- Foreign direct investment (FDI) provides the structure of global production, while trade and supply chain finance (TF/SCF) provide the motion. FDI anchors long-term capital formation, technology transfer and organizational know-how, determining where production occurs. TF/SCF-through letters of credit, guarantees, factoring, and receivables finance-supplies the short-term liquidity that keeps goods and intermediate inputs moving. Without this dual-capital system, GVC integration remains shallow: investment without liquidity traps firms outside supply chains; liquidity without investment keeps them in low-margin roles.
- Liquidity constraints severely limit firm participation in GVCs–even where FDI presence is strong. Evidence from banking, World Bank Enterprise Surveys (WBES), and regional surveys shows that 71% of exporter working capital in developing economies is self-financed, with only 18% coming from banks; 40% of sales occur post-delivery, creating long cash-flow gaps. Payment cycles of 60-120 days, high collateral requirements, and rejection rates above 20-25% in parts of Africa and the Mekong region prevent SMEs from supplying multinational firms. The global trade-finance gap reached USD2.5 trillion in 2022, reflecting severe structural shortages in short-term credit. Trade-finance pricing remains prohibitively high: confirmed letters of credit cost 3.5-4% of transaction value in many emerging markets versus 0.25-0.5% in advanced economies. Trade-finance coverage remains extremely low-3-20% in many emerging economies-compared with more than 60% in advanced countries. WTO-IFC modelling shows that raising trade-finance coverage from 25% to 40% and lowering costs to emerging-market benchmarks would boost annual trade flows by ~8%.
- Supply chain finance (SCF) is expanding but highly concentrated and inaccessible to lower-tier suppliers. SCF supports only 0.5% of trade in Viet Nam and Cambodia and 1% in Mexico, where 90% of SCF is provided by just three banks concentrated on top-tier firms. In Mexico, domestic SCF is four times larger than cross-border SCF but still dominated by a handful of institutions and multinational anchors. Most SMEs lack access to receivables finance or pre-shipment working capital: 70% of exporting SMEs in Viet Nam cannot access working-capital loans, and 75% of Mexican MSMEs do not qualify for bank credit. These constraints limit their ability to meet multinational procurement requirements and weaken domestic linkages created by FDI.
- Trade and FDI respond to different financial architectures, creating diverging integration patterns. Gravity-model estimates show that bilateral stock market development strongly raises trade flows, while banking sector depth and private credit availability drive FDI. This “financial duality” implies that comparable levels of trade and investment openness require different institutional reforms. Economies with more compatible financial systems trade and invest more with each other, reinforcing the importance of financial system compatibility for GVC integration.

Chapter 7: Technology, Productivity, and Inclusive Growth through Global Value Chains

Key messages

- Technological change and GVCs are mutually reinforcing. Advances in ICT, logistics, and digital platforms enable finer fragmentation of production, while GVCs operate as channels for technology transfer and learning. However, the benefits are structurally selective: they accrue mainly to economies with sufficient absorptive capacity, appropriate industrial structures, and strong firms, rather than automatically diffusing to all GVC participants.
- Between-economy inequality has declined on a population-weighted basis since the 1990s, but convergence is uneven and limited for many low-income economies. New evidence shows that productivity gains from GVC participation are strongest where sectors rely on sophisticated intermediates and where economies occupy technology-intensive or central network positions; many low-income economies remain in low-complexity segments that deliver modest convergence at best.
- Macro-level studies highlight the importance of linkage types and network position. Forward GVC linkages, where domestic inputs feed into other economies' exports, generate relatively rapid productivity convergence even at modest participation levels, while backward linkages require higher thresholds before strong gains materialize. A new concept of "global TFP" shows that productivity improvements in one economy propagate through GVCs and can have larger indirect effects on trading partners than direct domestic gains, reinforcing the importance of network structure for welfare outcomes.
- Firm-level evidence indicates that GVC participation primarily helps lagging firms catch up rather than pushing leaders further ahead. Joining multinational or superstar supply chains raises supplier productivity, employment, and access to better buyers, largely through direct knowledge transfer and the diffusion of "relationship capabilities". These mechanisms generate within-industry convergence in productivity, even as overall rents remain skewed toward highly connected firms.
- The same mechanisms that support productivity growth can widen gaps within economies. GVC integration and technology adoption are associated with falling labor shares, higher skill premia, and job polarization. Women, youth, and informal workers are disproportionately concentrated in routine or low-protection roles that are more exposed to automation and upgrading shocks, while superstar firms, digitally connected MSMEs, and core regions capture a growing share of value added and innovation rents.
- Emerging technologies such as AI, advanced robotics, and digital platforms interact with GVCs in two opposing ways. On one side, they lower trade and coordination costs and can open new upgrading paths, including for smaller firms that can leverage digital intermediation. On the other side, they extend automation into non-routine tasks, erode low-wage comparative advantages, reinforce firm and regional concentration, and create algorithmic barriers to visibility in platform-mediated trade, with ambiguous net effects on inclusive development.

- Policy choices determine whether GVCs and technology become engines of inclusive growth or sources of new divides. The chapter emphasizes the need for selective GVC integration aligned with domestic capabilities, sustained investment in skills and absorptive capacity, active labor market and social protection systems, competition and tax policies that limit excessive concentration, and technology governance that keeps AI and digital rents from being locked into a narrow set of frontier firms and locations. Economies that combine these elements are more likely to translate GVC-linked productivity gains into broad-based improvements in incomes and opportunities.

Chapter 8: Targeted Trade Deals as A New Form of Global Value Chain Governance

Key Messages

- Targeted trade deals (TTDs), sectoral or otherwise limited trade agreements often focused on addressing non-tariff barriers through soft law provisions, are not a new phenomenon, but they have seen a sharp rise in the past five years.
- TTD formation is driven by a limited set of factors clearly linked to their specific objective. For instance, digital TTDs are signed primarily by economies with strong digital capabilities while critical mineral TTDs require at least one signatory to have high resource endowments.
- Empirical evidence is consistent with TTDs increasing trade between the signatories in the regulated areas. The strongest evidence of a systematic effect on trade is found for CRMTTDs with an average effect of 12%, whereas for digital TTDs significant effects are limited to more ambitious agreements.
- TTDs fulfil pragmatically strategic objectives and contribute to international cooperation. Their flexibility provides policymakers with a simple tool to address frontier issues through a cooperative approach. Increased transparency could further the goals of TTDs and address concerns regarding policy fragmentation and public accountability.

Executive Summary

The Resilience and Rewiring of Global Value Chains

This report finds that global value chains (GVCs) remain the backbone of the world economy, even as their structure and logic evolve in response to economic, technological, and geopolitical change. Over the past quarter century, trade in intermediate goods and services has linked nearly every economy into a dense network of production relationships. These networks have proved remarkably durable through successive crises – the global financial shock of 2008-09, the pandemic, and the recent surge in geopolitical and climate-related disruptions. Measured in value-added terms, cross-border production continues to account for almost half of world trade, and the nominal volume of trade in intermediates has reached record highs according to the latest ADB GVC data. The evidence collected for this report confirms that globalization is being reconfigured rather than reversed: supply chains are adapting through regionalization, digitalization, and diversification. These adjustments revolve around three core dimensions that structure the report: building resilience to shocks, broadening inclusion across economies and firms, and advancing sustainability through technological and policy innovation.

Between the mid-1990s and the late 2000s, globalization entered a phase of rapid expansion driven by falling transport costs, trade liberalization, and the integration of large emerging markets. The period from 2011 to 2019 brought slower growth in global trade, but also the emergence of new forms of specialization based on services and knowledge flows. Since 2020, a third phase has taken shape. Firms now balance efficiency with resilience, re-examining supplier concentration and investing in digital coordination tools that allow them to operate more flexibly. Although the global ratio of trade to GDP has plateaued and recent data from OECD TiVA show that backward participation – the share of imported inputs used in exports – has stabilized near 47% of total exports, the intensity of regional linkages has strengthened, particularly within Asia and North America. This shows continuity in international production but a change in its geography.

Using updated value-added trade and network measures, the report finds that regional hubs in Asia, Europe, and North America still account for the majority of GVC trade, while emerging nodes in Latin America and Africa remain mainly on the periphery of investment and trade integration compared to the main regional hubs. Digital trade and data flows have become the connective tissue allowing networks to adapt without fragmenting and these are key challenges for many least developed and developing countries. However, despite this, the current configuration of value chains is more multipolar than at any time in the past two decades. The People's Republic of China (PRC) remains a central hub for manufacturing and assembly, yet its share of world manufacturing value added has leveled off, and production capabilities are diffusing

to a wider set of economies. Viet Nam, Mexico, Poland, and Türkiye have expanded their roles in electronics, machinery, and transport equipment. India, the Philippines, and several African economies have strengthened their positions in business-process and digital-service exports. These shifts reflect both market forces and deliberate policy choices to diversify risk and attract new investment. Services value added now represents more than one-third of the content embedded in manufacturing exports, underscoring the centrality of design, logistics, and digital functions in modern competitiveness.

Opportunities for New Players if Structural and Policy Gaps are Addressed

The reorganization of GVCs also has a social and developmental dimension. The distribution of participation remains uneven, with Latin America and Africa together accounting for less than five percent of complex manufacturing trade. Their integration into higher-value segments is constrained by logistics gaps, limited digital infrastructure, and shortages of skilled labor. Nonetheless, opportunities are expanding as firms seek new regional bases for supply security. In Latin America, proximity to North American markets has generated interest in near-shoring, while in Africa, growth in demand for critical minerals and light manufacturing is opening new avenues for inclusion. Economies that pair openness with institutional reform – modern customs, improved transport corridors, and investment in skills – recover more quickly from shocks and attract more sustainable investment. Regional analysis shows renewed interest in Latin America as a near-shoring destination given proximity to North American markets, though shallow integration and fragmented logistics still constrain deeper participation. In Africa, modest gains in manufacturing GVCs are accompanied by rapid growth in trade of green minerals and processing activities. Readiness indicators highlight that customs efficiency, broadband access, and skills shortages remain decisive factors determining who benefits from diversification.

The report emphasizes that resilience and inclusiveness reinforce each other. Economies with diversified export bases and sound financial systems absorb external shocks more effectively than those dependent on a narrow range of commodities or buyers. Near-shoring and regional supply networks can broaden participation, but only when supported by complementary domestic policies. Without such reforms, diversification risks producing enclaves with limited spillovers. Regional initiatives such as the African Continental Free Trade Area and the Pacific Alliance can enhance both scale and policy coordination if implementation keeps pace with ambition.

Opportunities for Green GVCs

Zooming in on one sector, electric vehicles (EVs), the report highlights how structural shifts in GVCs provide new opportunities. The rapid rise of EVs is reshaping traditional global automotive supply chains. In 2023, China accounted for 76.9% of global EV

production – far surpassing the United States, Germany, and Japan. This stands in sharp contrast to internal combustion engine vehicles (ICEVs), which have traditionally been dominated by these three economies. As the core component of EVs, batteries depend heavily on mineral inputs. In 2023, global battery manufacturing consumed 85% of the world's lithium, 70% of its cobalt, and more than 10% of its nickel. While this creates new opportunities for resource-rich developing economies to upgrade within the EV supply chain, the extreme concentration of mineral resources in specific economies exposes upstream segments to significant vulnerabilities. Diversifying sources of critical minerals may therefore become an urgent strategic priority for major battery- and vehicle-producing economies.

EVs play a pivotal role in global transport decarbonization. Life-cycle assessment results based on a newly developed inter-country input-output model – one that separates EVs and ICEVs from the broader auto sector – show that each EV emits 2–4 more tons of CO_2 during production than an ICEV because of battery manufacturing. However, EVs yield substantial reductions in emissions over their full life cycle. The carbon payback period varies considerably across economies: 1.7 years in the United States, 5.7 years in China, and 7.6 years in Japan. Simulation results indicate that a 15% increase in renewable electricity and electric-drive efficiency would shorten these payback periods to 1.4, 4.5, and 5.9 years, respectively, underscoring the critical role of policy interventions in accelerating the climate mitigation benefits of EVs.

Product space analysis, a method that maps how easily economies might, in principle, shift from the products they already make to more complex, related ones, suggests that countries tend to develop new EV capabilities through three broad patterns. Some make "breakthrough" moves into activities far from their current strengths, a pathway common among large developing or resource-rich economies entering battery processing or upstream minerals. Others follow "cluster" pathways by adding EV components that are closely related to existing capabilities, while "chain" pathways involve step-by-step upgrading into adjacent functions along the supply chain. Advanced economies such as the United States and the Republic of Korea mostly expand through cluster and chain pathways, deepening established competencies, whereas emerging and resource-rich economies more often rely on breakthrough and early chain upgrading as they seek to build new competitive advantages in EVs.

The environmental implications of global production extend well beyond the EV sector. Using a new GVC-based emissions accounting framework, this report finds that advanced economies have achieved a clear and broad decline in both production-based and consumption-based CO_2 emissions during 2000-2023. These reductions appear not only in production for domestic final demands but also for exports. Importantly, this progress has continued even though these economies already operate at relatively low levels of carbon intensity, reflecting steady improvements in emissions efficiency. Middle- and lower-income economies, however, follow a different trajectory. Their reductions in carbon intensity have been limited – their pace of decline between 2000

and 2023 was only about 60% of that of advanced economies. The carbon cost of GVC participation is particularly striking: for every additional US dollar of value-added generated through GVC participation via trade and FDI, middle- and lower-income economies emit about 3.6-4.7 times more CO_2 than advanced economies in 2023. This gap largely reflects the rapid growth of South-South trade in energy-intensive intermediates and the structural position of developing economies in GVCs, where they are concentrated in upstream, manufacturing-heavy, and carbon-intensive activities. This widening emissions disparity raises great concerns for achieving the UN Sustainable Development Goals and meeting the IPCC target of limiting global warming to 1.5°C.

Building on analytical results from GVC-based emissions accounting, the report also shows that global value chains are deeply embedded in domestic production systems while also relying on cross-border production sharing. This dual structure means that effective emissions reduction must target both domestic and international segments of GVCs; meaningful climate mitigation requires coordinated action across all nodes of the chain.

Governments have begun responding with a range of carbon-pricing instruments – including carbon taxes, emissions trading systems (ETSs), and carbon border adjustment mechanisms (CBAMs) – as well as other trade-related environmental policies. The report highlights that well-designed national ETSs can play a pivotal role in GVC decarbonization. Evidence from China's case study suggests that expanding carbon pricing to cover more firms and improving equitable financial access can enhance emissions efficiency while keeping GDP losses relatively low.

Using GVC-based CGE modeling that explicitly distinguishes the production functions of multinationals and domestic firms, the report finds that CBAMs can mitigate carbon leakage and create positive spillovers by encouraging trading partners to adopt or strengthen domestic carbon pricing, provided they are implemented with sufficient sectoral coverage and transparency. At the same time, the report also shows that EU CBAM can generate uneven impacts across economies and across firms with different ownership structures. The report cautions that fragmented policy landscapes might introduce regulatory frictions in GVCs. When economies adopt different environmental regulations, this can introduce border adjustment complexities, disrupt economies of scale for firms operating across multiple jurisdictions and create a need for "regulatory hedging" strategies, where firms adjust production to serve specific regulatory markets.

Trade-related environmental policies also shape GVCs by influencing green innovation and technological change. Policies that incentivize green innovation – such as R&D subsidies, intellectual property reforms, and market-based instruments that reward low-emission technologies – can accelerate the shift of firms and sectors toward the green technological frontier. Drawing on the WTO Environmental Database, which includes more than 13,000 environment-related measures, the report shows that such

policies can induce structural shifts in competitiveness over time, enabling some countries to move into higher-value segments of environmental goods production.

Finance and technology are also essential for supporting green GVCs. Firms integrated into GVCs adopt cleaner and more efficient processes more rapidly when they have access to capital and reliable market signals. Yet access to green finance remains uneven. Global demand for trade finance exceeds available supply by over $2.5 trillion according to the ADB, with small and medium-sized enterprises facing the largest gaps. Expanding digital trade finance platforms, blended finance vehicles, and credit guarantee schemes can help close this deficit. Stronger verification standards and clearer taxonomies can direct more of this capital toward emission-reducing projects in developing regions.

Financing and Investing in the Rewiring of GVCs Amid Technological Change

Financial and investment linkages underpin the adaptability of global value chains. Firms with reliable access to finance recover faster from shocks, and economies attracting diversified foreign direct investment experience quicker technological diffusion. Yet the global trade finance gap remains substantial, and FDI inflows are still 15% below their 2015 peak. These disparities highlight that resilience depends as much on financial intermediation and investment climate as on physical supply chain configuration.

More broadly, financial intermediation and investment allocation shape who participates in global value chains and how resilient these networks are when shocks occur. Firms with strong access to finance are more likely to export, adopt new technologies, and recover quickly from disruptions. Yet financing conditions remain highly uneven across economies and sectors. In many developing economies fewer than one in five firms report access to formal credit, while the persistent trade-finance gap constrains exporters of intermediate goods. The pandemic widened that gap as global banks cut exposure and supply-chain disruptions increased risk aversion. Digital verification platforms and guarantee facilities supported by development banks have since begun to close it, but progress is uneven. Expanding digital trade-finance ecosystems and blended finance instruments is therefore essential for inclusive reorganization of globalization.

Empirical evidence links access to external finance directly to productivity growth and export participation. Firms with better credit access are 40% more likely to enter export markets and adopt new technology. Yet financing remains concentrated: less than one in five firms in developing economies report access to formal credit.

Foreign direct investment remains the primary conduit for technology transfer and integration into global production systems, though its structure is shifting. Global

FDI inflows in 2023 were still about 15% below their 2015 peak, yet greenfield projects in digital and clean-energy sectors now account for more than half of new announcements. These flows mirror policy incentives in major economies but also the pull of large emerging markets with growing domestic demand. The benefits of FDI depend heavily on absorptive capacity. Where infrastructure, human capital, and governance are strong, spillovers to domestic firms are measurable; where they are weak, investment can create isolated enclaves. Supplier development programs, training partnerships, and regional investment compacts can magnify the developmental impact of foreign capital.

Sustainable finance markets are beginning to link investment decisions directly to environmental outcomes. Green and sustainability-linked bonds have surpassed $5 trillion in cumulative issuance, and ESG-oriented funds account for nearly a quarter of global assets under management. However, most of this financing remains concentrated in advanced economies, with less than five percent reaching low-income regions. Divergent taxonomies and disclosure rules impede cross-border flows. Coordinated standards and transparency are therefore crucial for mobilizing private finance in support of the climate transition. Multilateral development banks and export credit agencies can reinforce these efforts by de-risking projects and standardizing reporting practices. Finance, investment, and trade policy thus form an integrated triad: each affects the scale, direction, and sustainability of value chain participation.

Technology and intangible capital are reshaping productivity dynamics within global value chains. Participation in GVCs remains one of the most powerful mechanisms for knowledge diffusion and learning-by-doing. Firm-level data confirm that backward participation boosts productivity by two to five percentage points per year relative to non-participants, with the strongest effects in technology-intensive industries. Investments in software, data, and organizational know-how now exceed spending on physical capital in many sectors, shifting the geography of value creation toward knowledge-rich activities. Programs linking vocational education and SME mentoring to multinational networks in East Asia and Eastern Europe demonstrate how domestic capability building converts openness into broad-based gains. Firms that combine imported technology with domestic capabilities achieve faster growth in output and wages. These benefits, however, are unevenly distributed. In economies with poor digital connectivity or limited access to finance, many small and medium-sized enterprises remain trapped in low-productivity segments. Strengthening broadband infrastructure, expanding digital-skills training, and facilitating SME access to finance can convert participation into productivity gains.

Intangible capital – software, data, intellectual property, and organizational know-how – has become the main source of competitive advantage. In manufacturing, intangible investment now exceeds spending on machinery and structures in many advanced economies. Firms with high intangible-to-tangible asset ratios exhibit greater adaptability and resilience because these assets enable rapid reconfiguration when

shocks occur. This shift challenges conventional trade statistics, since much of the value now crosses borders through intellectual-property royalties and digital services rather than physical goods. Accurate measurement of intangible flows will be essential for understanding future competitiveness.

Technological upgrading also influences labor markets and inclusion. Globalization has created millions of better-paid jobs in export sectors, but automation and digitalization are altering the composition of work. Routine tasks are declining while demand grows for technical, managerial, and service-oriented skills. Without complementary education and training policies, the digital transition can widen inequalities both within and across economies. The report highlights programs in East Asia and Eastern Europe where vocational training, SME mentoring, and innovation hubs have successfully linked local firms to international production networks. These examples show that openness combined with domestic capability building remains the most effective path to inclusive growth.

Adapting Governance Approaches to the Rewiring of GVCs

The institutional architecture of globalization is reorganizing alongside production and finance, driven by two complementary but distinct governance shifts: the resurgence of industrial policy and the proliferation of targeted trade deals. Both reflect governments' efforts to navigate the same structural forces – climate imperatives, technological competition, and geopolitical tensions – while maintaining the benefits of economic openness. Understanding how these instruments interact, and ensuring their transparency and coherence, has become central to the management of global value chains.

Industrial policy has re-emerged as a defining feature of the new global economy. Governments are using subsidies, tax incentives, regulatory mandates, and public procurement to accelerate technological transformation and strengthen domestic capacity in strategic sectors. Since 2020, announced programs across major economies exceed US$2 trillion, concentrated in semiconductors, clean energy, digital infrastructure, and the upstream inputs – such as critical minerals and battery components – needed to support them. These interventions aim to enhance resilience, meet climate objectives, and secure technological leadership, but they also blur the line between domestic and international policy. Three forces underpin this resurgence: climate commitments and technology rivalry that push governments to shape innovation systems directly; security concerns that encourage 'de-risking' of critical supply chains; and renewed domestic pressure to sustain manufacturing employment.

Empirical evidence shows that most subsidies target upstream inputs in green-technology sectors – batteries, renewable components, advanced semiconductors, and clean hydrogen – where public support determines location decisions and shapes global investment allocation. The diffusion of industrial policies across both advanced and

emerging economies signals a structural shift toward more active state involvement in shaping production. Yet poorly coordinated interventions risk duplication and subsidy races that erode efficiency. Overlapping measures already contribute to investment races and rising costs. The report proposes a transparency framework assessing industrial-policy instruments by intent, scale, and cross-border impact. Greater notification and peer review through international institutions could align national programs with collective goals such as decarbonization and inclusive growth, while distinguishing legitimate public-goods objectives – such as climate mitigation and supply chain resilience – from protectionist distortions.

Traditional multilateral negotiations have slowed, prompting governments to experiment with more flexible instruments. The rise of targeted trade deals (TTDs) – agreements that are typically sectoral or otherwise limited in scope and focused on addressing regulatory barriers – represents a complementary governance response to the same structural pressures driving industrial policy. More than 185 TTDs were signed by the end of 2024 in the areas of digital trade and critical minerals alone. The number of economy pairs linked by digital-trade TTDs has increased more than thirtyfold since 2019, while 80% of all mineral-related deals have been concluded since 2022. These instruments allow rapid, issue-specific cooperation in areas where multilateral rules are incomplete or outdated, such as data flows, digital services, AI governance, and access to critical raw materials. Unlike traditional trade agreements, TTDs emphasize regulatory cooperation through consultative mechanisms, knowledge sharing, and joint standards development, reflecting the shift from tariff liberalization to managing non-tariff regulatory frictions.

The interaction between industrial policy and targeted trade deals is becoming increasingly important for shaping how supply chains evolve. Industrial subsidies, local-content rules, and regulatory incentives often intersect with targeted trade frameworks, jointly determining investment locations, technology transfer patterns, and sourcing strategies. For example, critical minerals TTDs signed to secure access to lithium, cobalt, and rare earths directly interact with industrial policies that subsidize battery manufacturing and electric vehicle assembly. Similarly, digital TTDs establishing data governance frameworks interact with industrial policies supporting domestic cloud infrastructure, semiconductor production, and AI development. This overlapping policy space creates both opportunities for coherent strategies and risks of fragmentation if measures are poorly aligned.

Transparency in both domains is essential for trust and effective coordination. Because most TTDs are negotiated outside legislative oversight and rarely notified to the WTO, public scrutiny is limited. Industrial subsidies similarly suffer from notification gaps and incomplete disclosure, making it difficult for trading partners to assess their scale, intent, and competitive effects. Establishing a central repository for targeted trade deals and improving comparability of industrial policy data would strengthen accountability and help distinguish cooperative measures from those that distort competition.

Enhanced data collection by international institutions – building on initiatives such as the Joint Subsidy Platform and WTO thematic mapping efforts – could facilitate peer review and reduce tensions arising from perceived unfairness. Better information on the intent and magnitude of support measures would help countries evaluate whether interventions serve shared objectives like decarbonization and resilience, or whether they risk triggering retaliatory cycles.

Initial evidence suggests that TTDs can influence trade flows and investment decisions even when non-binding. Bilateral arrangements on critical minerals have raised trade volumes between partners by an estimated 12%, while digital trade frameworks with interoperability provisions have expanded cross-border services in participating economies. The flexibility of TTDs thus brings both benefits and risks. If left uncoordinated, overlapping rules could fragment the global trading system; if embedded within transparent reporting and dialogue mechanisms, they can complement the multilateral framework. The same principle applies to industrial policy: when transparent and coordinated, subsidies can address market failures and accelerate green transitions; when opaque and duplicative, they risk subsidy competition that weakens collective welfare.

Viewed together, the resurgence of industrial policy and the proliferation of targeted trade deals represent a reconfiguration of global economic governance rather than its breakdown. Both tools reflect pragmatic efforts to address urgent challenges – climate change, technological competition, supply-chain vulnerabilities – within a more contested and multipolar world. Success will depend on managing the complementarities and tensions between them. Governments must balance national objectives with the benefits of policy coordination. Transparency, comparability of measures, peer review, and inclusive dialogue are the institutional foundations needed to ensure that this new governance architecture supports rather than undermines the reorganization of globalization. Multilateral forums remain indispensable for sharing evidence, resolving differences, and ensuring that flexibility does not become fragmentation. Regional and plurilateral initiatives can serve as laboratories for new rules, provided that their lessons feed back into a coherent global framework.

The Three Main Takeaways

Viewed together, the report's findings show that globalization is entering a new structural equilibrium rather than disintegrating. Regionalization, digitalization, and sustainability are its defining features. Production remains global in scope but is increasingly organized through overlapping regional networks and governed by a more diverse set of rules and institutions. Success in this environment depends on the capacity of economies to adapt, innovate, and cooperate. Policies that expand participation, manage risk, and reduce environmental impact form the foundation of what this report terms reorganization of globalization.

The policy implications are threefold. First, globalization must become more inclusive. Expanding access to finance, technology, and markets for developing economies and small firms is essential. Digital trade platforms, trade finance initiatives, and regional integration programs can lower entry barriers. Capacity-building support from multilateral agencies should focus on logistics, customs modernization, and digital infrastructure, which together determine readiness for GVC participation.

Second, globalization must become more resilient. Diversified sourcing, transparent supply chain mapping, and sound macro-financial frameworks help economies withstand shocks. Governments should encourage information sharing between public and private sectors to anticipate disruptions. Regional contingency arrangements, including cooperative stockpiles or mutual-assistance frameworks for essential goods, could add further stability. Financial resilience is equally important: maintaining stable capital flows and prudent debt management prevents abrupt reversals that undermine trade and investment.

Third, globalization must become sustainable. Climate and trade policies need to be aligned so that emission reductions and competitiveness reinforce each other. Carbon accounting standards, investment in renewable energy, and support for circular economy practices can reduce environmental pressure without curbing growth. International coordination on carbon pricing and border adjustments will be critical to prevent fragmentation. Developing economies require access to climate finance and technology to participate on equal terms in this green transition.

Beyond these priorities lies the task of rebuilding trust in global economic cooperation. Transparency in industrial and climate policy, comparability of data across economies, and consistent communication between governments and international institutions are necessary to maintain confidence in open markets. Multilateral forums remain indispensable for sharing evidence and resolving differences, even as the landscape of agreements becomes more varied. Regional and plurilateral initiatives can serve as laboratories for new rules, provided that their lessons feed back into a coherent global framework.

The data and evidence collected for this report mainly covers the period until the end of 2024 while 2025 has been another challenging year for global trade co-operation. Average tariffs and other trade-restrictive measures reached levels not seen in decades, with potentially even more distortive effects resulting from heightened trade policy uncertainty. And yet, forecasts by the World Trade Organization suggest that trade growth remained robust. This confirms the key findings of this report. Supply chains are resilient thanks to firm agility and creative policy approaches to managing disruptions. However, 2025 also underlines that the task of rebuilding trust in global economic co-operation has become even more pressing to sustain the benefits of international trade.

The *Global Value Chain Development Report 2025* continues a series that began in 2017 on GVCs and development, followed by volumes on technology, resilience, and inclusion. This edition situates those themes within a post-pandemic, digitally connected, and climate-constrained world. Its central message is pragmatic optimism: global production is reorganizing, not retreating. The task for policymakers is to harness interdependence for inclusive, resilient, and sustainable prosperity.

1

Recent Developments in Global Value Chains

Nomundari Baatar, Angelo Jose Lumba, and Mahinthan Joseph Mariasingham

1.1 Introduction

Global value chains (GVCs) have proven resilient over the past two decades. As shown in the 2023 edition of the *GVC Development Report*, despite facing successive shocks, there had been periods of growth in the value of world exports immediately following episodes of considerable contractions, underscoring the adaptability and soundness of the international trade foundation. In fact, in the two years that followed the COVID-19 pandemic's onset, world gross exports and GVC-related trade reached an all-time high – both in nominal and real terms – while composite measures of globalization such as the DHL Connectedness Index also rebounded strongly (DHL, 2022).

Such remarkable resilience coincided with key changes that came along the way, which draws attention to the process of reconfiguration that has surrounded the recent discourse on GVCs. The specialization brought about by trade and GVCs has led to the offshoring of production processes to where they are most efficiently executed (Inomata and Hanaka, 2024). Often, such reallocation points towards a few state actors, thereby leading to considerable concentration of production capacities. Together with the emergence of highly specialized products that have limited suppliers, these create bottlenecks and choke points, especially during periods of high uncertainty. In this sense, reconfiguring GVCs entails efforts to shore them up and introduce sufficient redundancy into the system (Yusuf, 2024).

The rising discontent and scepticism directed towards international trade and globalization has given new energy to doubts surrounding its capability to deliver on promises of increased productivity, technology transfers and knowledge spillovers, as

Note: The work on this chapter was led by the Asian Development Bank (ADB). The views expressed are those of the authors and do not necessarily reflect the views and policies of ADB or its Board of Governors or the governments they represent.

well as income and employment gains. With this, the calls to sacrifice some of these benefits in favour of reducing poverty and inequality, addressing climate change, and maintaining peace and security are gaining more traction. In recent decades, this structural reconfiguration manifested in shifts towards bringing production "closer to home", especially as global alliances have shifted with political winds. It is in this context that the concept of reglobalization, the theme of this report and a term sometimes used interchangeably with reconfiguration, was born out of. However, evidence suggests that trade and GVCs remain adaptable mechanisms capable of advancing both efficiency and broader developments such as inclusive growth, sustainability and stability (WTO, 2023).

In this first chapter of the *GVC Development Report 2025*, the two interlinked themes of resilience and reconfiguration are revisited and explored in more detail in the face of ongoing trade and geopolitical disturbances. The first section presents current trends in global trade, particularly focusing on developments since the Russian war in Ukraine started. Some findings mirror patterns observed during past global crises, where the initial year showed little impact on world exports, followed by a sharp decline and then a swift recovery, driven largely by the growth of services trade. However, the gap between traditional and GVC-related trade has widened in recent years, which may be indicative of structural shifts that occurred along the way.

To assess reconfiguration, the second section examines the phenomena of deglobalization, export diversification, reshoring, regionalization and trade fragmentation. In recent periods, while the correlation between growth in gross domestic product (GDP) and exports remained positive, economies have appeared to be decoupling cross-border trade from domestic growth. Furthermore, significant rises in export concentration and reduced reliance on foreign intermediates have been observed in certain economies. These trends may partially account for the recent phenomenon of traditional trade surpassing GVC-related trade. Lastly, a general trend of regionalization cannot be deduced based on the ratio of intra- to inter-regional dependence on trade, though some evidence of fragmentation along geopolitical lines as well as rerouting through intermediary channels is present.

The final section examines regional trends to highlight differences that may help explain the recent drop in global GVC participation. The European Union (EU) has been decoupling from the Russian Federation while increasing its intra-regional GVC-related trade, and Central and West Asia has emerged as a key transit hub even as the trade volumes remained low. Southeast Asia has deepened its GVC integration through significant mega free trade agreements while the Middle East and North Africa (MENA) continued to face shipping disruptions that highlight the trading corridors' vulnerabilities. East Asia and South Asia have maintained steady growth in traditional trade but have faced disruptions in GVC-related trade since the start of the pandemic. North America, on the other hand, has shown uneven trade dynamics, with stronger growth in intra-regional than inter-regional trade in recent years, while South

America sustained expansion in traditional but not GVC-related trade as it increasingly reoriented towards Asia. Overall, these developments convey how GVCs continued to adapt in the face of crises. Some structures that existed for a long time are already gone, but new ones are being created, paving the way for economic globalization, albeit in a different form and fashion, to continue forging ahead.

1.2 Recent Trends in International Trade and Global Value Chains

Following successive global trade developments, global value chain-related trade saw more volatility in year-over-year changes than traditional trade.

Global trade rebounded after the initial shock of the COVID-19 pandemic, but recovery has been uneven and was shaped by a combination of geopolitical realignments, policy uncertainty and weak demand. Using a framework pioneered by Koopman, Wang and Wei (2014) and refined by Borin and Mancini (2019), the Asian Development Bank's multiregional input-output tables (ADB MRIOTs) are used to decompose gross export flows into value-added categories, providing a deeper understanding of both gross trade patterns and the structure of value-added trade along GVCs[1]. As shown in Figure 1.1, since 2017, global gross exports have exhibited considerable fluctuations up until the post-pandemic stabilization. The impact of the trade dispute between the People's Republic of China (PRC) and the United States (US) was one of the major triggers of world exports falling by around 6.63%, from $25.48 trillion in 2018 to $23.8 trillion in 2019.[2]

Global trade activity was initially suppressed in 2020 but recovered swiftly and returned to pre-pandemic levels by 2021. Notably, the annual growth in world exports reached its highest point in two decades this year, increasing by approximately 25.8%, and sustained in 2022 with a further increase of 11.2%. Both components of trade, namely traditional[3] (value of gross exports corresponding to purely bilateral trade) and GVC-related[4] (value of gross exports involving multiple border crossings), peaked during this period, with the latter growing at a faster pace, underscoring the role of intermediates trade in driving

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1 Using the methodology detailed in ADB (2021), gross exports are decomposed into three broad categories – value-added from domestic sectors (DVA), value-added from foreign sources (FVA) and those that did not originate from value-added at all. The last, called pure double-counting (PDC), refers to duplicated recordings of the same value-added crossing the same border more than once. DVA, in turn, is further divided into three components – directly absorbed by the importer (DAVAX), reexported by the importer and eventually absorbed abroad (REX), and reexported by the importer and eventually returns to and is consumed by the exporter ("reflection" or REF).

2 For why all values in the report chapter are in current terms, see Box 1.1.

3 This is given by the sum of domestic value added directly absorbed by the importer in the form of final consumption (DAVAX1) and in the form of intermediates consumption (DAVAX2) or quite simply DAVAX, following the framework of Borin and Mancini 2019.

4 This is given by the sum of REX, REF, FVA and PDC, following the framework of Borin and Mancini 2019.

post-pandemic recovery. GVC-related trade grew by 34.2% in 2021 and 14.9% in 2022, as compared to 19.3% in 2021 and 8% in 2022 for traditional trade.

However, this momentum did not persist as growth in gross exports contracted by 2.4% in 2023 and recovered by 4.23% in 2024. From 2022 to 2024, there was a marked slowdown in trade between the Russian Federation and the EU, with the former intensifying its transactions with both the Central and West Asia region and the PRC. Furthermore, while global trade statistics showed a decline in gross exports in 2023, half of the economies covered by the ADB MRIOTs proved resilient and achieved export growth. In fact, Armenia, Bhutan, Fiji, Georgia, Lao People's Democratic Republic (PDR) and Mongolia posted double digit growth, likely reflecting delayed expansion following the COVID-19 restrictions and the effect of price inflation, especially after the Russian war in Ukraine began and the volatility of commodity prices (Box 1.1). Furthermore, 12 European economies achieved export growth throughout 2021 to 2024 regardless of geopolitical shifts in the region, including the Czech Republic, Croatia, Poland, Portugal and Slovenia.

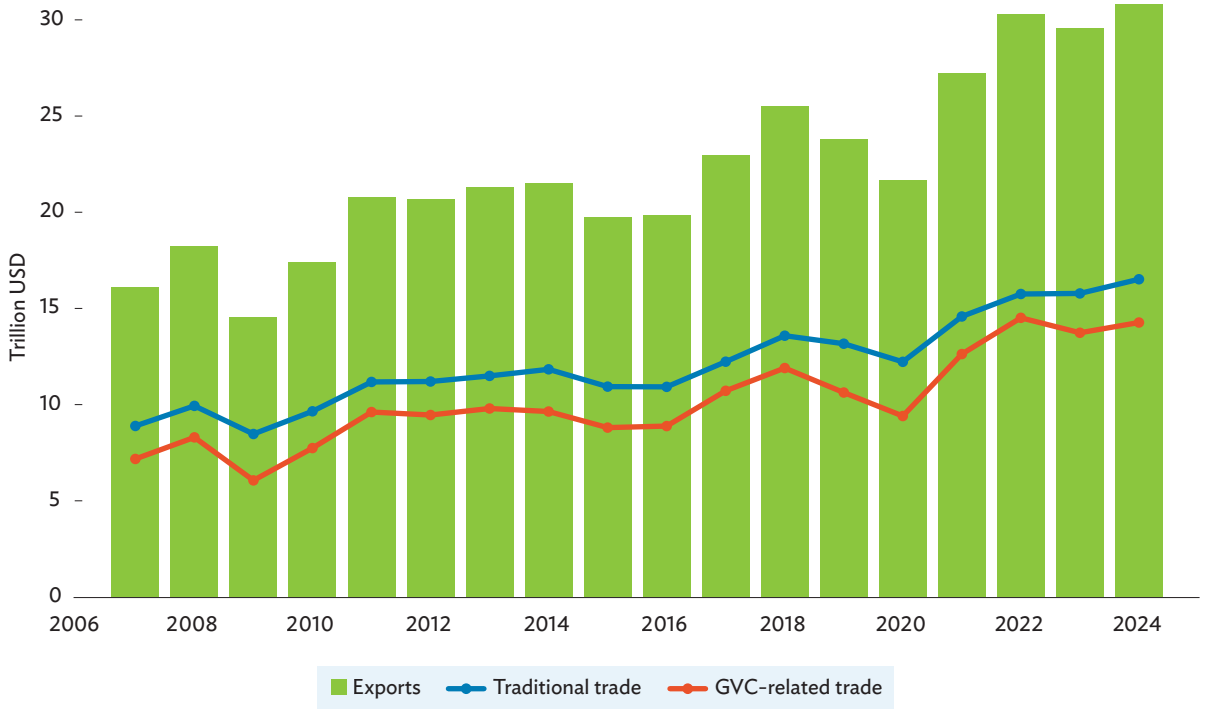
Notably, GVC-related trade saw a significant contraction in 2023, declining by 5.35%, compared to traditional trade's increase of 0.18% while in 2024, both grew at similar paces of 3.87% and 4.67%, respectively. The gap between GVC-related and traditional trade widened, especially during the 2019–2020 PRC-US trade dispute and COVID-19 pandemic, which coincided with GVC production lengths increasing. As such, the share of GVC-related trade in total trade declined from its peak of 48% in 2022 to 46.3% in 2024. Compared with gross exports growth, only 20 economies have seen their GVC-related trade increase by more than 1% in 2023. Several of these economies have abundant commodities, including Armenia, Australia, Lao PDR, Mongolia and the United Arab Emirates (UAE). Others, such as Georgia, the Kyrgyz Republic and various Eastern European economies, maintained substantial trade relations with the Russian Federation. More unexpectedly, highlighting the role of services in GVCs, Malta and Hong Kong, China also saw gains in GVC-related trade, driven in part by a post-pandemic revival in these sectors.

Services have overtaken goods in global value chain participation rates since 2019, showing steadier growth after the COVID-19 pandemic compared to the volatility of goods trade.

Figure 1.2 illustrates global annual growth rates of gross exports and GVC-related trade across five aggregate sectors – primary, low-technology manufacturing, medium- to high-technology manufacturing, business services, and personal and public services – and selected subsectors that recorded the strongest post-pandemic growth. Primary sectors such as agriculture and mining, as well as manufacturing sectors such as refined fuels and metals, saw higher volatility, reflecting fluctuations in commodity price cycles and global demand. GVC-related trade in the primary sector saw even higher swings. In contrast, trade in services proved to be more resilient between 2021 and 2024, with

Figure 1.1: Decomposition of World Gross Exports, 2007-2024

Global trade increased after the COVID-19 pandemic, but the gap between traditional and GVC-related trade widened.



Note: Gross exports decomposition follows the framework of Borin and Mancini (2019). Traditional trade refers to the value of gross exports corresponding to purely bilateral trade. GVC-related trade refers to the value of gross exports involving multiple border crossings.

Source: Asian Development Bank Multiregional Input-Output Database; and Asian Development Bank estimates.

Box 1.1: Using Current Prices in an Inflationary Period

Global inflation surged in 2022, driven primarily by aggressive fiscal and monetary stimulus during the COVID-19 pandemic, a subsequent surge in consumer demand and related supply chain bottlenecks, as well as soaring food and energy prices following the start of the Russian war in Ukraine, which impacted Europe, Central and West Asia, the Middle East and even Sub-Saharan Africa. In response, central banks launched vigorous programmes to manage demand, and by extension, price inflation, dubbed the "Great Tightening". Although institutions such as the International Monetary Fund (IMF) have reported that global inflation eased in 2023, the inflation level remained well above pre-pandemic figures. The composition of inflation also shifted over time. In 2022, inflation in energy-intensive sectors peaked; while towards the end of 2023, inflation broadened into less energy-dependent industries and was driven primarily by inflexible-price sectors such as clothing, communications and health (IMF, 2024).

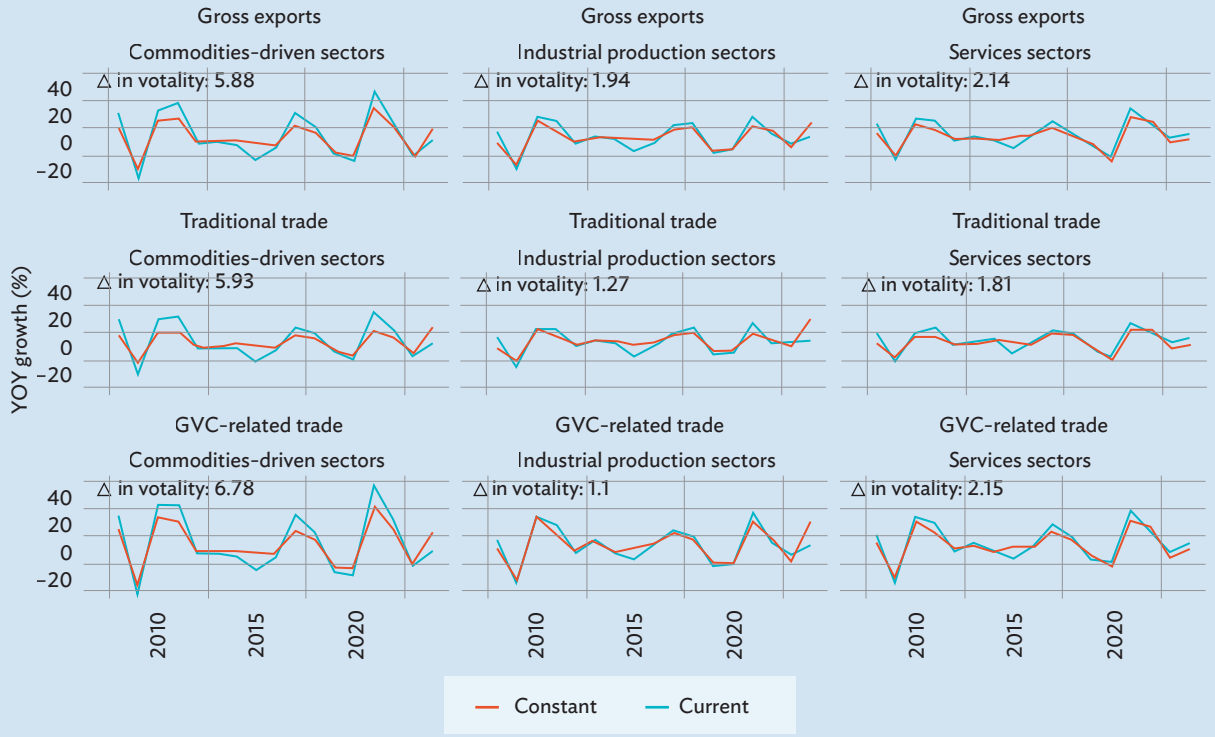
This inflationary environment underscores the importance of distinguishing analysis using current versus constant prices. Constant (real) prices strip out inflation effects by fixing prices to a base year, enabling a clearer view of underlying growth. Current (nominal) prices, by contrast, reflect both price and volume movements, which can distort comparisons during inflationary spikes. For instance, global trade growth between 2020 and 2021 appeared much stronger in current prices (25.8%) as it exaggerates growth by conflating volume and price effects, compared to constant prices (17%). Furthermore, the decline in 2023 is much more pronounced in constant prices (-4.8%) than in current prices (-2.4%) as global markets deflated.

The Asian Development Bank's Multiregional Input-Output (ADB MRIO) database provides both constant and current price tables. Constant price tables, which are pegged to 2010, were introduced in 2020 as an experimental dataset. The methodology behind these tables is described in the GVC chapter of ADB's *Key Indicators for Asia and the Pacific 2023* publication. Current price tables, however, remain the reference point for capturing the latest economic shifts, even when inflation and commodity price swings significantly affect measured trade flows, as these have been validated across different data sources and extensively used as a global public resource for informing research and policy on various development issues.

continued on next page

Box 1.1: continued

Differences in Volatility Between Constant and Current Price Measures of Global Trade Growth, By Sector and Trade Type, 2007-2024



Note: Sectoral volatility measures the absolute variation in year-on-year growth for each sectoral grouping independently. The reported delta in volatility represents the difference between volatility measured in current prices and constant prices. Gross exports decomposition follows the framework of Borin and Mancini (2019). Traditional trade refers to the value of gross exports corresponding to purely bilateral trade. GVC-related trade refers to the value of gross exports involving multiple border crossings. Commodities-driven sectors include agriculture (c1), mining (c2), refined fuels (c8), chemicals (c9), metals (c12) and other minerals (c11). Industrial production sectors include all other low- to high-technology sectors not included in the commodities-driven sectors. The services sectors are all the services sectors as classified in the ADB MRIOTs (c19–c35).

Source: Asian Development Bank. Multiregional Input–Output Databases; and Asian Development Bank estimates.

Notably, the relationship between current and constant prices varies across sectors and economies. Commodity-driven sectors such as refined fuels and metals, as well as regions like Central and West Asia, display far greater volatility in current-price measures compared to constant-price data. This highlights how constant prices can better reflect the real trajectory of production and trade, while current prices more accurately represent the actual value of global exchanges. For analytical purposes, sectors were grouped into three broad categories: commodities-driven sectors, such as agriculture, mining, refined fuels, chemicals, metals and other minerals, whose output values are closely linked to global commodity price movements; industrial production sectors, including low- to high-technology manufacturing; utilities and construction; and services sectors, which are generally less price-sensitive but may indirectly reflect inflation through cost pass-throughs. The figure below provides a comparison of trade growth measured in constant versus current prices, where commodities-driven sectors saw a higher degree of volatility between current and constant prices.

Over the given period, the change in volatility between current and constant prices of these sectors was roughly three times greater than in manufacturing and services, highlighting how inflation disproportionately drives swings in commodities trade values relative to other sectors. Industrial production showed the lowest degree of variability. Policymakers therefore need to interpret nominal data cautiously, especially in economies exposed to exchange rate fluctuations, persistent inflation or commodity dependence, to ensure timely and accurate policy assessment.

References:

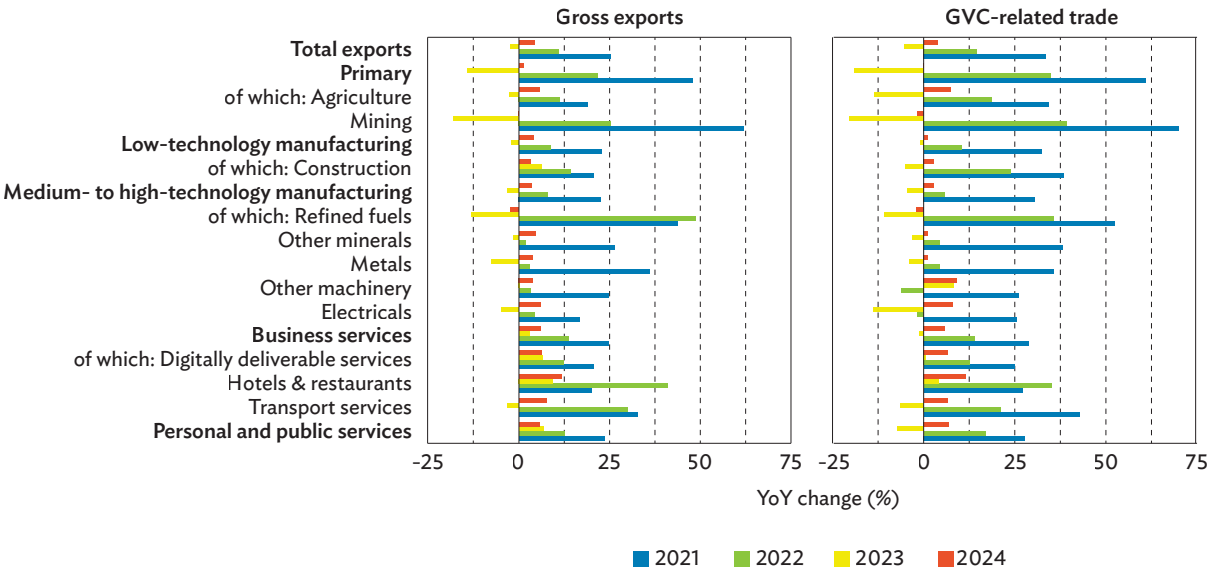
Asian Development Bank (2023). *Dollar and Price Wedge Between Nominal and Real Global Value Chain Participation. In: Key Indicators for Asia and the Pacific 2023.* Manila: ADB. Available at: https://www.adb.org/publications/key-indicators-asia-and-pacific-2023

International Monetary Fund (2024). *Chapter 2: The Great Tightening: Insights from the Recent Inflation Episode. In: World Economic Outlook, October 2024: Policy Pivot, Rising Threats.* Washington, D.C.: IMF. Available at: https://www.imf.org/en/Publications/WEO/Issues/2024/10/22/world-economic-outlook-october-2024

certain subsectors such as finance and telecommunications, grouped under digitally deliverable services, demonstrating consistent growth across the years. Transport sectors – including land, air and water transport services, and the travel sector – showed sharp cyclical rebounds, benefitting from the relaxation of pandemic-related mobility restrictions, with the travel sector seeing a much stronger growth from 2021 to 2023. Service sectors experienced sharper fluctuations in GVC-related trade than gross exports, though these changes were less extreme compared to goods sectors. In 2024, most service sectors sustained their growth while the exports of goods sectors linked to price-sensitive commodities, such as mining and refined fuels, continued to decline.

Figure 1.2: Trade Growth By Selected Sectors, 2021-2024

While medium- and high- technology manufacturing drove global trade, services showed sustained GVC resilience.



Note: GVC-related trade refers to the value of gross exports involving multiple border crossings.
Source: Asian Development Bank Multiregional Input-Output Database; and Asian Development Bank estimates.

As seen in Figure 1.3, GVC participation rates have consistently declined following major global shocks, such as the global financial crisis in 2008, the PRC-US trade dispute in 2018 and the COVID-19 pandemic in 2020 – a pattern that is consistent with longer-term developments. The more tempered growth of GVCs after the global financial crisis in 2008 suggests that GVC formation may have matured, or at least became more selective, reflecting shifts in production strategies and possibly nascent trends towards regionalization, reshoring or "near-shoring" – as seen with a significant contraction in global demand (especially for durables such as automobiles and machinery) – causing a notable reduction in GVC participation rates (Eaton et al., 2016). The COVID-19 shock lowered GVC participation rates, mainly due to supply-side impacts from containment policies (IMF, 2022).

While participation rebounded briefly in 2021-2022, it began falling again after 2022, which transpired alongside the rise in geopolitical fragmentation and shifts in the US trade policy. Notably, the composition of GVC participation by type of exports has shifted since 2019 – while historically, goods had higher participation rates than services; the latter have shown greater resilience in recent years. The decline during the pandemic and the subsequent downturn from 2023 to 2024 was less severe than that of goods, widening the gap between the two in the most recent period. GVC intensive sectors, especially in goods, were more exposed to disruptions in the supply chain during the pandemic; however, certain services sectors mitigated the negative effects of reduced worker mobility by transitioning to remote work (IMF, 2022). Furthermore, digital services rely less on physical infrastructure, so disruptions in transport, logistics or commodity markets have less impact on their delivery. Meanwhile, digitally deliverable services – encompassing telecommunications, finance, insurance and information technology (IT) sectors – have seen some of the most consistent sectoral growth (Figure 1.2), suggesting that not only have these sectors become more prevalent since the pandemic, but that their GVC participation has also gotten more resilient to shocks.

Figure 1.3: Trends in Global Value Chain Participation By Exports Type, 2007-2024

Compared to goods, services' GVC participation rates were more stable and have softened the blow on the overall figure in recent years.

Note: GVC participation rates are computed using the methodology in Asian Development Bank (2021).
Source: Asian Development Bank Multiregional Input-Output Database; and Asian Development Bank estimates.

Global production along global value chains has lengthened since the COVID-19 pandemic, especially among European economies in the period between 2020 and 2024.

Decreased GVC participation may also occur due to supply shortages arising from choke points in the system. Stehrer et al. (2025) show that all sectors globally are dependent on the PRC, the EU and the US, while certain industries in other economies are strongly dependent on India, Japan, the Republic of Korea or Singapore. Large and proximate economies are often found to act as choke points for an economy's existing trade. Such dependence may either lead to a shortening or lengthening of paths that intermediates go through before reaching final consumers. If shocks discourage economies from continuing offshoring processes due to concerns about sustainability or even rising home bias, this may remove certain production layers away from foreign economies in favour of domestic sectors thereby reducing the length of the supply chain path. On the other hand, if at their current level of capacity utilization, domestic sectors are unable to accommodate increased demand and the goods/services that are lost from a foreign supplier are too specialized for only a handful of economies to offset, then more players may be involved, which could lengthen the supply chain paths.

GVC production lengths are shown in Figure 1.4, which give the average number of stages separating domestic value-added creation by primary factors of production to final consumption. A general lengthening occurred during the pandemic onset, which coincided with the numerous supply shocks experienced during the pandemic, most notably in the shipping industry, which saw a surge of 20% in global container port congestion in the second half of 2020 (PortCalls Asia, 2021). From 2018 to 2020, 34 economies (47%) experienced lengthening GVC-related trade, including 15 in Asia and the Pacific (50%). From 2020 to 2022, as the pandemic continued to disrupt supply chains and with the start of the Russian war in Ukraine, the global production length further elongated. During this period, 48 economies (67%) experienced lengthening, including nearly all European and Central and West Asian economies (except for Norway and Türkiye) and all MENA economies apart from the UAE. Conversely, most economies in Asia and the Pacific (67%) exhibited shorter production lengths.

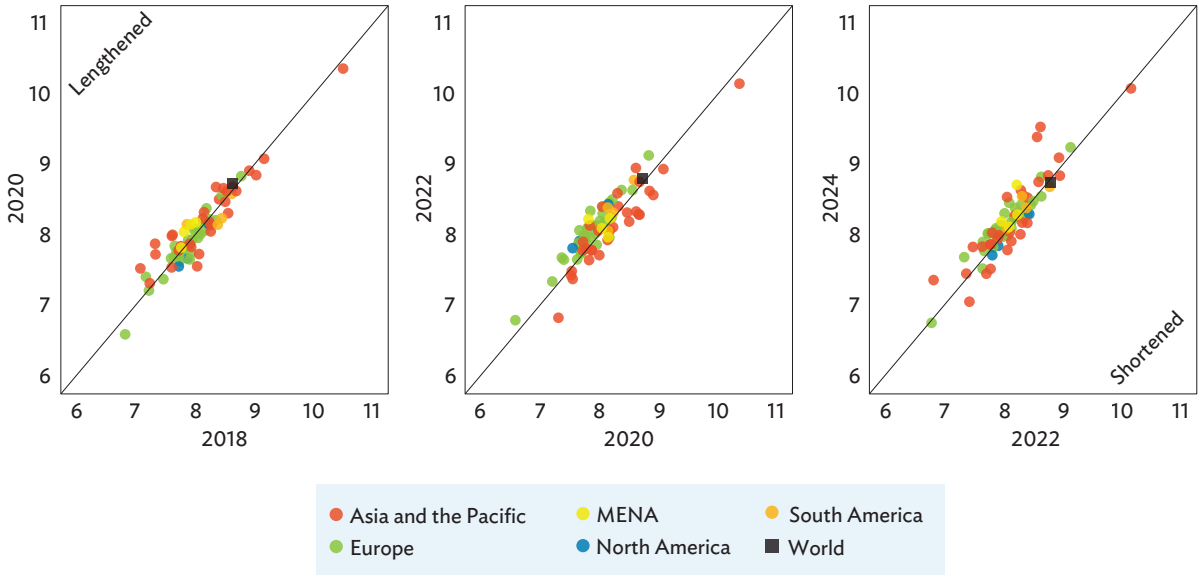
This trend intensified between 2022 and 2024, as major global trade developments ignited widespread reallocation of trade flows. An extended lengthening was recorded in 45 economies (62.5%), with significant expansions noted across Europe (18 economies), Asia and the Pacific (19 economies), as well as all economies within the MENA region. The sharpest increases occurred in Mongolia (10.5%), the Republic of Korea (9.6%) and Bhutan (7.8%), setting a record of lengthening across all time periods, while North American economies saw a shortening of production lengths (by 1-2%).

Across the entire period, 16 economies (22%) recorded persistent lengthening. These include European economies such as Belarus, Bulgaria, Croatia, Georgia, Romania and the Russian Federation, along with Egypt, India, Kuwait, New Zealand, Pakistan,

Saudi Arabia and Sri Lanka. In MENA, the ongoing increase may indicate both diversification and logistical disruptions, which will be discussed further below. On the other hand, only three economies consistently shortened their GVC production lengths: Taipei,China (by 4.04%), the Lao PDR (4.43%) and the PRC (4.75%).

Figure 1.4: Global Value Chain Production Lengths By Region, 2018-2024

The production length of GVCs has generally increased, especially among European economies.



Note: Global value chain production lengths are the sum of backward and forward lengths. These are computed following the methodology of Wang, Wei, Yu and Zhu (2017).
Source: Asian Development Bank Multiregional Input-Output Database; and Asian Development Bank estimates.

Although high-global value chain trading economies still account for most of the global GVC-related trade, their collective share has declined from 76% in 2010 to 63.6% in 2024, reflecting the gradual integration of other economies into GVCs.

Global production length averages mainly reflect the influence of major GVC traders, as calculations are weighted by value-added shares. While many smaller economies have experienced lengthening since 2018, the influence of major hubs dominates the overall picture. Indeed, there is evident concentration when looking at sources of value-added[5] in exports. In 2024, just 10 economies accounted for 53.5% of global domestic value-added (DVA) in exports, with the PRC, the US and Germany ranking at the top. These economies, long recognized as major GVC hubs in the relevant literature, have maintained their dominant positions since 2007. Yet, some shifts are also evident over an extended period. India, an economy that has seen a consistently growing integration

5 This is given by the domestic value-added in an economy's exports, which is the sum of DAVAX, REX and REF in the Borin and Mancini (2019) gross exports decomposition framework.

into GVCs, has risen to become part of the top 10 value adding economies since the onset of the pandemic, with a share of 2.8% of global DVA in exports in 2024. This may be explained by the successes of its information technology industry in exporting business process management services (Nano and Stolzenburg, 2021), recently enacted free trade agreements and policies aimed at attracting investments from multinational enterprises (Choorikkadan, 2024). However, the overall stability of the leading contributors highlights the structural barriers that many economies face when attempting to integrate into GVCs.

Changes in global value chain participation and shares in global GVC-related trade by category of traders are examined in this context. To identify the categories, values for the 25th percentile, median and 75th percentile were derived for decade (2010-2019) averages of GVC-related trade. The year 2020 was deliberately excluded due to abnormalities in trends and patterns observed during the pandemic onset. Each economy was then categorized into the following:

1. **High GVC traders** – decade average of GVC-related trade greater than or equal to the 75th percentile
2. **Upper middle GVC traders** – decade average of GVC-related trade greater than the median but less than the 75th percentile
3. **Lower middle GVC traders** – decade average of GVC-related trade greater than the 25th percentile but less than the median
4. **Low GVC traders** – decade average of GVC-related trade lower than or equal to the 25th percentile

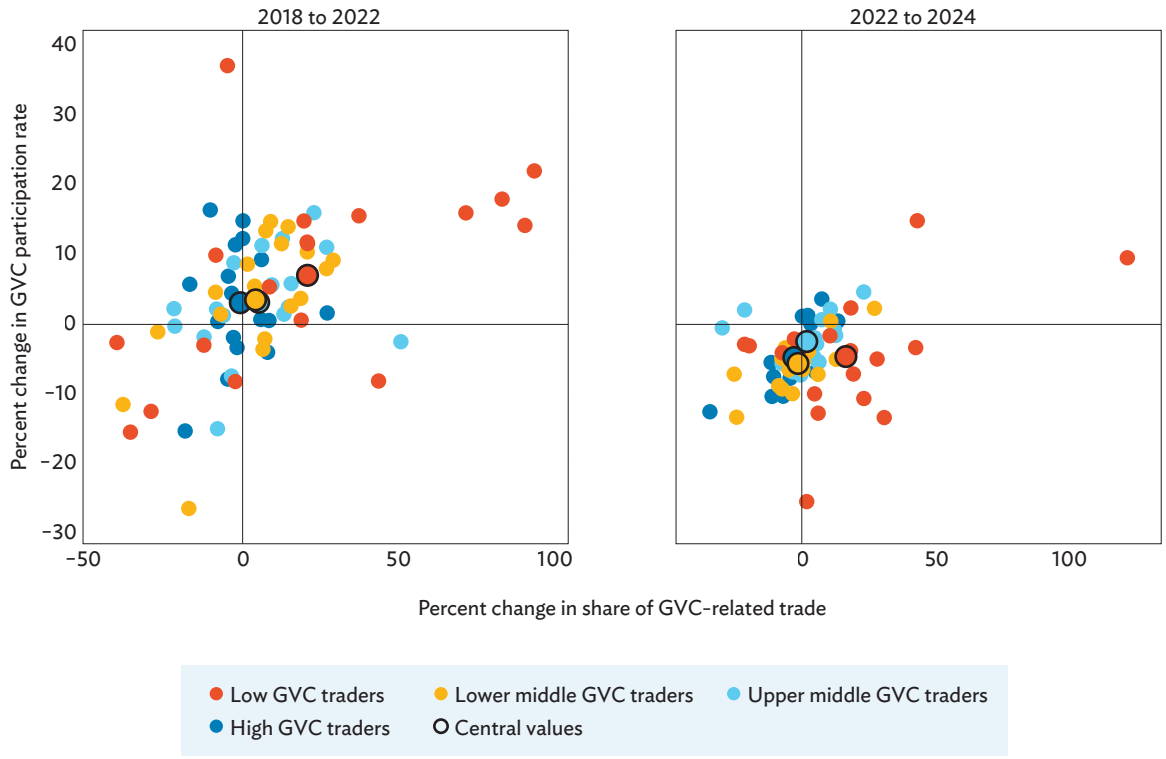
For the 19 low GVC traders, five were from South Asia (Bangladesh, Bhutan, Maldives, Nepal, Sri Lanka), four were from Europe (Cyprus, Estonia, Latvia, Malta) and three were from Southeast Asia (Brunei Darussalam, Cambodia, the Lao PDR). In 2010, these economies contributed 0.69% and 0.66% to the global gross and GVC-related export values, respectively. By 2018, these shares rose to 0.85% and 0.81% while in 2024, these further grew to 1.26% and 1.24%. This general trend is seen in Figure 1.5 in the central value of the group. In addition, average GVC participation also grew for these economies between 2018 and 2022, indicating a stronger reliance on GVCs for exports, but have gone down between 2022 and 2024.

The high GVC traders were composed of the typical hubs identified for GVC trade – Japan, the PRC and the Republic of Korea from East Asia; North American economies; and European economies such as France, Germany, Italy and the United Kingdom (UK), among others. Figure 1.5 also shows that the “appetite” towards GVCs grew between 2018 and 2022 in this group as evidenced by an increase in the participation rate before falling between 2022 and 2024, while their capture has consistently got smaller due to the growth in other groups. In 2010, their combined shares in gross exports and GVC trade were 77.46% and 76.07% respectively, but these went down to 76.84% and 75.16% in 2018. By 2024, these further contracted to 64.15% and 62.63%.

It is also worth noting that while high and upper middle GVC traders tended to send most of their value-added exports[6] to the high GVC traders, low GVC traders' export destinations were a bit more diverse – the top 10 destinations were split between high GVC traders, upper middle GVC traders and lower middle GVC traders.

Figure 1.5: Changes in Extent of Global Value Chain Integration – Relevance and Participation

Economies that contributed the least to GVC-related trade prior to the pandemic have taken up larger shares as global players went through reconfigurations.



Note: Gross export decomposition follows the framework of Borin and Mancini (2019). High GVC traders pertain to economies that fall in the 75th percentile of decade average GVC-related trade, while low GVC traders fall below the 25th percentile. Lower middle and upper middle GVC traders have values falling below the median but above the 25th percentile and above the median but below the 75th percentile, respectively. GVC-related trade refers to the value of gross exports involving multiple border crossings.
Source: Asian Development Bank Multiregional Input-Output Database; and Asian Development Bank estimates.

Diverging policy priorities across major global markets are exerting a stronger influence on global value chain-related trade than on traditional trade.

Global trade developments summarized in Table 1 underscore how geopolitical shocks and supply chain disruptions affected global GVC trade. Large markets such as the PRC and the US set de facto standards, while smaller economies navigated between blocs,

6 Derived as the sum of REX and REF, thereby pertaining to GVC-related value-added exports

aligning themselves with dominant regimes where market access is essential. This has led to the emergence of "connector economies", which have helped replace direct trade between areas affected by geopolitical tensions. Mexico and Viet Nam have both gained the most in US import shares and the most in PRC export shares (Gopinath et al., 2025). At the same time, stricter geoeconomic screening and export controls have followed in trade between the East and the West, with tighter outbound and inbound investment screening and critical mineral curbs slowing down long-term growth of enterprises (Huang et al., 2025).

Understanding these structural and 'bloc' developments is therefore essential for evaluating how GVCs are being reconfigured: whether global production processes are being brought closer to home or if networks are being reconfigured with new partners, corridors and standards while overall openness is maintained. In the following section, these dynamics are assessed through measuring deglobalization, diversification of exports, reshoring, regionalization and trade fragmentation. In doing so, this chapter aims to assess whether current developments reflect a fundamental restructuring of global production networks or a rebalancing of trade along geopolitical and regional lines.

Table 1: Global Developments Affecting World Trade, 2017-2024

Year	Trade Developments	Exports, In USD and Annual Change	GVC Trade, Value And Yoy	Traditional Trade, USD and Annual Change	Global GVC Average Production Length	Export Sector Forward GVC Participation	Export Sector Backward GVC Participation
2017	US trade policy shifts (NAFTA renegotiation)	$22.94 trillion, 16%	$10.7 trillion, 23%	$12.2 trillion, 12%	8.66	19.34	26.73
2018	PRC–US trade dispute	$25.48 trillion, 11%	$11.9 trillion, 11%	$13.5 trillion, 11%	8.63	19.45	26.59
2019	Global trade slowdown	$23.8 trillion, -6.6%	$10.5 trillion, -11.8%	$13.1 trillion, -3%	8.61	18.99	25.49
2020	COVID-19 pandemic	$21.6 trillion, -9%	$9.4 trillion, -10.3%	$12.2 trillion, -7.15%	8.73	18.58	24.72
2021	Supply chain bottlenecks; container shortages	$27.2 trillion, 25.8%	$12.6 trillion, 34.2%	$14.58 trillion, 19.3%	8.68	19.55	26.72
2022	Start of the Russian war in Ukraine	$30.26 trillion, 11%	$14.5 trillion, 14.9%	$15.74 trillion, 8%	8.80	20.03	27.64
2023	Conflict in the Red Sea; Panama Canal drought; conflict in Gaza	$29.5 trillion, -2.4%	$13.7 trillion, -5.35%	$15.77 trillion, 0.18%	8.84	19.42	26.54
2024	Expansion of carbon border policies; continuation of geopolitical tensions; threat of universal tariffs on RoW from the US	$30.7 trillion, 4.23%	$14.26 trillion, 3.8%	$16.5 trillion, 4.6%	8.75	19.41	26.40

Source: Asian Development Bank Multiregional Input-Output Database; and Asian Development Bank estimates.

Having established the recent trends and volatility patterns in world trade, the following section turns to the structural mechanisms behind these shifts, testing whether they reflect temporary adjustments or deeper changes in how GVCs are organized.

1.3 Structural Shifts in Global Value Chains

In this section, various aspects of trade and related phenomena are examined to offer viable explanations behind key observations seen from current trends, namely the widening of the gap between traditional and GVC-related trade, as well as the lengthening of production chains in several economies.

These are first explored from the perspective of the nexus between growth of exports and GDP to assess if there are signs of deglobalization (output increasingly being reallocated to local consumers; a retreat from international trade as a means of furthering growth). Following this, a host of reconfiguration strategies, namely export and import diversification, reshoring (replacing foreign dependence on supply in favour of domestic sectors), regionalization (reallocating trade to allies and/or neighbouring economies for strengthening regional resilience instead of global connectivity) and decoupling are analysed to assess how and to what extent adjustments were made in response to anomalies in global production, particularly those borne out of consecutive – and at times, overlapping – global crises.

To unpack these mechanisms systematically, the analysis begins with the macro-link between export and GDP growth, a traditional gauge of trade-output coupling, before turning to reconfiguration strategies such as diversification in trading partners, reshoring and regionalization.

The strong relationship between export growth and GDP growth weakened since the pandemic and has not gone back to previous levels, despite remarkable recovery in global trade.

In 2020, the global economy was shaped by disruptions in international logistics, curtailed cross-border movement and widespread shutdowns of production networks. Most economies saw a decrease in both GDP and exports growth in 2020, which successfully reversed in 2021 and 2022 as the same economies showed strong recoveries in both. In 2021, the only economies that posted a further decrease in GDP were Fiji, Japan and Lao PDR, even as the latter two's exports increased. In 2022, 46 more economies recorded increases in their GDP and exports, and resource-dependent economies such as Cambodia and Mongolia saw disproportionately strong recovery in exports relative to GDP growth, reflecting their integration into resilient commodity supply chains.

In the post-pandemic normalization and realignment period in 2023 and 2024, heterogeneity among economies became more pronounced. While the global trading system has adjusted to post-pandemic realities, "geoeconomic fragmentation" may be emerging, which refers to policy-induced changes in trade flows as guided by strategic efforts of governments to secure certain alliances. Importantly, this occurrence may also see an associated decline in global trade relative to GDP (Gopinath et al., 2025). New trade corridors formed, particularly between the Russian Federation, Central and West Asia, and the PRC, with some economies, such as Georgia and the Kyrgyz Republic, experiencing sharp increases in exports, possibly in response to sanctions on the Russian Federation. Lastly, several economies exhibited strong export growth despite low domestic activity, potentially benefiting from favourable exchange rate adjustments, surges in commodity exports or sanctions-driven trade diversion.

Economies maintained a diverse set of trading partners along global value chains, but several cases showed rising concentration as pre-existing relationships were challenged or reliance on neighbours grew stronger.

Based on this increased divergence over the years, the link between trade and GDP growth has weakened, perhaps due to existing vulnerabilities in international trade becoming more discernible in the face of crises. However, economies deeply integrated into global production networks may not have enough flexibility to disentangle GDP growth from increased trade. Instead, the most viable option would be to reconfigure existing structures to address weaknesses or limitations in the system, one of which being the concentration of trade flows as well as production capacities. To mitigate such risk, it is essential to diversify supply or demand and build more slacks in the network.

This practice is already commonplace in a handful of production chains as multinationals do tap multiple suppliers for items (Yusuf, 2024). Tradlinx (2025) says that enterprises are starting to adopt so-called "China+1" or "China+2" strategies to ensure multi-supplier sourcing. Apart from these, multiple modes of transportation (e.g., by air, rail or sea) are also being integrated into the system. In a 2022 study by Ernst and Young, 62% of enterprises surveyed have made significant changes to their supplier base, 57% initiated operations in at least one economy, while 53% have either nearshored or reshored their operations (DHL, n.d.). To investigate if this import diversification or concentration phenomenon is also occurring along global value chains, Herfindahl-Hirschman indexes (HHIs) are produced using GVC-related trade from the perspective of the destination economy, which is a standard measure of how diversified or concentrated an economy's trade relationships are[7]. In the context of GVCs, the index is calculated separately for exports and imports to show how widely an economy sources from or sells to its partners. Lower HHI values indicate a more diversified and resilient trade structure, while higher HHI values point to greater

[7] The detailed mathematical specification, variable definitions, and weighting methodology are provided in Annex 1 (Methodological Notes for Chapter 1).

concentration and potential vulnerability to partner-specific shocks. Thresholds used by the US Federal Trade Commission (FTC) and the UK Competition and Markets Authority (CMA) classify HHIs below 0.10 as unconcentrated, between 0.10 and 0.18-0.20 as moderately concentrated, and above 0.18-0.20 as highly concentrated (Madhu et al., 2024; FTC, 2023; CMA, 2023).

Apart from mitigating risks from the supply side, economies can also do so from the demand side by diversifying beyond their main export destinations. A similar approach is used to capture this export diversification phenomenon by producing HHIs from the perspective of the origin economy. Looking at the results of these analyses in Figure 1.6, several key observations can be drawn, the first of which is a general picture of diversification in complex cross-border demand and supply of intermediates during the pre- and post-pandemic era. Following the thresholds compiled by Madhu et al. (2024) from the US FTC and the UK CMA, the average values[8] for exports-related HHI were 0.093 in 2019 and 0.092 in 2024, while those for imports-related HHI were 0.083 in 2019 and 0.082 in 2024.

Next, there were fewer economies that became less diversified in 2024. Only 23 out of the 72 (31.9%) economies had higher exports-related HHIs in 2024, most notably the Russian Federation (increase of 247.3%), Argentina (121.1%) and Viet Nam (48.6%) – all of which were reclassified to "moderate concentration" from "no concentration" five years prior. The changes exhibited by these economies were more pronounced compared to those that diversified, with an average increase of 32.36% as compared to just 16.06% (in absolute value terms) for the latter. On the other hand, 30 out of the 72 (41.67%) economies registered higher imports-related HHIs in 2024. The Russian Federation (186.45%), Slovenia (154.72%) and Pakistan (92.64%) had the highest increases, leading to a reclassification from "no concentration" to "moderate concentration". Like the export counterpart, instances of positive changes in this indicator were more significant with an average absolute change of 28.57% compared to 12.01% for those that diversified.

Looking at individual economies, there are a few which display notable patterns and trends. First is the Russian Federation, which had the smallest export-related HHI in 2019 (0.036), thereby having the most diverse set of destinations for its GVC-related trade. Its main trading partners were the PRC (7.48%), Germany (7.34%), Poland (5.22%), the US (4.60%) and Türkiye (4.55%), with exports even reaching small, open economies such as Maldives and Fiji. By 2024, however, the Russian Federation became the 13th most concentrated economy with its HHI increasing to 0.124, which (as mentioned above) made its GVC-related exports moderately concentrated. Evidence of lessened reliance on the US and Europe (Germany, Poland, Italy, the Netherlands, Finland and the UK) is also apparent as all these economies fell out of the top 10. Meanwhile, the

8 Weighted averages are calculated by using the total value of exports for exports-related HHIs and the total value of imports for imports-related HHIs

PRC's share rose to 27.94% in this year while dependence on India also saw a dramatic increase – from 1.96% to 17.57%. In terms of imports-related HHI, the Russian Federation moved from being the 9th most diverse economy (HHI = 0.054) to having the 11th highest HHI (0.154). This was mainly driven by imports from the PRC, whose share increased from 13.50% to 36.88% between 2019 and 2024.

Next are the most concentrated economies in terms of GVC-related exports, namely Mongolia, Mexico, Bhutan and Canada. An obvious characteristic shared by this group is a strong dependence on neighbouring economies. Mongolia's HHI increased from 0.735 in 2019 to 0.827 in 2024, which coincided with the PRC's share rising from 85.62% to 90.93%. Mexico and Canada, on the other hand, were highly reliant on the US market and to a certain extent on each other. The US received 76.55% and 60.29% of Mexico and Canada's GVC-related exports in 2024, respectively, while both economies were in each other's top five destinations across the years. As for Bhutan, India took up the majority of its outbound trade in 2019 and 2024. It is also worth noting that there were differences in trends among these economies, with Mongolia and Mexico having registered higher HHIs over time while Bhutan and Canada showed signs of diversification – some of India's share in Bhutan's exports were taken up by Thailand and Bulgaria, while reliance on the PRC increased for Canada.

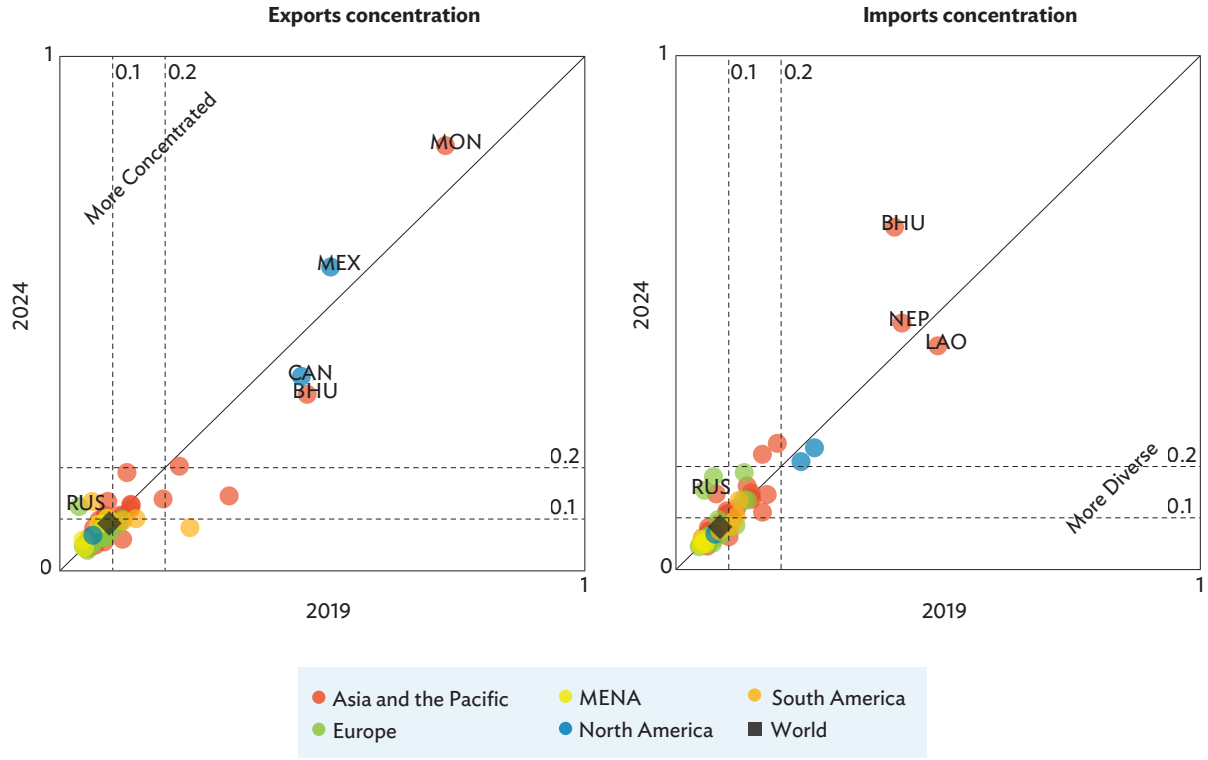
The most concentrated economies in terms of GVC-related imports were the Lao PDR, Nepal and Bhutan, all of which are small, landlocked economies that heavily rely on a few industries (e.g., agriculture). All three remained in the "high concentration" category between 2019 and 2024, with Bhutan (0.42 to 0.67) and Nepal (0.43 to 0.48) registering increases in the index. Similar to what was seen for exports, dependence on neighbouring economies was quite high – Bhutan's reliance on India went up to 81.3% from 63.2%, Nepal's imports from India also increased (64.4% to 68%), while the combined shares of Thailand, Viet Nam and Singapore in the Lao PDR's supply of GVC-related trade were 79.9% and 71.1% in 2019 and 2024, respectively.

Apart from mitigating risks from the point of view of trade partners, economies can also approach this by diversifying beyond their main exporting sectors. 27 out of the 72 (37.5%) economies have become less diverse both in gross and value-added exports[9], primarily concentrated in Southeast Asia (e.g., Brunei Darussalam, Indonesia, the Lao PDR, Singapore and Thailand), 12 economies in the EU and the biggest players in the Americas. These economies are far less concentrated than resource-dependent economies, but they might have reached their diversification capacity or are starting to focus on fewer products as they specialize. On the other hand, 18 economies have become more diverse in both gross and value-added terms. The biggest changes came from the Russian Federation as well as economies it shares close trading relationships with such as Georgia, Kazakhstan, the Kyrgyz Republic,

9 These refer to value-added exports based on forward industrial linkages, which allows contributions of other sectors in exports that may not be captured by traditional measures to be included.

Figure 1.6: Herfindahl-Hirschman Indexes of Economies for Global Value Chain-Related Trade, 2019-2024

GVC-related trading activities remained diverse across the years, with a few exceptions of higher concentration due to trade redirection or increased reliance on neighbouring economies.



BHU = Bhutan; CAN = Canada; LAO = Lao People's Democratic Republic; MEX = Mexico; MON = Mongolia; NEP = Nepal; RUS = Russian Federation

Note: The Herfindahl-Hirschman Index (HHI) is a measure of an economy's export concentration. Thus, higher values of HHI correspond to lower levels of diversification. The HHI indexes shown in the figure are computed using GVC-related exports/imports derived from the value-added accounting framework of gross exports of Borin and Mancini (2019). The Rest of the World aggregate is excluded from the analysis.

Source: Asian Development Bank Multiregional Input-Output Database; and Asian Development Bank estimates.

India and the PRC. Significantly, all MENA economies in the database have shown a decrease in concentration, signalling that these resource dependent economies may already be maturing and starting to diversify away from minerals. It must be noted, however, that most of these changes are very minimal and the more general picture is that of stability, which points to the fact that diversifying may often be an expensive proposition that requires various feasibility studies, as well as investments in soft and hard infrastructures, among others (Yusuf, 2024).

Having examined how diversification and concentration in trading partners have evolved, the next step considers whether economies have sought resilience through reshoring production closer to home or by strengthening regional supply networks.

Dependence on foreign value-added sources to satisfy domestic final demand decreased since the pandemic onset for the People's Republic of China, the United States and the European Union, possibly indicating some level of reshoring. Simultaneously, signs of regionalization were also present in this period.

Aside from concerns related to risks associated with concentration in global production networks, there is also an alternative strain of ideology that promotes distaste for economic globalization, often associated with bringing production closer to home. Such interventions, motivated by geopolitics and self-sufficiency, are often associated with reshoring and regionalization. Cai and Miroudot (2024) analysed the extent of reshoring by looking at the ratio of foreign to domestic value-added in domestic final demand. Percent changes in this ratio are derived for two periods – pre-pandemic (2011 to 2019) and pandemic onset onwards (2019-2024). Using structural decomposition analysis, these changes are then attributed to five factors:

1. **Final demand composition**: the industry mix in an economy's final demand (e.g., the change in economy A's agriculture sector's share in economy A's final demand)
2. **Final demand sourcing**: the location where products for final use are being sourced (e.g., economy A substituting final products from economy B in favour of economy C)
3. **Input industry mix**: the use of intermediates irrespective of origin (e.g., an increasing use of manufacturing input corresponding with declining purchases of business services)
4. **Input sourcing mix**: the location where intermediates are being sourced (e.g., economy A substituting intermediates from economy B in favour of economy C)
5. **Value-added coefficient**: the ratio of value-added to gross output

This methodology is replicated using the ADB MRIOTs, which extends the pandemic onset period to 2024. In the pre-pandemic period, almost all economies with major roles along GVCs appeared to have increased their extent of vertical specialization, as evidenced by the growth in the foreign to domestic value-added ratio. However, the PRC and the Republic of Korea, economies capable of producing their own advanced industrial goods with track records of vertical integration, were obvious exceptions. During the phase of globalization that saw intermediate goods becoming the driver of trade as well as an increasing participation of a more diverse – i.e., non-Western group of economies and individuals (called "Globalization 3.0" by Thomas Friedman in 2005), the PRC was recognized as the workshop of the world, wherein more downstream processes were allocated for efficiency gains. However, the PRC, in its "dual circulation" strategy, has emphasized domestic growth and economic self-sufficiency, leading to a transition from a relatively downstream to a relative upstream position along GVCs in recent years (Schneider-Petsinger, 2023) and marking a significant shift in the structure of international trade.

Structural decomposition analysis shows that the main drivers for growth between 2011 and 2019 were final demand sourcing and input sourcing mix for 16 out of 72 economies covered. This means that the key reasons more economies appeared to have increased their reliance on foreign sources were changes in the locations where final products and intermediate inputs were sourced from, i.e., the distribution of import partners changing during the period. On the other hand, the input industry mix, used as a proxy for productivity gains arising from technological innovations, contributed significantly to the decline in foreign value-added embedded in domestic consumption for Asia and the Pacific economies such as the PRC, the Republic of Korea, Viet Nam and Mongolia. For example, the Republic of Korea has increased its domestic production of high-end semiconductors and electric vehicles (EVs), requiring more IT services and R&D, which meant that there was considerable substitution of inputs[10] and changes in technology and specialization that took place in this period.

During the pandemic onset and beyond, a reversal of the pattern was seen for the EU, primarily driven by final demand sourcing and composition, while the level of reliance of the PRC and the US on foreign intermediates also declined (Figure 1.7). This may be taken as a sign of reshoring in recent times as it suggests some degree of substitution of foreign value-added sources for domestic ones. However, large economies like India, Japan and the Republic of Korea showed an increase in the indicator, which renders such a reversal to be more of a location-specific trend. Interestingly, even though the trade dispute between the PRC and the US occurred in this period[11], the decline in the ratio was not too drastic, which may partly be explained by reports and observations of ensuing trade redirection that took place in response to losses associated with retaliatory tariffs imposed on each other.

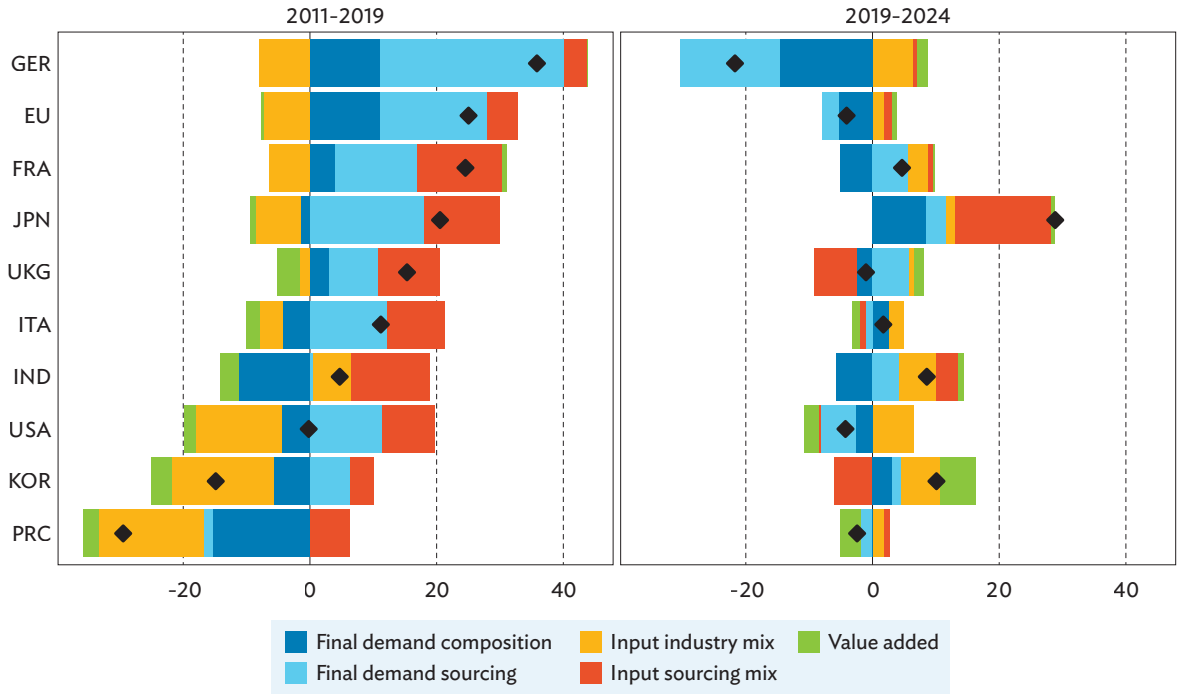
As for regionalization, trends in the ratio of intra- to inter-regional domestic value-added embodied in intermediate trade are presented in Figure 1.8. A rise in this indicator conveys that internal trade reliance – both in terms of exports and imports – of economies belonging to the same region has got stronger, thereby suggesting regionalization. There are two useful ways to look at the trends – first from the perspective of levels and the second from growth. It is quite clear how the EU is more "regionalized" as compared to the rest of the world, which points to the "single market" approach within the bloc. By 2019, this ratio jumped to what appears to be a new equilibrium hovering around 1.5.

10 Produced primarily by a particular industry.

11 Largely driven by the fact that there was a considerable dependence between the two economies – hence the US administration's push for decoupling strategies.

Figure 1.7: Percent Change in the Ratio of Foreign to Domestic Value-Added in Domestic Final Demand, Structural Decomposition Analysis, Selected Economies

Reliance on foreign intermediates in selected economies has declined, driven by a range of factors.

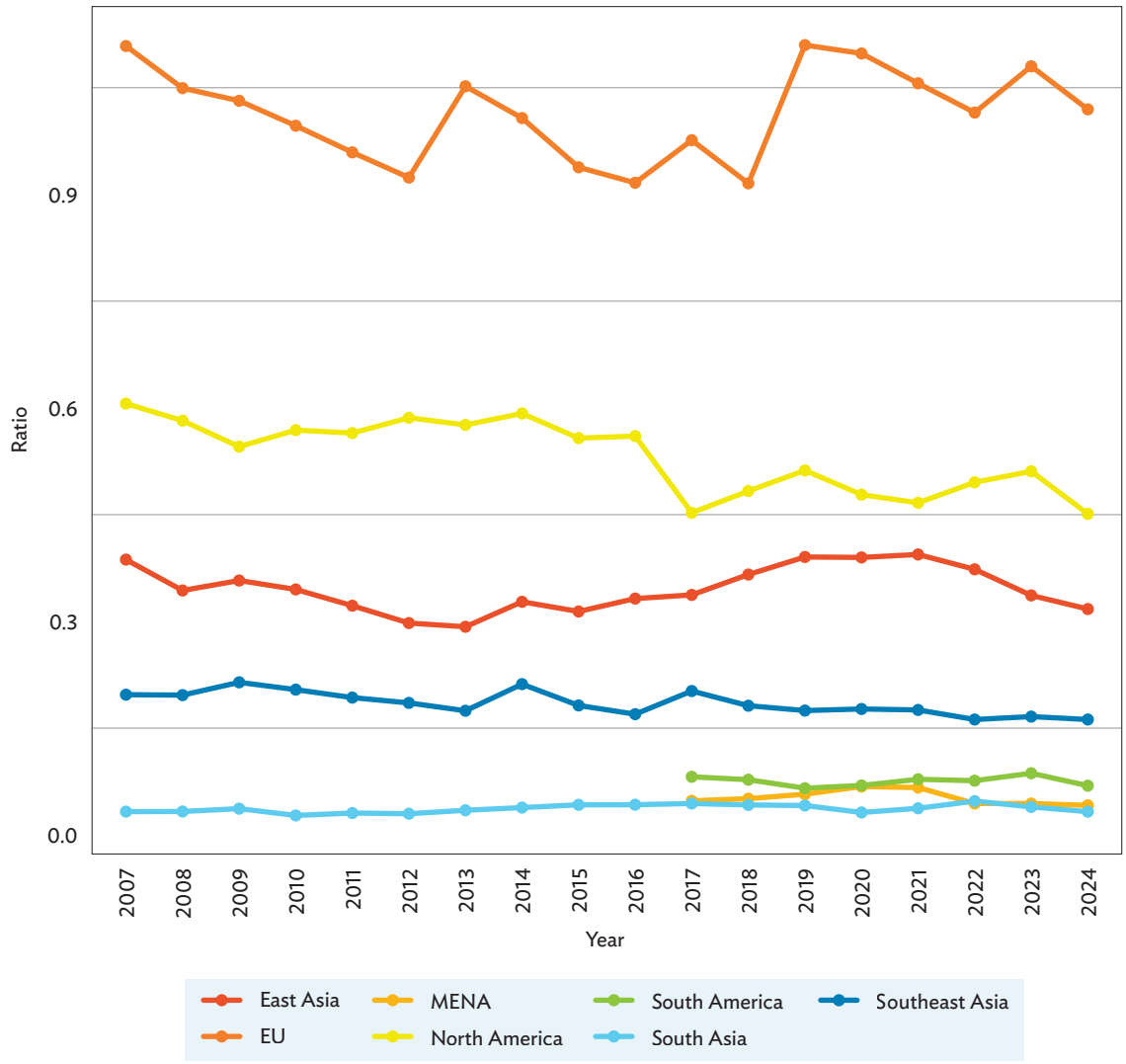


EU = European Union; FRA = France; GER = Germany; ITA = Italy; JPN = Japan; KOR = Republic of Korea; PRC = People's Republic of China; UKG = United Kingdom; USA = United States.
Note: The European Union is treated as a single economy.
Source: Asian Development Bank Multiregional Input-Output Database; and Organisation for Economic Co-operation and Development estimates.

While the relatively high ratios in North America are self-explanatory, it is interesting to see how the trend appears to be the opposite of what was seen for the EU – stable values around 0.6 are observed from 2007 to 2016 before going down and staying close to 0.5 in the years that followed. Meanwhile, East Asia exhibited an increasing internal reliance from 2015 to 2021 before declining in more recent years. Lastly, MENA, South America, South Asia and Southeast Asia appeared to consistently trade more externally than internally, despite the numerous trade agreements in place (e.g., ASEAN Free Trade Area, Greater Arab Free Trade Area, Mercosur, South Asian Free Trade Area and the Regional Comprehensive Economic Partnership).

Figure 1.8: Ratio of Intra- to Inter-Regional Domestic Value-Added in Intermediates Trade

Trends in trade dependence within regions were quite variable, with some stabilizing at higher or lower levels and others remaining steady across the years.



EU = European Union; MENA = Middle East and North Africa.

Note: Intra- and inter-regional value-added is calculated based on Hamanaka methodology (2015), where region i's intra-regional share = T_{ii} / T_i, where T_i = total exports of region i to the world plus total imports of region i from the world, and T_{ii} = exports of region i to region i plus imports of region i from region i.
Asia and the Pacific regional groupings are based on ADB classifications.
East Asia: Hong Kong, China; Japan; the Republic of Korea; Mongolia; the People's Republic of China; and Taipei,China.
South Asia: Bangladesh, Bhutan, India, Maldives, Nepal, and Sri Lanka.
Southeast Asia: Brunei Darussalam, Cambodia, Indonesia, the Lao People's Democratic Republic, Malaysia, the Philippines, Singapore, Thailand, and Viet Nam.
The EU: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden.
North America: Canada, Mexico, and the United States.
South America: Argentina, Brazil, Colombia, and Ecuador.
MENA: Egypt, Kuwait, Saudi Arabia, and the United Arab Emirates.
Data for MENA and South American economies are available from 2017 onwards in the ADB MRIOTs.

Source: Asian Development Bank Multiregional Input-Output Database; and Asian Development Bank estimates.

Gross and direct value-added trade were negatively affected by growing fragmentation along geopolitical lines, while indirect value-added trade was generally unaffected.

While there is some level of stability in intra- to inter-regional dependence on intermediates trade, blocs that transcend geographic barriers may be of more relevance, especially given current developments. Recent evidence points to a growing fragmentation of global trade along geopolitical lines since the start of the Russian war in Ukraine (Blanga-Gubbay and Rubínová, 2024). Trade between hypothetical East and West blocs – measured using UN General Assembly voting patterns (Bailey, Strezhnev and Voeten, 2017) – grew around 4% slower than trade within each. Extending the analysis to a more recent period, after an initial widening of this gap, fragmentation appears to have stabilized in 2023 and 2024. In the first half of 2025, further fragmentation is observed but, unlike 2022, this is so far mostly explained by an acceleration of the PRC-US decoupling.

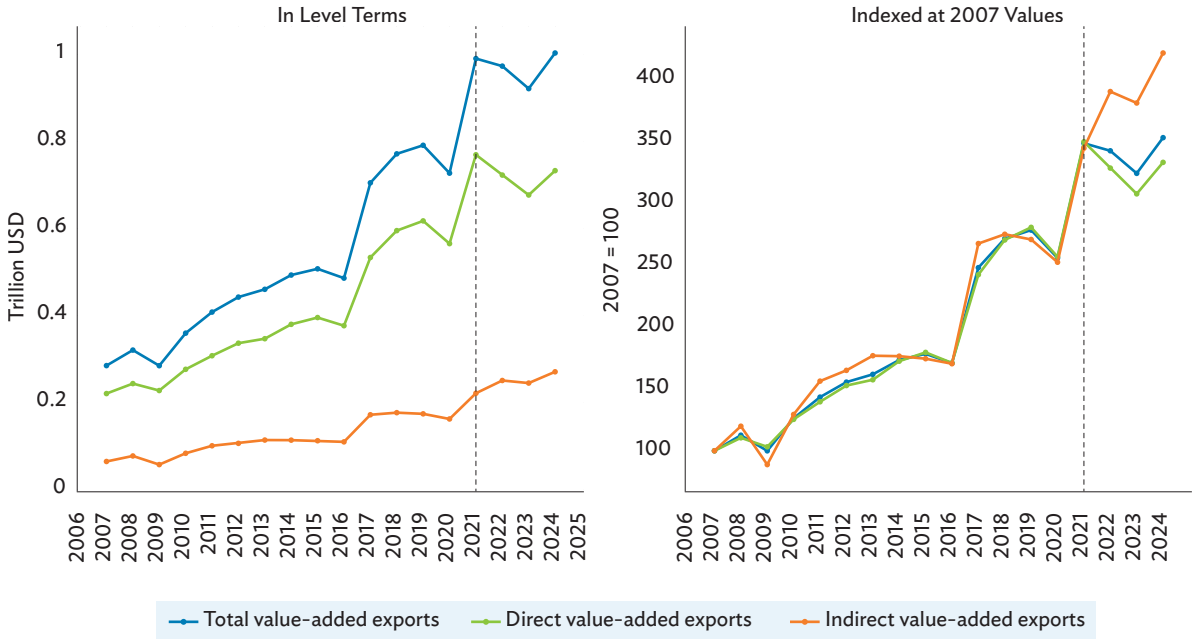
In fact, rising trade tension between the PRC and the US since 2018 has intensified decoupling pressures. The tit-for-tat tariff increase, followed by global uncertainty and geopolitical shocks, has had a strong impact on bilateral flows – trade between the two grew substantially slower (around 30%) than their trade with the rest of the world. This led to preliminary evidence of trade diversion and rerouting of goods through connector economies, highlighting how geopolitical frictions can reshape trade geography. For example, Alfaro and Chor (2023) show that decoupling was accompanied by an increase in US import shares from Viet Nam and Mexico, which in turn increased their imports from the PRC.

It is, however, difficult to assess the magnitude of trade rerouting using gross trade data alone. To go beyond gross flows in the analysis of decoupling and connector economies, value-added trade data from ADB MRIOTs are used, which shows that rerouting makes up for only a small share of the fall in PRC-US trade[12]. In a world increasingly organized around GVCs, input-output linkages provide a clearer view of underlying exposure as they enable quantification of indirect value-added trade (e.g., PRC value-added in the exports of intermediary economies like the EU, Mexico or Viet Nam, to the US). Looking at Figure 1.9, direct value-added trade between the PRC and the US declined in parallel with gross exports while indirect value-added trade increased from 2021 to 2024, indicating some redirection of trade through connector economies. However, the level of indirect value-added trade remains small compared to direct flows, such that its growth has not compensated for the decline in direct value-added trade. This implies that the trade tensions have significantly lowered PRC-US trade linkages despite anecdotal evidence of rerouting.

12 See Blanga-Gubbay, Majune, Rubínová, and Stolzenburg (forthcoming) for details.

Figure 1.9: Value-Added Trade Between the People's Republic of China and the United States

Rerouting trade through intermediary economies increased but only partially cushioned the blow of increased trade tensions between the PRC and the US.



Note: Left panel shows the value of trade in trillions of dollars (current prices). The right panel sets 2007 as the baseline year, thus all figures are expressed in terms of percentage of this initial value.
Source: Asian Development Bank Multiregional Input-Output Database; and Asian Development Bank and World Trade Organization estimates.

Blanga-Gubbay, Majune, Rubínová and Stolzenburg (forthcoming) also demonstrate how trade patterns between geopolitically aligned economies showed obvious signs of fragmentation when viewed through the lens of value-added trade. Results from their study indicate a decline in direct value-added trade since the Russian war in Ukraine began, consistent with findings based on gross trade flows, but, in contrast to the PRC-US case, indirect value-added trade showed no significant movement. Turning to services, no comparable signs of fragmentation were observed, which may be linked to the fact that services trade is highly concentrated, thereby making redirection more challenging. It also likely reflects the fact that trade policy remains focused on manufacturing and critical minerals, despite the growing role of services for trade discussed in this chapter and the GVC Development Reports of 2017 and 2021 (Heuser and Mattoo, 2017; Nano and Stolzenburg, 2021).

In summary, the weaker relationship of GDP and trade growth among economies may be taken as a sign of prioritizing local versus foreign consumption of domestically produced goods and services, especially after the pandemic onset. It must be noted, though, that the correlation remained positive and significant throughout the study period, which means that in general, international trade remains highly tied with economic growth – a result that has persisted despite numerous global crises having occurred in recent decades. In addition, despite some marginal increases in export

concentration metrics for some economies – both in terms of suppliers and consumers of GVC-related trade – the overall picture still suggests diversification across the board.

Recent developments, such as challenges in existing trade relationships and growing reliance on neighbouring economies, combined with a decline in the reliance on foreign intermediates, warrant a more careful look, as they may partly explain the widening gap between traditional and GVC-related trade observed from 2023 to 2024. Lastly, while there is stability in intra- to inter-regional dependence on trade, there appears to be evidence of fragmentation between hypothetical East and West blocs as well as decoupling and trade rerouting, especially after major periods of geopolitical crises.

Overall, there is still a good deal of heterogeneity in the paths that economies have taken since the disruption of the COVID-19 pandemic. Some structures that existed for a long time are already gone – e.g., the EU's dependence on the Russian Federation, the PRC's downstream position in GVCs – while new patterns are emerging. These shifts suggest that globalization is not retreating but rather being reshaped in different forms and through new channels. The next section turns to regional trade developments and the extended application of inter- and intra-regional trade within regions to analyse these emerging patterns and reconfigurations in more detail.

1.4 Regional Trends

As economies face rising uncertainties, regional trade patterns are diverging – highlighting that while global value chains remain broadly resilient, the pathways through which trade flows are changing.

Understanding regional trade trends is essential for assessing the evolving structure of globalization. While global aggregates point to stabilization in overall trade, they conceal important divergences across regions that point to the patterns seen in GVC-related trade. Regions faced distinct strategic trade-offs: some, like parts of the EU, have had to substitute Russian energy imports while facing internal tensions of decreasing trade with the PRC, even as the PRC had simultaneously increased its trade ties with individual EU economies like Hungary, Poland and the Slovak Republic (PISM, 2024). South America has also been diversifying to the PRC over the past two decades, with the latter becoming the largest trading partner to Brazil, Chile, Peru and Uruguay and signing free-trade agreements with Chile, Costa Rica, Ecuador, Nicaragua and Peru (CRS, 2023).

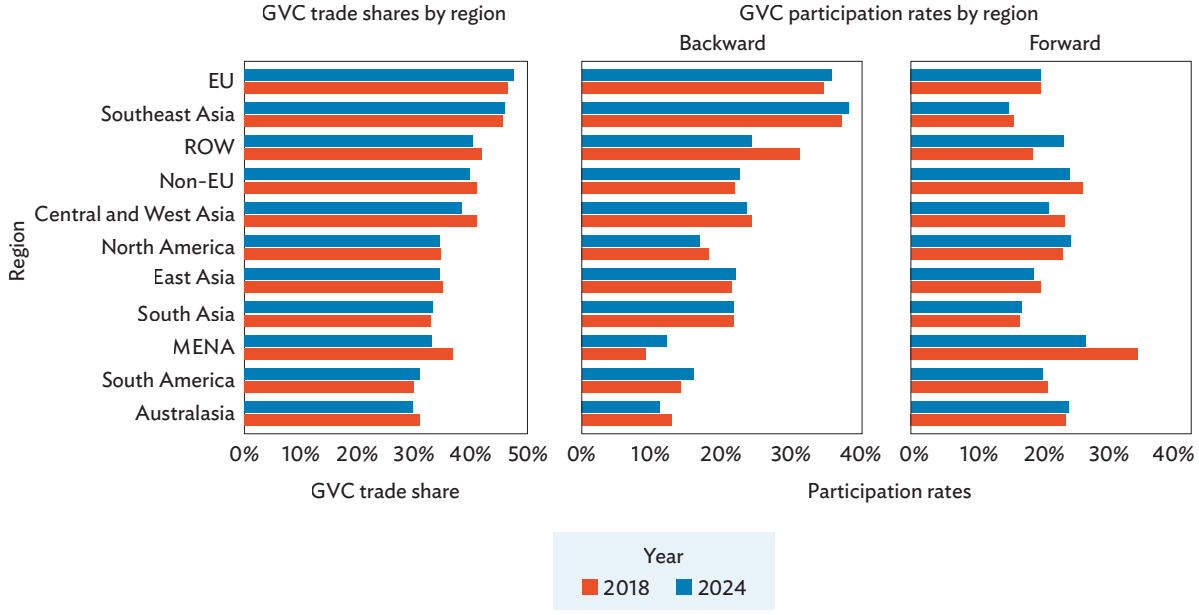
Figure 1.10 shows regional differences between the role of GVCs in exports. The EU and Southeast Asia remained the most integrated into GVCs, with both regions maintaining the highest GVC-related trade shares over the period. Notably, the EU experienced further increase in its GVC trade share by 2024, reinforcing its role as a global hub. Southeast Asia also sustained a high GVC-related trade share, highlighting

its emerging importance in manufacturing and re-export activities. By contrast, several regions, such as Australasia, Central and West Asia, MENA and other European economies, recorded declines, reflecting either reduced reliance on foreign inputs or weaker integration of domestically produced intermediates in complex production networks. Meanwhile, respective shares of East Asia, North America, South Asia and South America remained stable, indicating that their structural positions in GVCs were largely entrenched. As such, there is persistence in long-standing GVC hubs and divergence across other regions.

Backward participation rates remained highest in the EU and Southeast Asia, reflecting their deep reliance on imported intermediate inputs and relatively downstream position in global production networks. By contrast, Australasia and MENA displayed lower backward participation rates and higher forward participation rates, underscoring their importance in upstream production chains. However, between 2018 and 2024, their trajectories diverged – while MENA had decreased its participation in upstream inputs into GVCs and increased their backward GVC participation, suggesting diversification away from raw resources, Australasia maintained their participation patterns. Altogether, this suggests that regional trajectories differed: some economies reinforced their roles as hubs for complex supply chains, while others reconfigured their GVC linkages. In this section, we take a closer look into the regional breakdown of trade flows to assess whether these shifts represent early signs of new trading patterns.

Figure 1.10: Global Value Chain Participation Rates By Region, 2018 and 2024

GVC-related trade remains concentrated in the EU and Southeast Asia, with diverging backward and forward linkages across regions.



EU = European Union; MENA = Middle East and North Africa.
Note: Asia and the Pacific regional groupings are based on ADB classifications.
Australasia consists of the following economies: Australia, Fiji, and New Zealand.
Central and West Asia: Armenia, Georgia, Kazakhstan, the Kyrgyz Republic, Pakistan, and Türkiye.
Non-EU economies: Norway, the Russian Federation, Switzerland, and the United Kingdom.
Source: Asian Development Bank Multiregional Input-Output Database; and Asian Development Bank estimates.

The European Union saw growth in trade within the bloc, while the Russian Federation and the United Kingdom diversified trade to outside of the region.

Since 2017, EU trade has undergone major reconfigurations. The UK's withdrawal from the EU Single Market and Customs Union in 2020 triggered a sharp decline in EU–UK trade (Kren et al., 2024). A second and even more profound adjustment came in 2022 when the EU, the UK, the US and other allies responded to the start of the Russian war in Ukraine by imposing sweeping sanctions targeting the Russian Federation's financial sector, energy exports and industrial base. For decades, the Russian Federation was one of the EU's primary trade partners, particularly in energy. Germany sourced around 60% of its natural gas imports from the Russian Federation, while reliance in Central and Eastern European economies reached as high as 90% (Rojas-Romagosa, 2024; Yusuf, 2024). By 2023, however, EU sanctions such as embargoes on coal, refined oil and a G7-led crude oil price cap, had reduced the Russian Federation's refined fuel exports to the EU to just 12% of total sectoral exports, down from 42% only a year earlier.

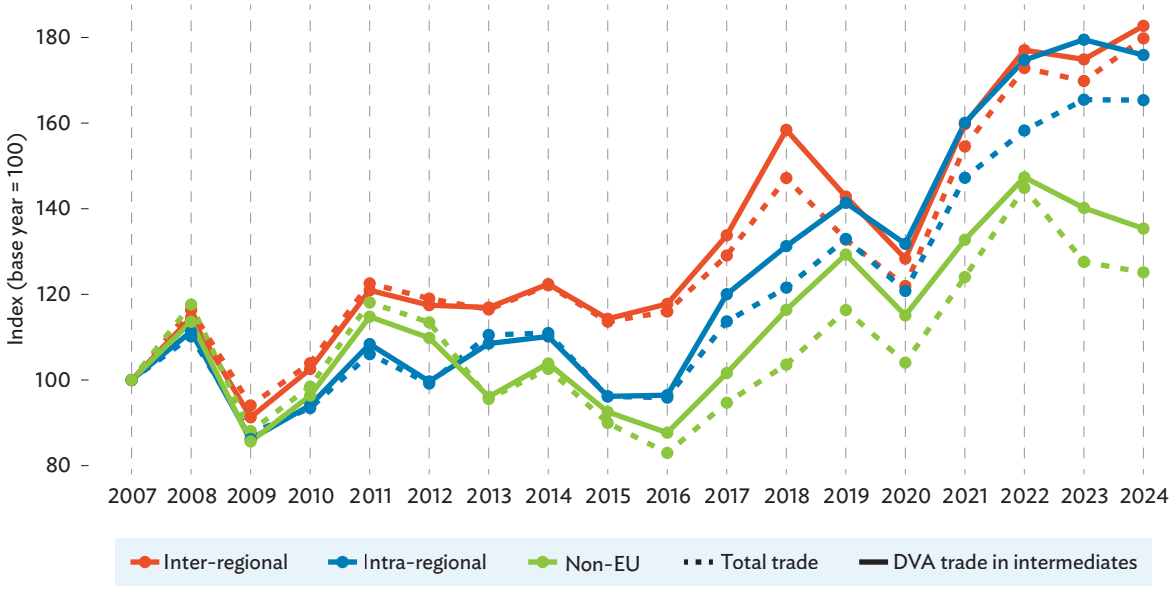
The EU's move to decouple had immediate repercussions – bilateral goods trade with the Russian Federation fell to its lowest level in decades, energy prices spiked through 2022-23 and supply chains for both energy and agriculture were disrupted (Schneider-Petsinger, 2023; Steinbach, 2023). In response, the EU diversified by shifting to liquefied natural gas (LNG) imports from the US, expanding renewables and rerouting export flows towards Central and West Asia, which absorbed over $20 billion of redirected EU exports (Birch et al., 2024). While these shifts imposed economic costs through higher energy prices and trade distortions, they also accelerated the EU's long-term structural adjustment, reducing dependence on Russian energy and reinforcing investment in alternative supply routes and sustainable energy sources.

Figure 1.11 shows that both intra-regional total trade and domestic value-added in intermediates trade[13] grew at a higher pace than with other regions since 2019, highlighting a stronger internal reliance, particularly in satisfying final demand. While inter-regional trade also expanded, its trajectory has been uneven – trade ties with the UK and the Russian Federation contracted, while flows to other regions strengthened between 2023 and 2024. This pattern suggests that, although the EU has faced significant shocks in the region in the past five years, it has reinforced internal integration while diversifying inter-regional partnerships to mitigate vulnerabilities exposed by rising geopolitical tensions.

13 The sum of DAVAX2, REX, and REF from Borin and Mancini's gross exports decomposition framework

Figure 1.11: Change in the EU's Inter- and Intra-Regional Total Trade and Domestic Value-Added in Intermediates Trade, 2017-2024

The EU's intra-regional trade strengthened as trade with other European economies decreased since 2022.



DVA = domestic value-added.
Note: Other European economies ("Non-EU") include Norway, the Russian Federation, Switzerland and the UK. Inter-regional trade includes these European economies.
Source: Asian Development Bank Multiregional Input-Output Database; and Asian Development Bank estimates.

Central and West Asia emerged as a growing intermediary hub while the European Union, the Russian Federation and the People's Republic of China looked for alternative routes.

Europe's pivot from the Russian Federation redirected flows towards Central and West Asia, elevating the Trans-Caspian International Transport Route as an alternative Eurasia channel. Economies in the region experienced significant trade growth by acting as intermediaries while maintaining trade with both the Russian Federation and the West. With the Russian Federation cut off from many direct Western imports, trade data is consistent with these neighbours becoming key transit hubs for "parallel imports", where goods are rerouted through third economies. The Russian Federation officially legalized parallel imports in 2022, facilitating this practice through trade partners like Türkiye and Kazakhstan (UNCTAD, 2022). In 2022, bilateral exports from the Kyrgyz Republic and Kazakhstan to the Russian Federation, for instance, grew by 47.6% and 82.57%, respectively[14]. In fact, between 2022 and 2023, the Russian Federation was the largest export partner for economies in the region – Armenia, Georgia and the Kyrgyz Republic and the second largest for Kazakhstan, after the PRC. At the same time, product-level analysis for Armenia, Kazakhstan and the Kyrgyz Republic suggests that these economies experienced strong import growth from the

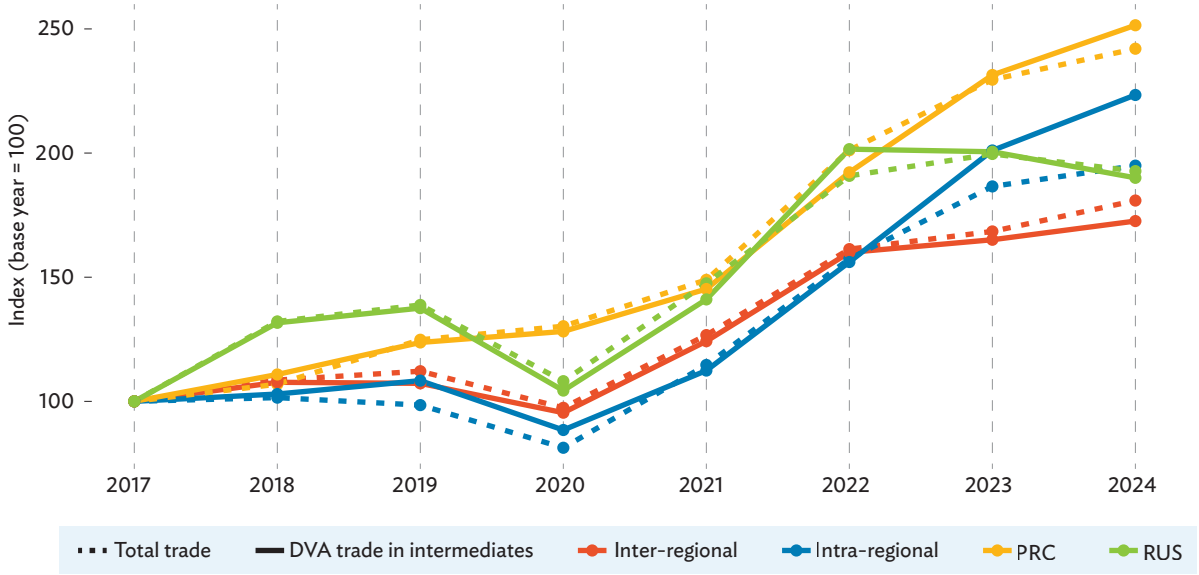
[14] The increase in trade values is likely amplified by inflationary effects, as the analysis is based on current price tables. For an explanation of the rationale behind using current rather than constant price tables, refer to Box 1.1.

EU, particularly pronounced in product groups partially or fully subject to sanctions (Chupilkin et al., 2023).

Beyond the Russian Federation, regional trade integration accelerated through the Trans-Caspian International Transport Route, otherwise known as the Middle Corridor. Cargo flows doubled in 2022 to 1.5 million tons, while the traditional Northern Route fell by 34% (Euronews, 2025). The PRC has deepened its engagement in the region, signing bilateral agreements with Azerbaijan, Georgia and Kazakhstan to expand the corridor (Trends Research, 2024), which reflected in the rapid increase of exports from the region to the PRC. Figure 1.12 shows that Central and West Asian economies have seen a strong trade growth since 2020, including both inter- and intra-regionally, with the Russian Federation and especially with the PRC. Furthermore, Central and West Asia became one of the only regions that has not seen a significant decline in trade from 2022 to 2023, and a steady increase in domestic value-added trade in intermediates, overtaking growth in traditional trade with external regions. These developments underline how Central and West Asia has become pivotal in both sustaining Russian trade and reshaping Eurasian connectivity in GVCs.

Figure 1.12: Change in Central and West Asia's Inter- and Intra-Regional Total and Domestic Value-Added in Intermediates Trade, 2017-2024

Central and West Asia's trade with the rest of the world strengthened, particularly with the PRC and the Russian Federation.



DVA = domestic value-added; RUS = Russian Federation; PRC = People's Republic of China.
Note: Inter-regional trade figures include flows with the Russian Federation and the PRC.
Source: Asian Development Bank Multiregional Input-Output Database; and Asian Development Bank estimates.

The People's Republic of China and India deepened trade ties with the Russian Federation, as other economies in East Asia and South Asia looked to diversify their trading partners.

As geopolitical tensions unfolded in the West, the PRC and India deepened their north-bound links, reshaping partner portfolios with the Russian Federation. The PRC did not join Western sanctions, opposing unilateral restrictions and continuing regular trade with the economy. The Russian Federation, in turn, weathered the initial sanctions shock by pivoting to trade with Asia, propping up its economy through state intervention and leveraging its commodity wealth. By 2023, total trade between the two economies had reached a record high, surpassing the Russian Federation's trade volume with the EU (Figure 1.13). The PRC's share of Russian imports more than doubled, from 19.5% in 2017 to 39.4% in 2024, with notable acceleration during the COVID-19 pandemic and after February 2022. The PRC's domestic value-added in exports to the Russian Federation, including machinery, electronics, automobiles and other consumer products, has increased by 56% from 2021 to 2023, effectively replacing lost European trade. However, at the same time, foreign value-added embedded in PRC exports to the Russian Federation has increased by 70% in the same time period – a higher rise compared to all other trade components.

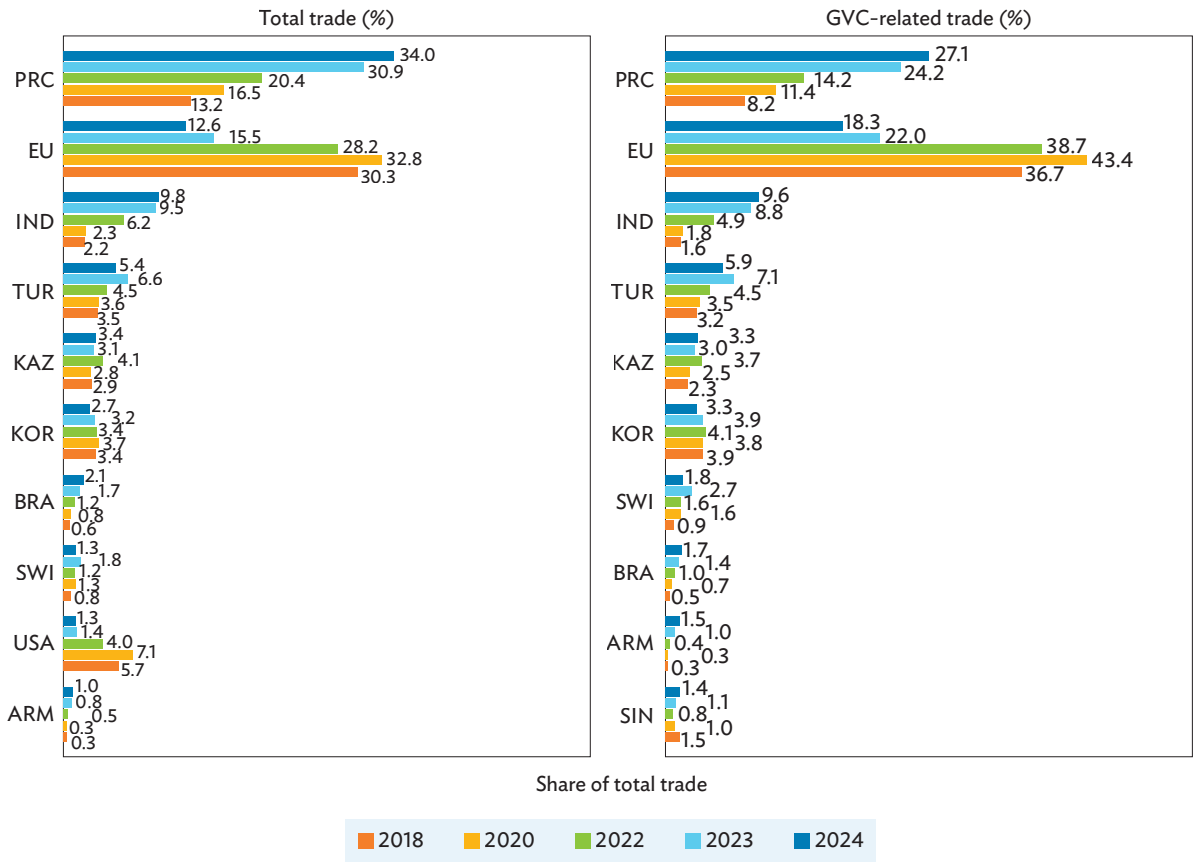
The Russian Federation also strengthened its trade relations with India, with exports doubling between 2021 and 2022. GVC-related trade similarly expanded – more than doubling and outpacing the growth of total trade (Figure 1.13). By mid-2023, the Russian Federation had become India's largest crude oil supplier, with the refined fuels sector accounting for approximately 28% of total Indian imports, compared to 3.6% in 2021. As with the PRC, India's trade with the Russian Federation showed a higher share of directly absorbed domestic value-added in intermediates (DAVAX2) rather than participation in broader GVCs. The PRC and India have also faced increasing barriers with trade from the US in 2025, which will likely affect the trade reconfiguration of the two economies and, by extension, of the region in the coming years.

Elsewhere in East Asia, the COVID-19 pandemic exposed the structural vulnerabilities of advanced economies, as the EU and the US have relied on the region for leading-edge chips. Advanced chip fabrication has been concentrated in Taipei,China and in 2023, its exports contracted by 9.6%, with traditional trade rising by 1.4% but GVC-related trade falling more sharply by 17.8%[15], indicative of the economy's relative downstream position in GVCs (positioned 58th out of 72 economies). However, in 2024, the economy's exports grew by 8.2%, with both GVC-related trade and traditional trade increasing. Across the sea, Japan registered weak overall trade performance, though GVC-related exports edged by 0.06% in 2024 despite a slight decline (-0.86%) in traditional trade. The Republic of Korea experienced a steep decline in GVC-related trade in 2023 (15.9%), followed by a strong rebound in 2024 (9.2%). Meanwhile,

[15] Out of which REF declined by 44%, REX declined by 28%, and FVA declined by 16%.

Figure 1.13: Top 10 Trading Partners of the Russian Federation By Trade Type, 2018-2024

While the Russian Federation's overall trade rapidly realigned after 2022, shifts in its GVC-related trade have not followed traditional trade.



ARM = Armenia, BRA = Brazil, EU = European Union, IND = India, KAZ = Kazakhstan, KOR = Republic of Korea, PRC = People's Republic of China, SIN = Singapore, SWI = Switzerland, TUR = Türkiye, USA = United States.
Source: Asian Development Bank Multiregional Input-Output Database; and Asian Development Bank estimates.

Mongolia, as a commodity-dependent economy, displayed more volatile traditional trade growth compared to relatively stable GVC-related trade, diverging from broader regional patterns.

North America's intra-regional trade grew at a higher rate than inter-regional trade, as United States' trade ties with Mexico deepened.

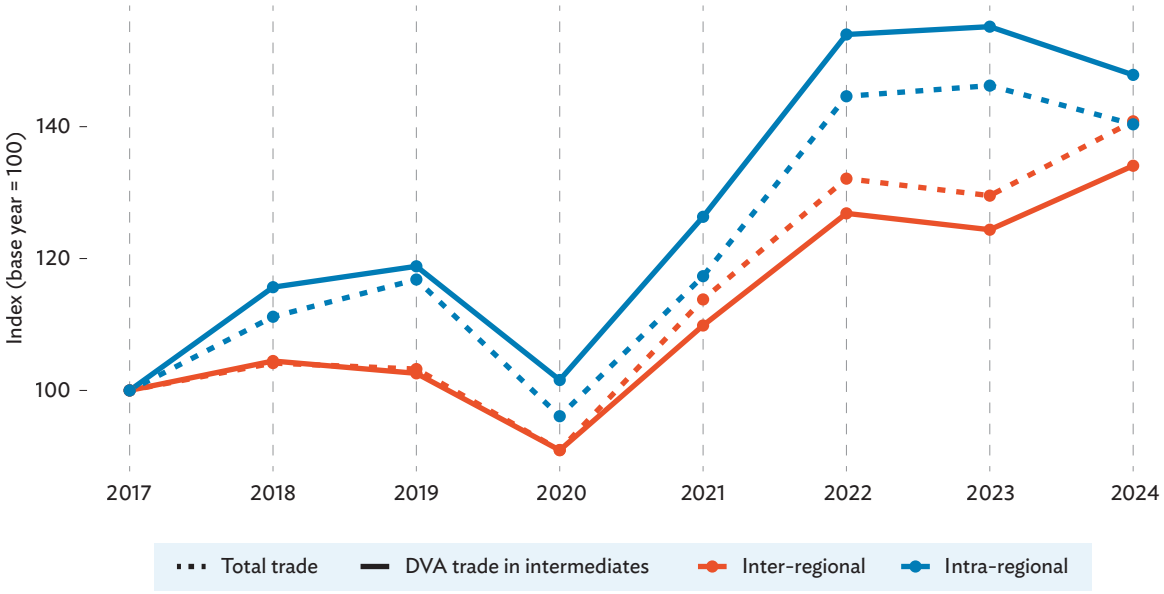
The role of the US is particularly significant in global production networks, as it remained the world's second-largest source of foreign value-added embodied in exports after the PRC. Yet, persistent policy uncertainty following the PRC-US trade dispute has prompted enterprises to reconsider sourcing strategies, supplier networks and investment destinations. Mexico has emerged as one of the key beneficiaries of this shift. By late 2023, Mexico overtook the PRC as the US' largest source of imports – a position it maintained through 2024. This development, widely seen because of

"friendshoring" dynamics, is reflected in Mexico's rising share of intra-regional GVC trade, which now surpasses that of Canada.

Figure 1.14 highlights that since 2017, both intra- and inter-regional trade in North America expanded through 2024, though the pace of growth varied across total and value-added trade. Intra-regional trade grew more strongly than inter-regional trade, reflecting the region's deepening integration. Within this, intra-regional domestic value-added trade in final goods rose faster than intra-regional domestic value-added trade in intermediates, whereas inter-regional flows grew at similar rates across both categories. At the economy level, the US continued to dominate, accounting for about 40% of both traditional and GVC-related trade within the region. Yet, differences between Canada and Mexico stood out – Canada captured a larger share of intra-regional traditional trade (about 33%), indicating that more of its exports were consumed directly within North America. By contrast, Mexico captured a higher share of GVC-related trade (about 35%), underscoring its vital role in intermediate production and re-exports within supply chains. However, Blanga-Gubbay, Majune, Rubínová and Stolzenburg (forthcoming) show that intra-regional trade has increased at a higher pace in recent years mostly due to indirect trade of the US with the PRC through Mexico and Viet Nam.

Figure 1.14: Change in North America's Inter- and Intra-Regional Total Trade and Domestic Value-Added in Intermediates Trade, 2017-2024

Intra-regional trade in North America grew faster than inter-regional trade, with value-added flows driving deeper integration.



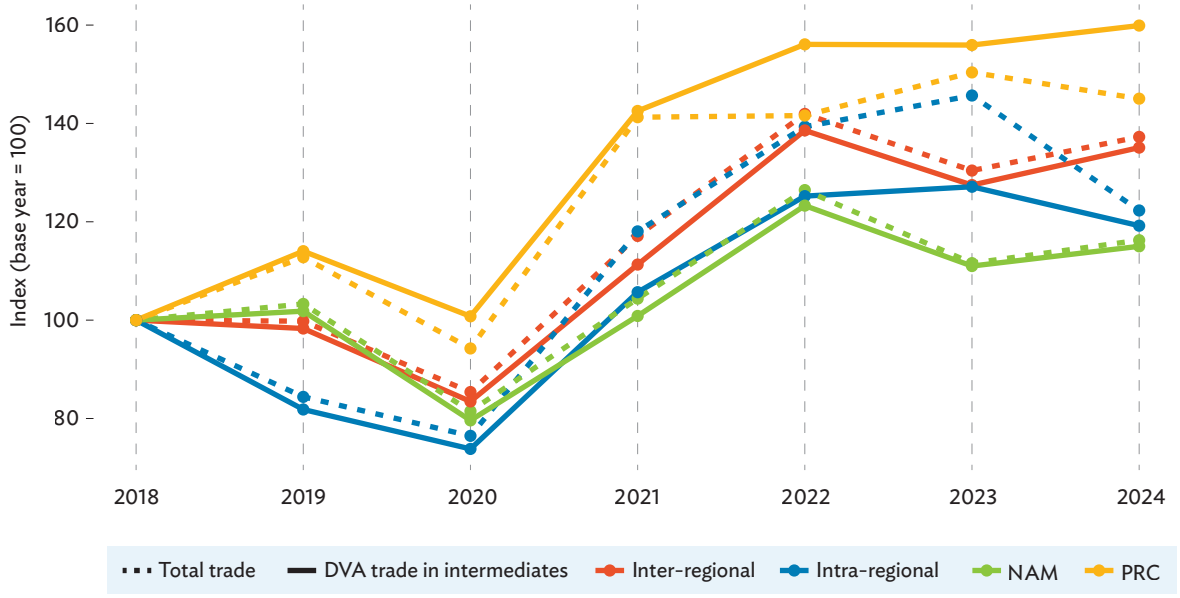
DVA = domestic value-added.
Note: North America includes the United States, Canada, and Mexico.
Source: Asian Development Bank Multiregional Input-Output Database; and Asian Development Bank estimates.

Amid the shift in North America, South America diversified towards the People's Republic of China through new free trade agreements.

In the past decade, South America has shown signs of redirecting trade away from traditional dependence on North America towards Asia, particularly through deeper engagement with the PRC (Figure 1.15). More broadly, the PRC's network of free trade agreements (FTAs) in Latin America expanded during this period, and as of 2024, FTAs were in force or ratified with Chile, Costa Rica, Ecuador, Nicaragua and Peru. These agreements form part of a strategic effort by many South American economies to hedge risk vis-à-vis US policy volatility, while accessing growing PRC demand for agricultural products. From the perspective of the PRC, its expansion of trade with the region may signal its interest in securing supply of raw materials. Symbolically, nine South American and 12 Central American and Caribbean economies have signed Belt and Road-related memorandums of understanding (MoUs) with the PRC, leading to a wider political and economic cooperation (European Parliament, 2025).

Figure 1.15: Change in South America's Inter- and Intra-Regional Total Trade and Domestic Value-Added in Intermediates Trade, 2017-2024

South America's exports have shifted decisively towards the PRC, with GVC-related trade leading growth while intra-regional and North American ties remain modest.



DVA = domestic value-added; NAM = North America; PRC = the People's Republic of China.
Note: South America includes Argentina, Brazil, Chile, and Ecuador, which account for more than 70% of the total region's total economic output.
Source: Asian Development Bank Multiregional Input-Output Database; and Asian Development Bank estimates.

Transport infrastructure dynamics, tariff concessions and logistics improvements under these FTAs are early indicators that South America may be reconfiguring its supply chains, favouring Asia-Pacific pathways. For instance, the Chancay deep-water mega port in Peru, the first port of which was inaugurated in 2024, will establish direct

access between Shanghai and Peru through the Pacific Ocean, benefitting other South American economies as well. As such, given the gradual implementation schedules of many FTAs, the full trade-flow effects are likely to manifest more clearly beyond 2024.

Southeast Asia doubled down on mega free trade agreements, cementing its role in inter-regional global value chain trade.

Southeast Asian trade is striking for its strong reliance on GVC-related exports, which dominated across all destinations (Figure 1.16), underscoring the region's role in upstream production, where exports are embedded in complex value chains rather than directly consumed. Furthermore, while the EU shared this upstream orientation, Southeast Asia stood out in terms of its inter-regional trade: on average between 2017 and 2024, 84% of its exports go outside of the region, compared to the EU's heavier dependence on internal trade (52%).

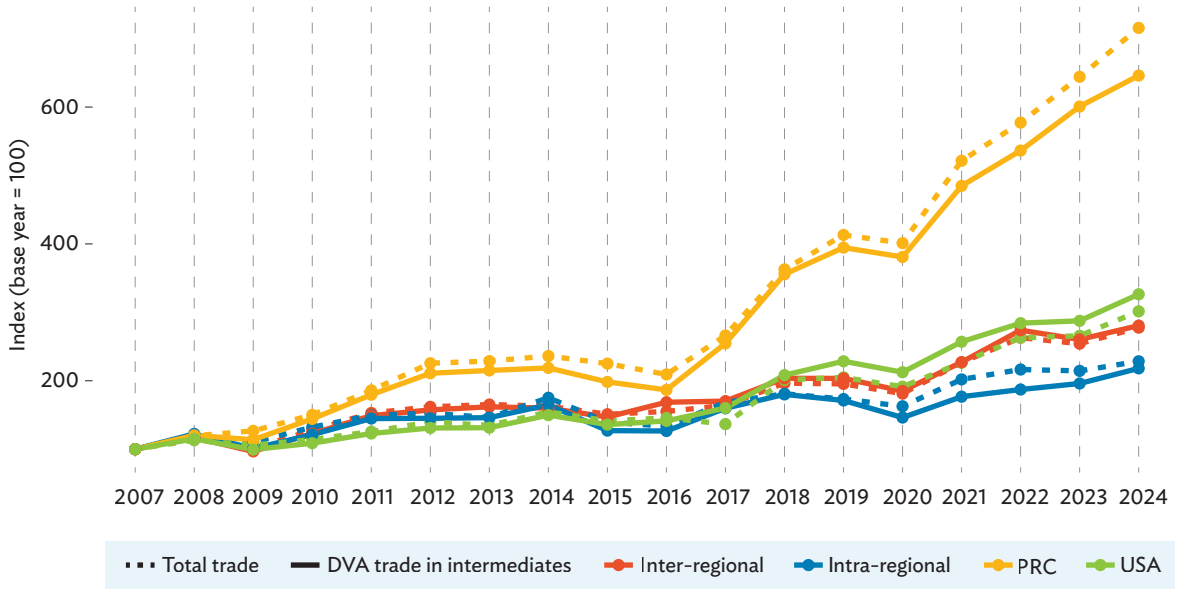
Southeast Asia has also actively deepened integration, both within the region and beyond. In November 2020, all members of the Association of Southeast Asian Nations (ASEAN) joined Australia, Japan, New Zealand, the PRC and the Republic of Korea in the Regional Comprehensive Economic Partnership (RCEP), which came into effect on 1 January 2022. Furthermore, several Southeast Asian economies joined the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) starting in 2018 – now the world's fourth largest free trade area. Within these frameworks, GVC-related trade has consistently outpaced traditional trade growth, defying the perceived global stabilization of GVCs after the COVID-19 pandemic.

Within ASEAN, several initiatives have been reinforcing this trajectory. The ASEAN Digital Economy Framework Agreement (DEFA), launched in 2023, aims to become the world's first binding regional pact focused solely on digital governance (World Economic Forum, 2025). By harmonizing rules on e-commerce, cross-border data flows, digital payments and cybersecurity, DEFA is expected to reduce regulatory fragmentation and transaction costs, creating a more seamless and competitive digital ecosystem across ASEAN. The Digital Economy Partnership Agreement, signed into agreement by Chile, New Zealand and Singapore in 2020, with the Republic of Korea acceding in 2024, looks to achieve comparable results, facilitating end-to-end digital trade.

Yet Southeast Asia's dependence on GVC-related trade implies that the bloc is more at risk from global trade uncertainties resulting from US's proposed tariff increases as well as its trading partners. In addition, regional geopolitical uncertainties pose ongoing risks to the region's trade resilience, even as trade with the PRC had seen significant growth in the past decade (Figure 1.16). Furthermore, members of the ASEAN are pursuing different growth strategies: the continental Southeast Asia (Cambodia, Lao PDR, Myanmar, Thailand and Viet Nam) have edged closer to the PRC's infrastructure, while the maritime states, surrounded by the ocean (Indonesia, Malaysia, Singapore, the Philippines and Brunei Darussalam), have more opportunities to diversify their trading partners.

Figure 1.16: Change In Southeast Asia's Inter- and Intra-Regional Total Trade and Domestic Value-Added in Intermediates Trade, 2017-2024

Southeast Asia's exports grew strongly from 2017 to 2024, with inter-regional driving gains and GVC-related exports outpacing traditional trade.



PRC = People's Republic of China, USA = United States.
Source: Asian Development Bank Multiregional Input-Output Database; and Asian Development Bank estimates.

Inter-regional trade overwhelmingly dominated MENA's trade profile, accounting for an average of 94% of total trade between 2017 and 2024. Within this mix, traditional trade continued to outweigh GVC-related trade, although the latter's growth rate has been more stable in recent years. The region's heavy reliance on traditional trade, particularly energy exports, has exposed it to recent geopolitical and logistical disruptions. 2023, in particular, saw a sharp drop in trade due to the conflict in Yemen and the Red Sea, which has severely disrupted shipping lanes, a situation compounded by drought-related capacity reductions in the Panama Canal. These constraints have forced container ships to reroute away from the Suez Canal and instead transit via the Cape of Good Hope, adding roughly 6,500km and 10-12 days to shipping times (UNCTAD, 2024). As a result, weekly transits around the Cape surged from 300 to 605 after the Houthis' Red Sea attacks in November 2023, remaining elevated through March 2024 (ONS, 2024). These developments have increased transport costs and delivery risks, weighing heavily on the region's trade flows.

Overall, the evidence suggests that globalization is adapting. International trade and participation in GVCs have expanded since 2018, though at uneven rates across regions. Europe's decoupling from Russian energy and Central and West Asia's emergence as a key transit hub all highlight how geopolitical shocks can accelerate structural change. At the same time, Southeast Asia's sustained integration through RCEP and CPTPP, and the MENA region's exposure to shipping disruptions, underscores the vulnerabilities

that remain. The challenge ahead will be to manage this transition in ways that strengthen resilience without undermining the efficiency gains that global integration has delivered.

1.5 Conclusion

This chapter provided the empirical foundation for understanding recent developments in international trade and GVCs. The analysis highlights three key findings. First, global trade growth has slowed since the COVID-19 pandemic recovery, but traditional trade has proven more resilient than GVC-related trade since 2022. However, even within GVCs, sectoral pathways diverge, as services sectors have overtaken goods sectors in terms of GVC participation rates.

Second, the weakening link between GDP and trade growth since the pandemic suggests a shift towards prioritizing domestic consumption, though trade remains a key driver of economic activity. While some economies have shown increased concentration in trade partners, overall patterns still point to diversification. However, recent geopolitical shifts and reduced reliance on foreign intermediates may explain the growing gap between traditional and GVC-related trade. Structural decomposition analysis underscores that much of the shift in GVC patterns stems from changes in final demand composition and sourcing, signalling that trade patterns are not merely cyclical nor due to regionalization, but undergoing longer-term restructuring. Despite stable intra- and inter-regional trade shares, signs of fragmentation and rerouting – especially between East and West blocs – are becoming more evident. These trends underscore the evolving nature of globalization, marked by adaptation rather than retreat.

Third, regional reconfigurations and trade patterns in the recent years are highly uneven: the EU has intensified intra-regional linkages, North America showed deepening integration driven by US-Mexico ties while indirect trade between the US and the PRC continued through connector economies such as Mexico and Viet Nam. Southeast Asia has deepened its GVC integration through mega FTAs and trade with other regions, while Central and West Asia has emerged as a strategic intermediary hub amid geopolitical disruptions.

Economies more tightly embedded in regional value chains, or aligned with industrial hubs like the PRC, ASEAN or the EU, appeared to have captured stronger export gains, while those at the periphery often lagged behind. Emerging free trade agreements, such as RCEP, DEFA and the African Continental Free Trade Area (AfCFTA), underscore this shift towards trade alignments, where digital integration and regulatory harmonization matter as much as traditional cross-border openness. Taken together, these insights suggest that future patterns of trade will be defined not only by globalization's scale but also by the structure and ownership of production networks. New methodologies such as the Trade in Factor Income (TiFI) framework (Meng et

al., 2024) and firm-level customs-based approach (Kee et al., 2024) provide a more granular understanding of how value is created, captured and redistributed along GVCs. By focusing on ownership and firm heterogeneity, these tools reveal structural shifts, such as the PRC's move towards more upstream and domestically controlled activities, that are not visible in aggregate trade measures alone, which are further explored in Chapter 3.

While the rising contributions of economies that are not traditionally linked to GVCs may signal a modest broadening of globalization, expanding their inclusivity in GVCs will require targeted strategies, such as through digital technologies. Digitalization lowers entry costs for micro, small and medium-sized enterprises, widens participation across populations and has proven critical to resilience during the COVID-19 pandemic (Park et al., 2023). Moreover, digitally deliverable services have been radically changing the global economy, amounting to more than half of total services exports (Ossa, 2023). The long-term future of trade may well be in services and not goods as digitalization will have profound effects on its scale, scope and speed (Schneider-Petsinger, 2023). Chapter 2 explores increased digital infrastructure in Africa and Asia, and participation gaps in Latin America, while Chapter 7 turns to finance and firm-level outcomes, including trade finance architecture, productivity gaps digital lending and inclusivity.

At the same time, industrial and climate policies are reshaping GVC configurations. The US has maintained restrictive tariffs on the PRC while introducing new duties on semiconductors, EVs and critical minerals under the Section 301 review, a mechanism that allows the US Trade Representative to impose trade measures in response to unfair trade practices, and the US Chips Act in the period between 2023 and 2024. Similarly, Canada and the EU have imposed restrictions on the PRC-linked EV supply chains. These measures reflect broader efforts to reduce dependence on the PRC, adding complexity and uncertainty to the trade environment. In parallel, global trade in green technologies has expanded (ADB, 2025), creating opportunities for long-term growth but also fueling new trade frictions, as reflected in the US tariffs targeting PRC solar cells and the EU's Carbon Border Adjustment Mechanism (CBAM). These dynamics will be taken up in greater detail in Chapter 3 and Chapter 4.

To address these emerging themes in global trade, the World Trade Organization has begun compiling thematic mapping, involving more than 100 economies across all regions, and identifying so called "mini deals" (Stolzenburg, 2024). Empirical evidence shows that such arrangements often cover more product lines than many headline FTAs and are increasingly being used as pragmatic tools to address supply chain disruptions and manage technical barriers to trade. These trends will be explored further in Chapter 8.

Global trade will continue to be shaped by ongoing developments. Deepening geopolitical tensions in Europe and the Middle East might harden into the new normal. In the US, the imposition of reciprocal tariffs on a widening set of partners might

further push trade reconfigurations as the added uncertainty for firms navigating cross-border networks turns away from the US's traditional partners. Already, the end of the "de minimis exemption" ruling in the US will affect global trade metrics, the full impact of which will not be seen immediately. At the same time, emerging trends in industrial policy, climate action and digital services may likely become more prominent in the trade landscape and further reconfigure global trade and value chain participation.

The structural realignments traced in Chapter 1 reveal not a retreat from globalization but its reconfiguration into new forms of connectivity. Yet the capacity of economies to benefit from this reglobalization depends on whether they are institutionally, technologically, and financially prepared to adapt. By linking global trends to economy-level capabilities, Chapter 2 tests whether digital trade facilitation, reliable energy-transition pathways, and predictable rulemaking translate into shorter lead times, lower costs and reduced uncertainty. In doing so, it distinguishes between structural diversification that builds resilience and spurious diversification that merely reflects rerouting – turning the empirical patterns documented in Chapter 1 into a readiness map for policymakers navigating the next phase of global integration.

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Annex 1.1: Methodological Notes for Chapter 1

Annex Box 1.A.1: Measuring Trade Partner Concentration in Global Value Chains

1. Import partner concentration ($HHI^{r}_{imports}$)
This index measures how concentrated an economy's sources of GVC-related imports are. It is calculated as:

$$HHI^{r}_{imports} = \sum_{s} \left(\frac{GVC^{sr}}{GVC^{*r}} \right)^2 = \sum_{s} (S^{s})^2$$

Where:
- GVC^{sr} is the value of GVC-related imports from economy *s* to economy *r*
- GVC^{*r} is the total GVC-related imports received by economy *r*

A lower HHI indicates a more diversified set of import partners, while a higher HHI suggests greater concentration.

2. Export partner concentration ($HHI^{s}_{exports}$)
This index measures how concentrated an economy's destinations for GVC-related exports are. It is calculated as:

$$HHI^{s}_{exports} = \sum_{r} \left(\frac{gvc^{sr}}{gvc^{s*}} \right)^2 = \sum_{r} (S^{r})^2$$

Where:
- GVC^{sr} is the value of GVC-related exports from economy *s* to economy *r*
- GVC^{s*} is the total GVC-related exports sent by economy *s*

Again, lower values reflect diversification, while higher values indicate concentration.

Interpretation thresholds
Based on guidelines from the US Federal Trade Commission (FTC) and the UK Competition and Markets Authority (CMA):
- HHI ≤ 0.10: No concentration
- 0.10 < HHI ≤ 0.18–0.20: Moderate concentration
- HHI > 0.18–0.20: High concentration

These thresholds help identify economies that may be vulnerable to supply chain disruptions due to over-reliance on a few trade partners.

Reference:
Madhu, D.M., Gunadal, N.M., Harshitha, H.C., Rosalin Geetha, I., Sri, K.K., Haripriya, S. & Hanumanthappa, R. (2024). *A Comprehensive Analysis of Export Performance and Trade Competitiveness of Millets from India. Journal of Scientific Research and Reports,* 30, pp. 43-55.

2

Resilience and Reglobalization: Global Value Chain Trends and New Opportunities

Antoni Estevadeordal, Anthony Cano Moncada, Robert B. Koopman, Victor Stolzenburg, and Michael Blanga-Gubbay

Overview

The current phase of reglobalization is less a reversal than a recalibration of production networks. Cross-border flows continue at near historic levels, but the logic of value creation is shifting toward resilience, technological capability and climate alignment. Supply chains are becoming shorter, more digital and regionally diversified as firms and governments seek reliability, resilience and lower-carbon competitiveness. The economies that will gain most are those that make trade corridors predictable, data and payment systems interoperable, and business environments transparent and investment ready.

Competitiveness in this new phase of globalization rests on five mutually reinforcing enablers.

- Digital infrastructure must deliver low-latency connectivity, secure internet exchange points, interoperable electronic identification and paperless-trade systems that reduce transaction costs and enable real-time visibility.
- Clean energy reliability is essential for removing barriers on energy-transition goods, scaling renewable power-purchase agreements and developing certified green industrial zones.

Note: The work on this chapter was led by Antoni Estevadeordal, Anthony Moncada, Robert B. Koopman, Victor Stolzenburg, and Michael Blanga-Gubbay

- Borders must move from control to facilitation through trusted-trader programs, pre-arrival processing and risk-based inspection that enhances predictability.
- Institutions and finance must de-risk investment via one-stop windows, standardized public–private partnership frameworks, and targeted credit guarantees that crowd in private capital.
- Firm-level capabilities and skills must rise so that micro, small and medium-sized enterprises (MSMEs) can integrate into higher-value global production tiers.

Progress everywhere can be tracked through a readiness scorecard combining indicators of corridor reliability, digital interoperability, grid stability, renewable energy penetration, customs efficiency and supplier upgrading. Implemented together, these measures reduce time, cost and uncertainty, increase domestic value capture and strengthen resilience across advanced, emerging and developing economies alike. They define the foundations of a more connected, sustainable and inclusive global economy – one where reliability, not retreat, shapes the next generation of globalization.

New evidence shows that post-2011 global value chain (GVC) integration has broadly slowed or plateaued, suggesting that reglobalization will reward economies that deliver reliability and digital trust, rather than those that merely add partners (see Figures 2.8–2.9). In Africa and parts of Latin America and the Caribbean (LAC), the affordability gap in fixed broadband remains a hard constraint on scaling data-driven services (Figure 2.4).

This chapter situates those global enablers within the shifting architecture of trade and production. It examines how geopolitical realignment, digital fragmentation and the energy transition are redrawing the map of comparative advantage and the rules of market access. While the world economy remains highly interconnected, its operating logic is being recorded around security, standards and resilience. Understanding how economies can adapt to this rewired landscape by converting connectivity into competitiveness is the central objective of the analysis that follows.

2.1 Introduction

Rather than collapsing, global trade is entering a new phase of reglobalization shaped by shifting centres of gravity and driven by technology, the energy transition and the search for reliability. The geography of production and exchange is being rewired as security, with resilience and standards moving to the centre of economic integration. Sanctions, export controls, investment screening and competing rulebooks now shape flows of semiconductors, shipping, finance and data. The outbreak of war in Ukraine and heightened geopolitical tensions have increased border frictions and redirected trade routes, yet they have not reversed globalization (WTO 2023). In parallel, debates over dedollarization signal a gradual reconfiguration of international finance, particularly for commodity exporters and highly indebted economies.

Climate imperatives are redefining comparative advantages across industries and regions. Fossil fuel assets face rising risks of stranding while demand surges for critical minerals, clean energy equipment and low-carbon logistics (IEA 2024; IRENA 2025). Artificial intelligence (AI) and general purpose technologies are transforming cost structures and market access, as choke points in computing power, semiconductors and data infrastructure increasingly determine who captures value (IMF 2024a). Divergent technical and digital standards are fragmenting markets and creating new layers of exclusion wherever domestic institutions cannot align with trusted, interoperable frameworks.

The result is selective and multipolar reglobalization. Production, finance and technology are reorganizing around politically aligned corridors and sector-specific standards regimes, while overall global connectedness remains near record highs (Altman and Bastian 2024). The new map of globalization is one of reliability-based integration, dense within trusted networks, thinner across contested ones. For all economies, this shift presents both opportunity and constraint. Earlier *Global Value Chain Development Reports* described LAC and Africa as peripheral yet promising, limited by shallow upgrading, low intra-regional trade and vulnerability to commodity shocks. Updated evidence confirms that many of these constraints persist. Diversification is often spurious – partner counts have increased but concentration and bottlenecks remain high, digital-infrastructure gaps restrict participation in scalable services, and climate and governance risks continue to weigh on investment and resilience.

Three datapoints frame the readiness challenge: first, participation, upgrading domestic firms in LAC/Africa remain concentrated in low-complexity tasks while foreign-controlled firms dominate high-value segments (Meng et al., 2024; Figure 2.5). Second, diversification quality matters, partner counts rose but concentration and bottlenecks remain elevated (Figures 2.1–2.3). Third, digital capacity binds, early submarine cable links raise cross-border banking positions with diminishing returns (Rubínová et al., 2024, Table 6), yet without affordable fixed broadband firms cannot scale services trade (Nordås & Xu, 2024; Figure 2.4). Building on the global baseline introduced in Chapter 1, this chapter applies a readiness lens to regional resilience, translating the report's global diagnostics into measurable regional capabilities and policy levers.

This chapter establishes the diagnostic foundation linking the global framework introduced in Chapter 1 with the sectoral and policy analyses developed in Chapters 3 and 5. It applies three analytical lenses: (1) structural versus spurious diversification, (2) participation versus upgrading, and (3) resilience versus vulnerability to assess whether economies can translate renewed connectivity into sustainable and inclusive integration. The assessment identifies readiness gaps and institutional levers across five core enablers: digital infrastructure and data regimes, clean energy and critical minerals standards, trade facilitation and logistics, financial deepening and risk management, and investment screening and partnership frameworks.

Building on the structural and geographic shifts outlined in Chapter 1, the following sections operationalize these dynamics through a readiness-based diagnostic. Whereas Chapter 1 examined what has changed in GVC geography, Chapter 2 evaluates how prepared economies are to convert these shifts into upgrading opportunities. The framework translates patterns of diversification, participation and resilience into measurable dimensions of technology and connectivity, trade and logistics, sustainability and energy, institutional and geopolitical conditions, finance and the business environment. Each dimension is benchmarked across LAC and Africa to measure how far domestic capabilities align with the emerging geometry of reglobalized production.

2.2 The Emerging Architecture of Geographic Reglobalization

Since the early 2000s, LAC and Africa have been characterized in global trade analysis as peripheral-but-promising participants in GVCs. The *2017 Global Value Chain Development* report highlighted their significant regional heterogeneity, limited intra-regional trade and persistent challenges in functional upgrading. Indicators like domestic value added (DVA) in exports and backward participation ratios demonstrated both regions' difficulties in moving into higher-value production segments and their underdeveloped regional production networks. However, the report also emphasized that integration alone was insufficient, as value capture, learning spillovers and structural transformation lagged, especially for domestic firms and small economies.

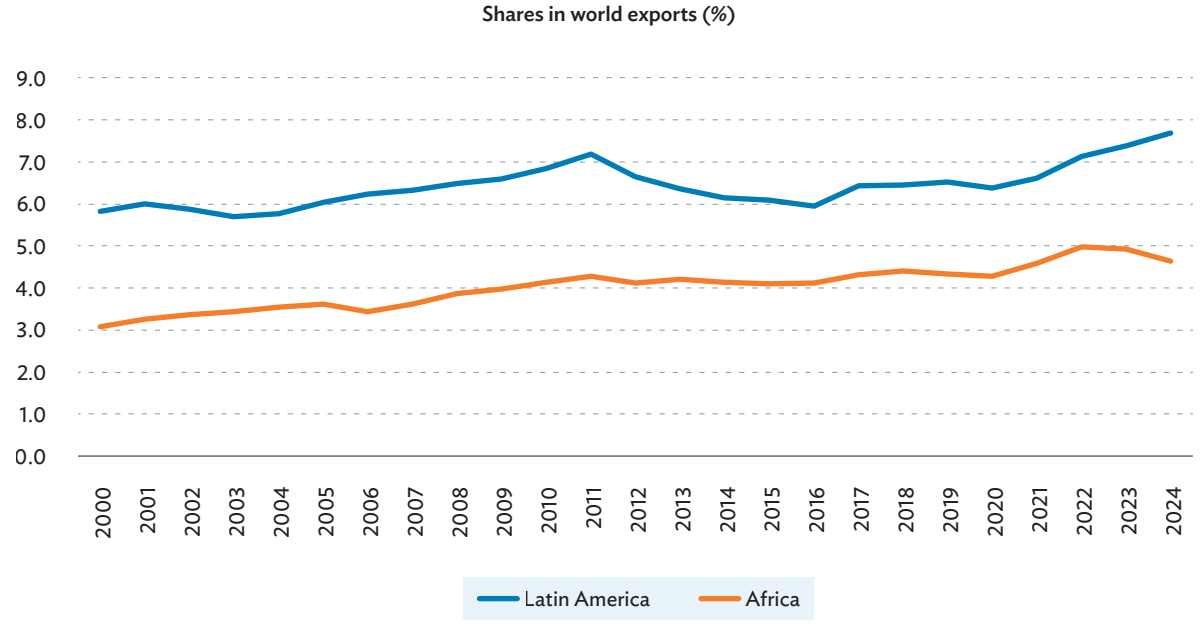
Today, in the wake of cascading shocks, from the trade tensions between the United States (US) and China, to COVID-19, the outbreak of war in Ukraine and intensifying digital fragmentation, the crucial question is not only whether these regions participate, but also if they are ready for the emerging architecture of geographic reglobalization. The term "reglobalization" has gained prominence, defined as the extension of global economic integration to more people, more economies and more issues. In this chapter we focus mainly on the geographical dimension, i.e. the extension of global trade to more economies. This reflects a world where the topology of trade is evolving-marked by declining concentration, increasingly regional configurations, yet still deeply interdependent.

There are indeed modest signs of geographic reglobalization, but the distribution of its benefits remains uneven. While some indicators point to broader participation, the evidence shows that the largest gains continue to accrue to economies already well-integrated into world trade, leaving many peripheral economies at the margins.

Focusing on trade participation first, we can examine the evolution of trade shares of regions that have often been at the margin. This presents a somewhat promising picture, the trade share of LAC and Africa (Sub-Saharan Africa and the Middle East

and North Africa, or MENA) has increased over the past 20 years, even when excluding mineral fuels and mineral oil. For LAC, the trade shares have increased by almost 32%, while for Africa the increase has been 51%, but from a much lower base. The two together represented less than 9% of global exports in 2000, and account now for 12.3%. This might suggest greater integration, but the relationship could be misleading without deeper analysis about diversification. Moreover, in absolute terms this remains a relatively low share given the two regions' share in the global population.

Figure 2.1: Shares of Africa and LAC in World Exports, Excluding Mineral Fuels and Mineral Oil

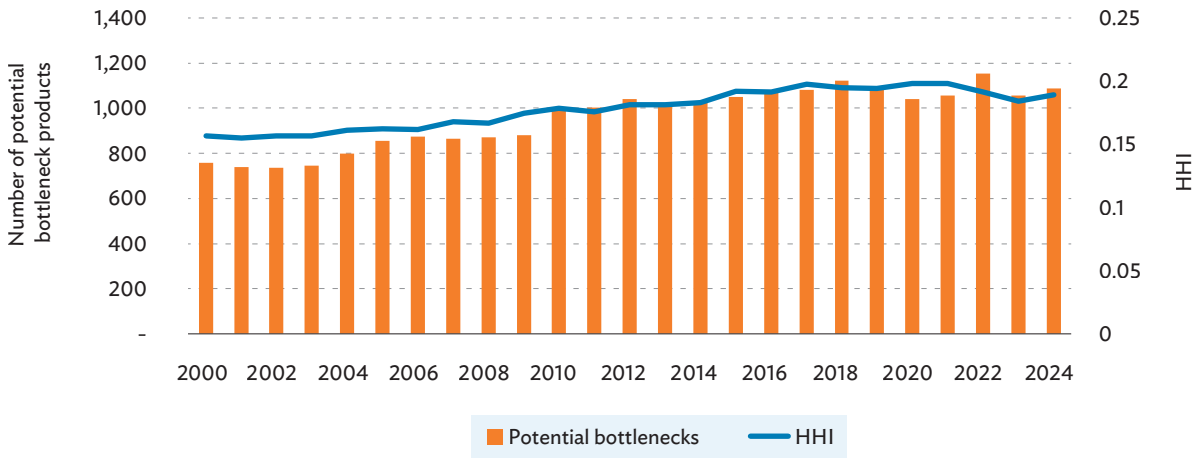


Note: Each region's share of total world merchandise exports excluding HS27 products.
Source: Blanga-Gubbay et al. (forthcoming).

Beyond trade shares, another lens on reglobalization is through diversification. On such measures of diversification are the number of trading partners. Recent data indicates a modest broadening of trade relations, even if the main gains accrue to economies that were already well-integrated into world trade. One way to see this is through the evolution of trade partners. The median number of trading partners per economy, product, and year has risen steadily from 17 in 2000 to 27 in 2024, with a somewhat faster acceleration after 2018. If we restrict the analysis to partners with more than 1% of trade shares in a specific product, the number remained flat at seven from 2000 to 2022 but increased to eight in the last two years. This shows that the geography of trade is gradually expanding, though the steep change in meaningful, large partners remains limited.

Yet, broader connections do not necessarily translate into meaningful diversification. A critical distinction is made between "structural diversification" and "spurious diversification" – temporary shifts driven by price shocks, as seen with liquefied natural gas after the outbreak of war in Ukraine. This distinction is particularly relevant for LAC and Africa. Recent analyses indicate that much of these regions' apparent integration into GVCs is either illusory or narrowly confined to commodities. Furthermore, cross-bloc trade is thinning, and "open bloc" dynamics – where new members join multiple production networks – are rare. In essence, inclusive reglobalization remains more promise than practice. Further evidence, using the Herfindahl-Hirschman Index (HHI) across the Harmonized Tariff System 6 digit categories, shows that nominal diversification has only marginally increased. These findings challenge the assumption that GVC fragmentation automatically creates new space for peripheral economies.

Figure 2.2: Index of Geographic Trade Diversification, 2000-2024



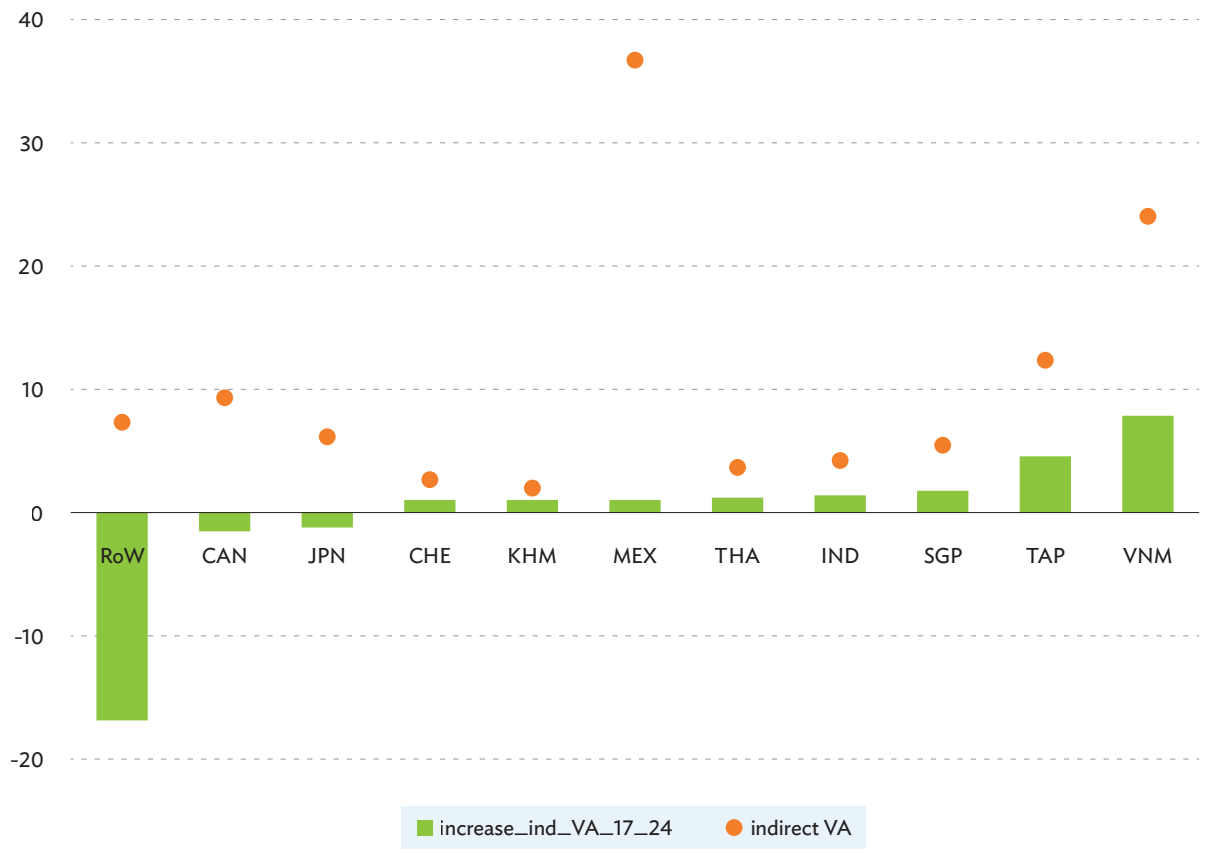
Note: Index captures the evolution of export-market diversification across partner economies, 2000-2024.
Source: Blanga-Gubbay et al. (forthcoming).

Additional evidence on import concentration and bottleneck products reinforces this diagnosis. The average concentration of imports fell in 2023 to its lowest level since 2015 but rose again slightly in 2024. A similar pattern holds for the number of bottleneck products, those with a highly concentrated market structure. The number of such products rose by nearly 10% from 1,057 in 2021 and to 1,153 in 2022, before easing back to 1,088 in 2024. This marginal improvement reflects both a compositional shift towards more diversified products, and a reduced concentration for the average product. However, the trend remains relatively weak and does not yet signal a substantial reduction in concentration.

These limits to diversification are mirrored in broader systemic shifts in global trade, most visibly in the reconfiguration of US-China trade relations, as previously discussed in Chapter 1. The tit-for-tat tariff increases since 2018 slowed bilateral trade flows between China and the US by about 30% relative to their trade with the rest of the world. Preliminary evidence points to trade diversion and rerouting of goods through "connecting" economies (Alfaro and Chor 2023).

The key issue is how much of this rerouted trade benefits peripheral economies. Using the Asian Development Bank's (ADB) multiregional input-output tables, an increase in Chinese indirect value added trade, value added embodied in third economies' exports to the US was observed. Chapter 1 demonstrates that this increase coincided with the decoupling period, suggesting some redirection of trade through intermediaries. However, indirect flows remain small relative to direct ones, and their growth has not compensated for the decline in direct value added.

Figure 2.3: Changes in Chinese Indirect Value Added to the US from 2017 to 2024 and Gross Value of Chinese Indirect Value Added to the US in 2024.

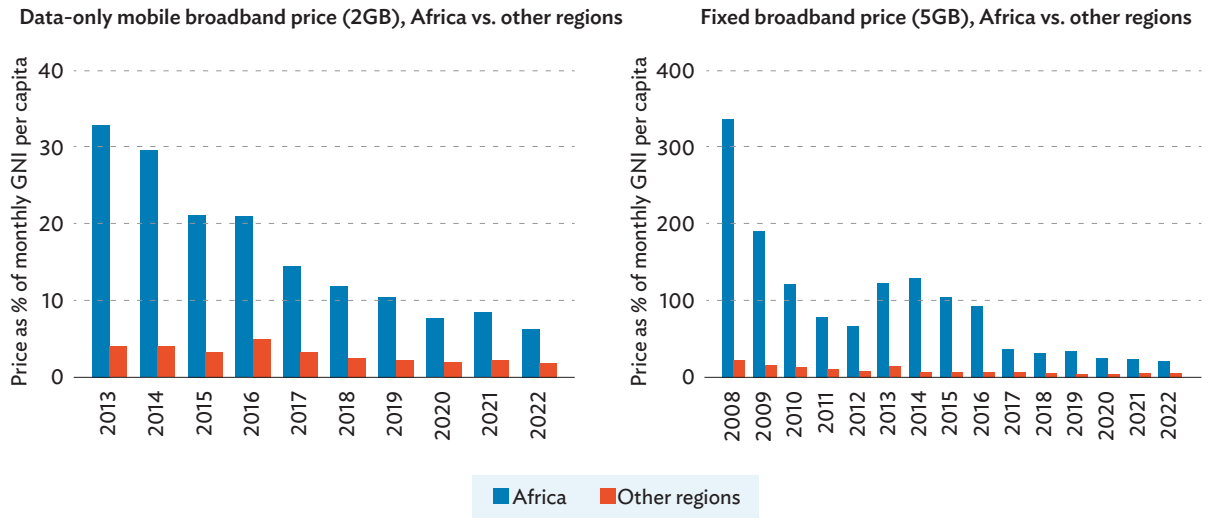


Note: Bars show change in Chinese indirect value added embodied in US imports (2017–2024), markers show gross indirect value added in 2024.
Source: Blanga-Gubbay et al. (forthcoming).

As the graph below illustrates, while there are some signs of diversification, the main benefits accrue to already well-established trading economies. Among the economies experiencing the highest increases in Chinese indirect value added trade to the US between 2017 and 2024 are Viet Nam, Chinese Taipei, Singapore, India, Thailand and Mexico. Among the ones experiencing the highest decrease are Japan and Canada, and the rest of the world, which includes most of the economies in Africa and some in LAC.

Digital connectivity is a foundational enabler for GVC services trade. Rubínová et al. (2024, Table 6) find that submarine-cable connections significantly increase cross-border banking positions, a proxy for financial services trade, rather than measuring direct export values. Their estimates indicate that most of the impact arises from the first connection, with diminishing marginal gains thereafter, and that the effect became statistically strong after 2004 and especially after 2012 as internet banking spread. For Africa, Nordås and Xu (2024) show that while mobile broadband penetration is high, it cannot substitute for fixed broadband, which is essential for stable, high-throughput service delivery. Fixed broadband remains prohibitively expensive, about 21% of monthly gross national income (GNI) per capita compared with 5% in other regions (Nordås and Xu, 2024) (Figure 2.5). Regulatory reforms alone have little impact where infrastructure is lacking, broadband policy effectiveness depends on expanding fixed line capacity and affordability. Without accessible fixed broadband, African and LAC firms remain constrained from entering data-driven segments of GVCs.

Figure 2.4: Fixed and Mobile Broadband Costs as Percentage of GNI per Capita, Africa vs. Other Regions



Note: Regional averages for fixed and mobile broadband costs as a share of GNI per capita.
Source: Nordås and Xu (2024), Global Value Chain Development Report 2025 Background Paper, Figure 5.

Regarding domestic firms' movement up the value chain, Meng et al., (2024), show that domestic-controlled firms in developing regions, including LAC and Africa, remain concentrated in low-complexity, low-margin stages of GVCs, while foreign-controlled

firms dominate value capture in high-technology sectors such as electronics. Their visualization for China's information and communications (ICT) sector (Figures 1.1 and 1.2) illustrates this dual structure: domestic firms contribute mainly at intermediate, assembly-intensive stages, whereas foreign-controlled firms capture most of the high-value design and downstream service functions. These results echo the 2017 Global Value Chain Development report's warning on "participation without upgrading", a challenge now compounded by the growing importance of digital and intangible capital. By contrast, Meng et al., (2024, Figure 1.3) show that US-based domestic-controlled ICT firms capture high value across the entire chain, underscoring how technological capability and firm ownership shape upgrading outcomes. Inomata's "who does what" framework further shows that domestic firms in many economies occupy isolated, low-productivity nodes within GVC networks. Collectively, these diagnostics confirm that formal participation alone does not equate to integration into high-value tasks.

Figure 2.5: Domestic vs. Foreign Firm Contribution to Value Added in Electronics GVCs, Selected Regions

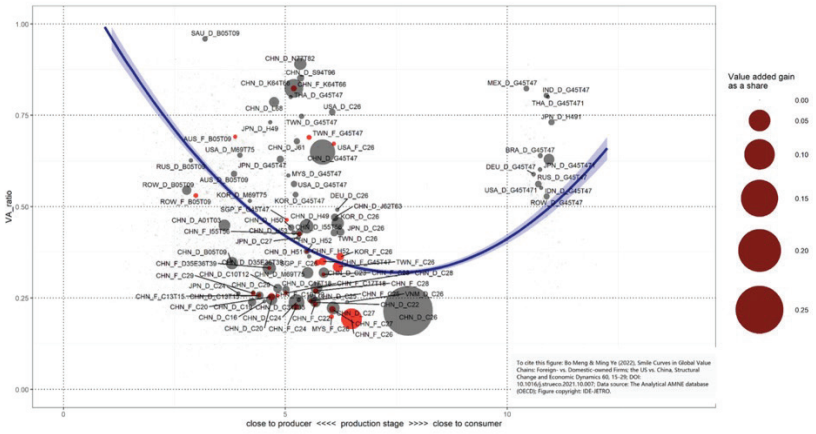


Figure 1.1. China-based domestic-controlled ICT firms' value chain (2019)

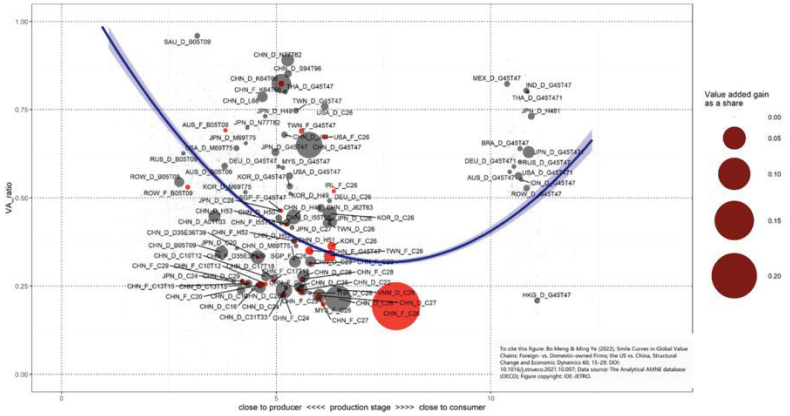
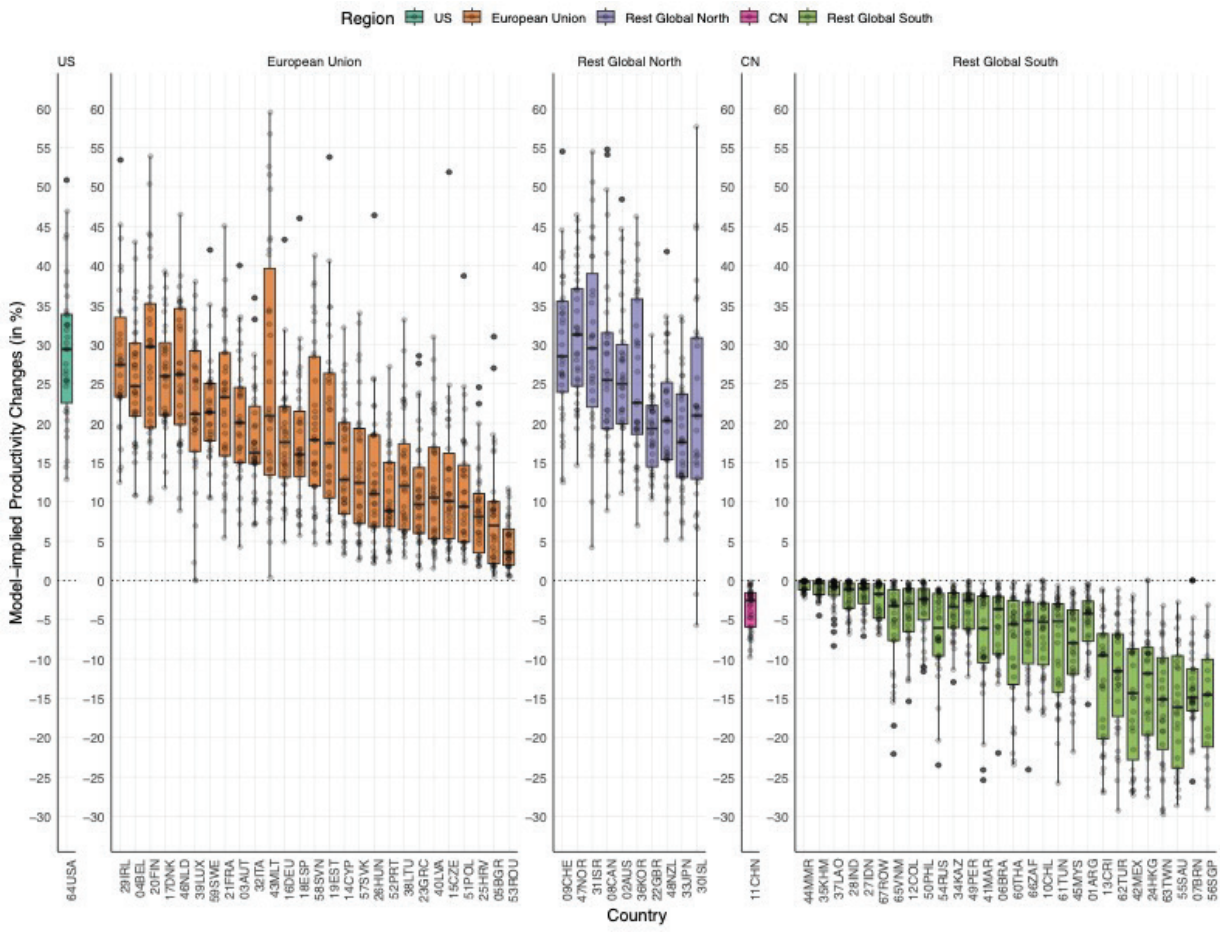


Figure 1.2. China-based foreign-controlled ICT firms' value chain (2019)

Note: Simulated differences in unit labor costs across major world regions under alternative global-trade scenarios.
Source: Meng et al. (2024), Global Value Chain Development Report 2025, Background Paper, Figures 1.1 and 1.2.

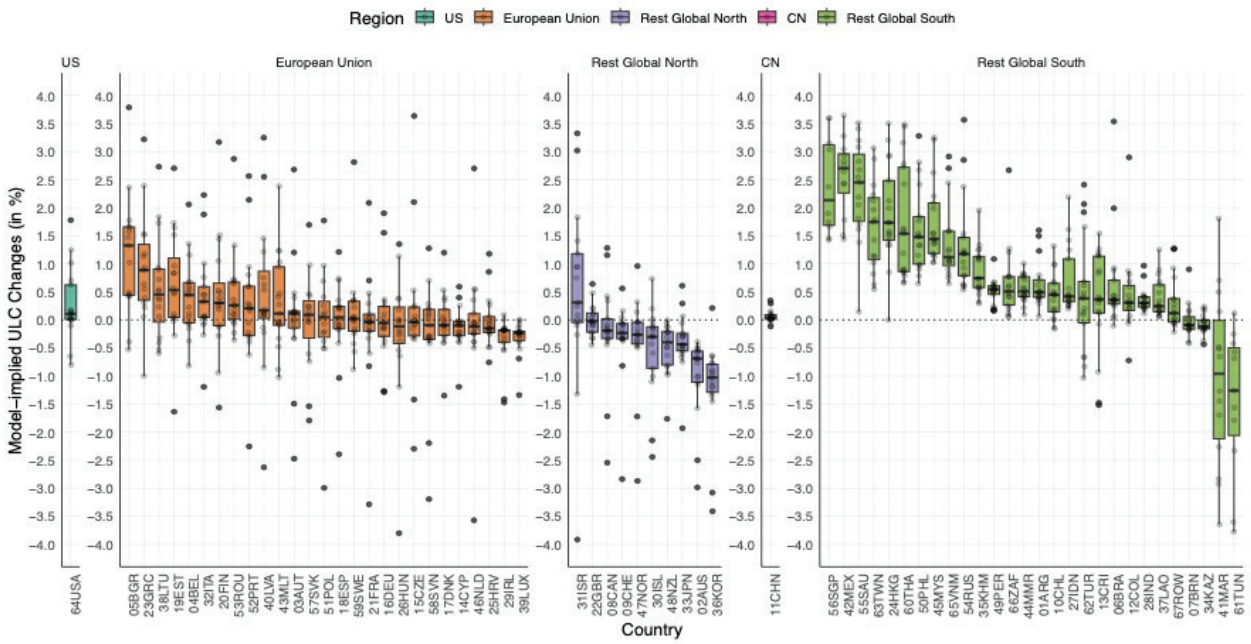
Geopolitical shocks are also shaping the landscape. Giammetti and Wirkierman (2025) models decoupling scenarios, finding that while North-South decoupling raises employment in the Global South (Figure 2.6), it does so in low-productivity roles, making these gains unsustainable without parallel upgrading (Figure 2.7). Gao, Zhang and Meng (2024) simulate friendshoring under conflict, demonstrating that multinationals shift investment toward politically aligned, strategically embedded regions – like the EU or Indo-Pacific – leaving less integrated areas behind. Stolzenburg confirms this in tracking foreign direct investment (FDI) trends, noting that US and Chinese firms now reallocate investment within existing networks, with few truly new entrants among peripheral economies. These insights suggest that fragmentation amplifies existing hierarchies unless latecomers rapidly build absorptive and infrastructural capacity.

Figure 2.6: Simulated Productivity Change under North-South Decoupling, By Region



Note: Simulated changes in regional productivity under a North-South trade-decoupling scenario.
Source: Giammetti and Wirkierman (2025)

Figure 2.7: Simulated Unit Labor Cost Differences, By Macro-Region and Scenario



Note: Simulated differences in unit labor costs across major world regions under alternative global-trade scenarios.
Source: Giammetti and Wirkierman (2025).

The simulated differences in productivity and labor costs highlight how fragmentation reshapes incentives and competitiveness across regions. Yet, model-based projections only capture potential outcomes. To understand how these dynamics have manifested in actual trade and production networks, Box 2.1 draws on Organisation for Economic Co-operation (OECD) trade in value added, or TiVA, (2022) data to trace the real-world evolution of GVC participation over the past three decades and its implications for developing-economy readiness.

2.3 Latin America and the Caribbean – Positioning for Reconfiguration

The global economy is undergoing a structural transformation with far-reaching implications for international trade, production networks and development strategies. LAC faces the urgent task of reassessing their position within GVCs. While rapid trade liberalization, technological change and a rules-based international system fuelled the expansion of GVCs in previous decades, the "hyper-globalization" model has slowed since the global financial crisis of 2008 (IMF 2025). A succession of economic and geopolitical shocks has exposed critical vulnerabilities, accelerating a shift towards supply chain resilience, diversification and strategic reconfiguration of sourcing (IMF 2024a).[1]

[1] This section draws on the background paper prepared by Antoni Estevadeordal for Chapter 2 of the *Global Value Chain Development Report 2025*, subsequently published as Estevadeordal, Kahn, and Werner (2024), *Latin America in the New Geometry of Global Supply Chains* (Georgetown Americas Institute and CAF – Development Bank of Latin America and the Caribbean).

Box 2.1: OECD-TiVA Integration Patterns (1995–2022)

Building on the preceding analysis of trade fragmentation and network decoupling, this section examines how patterns of GVC participation have evolved over the past three decades and what these shifts imply for developing economy readiness. Readiness hinges on institutional strength, digital and physical connectivity, and the ability to absorb, adapt and recover from external shocks. LAC and Africa serve as revealing test cases for this new geography of reglobalization.

The promise of broader integration remains uneven. While diversification rhetoric has intensified, structural indicators – from trade-concentration indices to cross-border investment flows – suggest that few new economies have entered the global GVC core. Blanga-Gubbay et al. highlights this disjunction, noting that headline trade growth often masks limited structural inclusion within the production networks of high-income and technologically advanced economies.

The *2017 Global Value Chain Development Report* chapter on LAC and Africa (World Bank et al., 2017) offered the first systematic framework for understanding these constraints. It emphasized:

- Weak domestic firm participation in high-value tasks
- Limited intra-regional trade and transport integration
- High DVA shares in commodities but low process upgrading
- The potential for services and regional value chains (RVCs) as steppingstones.

Since 2017, the expansion of available data, especially from the OECD TiVA 2022 update, has made it possible to revisit these dynamics across two distinct phases: 1995-2011, a period of rapid global production expansion, and 2011-2022, which was characterized by slower, regionally concentrated realignment.

Figure 2.8 compares average changes in backward, forward and total GVC participation across six macro regions – OECD, the US, China, ASEAN, LAC and Africa, over the two periods. Comparing the 1995-2011 and 2011-2022 periods using the OECD TiVA (2022 update) reveals a decisive slowdown in GVC integration. The first phase was characterized by broad-based gains across nearly all regions, reflecting the expansion and deepening of international production networks. The post-2011 decade, by contrast, shows stagnation and divergence. Several economies, including Morocco, Nigeria, Egypt, Brazil and Mexico, continued to strengthen their integration, while others such as Chile, Argentina and South Africa experienced slight declines. Backward linkages increased modestly, forward linkages flattened and aggregate participation remained broadly unchanged. This later period unfolded amid post-crisis stagnation, heightened geopolitical tensions and recurrent supply-chain disruptions, limiting the scope for new entrants and upgrading. Overall, the evidence points to a phase of consolidation rather than renewed globalization, with regional linkages stabilizing instead of expanding.

Figure 2.8: Total GVC Participation Regional Averages, 1995-2011 vs 2011-2022

Note: Average change in backward, forward and total GVC participation between 1995-2011 and 2011-2022, calculated as country means within each macro region. The analysis covers six regional groupings: OECD economies (Australia, Austria, Belgium, Canada, Chile, Colombia, Costa Rica, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Türkiye and the United Kingdom (UK)); Latin America and the Caribbean (LAC) (Argentina, Brazil, Chile, Colombia, Costa Rica, Mexico and Peru); ASEAN (Brunei Darussalam, Indonesia, Malaysia, Philippines, Singapore, Thailand and Viet Nam); Africa (Angola, Cameroon, Côte d'Ivoire, Democratic Republic of the Congo, Egypt, Morocco, Nigeria, Senegal, South Africa and Tunisia); China; and the US. The figure contrasts the earlier period of rapid integration (1995–2011) with the more uneven post-2011 phase, highlighting regional divergence in GVC participation trends.

Source: Authors' calculations based on OECD Trade in Value Added (TiVA) Database (latest edition).

continued on next page

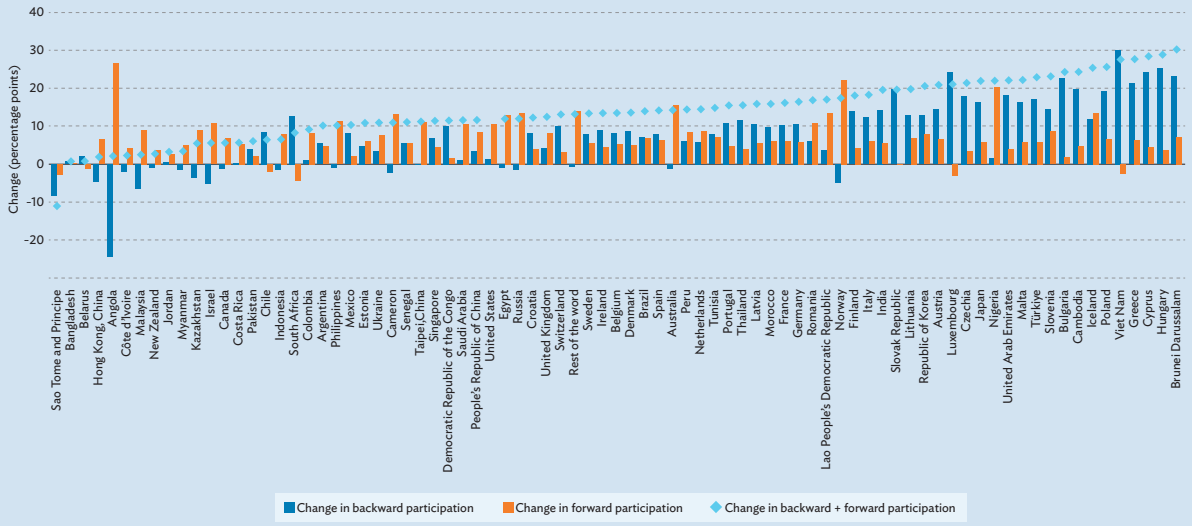
Box 2.1: continued

Country-level patterns reinforce the regional picture while highlighting persistent asymmetries in national trajectories (Figure 2.9). Overall, total GVC participation continued to expand between 1995 and 2022, but gains were uneven and highly concentrated.

- Europe and Central Asia recorded the strongest advances, driven by supply chain consolidation within the European Union (EU).
- East Asian economies, notably Korea, Japan and Viet Nam, maintained high participation through technological upgrading and production specialization.
- LAC and African economies achieved more modest progress, and several including Chile, Argentina and South Africa, registered slight declines.
- Backward participation (foreign value added in exports) expanded faster than forward participation (domestic value added re-exported by partners), underscoring continued reliance on imported intermediates.
- Resource-intensive exporters, such as Angola and Nigeria, increased forward linkages primarily through commodity trade rather than manufacturing diversification.

Taken together, these patterns indicate that globalization has not reversed but rewired. Production has become more concentrated around technologically advanced and regionally integrated hubs, while many late-integrating economies remain on the periphery of global production networks.

Figure 2.9: Country-Level Shifts in Global Value Chain Integration, 1995-2022



Note: Change in backward and forward GVC participation for 63 economies based on the OECD TiVA database. Economies included: São Tomé and Príncipe, Bangladesh, Belarus, Hong Kong (China), Angola, Côte d'Ivoire, Malaysia, New Zealand, Jordan, Myanmar, Kazakhstan, Israel, Canada, Costa Rica, Pakistan, Chile, Indonesia, South Africa, Colombia, Argentina, Philippines, Mexico, Estonia, Ukraine, Cameroon, Senegal, Chinese Taipei, Singapore, Democratic Republic of the Congo, Saudi Arabia, China, the US, Egypt, Russia, Croatia, the UK, Switzerland, Rest of the World, Sweden, Ireland, Belgium, Denmark, Brazil, Spain, Australia, Peru, Netherlands, Tunisia, Portugal, Thailand, Latvia, Morocco, France, Germany, Romania, Lao People's Democratic Republic, Norway, Finland, Italy, India, Slovak Republic, Lithuania, Korea, Austria, Luxembourg, Czechia, Japan, Nigeria, the United Arab Emirates (UAE), Malta, Türkiye, Slovenia, Bulgaria, Cambodia, Poland, Viet Nam, Greece, Cyprus, Hungary and Brunei Darussalam.
Source: Authors' calculations based on OECD TiVA Database (latest edition).

The new evidence underscores that the challenge for LAC and Africa is no longer entry into GVCs but effective participation and adaptation. Their resilience will depend on qualitative capabilities rather than participation volume. What the 2017 report could not capture, due to data and technology limitations, was a readiness framework encompassing:

- Digital infrastructure and services backbone capacity
- Ownership structures and task allocation inside GVCs
- Geopolitical and technological fragmentation as systemic constraints.

These dimensions collectively redefine competitiveness in the era of reglobalization. The diagnostics that follow therefore move beyond participation metrics to assess how effectively LAC and Africa can build resilience, upgrade industrial capabilities and reposition within a geographically fragmented production system. Figure 2.1 empirically maps this transition from diversification rhetoric to the tangible rewiring of production networks providing the quantitative foundation for the readiness framework elaborated in the next section.

Note: This box synthesizes evidence from the OECD TiVA 2022 update to show how GVC participation evolved between 1995 and 2022. The analysis highlights a post-2011 slowdown in international production integration and widening regional asymmetries, with participation gains concentrating in technologically advanced and regionally connected hubs.

Acknowledgements: The authors would like to thank Santiago Taborga of American University for his excellent analytical work with the OECD TiVA dataset, and Sébastien Miroudot of the OECD for his valuable guidance and insights on the use of the TiVA database.

This structural transformation is visible in trade data. As shown in Figure 2.1, LAC and Africa's shares in world exports have expanded since 2000, although from a low base. The region's participation rose by nearly one-third, but the pattern remains concentrated in a few economies and sectors. Likewise, Figure 2.2 shows that the apparent diversification of export partners often masks persistent concentration and limited structural change, evidence that integration has broadened more in scale than in depth.

In this evolving environment, GVCs are not vanishing but their logic is changing. Firms increasingly consider geopolitical risk, regulatory fragmentation, environmental performance and digital readiness in location decisions. New technologies like AI and automation are blurring manufacturing-services boundaries and reducing reliance on labor cost arbitrage. These shifts present both risks and opportunities for LAC (Aguilar et al., 2024). The region lags in GVC depth and diversification, with participation concentrated in a few sectors and economies, and weak regional integration. However, trade reconfiguration, particularly US-China decoupling, has opened nearshoring prospects. Mexico has already benefited, and other LAC economies could position themselves in strategic sectors. LAC's relatively clean energy mix, critical mineral reserves and improving digital infrastructure offer a comparative edge in a sustainability- and technology-intensive trade landscape.

Historical data confirm that the region's GVC participation plateaued after the Global Financial Crisis. Between 1995 and 2011, most LAC economies increased total GVC participation by 6 to 10 percentage points, but progress since 2011 has been modest and uneven (see Figures 2.8–2.9). Backward linkages strengthened slightly, forward linkages flattened and aggregate participation stabilized. These patterns mirror those in Africa and indicate that the challenge is no longer joining GVCs, but upgrading within them.

The following diagnostics apply the same readiness framework later used for Africa, benchmarking technology, logistics, sustainability, institutional, financial and business dimensions to evaluate LAC's capacity to convert renewed connectivity into inclusive upgrading.

2.4 LAC's Global Value Chain Preparedness and Capability

LAC's involvement in GVCs lags behind the EU and Asia. Figure 2.1 illustrates lower participation in backward and forward linkages, as well as reduced contributions from intraregional links, indicating weak regional value chains within LAC. A new index assesses LAC's preparedness based on three main subcomponents: technology, sustainability and geopolitics. The performance is compared to OECD (global benchmarks) and ASEAN (main competitor for investment).

Technology Readiness

Despite notable progress, LAC continues to trail behind OECD and ASEAN peers on all major technology readiness indicators, including digital infrastructure, human capital, regulation and innovation policy. These gaps directly constrain the region's competitiveness and its ability to move up the value chain networks. For governments, firms and investors, persistent deficits raise operational risks and increase the cost and complexity of integrating into advanced production networks. At the same time, continued digitalization presents a strategic opportunity for those able to capitalize on the region's untapped potential.

Closing these gaps demands coordinated action, expanding broadband access, accelerating digital and science, technology, engineering and mathematics (STEM) skills training, and aligning regulatory frameworks with global norms. Only through targeted investment and reform can LAC attract high-value firms, secure new digital FDI and move up the technology ladder. Without decisive progress, the region risks exclusion from the next wave of GVC integration.

Logistics Performance Index

Chile and Panama stand out as regional leaders in logistics, approaching global best practices and serving as key benchmarks within LAC. However, most LAC economies continue to underperform on the World Bank's Logistics Performance Index (LPI), with structural inefficiencies in customs procedures, transport infrastructure and supply chain reliability (World Bank 2025c). Persistent bottlenecks, especially in landlocked and lower-income economies, raise transaction costs, undermine just-in-time manufacturing and limit export diversification. Structural weaknesses in logistics raise operational risks and diminish LAC's competitiveness relative to OECD and ASEAN, eroding the region's appeal for nearshoring and supply chain relocation. Without accelerated infrastructure upgrades, customs modernization and coordinated regulatory reform, LAC risks losing high-value FDI to more prepared peer regions. Decisive action is critical as global firms reconfigure value chains in response to geopolitical and technological shifts.

Mobile Connectivity Index

Despite rapid expansion in major urban centres, mobile penetration in cities such as São Paulo and Santiago now rivals OECD benchmarks, LAC continues to face pronounced connectivity gaps in rural and underserved regions (GSMA 2025b; ITU 2025). High data costs, limited network coverage and device affordability barriers exclude large population segments, particularly in remote and indigenous communities from the Amazon to Central America. For example, while Chile's urban mobile broadband coverage exceeds 95%, rural connectivity remains well below 60%, mirroring divides across much of the region.

Restricted access to essential digital services constrains firms' ability to leverage mobile technologies for productivity, innovation and deeper integration into value chain networks. Structural deficiencies in mobile connectivity directly weaken the region's digital competitiveness and investment appeal. Decisive action is required for targeted infrastructure investment, policy reforms to foster market competition and affordability initiatives, or LAC risks ceding ground to global peers and remaining a less compelling destination for digital economy investment. Closing these gaps is essential to foster inclusive growth and position the region as a credible, scalable player in the global digital landscape.

ICT Capital Goods Imports Index

Access to advanced ICT capital goods remains a significant bottleneck across most of the region. While certain economies such as Mexico and Costa Rica have established globally integrated electronics and ICT manufacturing clusters, high tariffs, fragmented supply networks and insufficient policy incentives continue to constrain broader regional access to semiconductors, robotics and next-generation machinery. Import volumes of these high-value ICT inputs lag well behind Asia and other advanced economies. These constraints directly impede the region's ability to modernize production lines, transition to "industry 4.0 standards" and compete for new roles in evolving GVCs. For governments and investors, addressing these barriers should be a priority, requiring action on tariff rationalization, integration with established Asian supply networks and targeted incentives to attract and anchor capital investment in advanced manufacturing.

Unlocking this potential is not only vital for regional productivity, but also for positioning LAC as an investment destination poised to capitalize on global shifts in supply chains and technology. Failure to act risks missing the spillovers and innovation-driven growth that will define the next decade of global manufacturing.

Human Capital – AI Readiness Index

AI readiness and digital transformation remain defining constraints on the region's long-term competitiveness. While leading OECD and ASEAN economies have scaled investment in STEM education, digital skills and talent retention, most of the region continues to grapple with persistent underinvestment in human capital and limited capacity building (IMF 2025). This gap leaves much of the workforce unprepared to adopt and scale advanced technologies, such as AI, machine learning and data analytics, across both manufacturing and services. Recent national initiatives in Brazil, Colombia and Uruguay have begun to address these deficits through targeted digital skills programs, but results are uneven and coverage remains limited.

Strengthening AI-ready human capital must become a policy and investment priority. Building a robust digital talent pipeline requires stronger collaboration between the

public and private sectors in education, increased regional knowledge sharing and the alignment of training standards. Advancements in these areas will be crucial for the region to attract high-value investments, foster innovation ecosystems and achieve productivity improvements through next-generation technologies. The region risks falling further behind global peers in technology-driven growth and value chain integration.

Digital Services Trade Restrictiveness Index

The region's regulatory environment for digital trade stands out as a relative advantage. On the OECD's Digital Services Trade Restrictiveness Index (DSTRI), several LAC economies – most notably Chile, Colombia and Mexico – outperform other emerging markets, narrowing the gap with advanced economies (OECD 2025c). Proactive measures, such as streamlining licensing regimes, liberalizing cross-border data flows and participation in forward-looking agreements like the Digital Economy Partnership Agreement, have positioned parts of the region as leaders in digital commerce liberalization. However, momentum is at risk. Fragmented regulations across economies, combined with ongoing debates around data privacy, digital taxation and local content requirements, create policy uncertainty and the potential for future restrictions. These challenges, if unresolved, could slow investment and innovation. Gaps in licensing procedures, standards interoperability and regulatory predictability continue to limit the scalability of digital business models and the region's ability to capture value from digital trade expansion.

For governments and firms alike, the path forward is clear: advancing harmonized digital trade rules and strengthening regional regulatory cooperation are essential. Only by ensuring a stable, open and predictable regulatory environment can the region attract sustained investment and fully participate in the next wave of digital value chain integration, especially as global firms diversify their operations in response to geopolitical and technological shifts.

Digitally Deliverable Services Index

LAC's underdeveloped digitally deliverable services (DDS), including software, IT, financial and professional business services, have slowed the region's ability to compete in production networks. LAC's DDS exports, as a share of total services trade, remain well below OECD and ASEAN averages, highlighting significant underperformance despite notable exceptions such as Uruguay and Costa Rica. Structural impediments curtail the region's digital services growth. Fragmented digital infrastructure restricts seamless connectivity, while limited access to venture capital and financing stifles innovation and scale-up opportunities. Additionally, persistent skills shortages and an immature startup ecosystem hinder the emergence and expansion of competitive homegrown digital firms. Together, these barriers suppress the region's integration into global digital service chains and constrain its ability to capture value from the ongoing

digital transformation. Addressing these challenges is critical for attracting investment, fostering innovation and positioning LAC as a meaningful player in the expanding digital economy.

Government Promotion of Investments in Emerging Technologies Index

Public policy support for emerging technology investment, across AI, robotics, cloud computing and related fields, remains a critical constraint in LAC. Unlike OECD and ASEAN, where coordinated innovation strategies, sustained research and development (R&D) funding and strong public-private partnerships (PPAs) drive sectoral growth, most LAC governments provide only fragmented and under-resourced support (OECD 2025a). Notable cases such as the Brazilian Agency for Research and Industrial Innovation (Embrapii) and Chile's economic development agency (Corfo) highlight potential but these efforts are isolated, not systemic.

This lack of a unified, well-funded approach creates uncertainty for investors and impedes the scaling of domestic technology champions, limiting the region's ability to attract high-value FDI in advanced industries. Regulatory unpredictability and slow adoption cycles heighten investment risk. At the same time, these gaps present a strategic entry point for early movers both firms and multilateral partners to help shape nascent innovation ecosystems and unlock LAC's untapped potential. Targeted policy reform and strategic capital allocation could catalyze technology-driven growth, generate outsized returns and position the region as a credible hub for digital innovation.

Global Cybersecurity Index

Cybersecurity remains a critical operational and investment risk as digital connectivity accelerates across LAC. While OECD and ASEAN economies lead the International Telecommunication Union's (ITU) Global Cybersecurity Index, most economies in the region lag behind, with persistent gaps in legal frameworks, institutional capacity and technological readiness (ITU 2025). Only a handful of economies – including Brazil, Mexico and Colombia – have established national cybersecurity agencies or strategies, while the majority face chronic underfunding, talent shortages and fragmented regional coordination. These deficiencies undermine confidence in digital infrastructure, hinder cloud adoption and increase exposure to cyber threats, raising risk profiles and mitigation costs for firms and investors. The cybersecurity gap also threatens to slow digital transformation and limit the region's appeal as a destination for technology-driven FDI and digital business hubs.

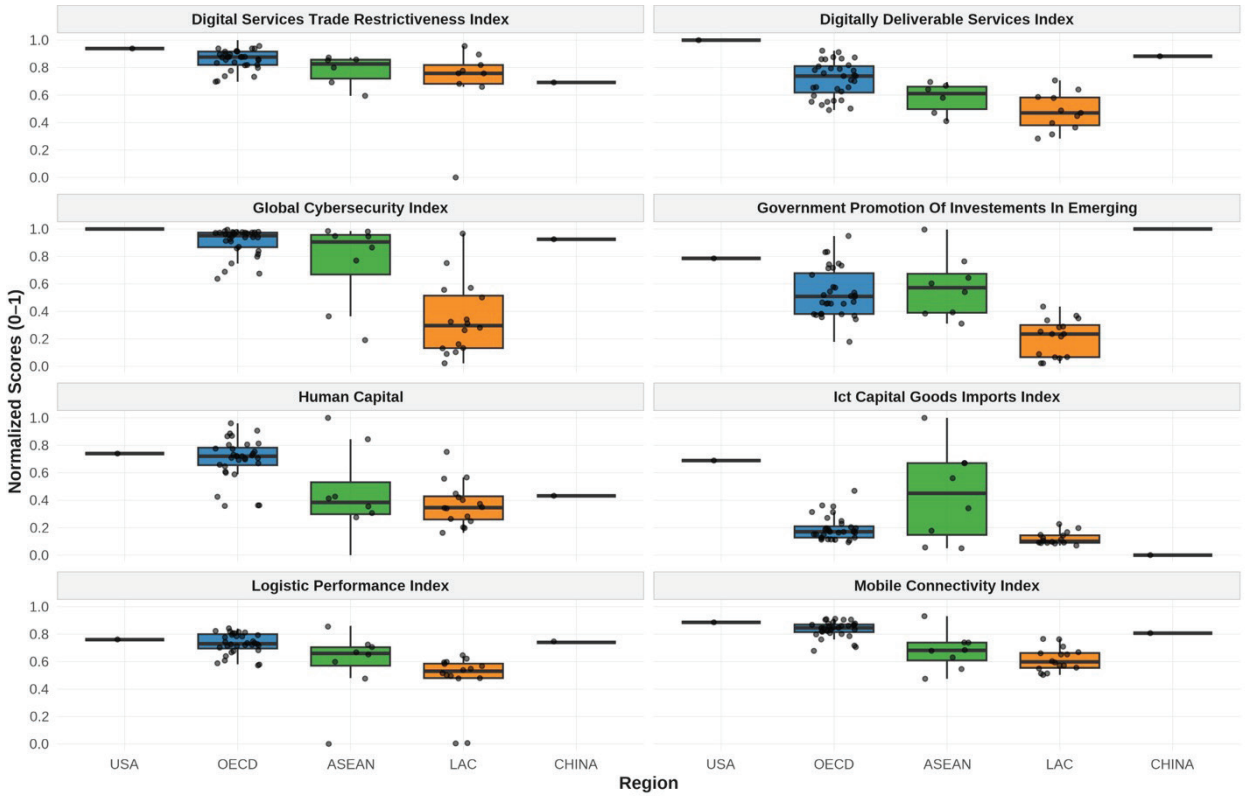
Yet, these vulnerabilities also create opportunities for targeted investment in cybersecurity solutions, skills development and regional collaboration. Prioritizing robust policy frameworks, workforce training and improved coordination will be essential to build resilience, attract investment and position LAC as a credible, secure node within global digital value chains.

2.5 Strategic Imperatives for Global Value Chain Upgrading in LAC

OECD economies continue to lead with more advanced infrastructure, strong skilled labor force and robust innovation ecosystem. In contrast, LAC and ASEAN both demonstrate moderate but uneven performance, with substantial internal disparities and persistent structural barriers. China remains broadly competitive but faces distinct gaps in digital trade restrictiveness and investment promotion. As Figure 2.10 illustrates, these patterns highlight the limitation of LAC's technology-driven GVC integration.

Seizing the next wave of supply chain opportunities demands that LAC economies act with urgency, expanding digital infrastructure, cultivating advanced workforce skills and advancing regulatory harmonization with global standards. Targeted investment and bold policy reforms are indispensable to attract transformative capital and position the region within the new geometry of global production.

Figure 2.10: Technology Readiness Regional Performance Distributions



Source: Authors' calculations; see Estevadeordal, Kahn & Werner (2024), Latin America in the New Geometry of Global Supply Chains (CAF-Georgetown Americas Institute).

Inattention to these imperatives risks LAC losing competitiveness and FDI to more prepared economies. Strategic reforms and sustained leadership are essential if the region is to shift from a peripheral participant to a credible competitor in GVCs.

Closing structural gaps in technology readiness, logistics and human capital will be decisive for governments, investors and firms seeking to upgrade LAC's position in the global economy (World Bank 2025c; Estevadeordal et al., 2024).

2.6 Sustainability Readiness

LAC's sustainability profile offers a clear comparative advantage in the shifting landscape of GVC integration, yet persistent vulnerabilities threaten to erode this lead. The region's clean energy matrix, anchored by hydropower and renewables, along with significant reserves of critical minerals and unique biodiversity, positions LAC as a natural leader in low-carbon and nature-based value chains (OECD 2024). However, structural barriers remain. LAC imposes the highest tariffs on energy transition goods among peer regions, curbing market access and creating obstacles to scaling green value chains and attracting sustainable investment (OECD 2025a; WTO 2023). Even as middle-income economies like Brazil, Costa Rica and Uruguay achieve very high shares of clean electricity, fragmented policy frameworks and limited downstream processing capacity continue to constrain broader value capture across LAC and the Caribbean.

Climate hazards, including recurrent floods and droughts, and uneven adaptation planning, weigh on corridor reliability and investor certainty, with pronounced vulnerabilities in parts of the Andes and Central America. Converting renewable leadership into diversified GVC participation will require predictable, region-coherent rules, targeted incentives for components, storage and services, and practical adaptation plans aligned with logistics and compliance bottlenecks.

Low Carbon Intensity Index

LAC's production structure is characterized by comparatively low-carbon intensity, a result of its reliance on hydropower and renewables (Energy Institute 2025; IEA 2025). Emissions per unit of output are substantially below global averages, reinforcing the region's position as a credible partner in decarbonized supply chains. Sustaining this edge calls for expanded investment in renewable infrastructure, greater access to climate finance and regulatory alignment with international best practices to enable deeper integration into low-carbon production networks.

Renewable Energy Consumption Index

Brazil, Costa Rica and Uruguay rank among the world's leaders in renewable energy use, supported by extensive hydropower, wind and solar capacity (IRENA 2025). This clean energy base underpins LAC's low-carbon advantage and contributes to energy security and sustainable growth. The region's early adoption of renewables, combined with large endowments of lithium and cobalt, creates a strategic platform for

supplying inputs essential to electric vehicle (EV) batteries, storage systems and green hydrogen production. To fully realize this potential, governments must ensure coherent regulation, harmonized standards and open trade in renewable energy goods to attract sustainable investment and promote local value added activity.

Trade in Energy Transition Goods Index

Exports of energy transition goods are emerging as a new pillar of economic diversification. Several LAC economies now manufacture components for solar panels, wind turbines and other clean technology systems, signaling growing specialization within green GVCs (González et al., 2024). Consolidating this momentum will depend on targeted industrial policies that strengthen linkages with international clean tech networks and foster innovation ecosystems supportive of green manufacturing. Coordinated public-private investment, streamlined trade procedures and consistent standards are key to attracting sustainable FDI and positioning the region within rapidly expanding low-carbon supply chains.

Protectionism in Energy Transition Goods Index

High tariffs on clean energy technologies continue to limit competitiveness across the region. These protectionist measures raise production costs, constrain technology diffusion and discourage the formation of regional industrial clusters. Aligning trade and sustainability objectives through tariff reduction, technical standard harmonization and simplified customs procedures would lower transaction costs and strengthen LAC's appeal as a destination for sustainable investment.

Critical Minerals Index

LAC's substantial reserves of lithium, copper, cobalt and rare earth elements provide a strong foundation for participation in the global energy transition economy. Yet much of this wealth is still exported in raw form, resulting in limited domestic value added capture. Strengthening sustainable mining practices, expanding processing capacity and harmonizing regional regulations are essential to transform mineral endowments into durable industrial and technological capabilities. These steps would enable LAC to position itself as a reliable, value added supplier within low-carbon GVCs.

Biodiversity and Habitat – Environmental Performance Index

Home to the Amazon Basin and other ecosystems of global importance, LAC holds exceptional natural capital that supports climate resilience and nature-based solutions (OECD 2024). However, performance in biodiversity protection and habitat management remains uneven. Deforestation, land degradation and weak enforcement

continue to erode environmental assets and long-term competitiveness. Integrating ecosystem services into trade and industrial strategies, while aligning national targets with international sustainability frameworks, will be critical for turning biodiversity strength into sustained participation in green value chains.

Exposure and Vulnerability to Natural Disasters Index

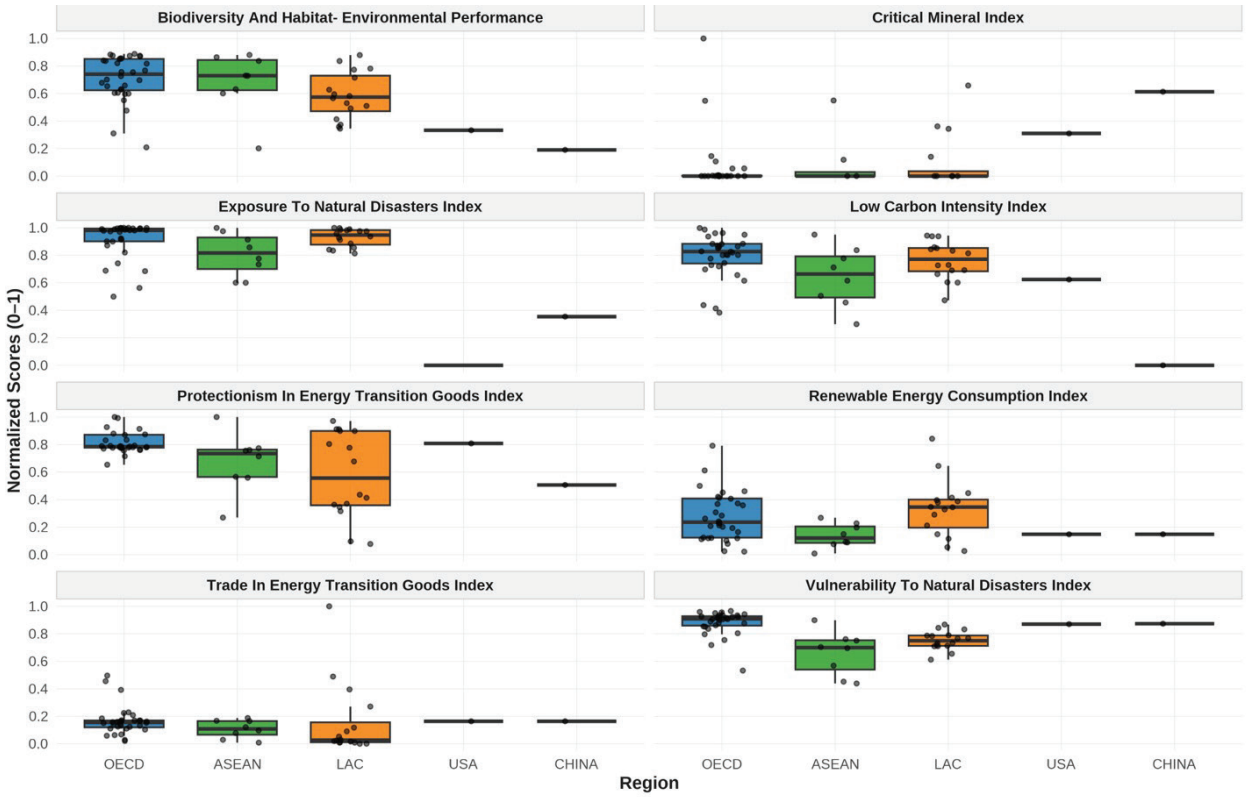
High exposure to hurricanes, floods and other natural hazards continues to constrain LAC's sustainable integration into GVCs (World Bank 2025a; UNECA 2025). Disruptions to infrastructure and trade routes elevate operational risks and discourage long-term investment. Closing the adaptation gap through investment in resilient infrastructure, improved risk assessment systems and stronger emergency response capacity will be essential for maintaining the region's attractiveness as firms increasingly prioritize resilience in their location decisions.

2.7 Regional Benchmarking and Strategic Priorities for LAC

Regional benchmarking (see Figure 2.11) highlights sharp contrasts in sustainability readiness across LAC, ASEAN, China, and OECD economies (OECD 2024). LAC demonstrates clear comparative strengths in biodiversity, low-carbon intensity and renewable energy deployment, but continues to lag in disaster resilience and climate adaptation. OECD economies set the benchmark across most indicators, while internal disparities and climate vulnerability remain persistent challenges within the LAC region. Detailed country-level results in Annex Table 2.A.2 further illustrate these variations, showing that higher-income and more diversified economies perform better on energy transition and environmental indicators than smaller, climate-exposed economies.

To sustain and build on its advantages, LAC must prioritize decisive policy and investment action. Embedding climate resilience into trade, investment and industrial strategies should become a central priority for both governments and firms. Reducing trade barriers on green goods, harmonizing standards and expanding climate-resilient infrastructure investment are essential steps to close the region's readiness gap. Without coordinated implementation, the region risks losing competitiveness as global capital and production increasingly favor economies with stronger sustainability and resilience credentials.

Figure 2.11: Sustainability Readiness Regional Performance Distributions



Source: Authors' calculations; see Estevadeordal, Kahn & Werner (2024), Latin America in the New Geometry of Global Supply Chains (CAF–Georgetown Americas Institute).

2.8 Geopolitics Readiness

As the global geopolitical environment grows more complex, the ability of economies to manage uncertainty and mitigate external risks has become a central determinant of value chain competitiveness (WTO 2024). Figure 2.12 illustrates how LAC has so far remained largely insulated from the most disruptive effects of US-China trade fragmentation, providing a degree of resilience and flexibility not observed in many other emerging regions (IMF 2025). Yet the region's moderate performance across core indicators, export similarity with China, exposure to sanctions, internal security and diplomatic alignment reveals both opportunity and persistent vulnerability.

LAC's limited exposure to direct US and Chinese trade restrictions, along with its relatively low share of commerce with sanctioned economies, has preserved business continuity and reduced compliance risks for firms operating in the region (World Bank 2025a). This has supported LAC's appeal as a "safe harbor" location for supply chains seeking diversification away from geostrategic choke points. However, high levels of organized crime, uneven institutional capacity and periodic social unrest continue to weigh on investor confidence and the reliability of logistics corridors (World Bank 2025b). Annex table 2.A.3 presents country-level results, showing considerable intra-

regional variation: several Caribbean and Central American economies outperform on governance and security metrics, while larger markets remain more exposed to institutional and safety risks.

Diplomatic non-alignment and moderate political proximity to major trading partners have enabled LAC to maintain diversified economic ties and avoid deep entanglement in "great power" rivalries. As GVC configurations increasingly reflect security, regulatory and political criteria, the stakes for effective risk management are rising. Strengthening governance, deepening regional coordination and enhancing economic diplomacy will be essential for building resilience, attracting sustainable investment and securing the region's role in the next phase of GVC integration.

Institutional readiness reflects the strength and predictability of domestic governance – how well rules, regulations and enforcement mechanisms support credible participation in GVCs. Yet the stability of participation increasingly depends not only on what happens inside national borders but also on how economies navigate shifting external conditions. Geopolitical readiness therefore extends the diagnostic outwards: it gauges each region's capacity to manage exposure to trade and investment fragmentation, aligns with new strategic partners and remains reliable nodes in a multipolar trading system. This transition from institutional to geopolitical readiness marks a shift from internal enablers of competitiveness to external buffers of resilience.

Export Structure and China Similarity Index

Export baskets across most of the region remain heavily weighted toward primary commodities, resulting in a persistent gap in export similarity with China compared to OECD and ASEAN peers. This structural profile constrains the region's ability to position itself as a competitive manufacturing hub for firms diversifying away from China, limiting prospects for advanced manufacturing FDI and value chain deepening. Mexico and several Central American economies stand as outliers, with export patterns closely integrated into North American and global manufacturing networks, particularly in automotive, electronics and medical devices, demonstrating the benefits of nearshoring and supply chain realignment (Aguilar et al., 2024). For the wider region, however, realizing opportunities from global production shifts will require targeted industrial policy, investment in productive capacity and concerted efforts to move up the value chain. If such reforms are absent, marginalization within the new industrial geography remains a tangible risk.

Exposure to Geopolitical Trade Restrictions Index

Despite rising global trade restrictions, LAC has thus far remained relatively insulated from direct US and Chinese export controls, bans and licensing requirements. This relative immunity has allowed LAC firms and governments to avoid some of the severe disruptions and compliance burdens that have afflicted other emerging markets heavily

embedded in geopolitically sensitive supply chains. Nonetheless, the evolving nature of global trade fragmentation demands proactive risk management. As US and Chinese trade policies increasingly focus on strategic sectors and extend extraterritorially, LAC economies must strengthen monitoring and early warning systems to anticipate indirect spillovers. Enhanced diplomatic engagement and diversified trade partnerships will be essential to mitigate exposure to escalating geopolitical tensions and to safeguard the region's access to critical markets and inputs.

Security and Institutional Stability Index

Security conditions across LAC present mixed challenges that bear directly on GVC participation and investor confidence. Security remains a "critical road blocker" for LAC's integration into the supply chain productions and sustain investment in the long-term. The region's average security threat index score continues to lag behind both OECD and ASEAN benchmarks (see Annex table 2.A.6), reflecting persistent exposure to organized crime, social unrest and institutional weakness in law enforcement.

These security pressures increase operational costs, disrupt logistics and erode investor confidence, even in the absence of large-scale armed conflict. Middle-income economies such as Uruguay and Chile ranked higher on security and institutional stability, while several Central American and Caribbean economies face elevated risk and ongoing governance challenges. Security risk shapes site selection and supply chain reconfiguration. Only economies making measurable progress in institutional capacity, rule of law and social inclusion can improve their security environment and attract investment. Investors, firms and government partners demand transparency and stability. Jurisdictions that close security gaps gain a clear advantage in GVCs dependent on reliability and trust.

Trade Exposure to Sanctioned Economies Index

Engagement with sanctioned markets presents rising risks for GVCs as international sanctions regimes, become more complex and far-reaching. LAC's trade exposure to sanctioned economies is lower than OECD levels and comparable to ASEAN, reflecting a generally cautious approach to sensitive trade relationships. This positioning reduces risks of secondary sanctions, reputational harm and compliance burdens for firms operating in the region. Maintaining rigorous customs enforcement, transparent financial oversight and strong due diligence is essential to preserve this advantage. As sanctions regimes continue to evolve, LAC must strengthen cross-border cooperation and regulatory alignment to prevent inadvertent violations and sustain trust with key trading partners. Building capacity in compliance and enforcement remains critical for resilient GVC integration.

Diplomatic Alignment and Nonalignment Index

In a period of heightened geopolitical fragmentation, diplomatic alignment and nonalignment increasingly influence trade access, investment flows and regulatory outcomes. LAC's middling score on these indicators reflects a pragmatic strategy balancing ties across major powers without deep entanglement in their rivalries. This approach supports diversified economic relationships and cushions the region from the risks of polarization. However, as political alignments become more consequential for GVC participation, LAC faces growing pressure to navigate complex partnerships with agility. Sustaining diplomatic flexibility, engaging with the US, China and the EU, while remain active in multilateral forums, will be paramount. This adaptability not only protects current market access but positions the region to capitalize on new GVC opportunities shaped by global contestation.

Social Cohesion and Demographic Readiness Index

Demographic and social cohesion are foundational to economic resilience and GVC competitiveness (UN DESA 2024). LAC's diverse social fabric yields varied outcomes: economies with high ethnic cohesion and a growing workforce benefit from greater stability, labor market dynamism and investment appeal, supporting inclusive, sustainable GVC integration. Conversely, economies experiencing social fragmentation, ethnic tensions or demographic slowdowns face heightened risks of instability and diminished growth potential. These dynamics can erode investor confidence and complicate the implementation of structural reforms necessary for upgrading in GVCs. Addressing social inclusion, fostering equitable economic opportunities and harnessing demographic potential through targeted policies are essential to ensuring long-term competitiveness and stability.

2.9 Geopolitical Readiness and Regional Positioning

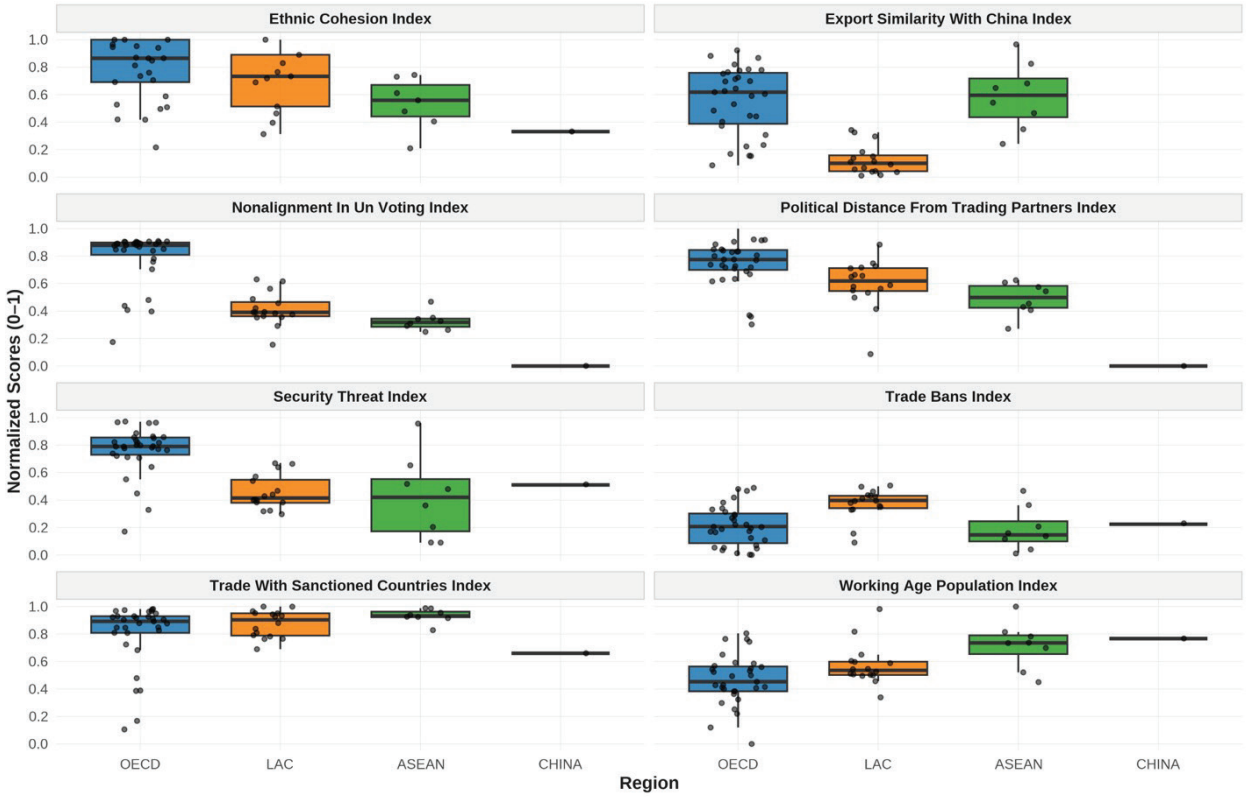
As geopolitical dynamics increasingly shaped trade and investment LAC's ability to strengthen institutions, manage risk and maintain diplomatic agility will determine its position in an increasingly fragmented GVC landscape. Advancing regional cooperation, reinforcing compliance infrastructure and pursuing targeted governance reforms are essential to translate resilience into a lasting competitive advantage. Without sustained progress, the region risks marginalization as global production networks continue to adjust to heightened uncertainty.

Regional benchmarking of geopolitical readiness (see Figure 2.12) highlights persistent misalignment across major regions. OECD economies set the standard in security, stability and political alignment, reflecting mature governance and robust institutions.

LAC and ASEAN display wider internal variation, underscoring uneven risk management capacity. China's manufacturing depth remains a key strength, yet gaps in security and diplomatic flexibility persist.

For LAC, moderate exposure to sanctions, pragmatic diplomacy and "safe harbor" status provide notable advantages. However, these strengths are offset by ongoing security, institutional and social cohesion challenges. Closing these gaps will be pivotal for LAC's integration into GVCs and its long-term competitiveness in the new era of reglobalization. Detailed country-level results are presented in Annex Table 2.A.3.

Figure 2.12: Institutional and Geopolitical Readiness Regional Performance Distributions



Source: Authors' calculations; see Estevadeordal, Kahn & Werner (2024), Latin America in the New Geometry of Global Supply Chains (CAF–Georgetown Americas Institute).

2.10 Intra-Regional Comparison

The country-level rankings reveal LAC's broad comparative advantage in sustainability, with emerging economies like Brazil, Chile, Costa Rica, Panama and Uruguay performing well. However, significant challenges remain in technology indicators, where all LAC economies are in the bottom half. Geopolitics presents varied results, with some Caribbean economies performing relatively well. Mexico, despite its GVC integration success, lags behind many LAC economies on sustainability indicators

and its growing investment links with China can expose it to US trade restrictions. Encouragingly, some small Caribbean and Central American economies show strong geopolitical indicators, suggesting they can leverage diplomacy to attract investments in strategic sectors. Panama, Paraguay and Peru also score well on sustainability, pointing to new opportunities in value chains.

Table 2.1: The LAC Playbook for Reglobalization

Policy responses for LAC	LAC must recalibrate development and integration strategies to benefit from GVC realignment. This includes fostering industrial and technological upgrading, improving regional logistics and infrastructure, strengthening institutional and regulatory frameworks, and embracing a pragmatic trade agenda.
Benefiting from digital technology transitions	Policymakers must prioritize robust digital infrastructure and digital literacy programmes. Addressing regulations on digital service provision and cross-border data flows, avoiding burdensome domestic regulations and striking a balance between data privacy and localization rules are crucial. Strategic PPAs can incentivize digital technology adoption.
Seizing green comparative advantage	Governments must translate clean energy resources into investment opportunities through stable regulatory frameworks. Upgrading electricity grids is essential. Policy frameworks should incentivize industries to reduce carbon footprints and accelerate transport sector electrification. Embracing market access and avoiding protectionism for clean energy technologies is vital. Facilitating R&D and leveraging trade agreements to promote sustainable practices are also key.
Attracting investment amid geopolitical risks	Governments can attract FDI by creating transparent and stable regulatory frameworks and investing in strategic infrastructure. Diversifying trading partners and fostering economic diplomacy are crucial. Strengthening anti-corruption and anti-money laundering frameworks, and establishing efficient customs controls, will mitigate risks for companies.
Aligning with major industrial policy initiatives (US and EU)	LAC can capitalize on nearshoring and friendshoring by enhancing competitiveness through targeted investments in digital infrastructure, innovation and sustainable practices, aligning with US and EU environmental and technological standards. Diplomatic engagement is crucial for integration.
Addressing unfinished regional and global integration	Promoting convergence of trade rules (especially rules of origin) and closing missing trade links within the region (e.g., Mexico-Brazil) are essential. Ambitious trade facilitation measures, like expanding national single windows and coordinated border management, will enhance connectivity. Active engagement with global partners through comprehensive trade agreements (USMCA, EU FTAs, RCEP, CPTPP) is vital for growth and resilience.
Roadmap for GVC integration for LAC	
Amid accelerating geopolitical realignment and recurring global shocks, the landscape for trade and investment is undergoing profound change. LAC's strengths in sustainability and pragmatic diplomacy position the region to capture new investment as a value chains pivot toward resilience and green growth. Yet, gaps in digital infrastructure, technology adoption and institutional quality – coupled with pronounced regional structural inefficiencies – continue to constrain LAC's full integration into value chains production networks. Capitalizing on this strategic moment requires coordinated, transformative policy action. LAC must implement digital transformation, harmonize regulatory frameworks and invest in skills and infrastructure to attract and retain high-value investment. Advancing regional cooperation and aligning with evolving global standards will be essential to translate resilience into sustained competitiveness. The region risks being bypassed as value chains recalibrate for a new era of uncertainty and competition.	

Note: This box outlines strategic policy priorities for Latin America and the Caribbean (LAC) to strengthen competitiveness and integration in reglobalizing supply chains. It summarizes regional responses across digital transformation, green industrial upgrading, investment attraction and trade facilitation.

Source: Background material drawn from the preprint Latin America in the New Geometry of Global Supply Chains by Estevadeordal, Kahn, and Werner (2024), CAF–Georgetown Americas Institute.

To translate these strategic imperatives into action, the following roadmap outlines priority policy areas, measurable indicators and institutional responsibilities that can guide LAC's integration into reglobalized value chains.

Table 2.2: LAC Policy Roadmap

Policy area	LAC-specific levers	Key performance indicators (KPIs) to track	Primary owner
Digital technology transition	• Light up IXPs on trade corridors (São Paulo-Santos, Santiago, Bogotá-Buenaventura, Mexico City-Laredo) • Universal e-ID and interoperability • Riskbased crossborder data rules • PPPs for SME cloud-AI adoption	• Broadband cost (percent GNIpc) • Corridor 4G/5G coverage • IXP count/traffic • EID coverage • Share of firms on cloud-AI	• ICT ministry & regulator • Competition authority
Green comparative advantage	• Fast track grid reliability to anchor nearshoring low/zerotariff lane for ETG • Enable green PPAs for exporters • Certify green industrial parks	• SAIDI/SAIFI • ETG MFN tariff level • Industrial renewables share • Parks certified to green standards	• Energy ministry • Customs • Standards body
Critical minerals & processing	• Develop lithium/copper value added hubs (Chile, Argentina, Peru, Bolivia) • Regional ESG protocols • Open access logistics from Andean & Southern Cone to ports	• Share of minerals processed domestically • Adoption of ESG/traceability standards • Corridor throughput	• Mining and industry ministries • Ports authority
Attracting investment	• Onestop FDI window • Beneficialownership registry linked to customs risk • Port proximate SEZ/bonded zones (Santos, Callao, Colón, Cartagena) • Unified permits and eprocurement	• FDI approval SLA • BO matches in risk engine • SEZ/bonded site count • Share of tenders via eprocurement	• Investment agency • Justice and customs
US/EU industrial policy alignment	• Conclude MRAs for conformity assessment, adopt ISO/IEC & cybersecurity baselines, CBAM readiness in exposed sectors, supplier compliance programmes for USMCA/EU buyers	• MRA coverage • CBAM ready sectors • Exporters certified to ISO-IEC cyber • Buyer audits passed	• Trade ministry • Standards body • Industry chambers
Regional integration (rules & procedures)	• Harmonize rules of origin (cumulation) across Pacific Alliance, Mercosur, SIECA, CARICOM • Expand national single window (NSW) • Mutual recognition of AEO • Coordinated border • Management of Southern Cone-Andean-Northern Triangle corridors	• NSW share of declarations • AEO MRA count • Average border release time • Rules of origin cumulation coverage	• Customs • RECs-secretariats • Foreign affairs
Connectivity and logistics	• Prioritize port-rail-dryport links to nearshoring clusters • Ensure Panama Canal reliability and alternative routings • Digitize port community systems	• Port turnaround time • Rail-truck dwell time • Canal reliability indicators • PCS transaction share	• Transport ministry • Port authorities
Security & compliance	• Integrate beneficial ownership • AML and customs risk targeting • Vetted logistics corridors • Joint ops with RECs to reduce cargo theft & smuggling	• Seizures per risk flag • Corridor incident rate • percent shipments via vetted operators	• Finance-justice • Customs • Interior security

IXP = internet exchange point; E-ID = electronic identification; AI = artificial intelligence; PPP = public–private partnership; SME = small and medium-sized enterprise; ETG = energy transition goods; PPA = power purchase agreement; SEZ = special economic zone; ESG = environmental, social, and governance; FDI = foreign direct investment; BO = beneficial ownership; MRA = mutual recognition agreement; CBAM = carbon border adjustment mechanism; ISO/IEC = International Organization for Standardization/International Electrotechnical Commission; USMCA = United States-Mexico-Canada Agreement; RoO = rules of origin; AEO = authorized economic operator; NSW = national single window; RECs = regional economic communities; PCS = port community system; AML = anti-money laundering; SAIDI = System Average Interruption Duration Index; SAIFI = System Average Interruption Frequency Index.

Note: This roadmap operationalizes the diagnostic findings presented in this chapter. It outlines key policy areas, LAC-specific levers and illustrative key performance indicators (KPIs) to monitor reform progress and institutional readiness for GVC integration. The KPIs serve as reference metrics rather than prescriptive targets, providing a foundation for benchmarking across economies and over time, and supporting evidence-based policymaking and regional coordination.

Source: Background material from Latin America in the New Geometry of Global Supply Chains by Estevadeordal, Kahn, and Werner (2024), CAF–Georgetown Americas Institute.

LAC's experience illustrates how reglobalization rewards economies that align natural endowments with institutional reliability and sustainability performance. Yet, the geography of opportunity is shifting. Africa enters this evolving trade cartography with scale, demographic momentum and renewable energy potential that position it to shape the next phase of global production. As LAC consolidates its comparative advantages through digital and green integration, Africa's readiness will hinge on translating structural endowments into systemic reliability through cross-border infrastructure, harmonized standards and deeper regional coordination.

Taken together, the preceding sections identify three binding conditions shaping LAC's current stage of GVC integration. First, diversification gains remain concentrated in a few globally connected hubs, with limited spillovers to peripheral economies. Second, digitally deliverable and data-intensive sectors face persistent backbone and affordability constraints that inhibit broader participation. Third, domestic firms capture limited value relative to multinational producers, underscoring that participation alone does not ensure upgrading. The following sections extend this analytical lens to Africa, where many of these same constraints appear in sharper relief, and then integrates both regions within a comparative, region-based roadmap that links digital, logistical and sustainability readiness. A central policy question that arises is therefore not whether to reglobalize but how to build price reliability, digital trust and low-carbon competitiveness into practical delivery mechanisms.

2.11 The New Trade Cartography for Africa – From Risk to Route

Building directly on the diagnostic evidence above, implementation is organized around four mutually reinforcing pillars: digital and data infrastructure, energy and sustainability readiness, trade facilitation and investment, and regional rules and infrastructure – each with concrete key performance indicators (KPIs) to track progress. Africa is entering a pivotal phase in the reorganization of the global economy. Despite strong resource endowments, demographic momentum and the potential of the African Continental Free Trade Area (AfCFTA), African economies remain only partly integrated into GVCs, concentrated in upstream resource-based segments. In 2018, the region accounted for 2.6% of world trade and 2.9% of output while representing more than 16% of the global population (Afreximbank 2019; UN DESA 2024). This imbalance underscores Africa's limited integration into global production networks. GVC participation rose only modestly from 1.5% in 2000 to 1.7% in 2019 (OECD 2024), reflecting the slow pace of structural transformation and persistent infrastructure and institutional-capacity gaps.

As shown in Figures 2.8 and 2.9, Africa's integration into GVCs has expanded only modestly over the past two decades. Average total participation rose by roughly 6 to 10 percentage points between 1995 and 2011 but then stagnated through 2022. Backward linkages grew

slightly while forward linkages flattened, leaving overall participation broadly stable. Country-level data confirms sharp heterogeneity: Morocco, Nigeria and Egypt achieved incremental gains, whereas South Africa and several smaller economies recorded declines. These patterns underscore that, despite policy reforms and infrastructure investment, Africa's integration remains concentrated in upstream, resource-based activities, with limited spillovers into higher-value manufacturing and services.

Manufacturing employment has expanded without equivalent value added gains, underscoring productivity deficits linked to weak innovation systems and unreliable energy and logistics (World Bank 2025a). Non-tariff barriers, ranging from inefficient borders to weak standardization, continue to inflate trade costs (UN ESCAP 2024). Research and innovation ecosystems remain underfunded, and the region attracts less than 2% of global clean energy investment (IEA 2024a).

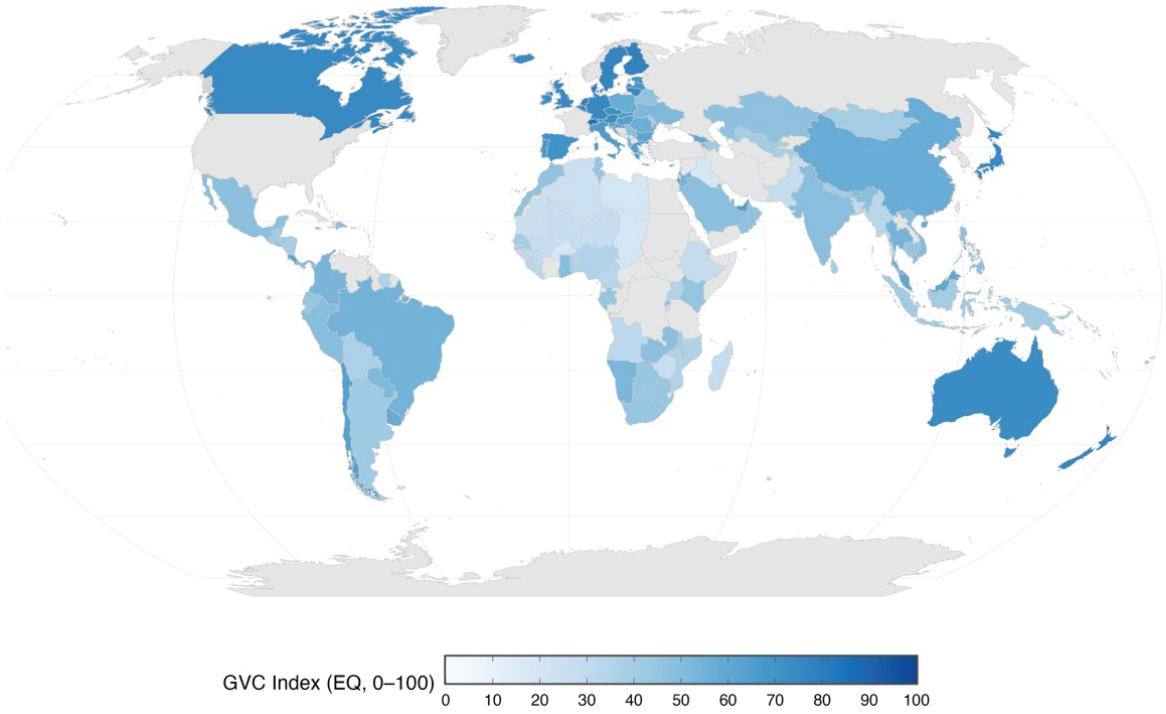
Global trade is rerouting rather than retreating, with overall connectedness near record highs even as border frictions rise (Altman and Bastian 2024). Patterns in LAC and Africa's expanding but uneven participation corroborate this shift (see Figure 2.1 for export-share trends and Figure 2.2 for diversification dynamics). For Africa, this rewiring of value chains creates corridor-based opportunities where logistics reliability, digital readiness and predictable regulation intersect. Strengthening transport, digital and financial infrastructure, anchored in interoperable data governance frameworks, can expand digitally delivered services and reinforce goods competitiveness. Paperless trade systems and coordinated border management reduce time and cost, while interoperable single window and cross-border data exchange platforms enhance transparency and resilience.

The diffusion of AI and harmonized data governance frameworks will shape productivity geography. Open and predictable trade in AI-enabling goods and services, combined with digital skills development and interoperability standards, is essential to prevent new divides (WTO 2025). Opportunities in the green transition are expanding. Lowering tariff and non-tariff barriers on energy transition goods (ETGs), scaling technology diffusion and developing robust measurement, reporting and verification (MRV) systems for embedded emissions are essential to integrate into low-carbon supply chains (ADB 2024; UNCTAD 2025).

In Figure 2.13, most African economies cluster in the lower-to-mid range, with higher-readiness pockets in North and Southern Africa. Sustainability outperforms other pillars, while digital infrastructure, logistics and institutional reliability remain binding gaps.

A resilient cohort is emerging, particularly in sustainability and governance. Targeted reforms, investment-grade renewable power and transparent PPP pipelines are attracting capital and improving productivity (UNECA 2025). Yet readiness remains uneven, most economies cluster in the lower-to-mid range, with stronger performance in North and Southern Africa.

Figure 2.13: Global Value Chain Readiness Index 2025



Note: Darker shading indicates higher readiness; grey shading denotes economies with data coverage below the publication threshold (66%) or with missing values. Scores represent the equal-weighted, direction-safe normalized average of six pillars: technology and connectivity, trade and investment readiness, sustainability and energy readiness, institutional and geopolitical readiness, financial readiness and business readiness. Each pillar aggregates three indicators normalized to a 0-1 range using the min-max method. Cost indicators are inverted so that higher scores reflect greater readiness. The overall Global Value Chain Readiness Index (GVCRI) is the simple mean of the six pillars and is rescaled to a 0–100 scale.

Source: International Monetary Fund (Artificial Intelligence Preparedness Index,); International Telecommunication Union (ITU); World Bank (World Development Indicators); GSMA (Mobile Connectivity Index); World Bank (Logistics Performance Index, LPI; Worldwide Governance Indicators; Global Findex Database; Enterprise Surveys; B-READY Program); World Trade Organization (WTO, World Integrated Trade Solution); International Renewable Energy Agency (IRENA); International Energy Agency (IEA); Ember (Yearly Electricity Data), and author calculations.

2.12 Africa in Inter-Regional Perspective – Global Value Chain Readiness Benchmarks

Africa's capacity to translate economic scale into value increasingly depends on the alignment of policies, backbone infrastructure and institutional frameworks with a standards-based, digitally enabled trading system. This section benchmarks Africa's GVC readiness against the OECD, ASEAN, LAC, the US and China to assess where the continent is gaining traction and where structural frictions remain. The region lags behind its peers in speed, reliability and border efficiency, reflecting gaps in logistics, digital connectivity and data exchange systems. However, Africa exhibits relative strength in sustainability, supported by favorable demographics and renewable energy potential. As global trade flows reroute rather than retreat, overall connectedness remains high even amid rising border frictions. Competitive advantage will accrue to trade corridors that combine credible logistics, predictable rules and digital readiness (Altman and Bastian 2024).

Readiness will hinge on progress across a narrow set of high-leverage enablers. Economies advancing interoperable digital trade systems, including national single windows (NSWs), e-signatures and e-payments, and predictable cross-border data regimes are scaling digitally delivered services that spill over into goods competitiveness. Paperless and coordinated border management compresses clearance times and logistics costs (UN ESCAP 2024). Lower barriers on ETGs, investment-grade renewable power, credible measurement, reporting and verification (MRV) systems for embedded emissions can further anchor Africa's participation in low-carbon value chains (ADB 2024; UNCTAD 2025). Collectively, these reforms reduce uncertainty, attract investment and strengthen firm-level productivity, positioning Africa to capture a greater share of rerouted global production.

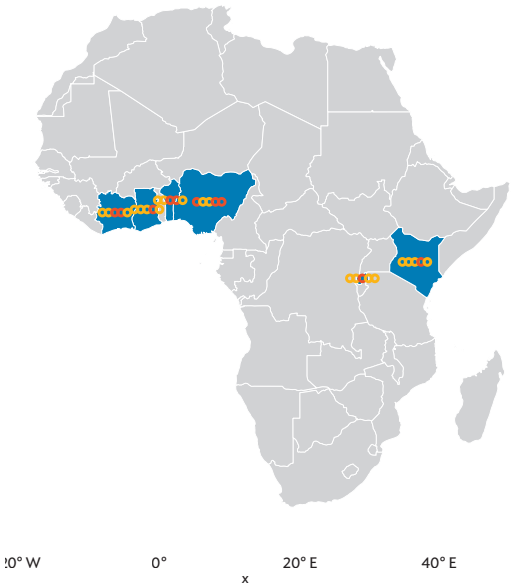
Figure 2.14 benchmarks Africa's digital trade policy readiness, comparing regulatory openness, interoperability and paperless trade implementation across six pilot economies and peer regions. Across these economies, core digital trade frameworks are in place but remain uneven in depth and enforcement. Most have enacted e-transaction and e-signature laws, yet judicial recognition, enforcement and user uptake still lag behind enactment. Online consumer protection frameworks are partial, while cross-border data flow and intermediary liability gaps continue to deter cloud adoption, platform growth and regional services trade. Paperless trade systems are advancing but typically cover only segments of the clearance chain rather than delivering end-to-end interoperability. In practice, digital trade readiness depends less on the existence of legal instruments than on their interoperability, institutional reliability and user confidence.

Technological Readiness

Digital transformation now defines the pace of competitiveness in GVCs and Africa continues to underperform on the digital foundations needed for upgrading. The most binding gaps lie in fixed-broadband reach and quality, the depth of backbone infrastructure such as terrestrial fibre broadband, internet exchange points and neutral data centres, and predictability of digital trade regimes. High last-mile costs keep rural and peri-urban areas underserved, limiting the growth of digitally deliverable services and constraining spillovers to manufacturing and agribusiness (WTO 2025).

As shown in Figure 2.15, Africa's dispersion across all six pillars remains wide, underscoring structural gaps in broadband depth, affordability and institutional reliability. Openness and data governance indicators appear stronger in legislative form than in practice, while most economies have adopted data protection and e-commerce frameworks, cross-border transfer rules remain inconsistent and only partially risk-based, creating uncertainty for investors and raising compliance costs. Human capital and AI readiness, together with enterprise adoption and innovation, also underperform relative to peer region benchmarks, reflecting shallow digital skills pipelines and limited diffusion of enterprise software, cloud computing and analytics

Figure 2.14: Digital Trade Policy Readiness



Country	E-transactions & e-signatures	Online consumer protection	Cross-border data flows	Intermediary liability	Paperless trade / single window
Benin	Partial	Partial	Absent	Absent	Partial
Côte d'Ivoire	Partial	Partial	Absent	Absent	Partial
Ghana	Partial	Partial	Partial	Absent	Partial
Kenya	Partial	Partial	Partial	Absent	Partial
Nigeria	Absent	Partial	Partial	Absent	Absent
Rwanda	Partial	Partial	Absent	Partial	Partial

In place = usable Partial = limited Absent = restrictive

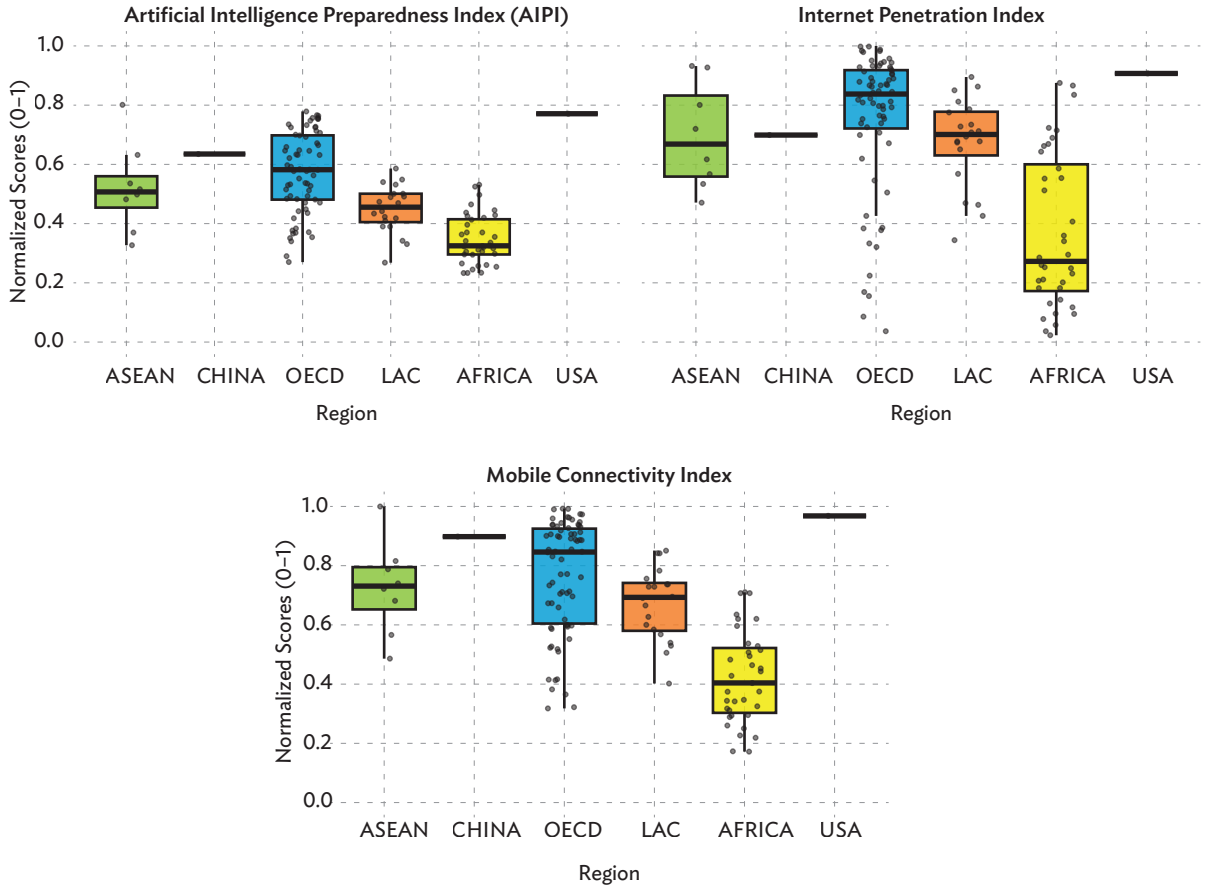
Note: Qualitative coding reflects the presence, usability and scope of national frameworks. "Paperless trade" refers to operational single window systems and the acceptance of electronic documents across customs and border procedures.
Source: Authors' compilation based on World Bank and World Trade Organization, Digital Trade for Africa (DTA) (2023, 2025).

tools. Cybersecurity and trust indicators remain below frontier standards, amplifying operational and reputational risks and raising the cost of digital participation.

Viewed globally, the US anchors the technological frontier, combining advanced AI preparedness, deep backbone networks, extensive cloud availability and mature cybersecurity ecosystems. It performs strongly on connectivity and enterprise adoption, but less so on openness and cross-border data governance, underscoring the trade-offs between scale and interoperability. Within Africa, however, several examples illustrate how targeted reform can narrow the gap. Developments in Kenya's fintech ecosystem, Nigeria's digital ID rollout and Rwanda's digital public infrastructure (DPI) initiatives demonstrate how coherent policy design, backbone investment and trusted data frameworks can translate into exportable digital services and faster firm-level adoption. Progress across these areas, expanding open access fibre and neutral data centres, operationalizing interoperable cross-border data transfer regimes, developing mid-career digital and AI credential programmes and completing paperless trade and single window integration, anchors a practical path forward (UN ESCAP 2024; WTO 2024).

Taken together, these developments confirm that technological readiness has become the decisive frontier for Africa's integration into reglobalized value chains: where connectivity, openness and trust converge, digital transformation becomes a direct channel for competitiveness.

Figure 2.15: Technology Readiness Regional Performance Distributions



Source: International Monetary Fund (Artificial Intelligence Preparedness Index); International Telecommunication Union (ITU-Internet Penetration Index); GSMA (Mobile Connectivity Index), and author calculations.

Trade and Logistics Capacity Readiness

Efficient logistics determine who participates, and at what margin in time-sensitive GVCs. Across Africa, persistent port congestion, fragmented overland corridors and limited customs automation continue to raise costs and extend lead times, excluding firms from higher-value production networks (World Bank 2025c; WTO 2024). On the Logistics Performance Index (LPI), most economies remain below the global average, with wide dispersion reflecting uneven infrastructure, border agency capacity and corridor reliability (World Bank 2025c; UNECA 2025). Regionally, overall GVC participation gains since 2011 have plateaued relative to 1995-2011, with wide cross-country heterogeneity (see Figure 2.8-2.9).

OECD systems are multimodal and data driven, integrating real-time tracking, risk-based inspections and paperless clearance. ASEAN economies, led by Viet Nam, Malaysia and Singapore have improved corridor performance through coordinated infrastructure investment and customs modernization. LAC performs above Africa

on average but continues to face institutional frictions that constrain reliability (ADB 2024; UN ESCAP 2024). As shown in Figure 2.16, Africa records the lowest medians on LPI and trade openness and the widest interquartile ranges, underscoring shallow integration and limited scalability (World Bank 2025c; OECD 2025a).

Africa's median Tariff Restrictiveness Index scores lag those of the OECD and ASEAN, reflecting residual protection on key intermediates and assembly inputs. Even where tariff schedules have been rationalized, non-tariff barriers remain high, manual clearance procedures, limited single window coverage and uneven authorized economic operator (AEO) adoption continue to inflate trade costs (World Bank 2025c; UN ESCAP 2024). Box 2.1 further illustrates how limited preference utilization across Africa and LAC constrains the potential gains from tariff liberalization and trade facilitation reforms.

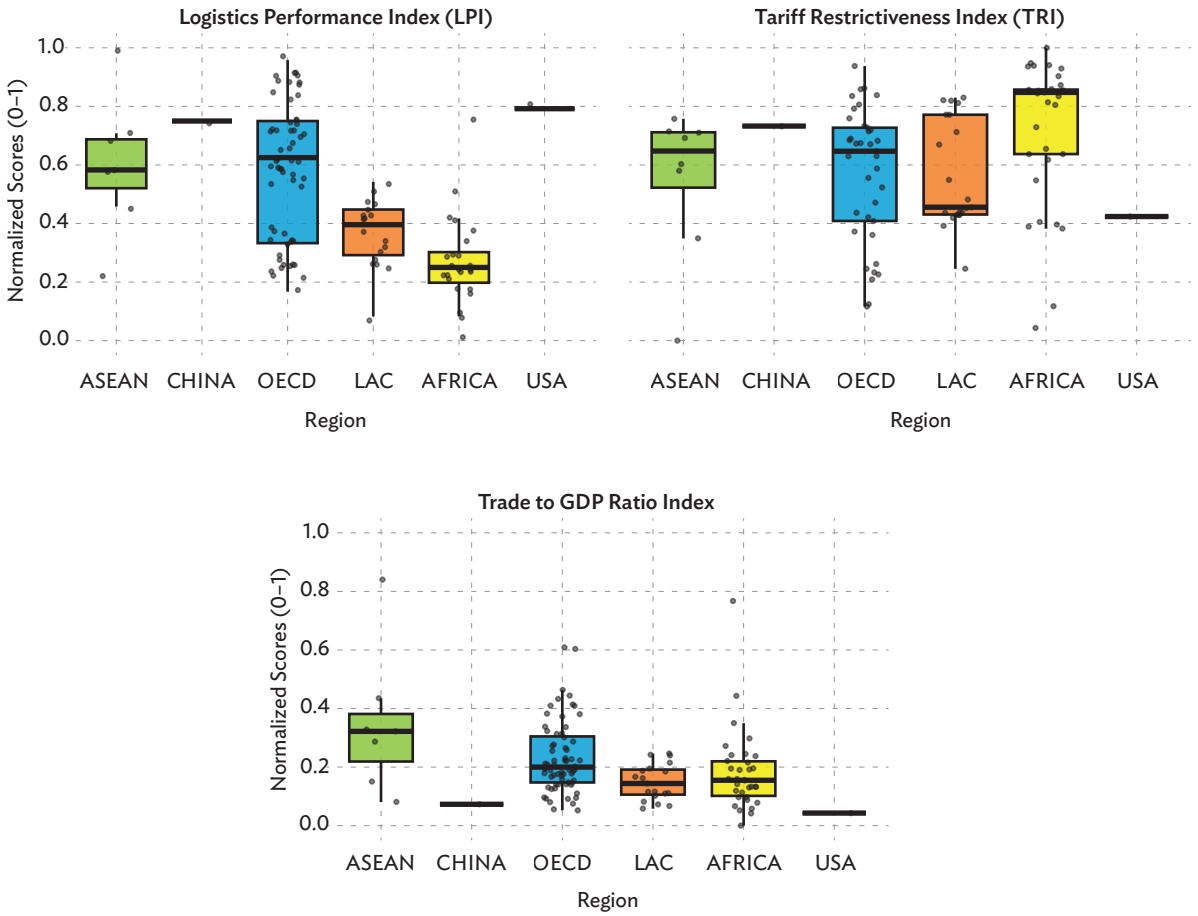
Country differences are pronounced. Morocco and South Africa have leveraged port modernization, special economic zones (SEZs) and regional corridor programs to improve LPI performance, while landlocked and Central African economies remain constrained by inadequate road and rail networks and limited cross-border coordination. The US and China, included as single economy benchmarks in Figure 2.16, anchor the global frontier. The US leads on LPI and trade facilitation, while China performs strongly on trade-to-gross domestic product (GDP) and corridor scale, reflecting sustained investment in logistics and customs digitalization.

Trade facilitation gains, reinforced by AfCFTA rules convergence and selective tariff relief on intermediate goods, are beginning to improve Africa's profile across LPI, trade-to-GDP and its Trade Restrictiveness Index scores. Sustained progress in corridor efficiency, risk management and digital border systems could reposition African economies within reglobalized production networks, enabling entry into time-sensitive, higher-value segments of global trade (TRALAC 2019).

Sustainability Performance Readiness

Sustainability has become a decisive factor in competitiveness and investment decisions as global production networks decarbonize and compliance regimes tighten. Benchmarked against OECD, ASEAN and LAC, with the US and China as single economy comparators, Africa shows relative strength in carbon efficiency (lower carbon dioxide, or CO_2, emissions per unit of GDP) and a growing share of modern renewables in several reform-oriented economies, including Kenya, Ethiopia, Morocco and South Africa. Yet the investment gap remains wide. In 2024, total energy investment across Africa stood at roughly $110 billion, with clean energy spending accounting for only a small fraction. By comparison, global clean energy investment exceeded $2 trillion and outpaced fossil fuel spending for the first time, underscoring the risk of widening competitiveness gap unless grid reliability, standards alignment and policy coherence advance in parallel (IEA 2024a; IEA 2024b).

Figure 2.16: Trade and Investment Readiness Regional Performance Distributions



Source: World Bank (Logistics Performance Index); World Trade Organization (WTO) and World Integrated Trade Solution (WITS) tariff data (Tariff Restrictiveness Index, ad valorem equivalents; direction-flipped); World Bank (World Development Indicators- Trade-to-GDP Ratio Index), and author calculations.

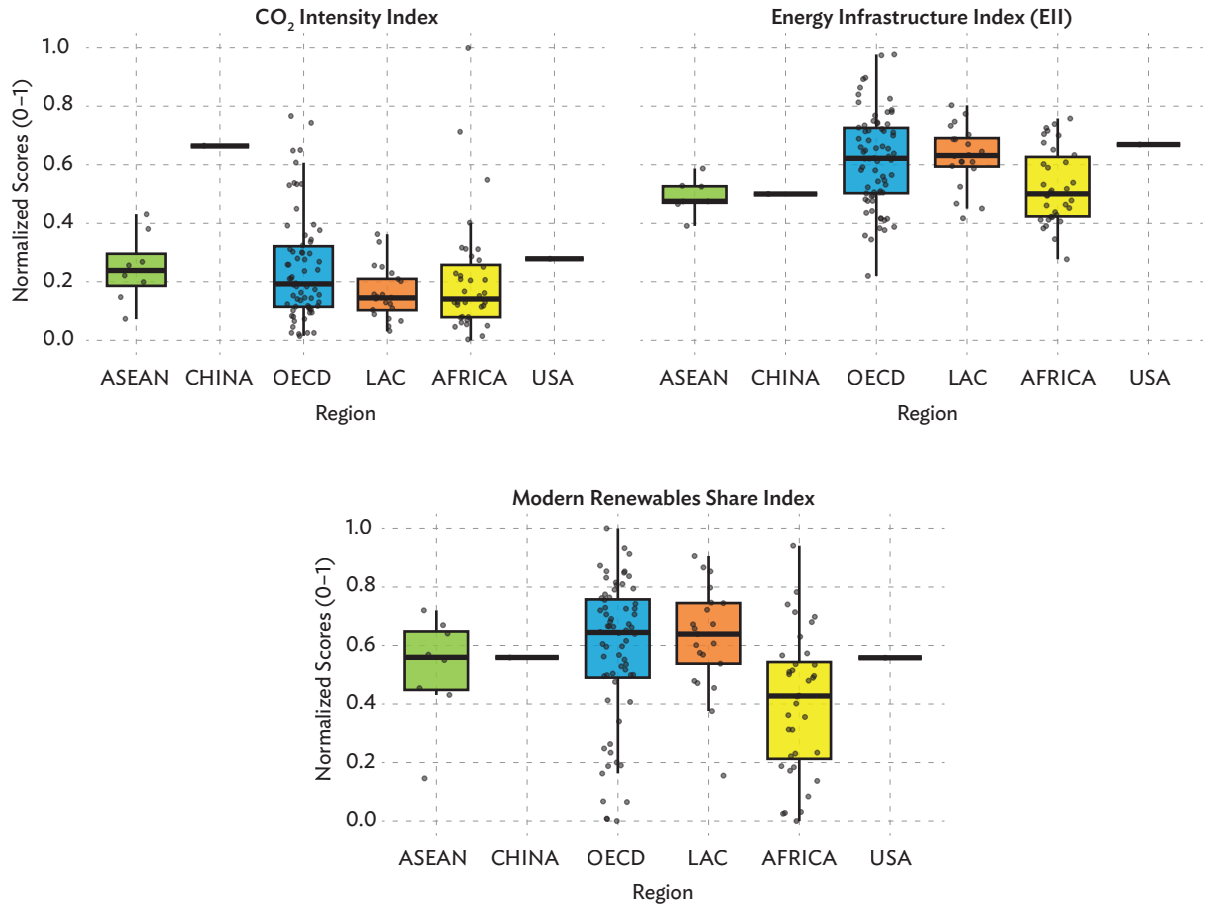
Three interconnected dimensions define Africa's sustainability readiness profile. The first concerns carbon efficiency and renewables, where median performance is relatively strong but dispersion wide. Several economies have achieved measurable progress in renewables generation and emissions intensity, but reliance on traditional biomass persists in many subregions (Ember 2025; IRENA 2025). The second dimension, energy infrastructure reliability, remains a binding constraint.

Grid connections are often slow, outages frequent and ancillary services thin, driving up energy costs for firms. Regulators are only gradually embedding SAIDI and SAIFI reliability metrics into tariff compacts and performance reviews, producing uneven outcomes across markets (AfDB 2025). The third dimension concerns input and standards. Africa's rich reserves of critical minerals contrast sharply with limited downstream processing and recycling capacity. Tariff and technical barriers continue to slow the deployment of energy transition goods (ETGs), while economies that align with International Electrotechnical Commission (IEC) and International Organization for

Standardization (ISO) norms– and streamline certification and testing regimes –see faster technology diffusion and cleaner supply chain integration (UNCTAD 2025; IEC 2024).

As shown in Figure 2.17, Africa's median scores remain below OECD and US benchmarks on energy infrastructure reliability but perform relatively better on carbon intensity (direction-flipped) than LAC. The widest dispersion appears in renewable energy shares, reflecting a patchwork of reform "bright spots" amid slower-moving peers. China, appearing as a single reference point, combines high ETG manufacturing and export intensity with comparatively low-carbon intensity, illustrating how scale, reliability and standards alignment interact to shape competitiveness across energy and industrial corridors (Ember 2025).

Figure 2.17: Sustainability Readiness Regional Performance Distributions



Source: World Bank (World Development Indicators – CO_2 Intensity Index); International Renewable Energy Agency (Renewable Energy Statistics, 2024 – Modern Renewables Share Index; Ember (Global Electricity Review and Yearly Electricity Data – Energy Infrastructure Index), and author calculations.

Institutional and Geopolitical Resilience Readiness

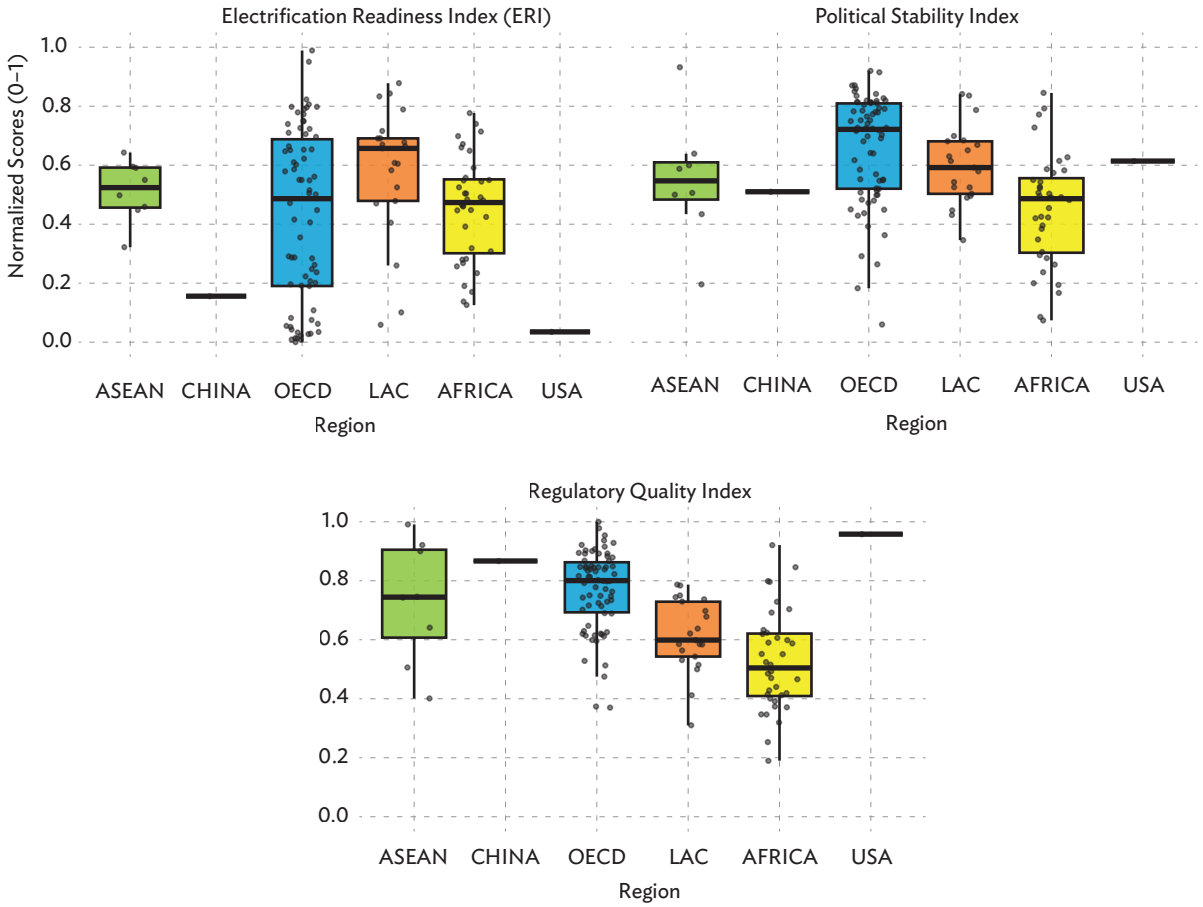
Institutional quality and political stability shape the risk premium of production locations in a reglobalizing world economy. Across Africa, persistent weaknesses in regulatory quality, contract enforcement and corridor governance continue to limit the reliability of upgrading and deter investment. Where policy coherence is weak and property rights remain unevenly enforced, risk premia rise, cross-border capital formation slows and compliance costs increase for firms operating in time-sensitive value chains (World Bank 2025b; AfDB 2025).

The institutional readiness composite spans six dimensions that together determine credibility and resilience. It captures regulatory quality and the rule of law, political stability and security, exposure to sanctions and compliance regimes, diplomatic alignment and geoeconomic positioning, business entry and exit governance, and the reliability of infrastructure. For the latter, an "Electrification Readiness Index" is introduced as a complementary composite that draws on conceptional elements of the Electricity Regulatory Index (ERI) and incorporates electricity access, reliability (SAIDI/SAIFI), and cross-border corridor "timeliness" using indicators from the Logistics Performance Index (World Bank 2025c; UN ESCAP 2024).

As shown in Figure 2.18, Africa's median scores are lowest, and dispersion widest, in regulatory quality and political stability, confirming persistent constraints on contract credibility and operational continuity. By contrast, sanctions and compliance exposure scores are relatively favorable, reflecting pragmatic non-alignment, though inconsistent screening and licensing procedures continue to raise transaction costs. Diplomatic alignment and geoeconomic positioning suggest broad neutrality but limited export similarity with China, constraining opportunities for "China+1" substitution beyond a few diversified hubs. Entry and exit governance improve where one-stop digital filing systems and alternative dispute-resolution mechanisms are in place, yet slow and costly insolvency processes still deter risk capital. ERI highlights reliability gaps in both energy and border infrastructure, though North and Southern African economies cluster above the regional median, supported by targeted regulatory and corridor reforms.

Globally, the US anchors the frontier in regulatory quality but lags on reliability due to ageing infrastructure, while ranks midrange on stability yet performs above average on regulatory effectiveness within this compilation. These contrasts provide practical benchmarks for assessing corridor risk and institutional performance across African economies.

Figure 2.18: Institutional and Geopolitical Readiness Regional Performance Distributions



Source: World Bank (Worldwide Governance Indicators – Regulatory Quality and Political Stability); Energy Institute (Statistical Review of World Energy– inputs for Electrification Readiness Index), and author calculations.

Financial Readiness

Finance is a decisive enabler of participation and upgrading in GVCs. Across Africa, performance on this pillar trails other regions, reflecting persistent gaps in inclusion, financial depth and macrofinancial buffers. These factors shape firms' ability to transact, invest and withstand shocks, core conditions for integration into production networks (World Bank 2025; IMF 2025).

Financial access has expanded rapidly with digital platforms and mobile money innovation, especially in East Africa. Yet inclusion remains below global norms and retains wide gender and rural gaps (World Bank 2025f; OECD 2024). Mobile money systems have broadened payments and savings, and lowered transaction costs, but contributions to credit and investment finance are still limited, with usage concentrated in low value transactions. Small firms face high collateral requirements and limit formal credit, constraining productivity growth and GVC participation (AfDB 2025).

Financial systems remain shallow and concentrated. Banks frequently favor sovereign paper over private sector lending, limiting funds for productive investment. High interest spreads elevated nonperforming loans, and thin capital markets reinforce this pattern. While bank capitalization and profitability are generally sound, the structural challenge is channelling liquidity to enterprise lending through stronger credit information systems, movable collateral frameworks and risk-sharing mechanisms for small and medium-sized enterprises (SMEs) (IMF 2025).

Many economies operate with narrow fiscal and reserve margins, leaving them exposed to tighter global financial conditions and rising debtservice costs. Debt vulnerabilities remain elevated, and limited access to concessional finance has intensified refinancing pressures (S&P Global 2024). Regional mechanisms are evolving: the African Development Bank (AfDB) and African Export-Import Bank (Afreximbank) have expanded liquidity and trade finance facilities, while initiatives such as the African Monetary Fund and Southern African Development Community (SADC) reserve pooling arrangements signal gradual moves towards regional safety nets and crisis prevention frameworks (AfDB 2025).

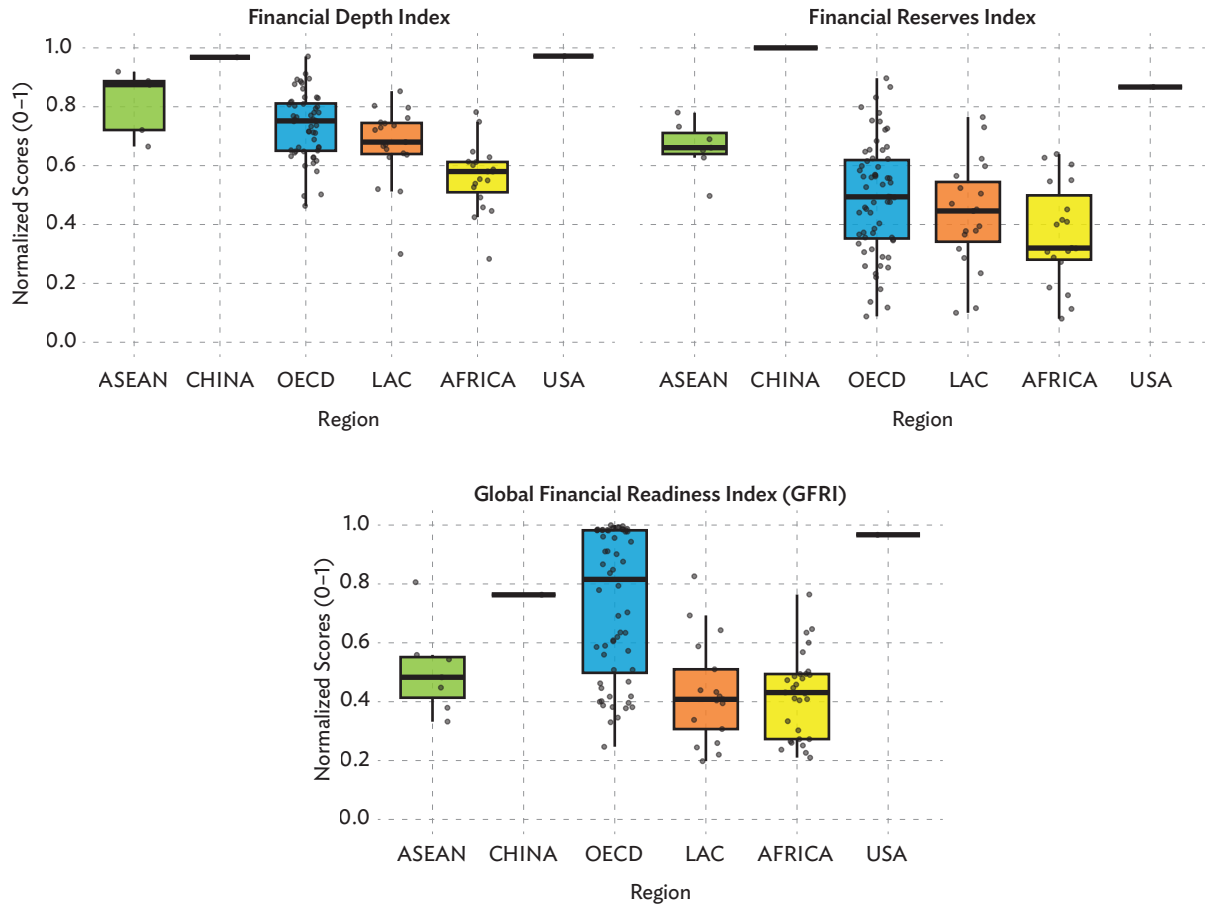
As shown in Figure 2.19, Africa's median scores are lowest across subpillars, with the widest dispersion in inclusion and depth. Even so, innovation in mobile finance and the gradual expansion of collective buffers provide a base for greater resilience. Priorities include strengthening credit infrastructure, harmonizing financial regulation and deepening capital markets to convert liquidity into investment and sustain GVC integration.

Regional financial connectivity is also deepening through institutional innovation. The Afreximbank and Pan-African Payment and Settlement System (PAPSS) enable intra-African trade in local currencies, reducing transaction costs and settlement risks. Complementary initiatives to digitalize SMEs, expand credit-guarantee facilities and scale fintech-enabled supply chain finance are gradually strengthening intermediation and extending access to working capital across emerging value chain sectors. These mechanisms mark early progress towards a more resilient continental financial architecture, aligning liquidity channels with productive investment.

Business Readiness

Business readiness reflects firms' capacity to operate productively, integrate into trade networks and respond to competition. It depends on firm capabilities, the operating environment and access to finance – factors that determine how effectively enterprises absorb technology, scale production and link to value chains (IMF 2025). Despite expanding connectivity and market access, productivity and managerial gaps remain binding. Enterprise surveys show that managerial quality, digital adoption and certification rates lag East Asia and LAC, with high software costs, shallow skills ecosystems and limited management depth constraining firm upgrading (World Bank 2025b; UNIDO 2023).

Figure 2.19: Financial Readiness Regional Performance Distributions



Source: International Monetary Fund (International Financial Statistics – Financial Depth and Financial Reserves Index); World Bank (Global Findex Database 2025 – Global Financial Readiness Index,), and author calculations.

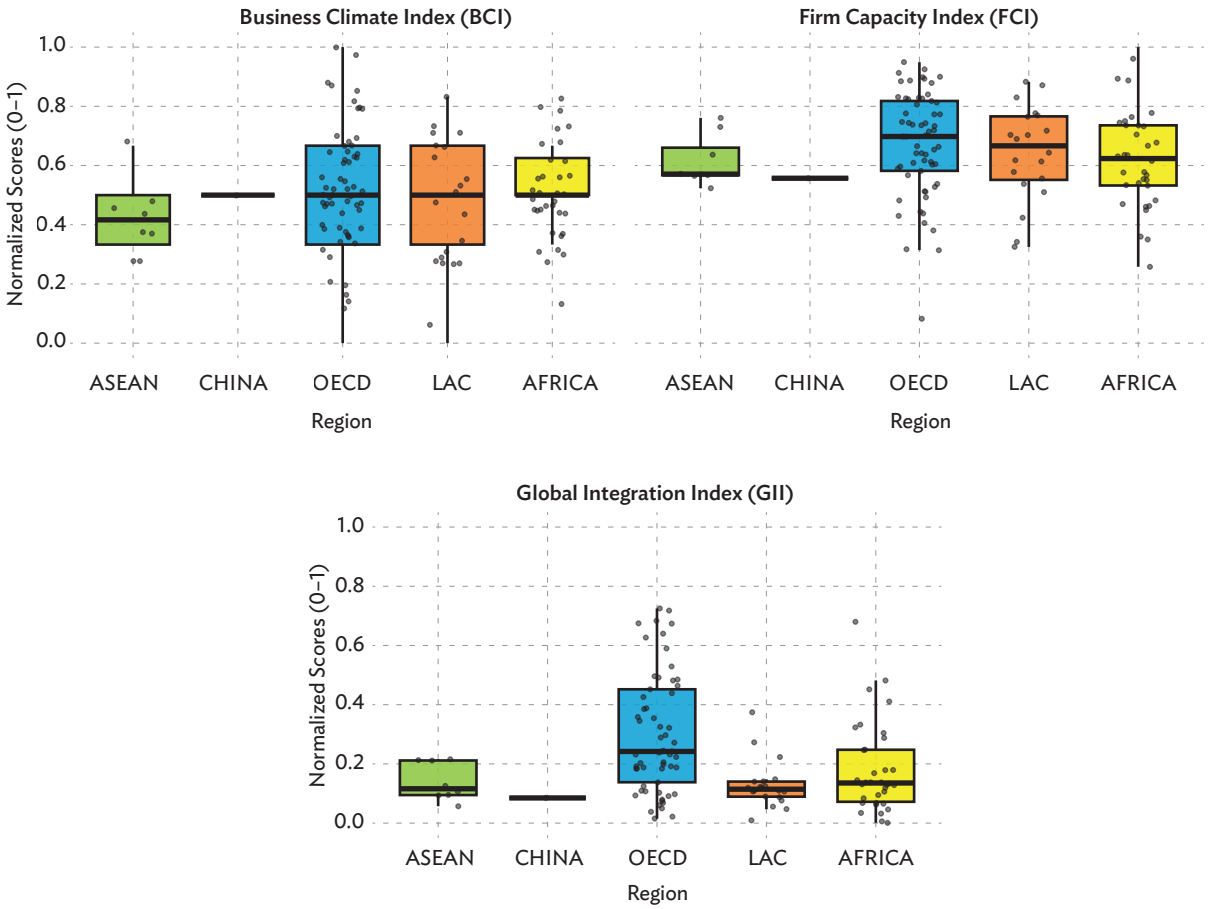
Recent firm-level literature shows that African enterprises participating in global value chains register higher rates of process and product innovation than non-GVC peers, albeit from a low base, underscoring the potential of international linkages to stimulate technological upgrading even in capacity-constrained environments. In Cameroon and Côte d'Ivoire, for instance, GVC-integrated firms tend to be larger, more productive and more export-oriented than domestic counterparts, while regional value chain participation in East Africa's textiles and apparel sector has supported backward integration and local supplier growth.

Infrastructure reliability and the operating environment continue to limit competitiveness. Power interruptions, transport delays and broadband deficits raise costs for manufacturing and logistics sectors, while complex tax procedures, informal payments and weak contract enforcement weigh on SMEs. Reform leaders such as Morocco and Rwanda demonstrate how streamlined regulation and digitalized administration can improve reliability and formalization (AfDB 2025). Access to finance remains restricted by high collateral requirements and fragmented credit systems,

leaving many firms dependent on informal funding. Expanding credit registries, movable collateral regimes and guarantee facilities is essential to mobilize capital and scale production (AfDB 2025; IMF 2025).

African firms also face higher trade costs and clearance times than peers. Non-tariff barriers, inconsistent documentation and limited risk-based inspections inflate costs, though digital single window systems and port modernization, such as Morocco's Tanger Med and Kenya's Northern Corridor, are improving corridor reliability. The AfCFTA offers a platform to unify markets and expand scale economies, but success depends on continued customs modernization, standards harmonization and transparent dispute resolution (OECD 2025a; WTO 2024). As shown in Figure 2.20, Africa's median scores remain below global benchmarks, yet reform-driven economies in North and East Africa demonstrate that coherent business climate and logistics reforms yield measurable gains.

Figure 2.20: Business Readiness Regional Performance Distributions



Source: World Bank (Enterprise Surveys – Firm Capacity Index, and Global Integration Index); World Bank (B-READY Program – Business Climate Index, BCI), and author calculations.

2.13 Africa's GVC Readiness Index: Intra-Regional Comparisons

Africa's readiness for GVC integration remains imbalanced, shaped by sharp contrasts in infrastructure, institutional quality and industrial structure. Southern and North Africa anchor continental performance, supported by stronger trade corridors, customs modernization and established manufacturing clusters in Morocco, South Africa, Egypt and Tunisia. These hubs combine relatively predictable regulation and corridor reliability with expanding renewables and digital connectivity. East Africa sits in transition: progress in digital public infrastructure and trade facilitation is tangible, yet recurrent power unreliability and corridor inefficiencies still cap competitiveness. West and Central Africa remain constrained by fragmented infrastructure, high logistics costs and institutional fragility, keeping firms at the periphery of production networks.

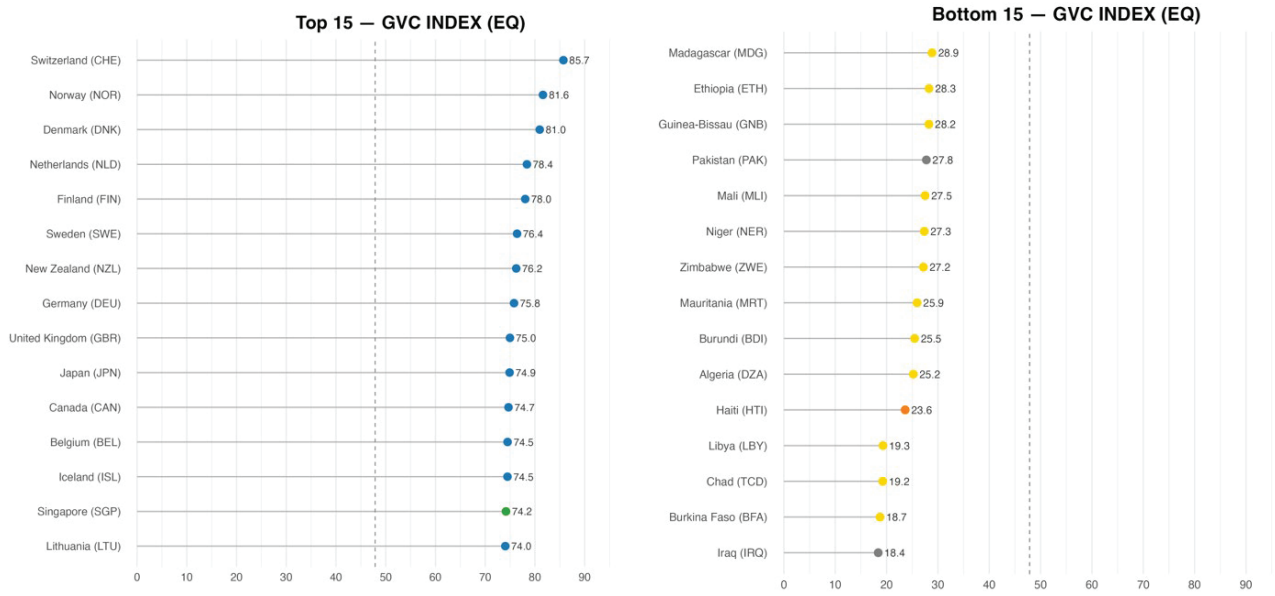
These disparities argue for differentiated policy pathways that reflect varied starting points while advancing continental coherence through the African Union, the AfCFTA Secretariat and regional economic communities (RECs). Scaling best practice in corridor management, single window interoperability and renewable grid reliability can accelerate convergence and strengthen Africa's position in reglobalized supply chains.

Variation across readiness dimensions is widest in technology and connectivity, and institutional and geopolitical resilience, underscoring persistent gaps in broadband depth, electricity reliability data governance and regulatory stability. Economies such as Kenya, Mauritius and Ghana perform relatively strongly where digital infrastructure, governance reliability and business regulation align. Gaps are narrower in trade and integration, and sustainability and energy, where investment has advanced, but systemic grid and border inefficiencies persist, especially in landlocked economies.

Figure 2.21 situates Africa within the global GVC-readiness distribution, and many African economies cluster near the lower quartile, confirming structural asymmetries in technology, governance and finance. Within Africa, North and Southern Africa consistently sit above the continental median, while dispersion elsewhere is among the widest globally. Frontier economies (Switzerland, Norway, Singapore) define the upper range with composite scores above 75, reflecting deep technological and institutional integration.

Financial and business readiness remain the most binding constraints. Shallow credit markets, limited trade finance and uneven diffusion of firm capabilities hinder upgrading into higher-value segments. Priorities include deepening financial intermediation, harmonizing credit infrastructure and promoting SME digitalization. The effectiveness of AfCFTA implementation, especially customs modernization, standards alignment and corridor investment, will determine whether demographic scale and natural endowments translate into durable competitiveness.

Figure 2.21: GVC Readiness Top 15 and Bottom 15 Economies



Note: The Global Value Chain (GVC) Readiness Index aggregates six equally weighted dimensions: technology and connectivity, trade and integration, sustainability and energy, institutional and geopolitical, financial, and business environment. Each pillar combines normalized indicators scaled from 0 to 1, with cost- and risk-based variables direction-adjusted so that higher scores represent stronger readiness. The composite index is rescaled to a 0-100 range.

Source: International Monetary Fund (Artificial Intelligence Preparedness Index); International Telecommunication Union (ITU DATA); GSMA (Mobile Connectivity Index); World Bank (Logistics Performance Index; Worldwide Governance Indicators; World Development Indicators; Global Findex Database; Enterprise Surveys; B-READY Program); World Trade Organization (World Integrated Trade Solution); International Renewable Energy Agency (Renewable Energy Statistics); International Energy Agency (IEA Statistics); Ember (Global Electricity Review), and author calculations.

Southern Africa

Anchored by South Africa, Southern Africa remains the continent's most integrated subregion. Strategic corridors (notably the North-South Corridor) link inland SADC economies to Durban, the Kazungula Bridge and one-stop border post (Zambia-Botswana) have cut transit times. SADC/Southern African Customs Union (SACU) programmes continue customs modernization via single window platforms, digital risk-based inspections and AEO scaling, with steps towards mutual recognition and e-certificates of origin. South Africa's AEO-US Customs-Trade Partnership Against Terrorism (C-TPAT) mutual recognition signals operational trust that can lower insurance premiums and corridor risk pricing.

The subregion ranks among the highest in trade and integration (strong LPI and trade-to-GDP, see Figure 2.16), though dispersion is wide given uneven corridor reliability and automation. Technology and connectivity sit above the continental median – broadband and mobile coverage are extensive – but AI preparedness lags comparators, pointing to the need for mid-level digital and data science skills.

Sustainability and energy are improving (with renewables led by Namibia and South Africa), yet grid reliability continues to limit industrial uptime despite adoption of SAIDI/SAIFI benchmarks around SEZs. Institutional and geopolitical scores benefit from relatively higher regulatory quality and political stability, with contracting and border transparency varying across states. Financial performance is mixed; South Africa leads in private credit and reserves, while smaller economies face thin intermediation. Business readiness is moderate given uneven firm digitalization and productivity.

North Africa

The region leads overall GVC readiness (see Figure 2.21), leveraging EU proximity, preferential access and sustained investment in logistics and renewables. Morocco and Egypt anchor this performance through large-scale SEZs, industrial platforms, and green hydrogen and renewables programmes.

Technology and connectivity is the strongest on the continent, with high internet penetration, expanding mobile broadband and rising AI preparedness. Trade and integration continue to strengthen top-tier LPI scores and corridor performance, especially around Tanger Med. Sustainability and energy sit well above the continental average with lower CO_2 intensity and higher modern renewables shares (see Figure 2.17).

Institutional and geopolitical readiness is comparatively robust due to higher regulatory quality and improving governance, though episodic policy uncertainty and administrative fragmentation can affect perceptions. Moreover, financial readiness benefits from larger banking systems and stronger FX buffers, venture/innovation finance remains narrow. Business readiness is strong in SEZs and export hubs but weaker among smaller firms where digital adoption and certification lag.

West Africa

West Africa combines notable digital progress with structural constraints. Nigeria and Ghana lead in fintech, mobile money innovation and digital services exports, lifting technology and connectivity and elements of financial readiness. In 2024, Nigeria's digital economy was nearly 20% of GDP – about four times the oil sector (US Department of Commerce 2024).

Yet, trade and integration trails continental and global medians (see Figure 2.16) as persistent non-tariff barriers, port congestion and weak overland connectivity raise costs. Additionally, sustainability and energy is held back by low renewables adoption and grid instability. Institutional and geopolitical readiness varies widely; Ghana and Côte d'Ivoire show improving frameworks, while several Sahelian economies face heightened risks. Finally, financial readiness is buoyed by mobile money penetration but constrained by shallow private credit and limited reserves, and business indicators point to low firm capacity and limit regional, and GVC integration.

Central Africa

Central Africa is the least integrated subregion, with broad deficits across all six pillars despite significant resource endowments. Chad, the Central African Republic and the Republic of Congo sit among the lowest globally on logistics performance, regulatory quality and digital connectivity (see Figure 2.18).

Technology and connectivity is weakest, with minimal broadband and high internet costs. Trade and integration suffer from fragmented corridors, inefficient ports and limited border automation. Sustainability and energy is undermined by unreliable grids and dependence on traditional biomass. Institutional fragility depresses regulatory quality and political stability, while weak grid management lowers electrification readiness. Financial performance is low due to thin reserves, high dollarization and limited credit. Firm-level gains are sporadic and urban-centered.

A coordinated strategy is required: sustained infrastructure investment, governance reform and stronger regional cooperation, translating policy into operational connectivity across transport, energy and digital networks.

Institutional Innovators

A subset of smaller economies, most notably Rwanda and Mauritius, demonstrates how targeted policy reform and institutional innovation can generate outsized gains in GVC participation even without large industrial bases. Rwanda has emerged as a continental leader in digital public infrastructure and governance innovation: interoperable e-government systems, national digital ID and e-procurement platforms, and open-data ecosystems have strengthened transparency, service delivery and investor confidence.

Sustained investment in digital skills development and the integration of ICT training into education frameworks have translated into measurable progress across the technology and connectivity, institutional and geopolitical, and business dimensions of the GVC Readiness Index. Mauritius, by contrast, illustrates how institutional depth and regulatory predictability can anchor diversification. Long-standing commitments to rule-of-law reform, investment promotion and innovation-friendly regulation have positioned the economy as a regional hub for digital commerce, fintech and green technology deployment. Strong performance across financial readiness, regulatory quality and business climate reflects close alignment between policy frameworks and private sector capability upgrading.

Taken together, these cases show that institutional strength, policy coherence and governance innovation, rather than scale or resource endowment alone, can determine GVC competitiveness. Both economies have leveraged transparent regulation, credible reform signaling and cross-sector coordination to attract knowledge-intensive investment and advance into higher-value segments of the global production system.

Broader Implications

The experience of these institutional innovators reinforces the broader findings in Annex 2.3, Africa's GVC readiness remains highly segmented, with deep asymmetries across subregions in industrial development, digital maturity, infrastructure access and regulatory quality. Uniform, continent-wide approaches are unlikely to yield results. Differentiated strategies are needed, raising underperforming subregions through targeted capacity-building and institutional development, while consolidating and scaling high-performing models through policy diffusion and peer learning.

Regional coordination platforms, including the African Union, the AfCFTA Secretariat and RECs, are well placed to benchmark readiness, disseminate effective policy models and align infrastructure and regulatory reforms. Progress towards a more inclusive and convergent readiness profile will depend on sequenced, evidence-based interventions that mobilize capital, technical assistance and regulatory harmonization across diverse economic geographies. These findings provide the empirical foundation for the strategic roadmap that follows, which sets out actionable policy and investment priorities to accelerate Africa's integration into global value chains.

2.14 Roadmap for Strategic Global Value Chain Integration – Aligning Africa's Policy Priorities

Africa's ability to compete in and capture value from the GVCs will depend on how effectively national and regional agendas align with an international production system that is being reshaped by digitalization, decarbonization and geopolitical realignment. As investors and multinational firms diversify sourcing to strengthen resilience, Africa faces a rare opportunity to reposition itself within emerging supply networks. Realizing this potential requires a coherent continental strategy that lowers participation risk, strengthens institutional credibility and delivers predictable, investable projects capable of attracting long-term capital.

This strategic roadmap identifies five mutually reinforcing policy levers – digital connectivity, renewable energy deployment, investment facilitation, regulatory adaptation and regional integration – that together define a pathway for accelerating GVC readiness. These levers are not standalone initiatives but interconnected pillars of an integrated investment strategy, aligned with Africa's diverse macroeconomic realities and institutional baselines. The framework seeks to channel public reform momentum and blended finance towards bankable, future-ready sectors, positioning policy coherence as the foundation for sustainable capital formation and cross-border value creation.

Harnessing the Digital Technology Transition

Digital transformation is the first enabler. With fewer than 30% of Africans having access to fixed broadband, and mobile broadband costs among the highest globally, closing the connectivity gap has become an economic imperative. Governments should earmark spectrum auction revenues for universal service funds and accelerate last-mile infrastructure, while implementing the AfCFTA Digital Trade Protocol 2024 to harmonize rules on e-signatures, data standards, cross-border data flows and cybersecurity. Regional programmes to certify at least 500,000 ICT professionals by 2028, with gender parity benchmarks, would strengthen the talent base. Complementary reforms, reducing ICT import tariffs, promoting affordable access devices, and investing in AI-readiness and digital public infrastructure – such as digital ID, payment systems and registries – can help African economies leapfrog legacy systems and expand their share of digitally deliverable services.

Seizing Africa's Green Comparative Advantage

Africa's abundant renewables and critical mineral reserves position it strategically in the global net zero economy, yet deployment is hindered by underinvestment and fragmented grids. Modernizing SEZ frameworks to reward renewable sourcing and enforce local content rules can anchor green industrial clusters. A blended finance facility led by the AfDB can de-risk cross-border renewable energy projects and strengthen regional power pool integration, where pooled procurement has already lowered costs by about 12% (AfDB, 2025). Eliminating non-tariff barriers and aligning standards with ISO/IEC benchmarks could cut certification lead times by 30-40%. With these reforms and effective risk-mitigation mechanisms, Africa can convert its green endowments into a durable competitive advantage in low-carbon GVC segments.

Attracting and De-Risking Global Value Chain-Oriented Investment

Investment facilitation and risk mitigation are critical for scaling participation. Operationalizing the AfCFTA Protocol on Investment by 2026 should include a centralized dispute resolution mechanism, enforceable investor protections and an African Arbitration Academy to strengthen legal certainty. Establishing a Pan-African Trade Disruption Observatory, modeled on LAC's ALADI system, would provide real-time analytics on trade frictions and supply chain shocks. Mobilizing long-duration private capital will also require scaled blended de-risking instruments, first-loss guarantees, political risk insurance and local currency hedging, supported by the AfDB, development finance institutions and sovereign wealth funds. Concentrating these efforts around industrial clusters and strategic logistics corridors can convert regulatory reforms into tangible investment pipelines.

Aligning with Global Industrial Policy and Market Access Regulations

Regulatory adaptation will determine competitiveness under new industrial policy regimes. The EU Carbon Border Adjustment Mechanism (CBAM) and the US Inflation Reduction Act continue to reshape access to major markets by linking trade preferences to emissions intensity, traceability and local content compliance. Africa must establish regulatory intelligence units within trade and industry ministries to monitor plurilateral negotiations, anticipate standards shifts and translate them into domestic legislation. Bilateral regulatory sandboxes with the EU and US in sectors such as smart grids, electric mobility, fintech and carbon capture can fast-track certification and testing, while capacity building in carbon accounting, rules of origin and environment, social and governance (ESG) due diligence for policymakers and firms will be vital for sustained compliance.

Finally, regional integration remains the anchor for scale and resilience. Effective implementation of the AfCFTA, through customs modernization, corridor investment, harmonized standards and dispute-resolution mechanisms, will determine whether Africa converts its demographic and resource scale into competitiveness. As GVCs reconfigure around trusted partners and transparent standards, alignment with these emerging frameworks is not optional: it is the condition for durable access to high-value trade corridors and a decisive step toward Africa's full participation in a standards-driven, reglobalized economy.

Strengthening preference utilization is only one component of the broader effort to deepen Africa's regional economic integration. The same institutional and logistical frictions that limit firms' ability to claim tariff preferences also restrict participation in intra-African and cross-regional production networks. Realizing the full potential of the AfCFTA therefore requires a shift from policy intent to operational connectivity, linking digital trade systems, interoperable rules-of-origin (RoO) platforms and corridor infrastructure into a cohesive regional production architecture.

Emerging evidence from the World Bank (2024), the World Trade Organization, or WTO (2025) and the AfCFTA Secretariat (2025) shows that economies with digitalized RoO verification, end-to-end paperless trade and interoperable customs platforms record higher preference utilization, faster clearance times and greater export diversification. In this context, regional integration becomes not only a political commitment but an economic multiplier, one that consolidates gains from improved preference utilization and amplifies them through cross-border logistics, harmonized data regimes and cumulative market access.

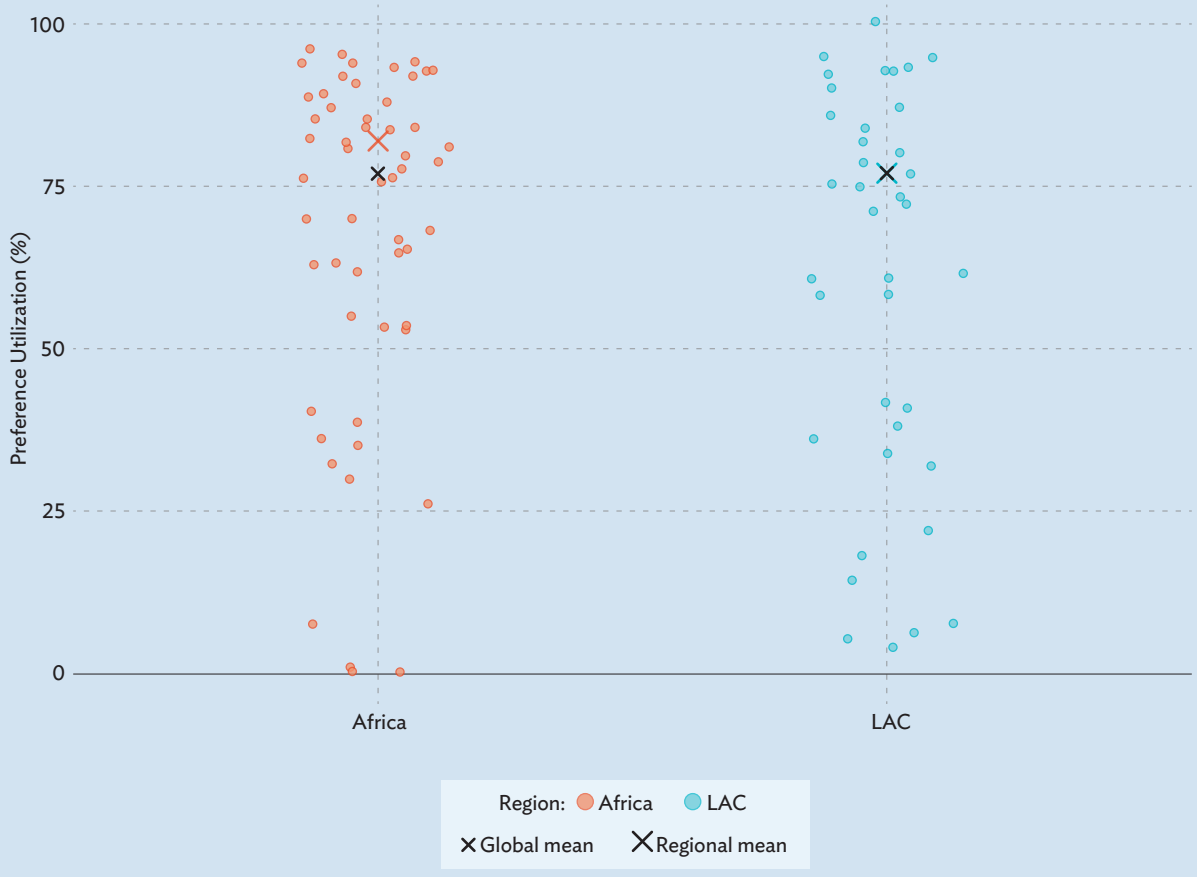
The following section outlines how Africa can institutionalize these linkages through digital RoO registries, blended finance corridor projects and data-driven monitoring frameworks, translating policy convergence into measurable trade and investment outcomes.

Box 2.2: Preference Utilization and GVCS in Africa and LAC

Regional trade agreements and unilateral schemes, such as the Generalized System of Preferences, often grant preferential market access through tariffs lower than those applied on a most-favoured nation basis. However, developing economies frequently face obstacles to fully utilizing preferences, due to structural and policy-related factors, including complex rule of origins, insufficient administrative capacity or low preference margins. This underuse of preferences is particularly detrimental in GVCs as the numerous border crossings of intermediate goods within these chains lead to costly tariff accumulation (see Escaith, 2017 in the GVC Development Report 2017) that effective use of preferential tariff rates could limit. In this context, a novel dataset by the World Trade Organization on preference utilization rates can provide new insights:

1. Detailed import data 2021-2023 indicate that, on average, preference utilization in Africa and LAC aligns closely to a global benchmark. Figure 2.22 shows that the global average preference utilization rate (PUR) stands at 77%. The identical average is calculated for LAC. In Africa, the average is higher, reaching 82%. However, the figure also shows that there is substantial variation within each region with some economies making barely use of their preferences.

Figure 2.22: Preference Utilization in Africa and LAC



Source: WTO Integrated Data Base (IDB), 2025

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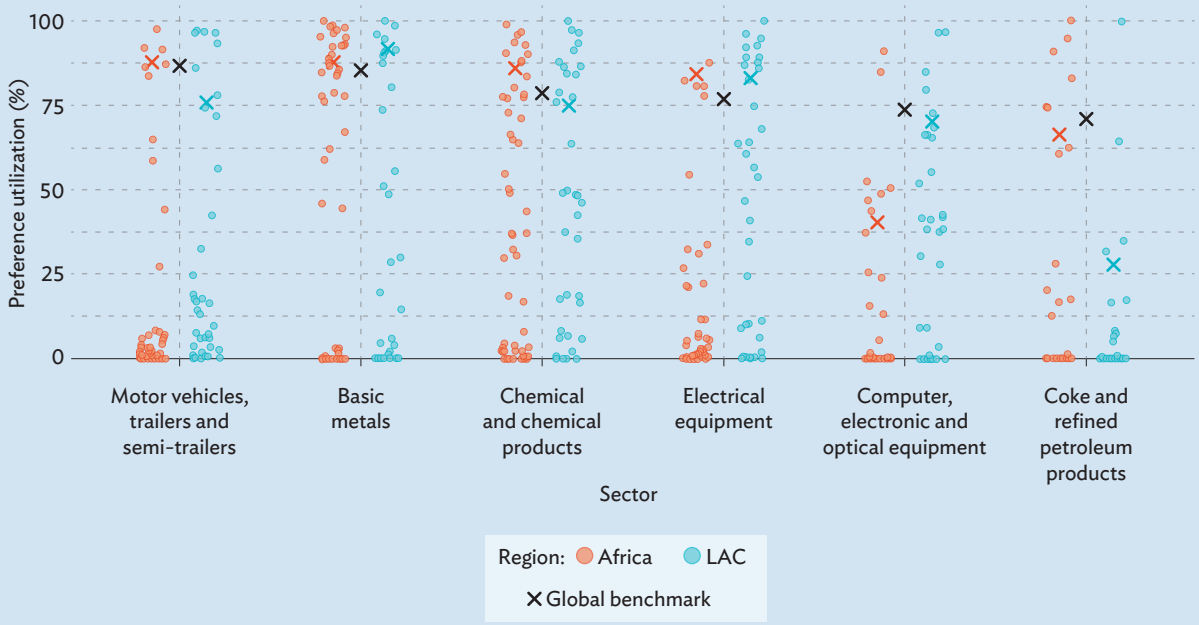
Box 2.2: continued

2. In some of the sectors that are most integrated in GVCs globally, based on the high foreign value added content in exports identified using the OECD TiVA database, Africa and LAC could improve their preference utilization rates (PURs). Figure 2.23 shows that PURs in LAC are particularly low in the key GVC sectors motor vehicles, and coke and refined petroleum. African PURs are particularly low for computer, electronic and optical equipment. Moreover, the large variation in PURs within both regions suggests that many economies could export under significantly more favorable terms across major GVC sectors than is currently the case.

Figure 2.23: Preference Utilization in Africa and LAC in High FVAX Sectors



Source: WTO Integrated Data Base (IDB) and OECD TiVA, 2025

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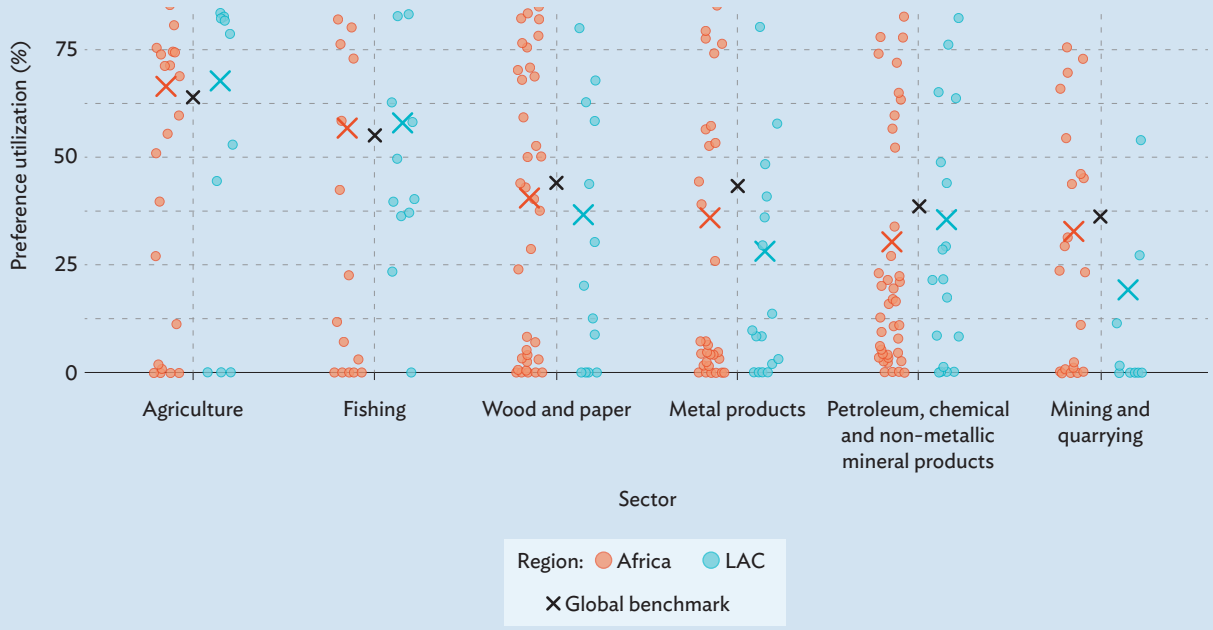
2.15 Completing the Agenda of Regional Economic Integration

Africa continues to lag comparator regions in regional trade integration (see Annex Table 2.A.8), reflecting weak logistics connectivity, non-harmonized rules of origin and underdeveloped cross-border infrastructure. Despite the entry into force of the AfCFTA, intra-African trade remains below 18% of total trade – less than half the level in ASEAN or LAC. The shortfall reflects an execution gap rather than a policy vacuum: customs modernization, corridor connectivity and digital interoperability have yet to converge at scale. Progress now depends on shifting emphasis from protocol ratification to operational delivery.

Box 2.2: continued

3. The sectors that are most critical to African and LAC integration into GVCs exhibit similarly PURs that indicate room for improvement. Unlike many of the sectors most integrated into GVCs worldwide, Africa and LAC are less active in downstream manufacturing and participate upstream mainly through the supply of raw materials such as minerals and agricultural products. To capture this and assess PURs in these sectors, we identify key GVC sectors for Africa and LAC by calculating forward integration measures based on the domestic value added content of the two regions that is re-exported by third economies, so called DVAR ratios, using the EORA database. This approach suggests that agriculture, fishing, mining, minerals, metal products, and wood and paper are critical sectors for these two regions. Yet, even in some of these sectors PURs are relatively low. While Africa and LAC have high PURs in agriculture and fishing, they have lower PURs than the global average in the other four sectors (see Figure 2.24). The difference is particularly pronounced for LAC in metal and mining exports.

Figure 2.24: Preference Utilization in Africa and LAC in High DVAR Sectors



Source: WTO Integrated Data Base (IDB) and EORA, 2025

Overall, we find that Africa and LAC could improve their competitiveness in GVCs if they made better use of their existing tariff preferences. Even in sectors where they have high average PURs, some economies within the regions record very low PURs. This suggests that there is substantive scope to lower import prices from these regions. Realizing these gains requires a thorough analysis of the barriers that continue to constrain preference utilization in these two regions.

Note: This box was contributed by Siramane Coulibaly, Tomasz Gonciarz, Victor Stolzenburg, and Thomas Verbeet (World Trade Organization). The analysis draws on data from the WTO Integrated Database (2025), OECD TiVA (2025), and EORA (2025). The views expressed are those of the authors and do not necessarily reflect the position of the WTO or its Members. The views expressed are those of the authors and do not necessarily reflect the position of the WTO or its Members. Foreign value added (FVAX) measures the share of imported intermediate inputs embodied in a country's exports and is commonly used to capture backward GVC integration. Domestic value added re-exported (DVAR or DVR) reflects the domestic value that is incorporated in a country's exports and subsequently re-exported by third economies, indicating forward GVC integration. These indicators help identify sectors where preferential market access can meaningfully reduce cumulative tariffs and strengthen participation in cross-border production networks.

A central priority is the AfCFTA Digital Rules-of-Origin Registry, under development by the AfCFTA Secretariat and United Nations Economic Commission for Africa, or UNECA (2025). The platform will enable real-time verification, full cumulation of regional inputs and automated clearance, especially for SMEs facing heavy documentation burdens. Integration with national single window and paperless trade systems will enable exporters to claim preferences seamlessly, cutting administrative costs and clearance times by up to 40% (ESCAP 2024). Digital RoO verification will also enhance trade-data integrity and support compliance with global transparency regimes under the EU CBAM and the US IRA.

Physical connectivity must advance alongside digital reform. The proposed AfCFTA Infrastructure Bond, structured through blended finance and partial sovereign guarantees, should prioritize high-impact corridors such as Abidjan-Lagos, Mombasa-Kigali and Durban-Lubumbashi, which together handle more than 40% of intra-African freight (AfDB 2025). Coordinated corridor programmes combining hard infrastructure, ports, rail and roads with soft systems customs harmonization, transit guarantees and electronic documentation could reduce transit times by 20-25% and logistics costs by up to 15% (WTO 2025). Complementary investment in cross-border power pools (SAPP, EAPP, WAPP and CAPP)[2] and regional internet exchange points will stabilize energy supply, expand high-speed data exchange and strengthen e-commerce and digital services trade (ITU 2025; GSMA 2025).

To ensure accountability, regional institutions should deploy data-driven integration dashboards tracking RoO utilization, corridor performance and regional investment trends. Real-time analytics drawing on World Bank LPI, WTO Integrated Database and AfCFTA data would enable policymakers to identify bottlenecks and target technical assistance. The African Union Commission and AfCFTA Secretariat could then calibrate financing and interventions where institutional gaps persist.

Africa's integration agenda must evolve from institutional aspiration to structural investment strategy. The goal is not only to expand intra-African trade volumes but to reshape their composition linking economies through interoperable digital trade systems, efficient logistics corridors and harmonized regulatory frameworks. The next phase of GVC participation will hinge on translating policy alignment into tangible connectivity that lowers trade costs, broadens market access and attracts sustainable investment. Integration into GVCs is therefore not only a development objective but a strategic investment proposition, requiring targeted capital deployment, regulatory modernization and coordinated regional infrastructure.

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2 SAPP (Southern African Power Pool), EAPP (Eastern Africa Power Pool), WAPP (West African Power Pool), and CAPP (Central African Power Pool) are the four regional electricity markets coordinating power generation and transmission across Southern, Eastern, West and Central Africa.

Table 2.3: Africa's Policy Roadmap

Policy area	Africa-specific levers	KPIs to track	Primary owner(s)
Digital technology transition	• Expand IXPs and open-access fibre along key trade corridors (Abidjan-Lagos, Mombasa-Kigali, Durban-Lubumbashi) • Operationalize AfCFTA Digital Trade Protocol (e-signatures, e-invoicing, cybersecurity) • Universal digital ID and data-interoperability frameworks across RECs • PPPs for SME cloud and AI adoption	• Broadband cost (percent GNI per capita) • Corridor 4G/5G coverage • IXP traffic volume • e-ID coverage • Share of firms using cloud/AI	• ICT and digital economy ministries • AfCFTA Secretariat (Digital Trade) • Competition and data protection authorities
Green comparative advantage	• Build green SEZs and eco-industrial parks near renewable corridors • Launch AfDB blended-finance facility for cross-border renewables • Align SEZ frameworks with renewable sourcing mandates • Eliminate NTBs for energy-transition goods (ETGs)	• SAIDI/SAIFI reliability metrics • Renewable share in industrial power • ETG tariff levels • Certified green-park count	• Energy and industry ministries • AfDB/RECs infrastructure units • Customs and standards authorities
Critical minerals & processing	• Establish value-addition hubs for lithium, cobalt, and rare-earths (DRC-Zambia-Namibia) • Regional ESG and traceability protocols via AU/UNCTAD • Open-access corridors for mineral exports (Central & Southern Africa)	• Share of minerals processed domestically • ESG/traceability compliance rate • Corridor throughput (tons/year)	• Mining and industry ministries • AU Commission (Minerals Unit) • Ports and corridor authorities
Attracting & de-risking investment	• Operationalize AfCFTA Protocol on Investment (dispute resolution, arbitration academy) • Beneficial-ownership registry integrated with customs risk engines • Expand port-proximate SEZ/bonded zones (Tema, Mombasa, Durban) • Unified digital permitting and e-procurement	• FDI approval SLA (days) • BO matches in customs risk system • SEZ/bonded zone count • Share of tenders processed online	• Investment promotion agencies • Justice and customs ministries • AfCFTA Secretariat (Investment)
Global industrial-policy alignment	• Establish regulatory sandboxes with EU/US for conformity testing and CBAM readiness • Adopt ISO/IEC and cybersecurity standards across RECs • Launch supplier-compliance programs for EU CBAM / IRA buyers	• MRA coverage by sector • CBAM-ready sectors • Exporters certified ISO/IEC-cyber • Buyer audit success rate	• Trade and industry ministries • Standards bodies • Chambers of commerce
Regional economic integration (rules & infrastructure)	• Implement AfCFTA Digital Rules-of-Origin registry • Issue AfCFTA Infrastructure Bond for corridor development • Mutual recognition of AEOs across RECs • Harmonize border management & electronic documentation	• Share of declarations via single window • AEO MRA count • Average border release time • RoO utilization rate	• Customs authorities • AfCFTA Secretariat • RECs' transport & trade directorates
Connectivity & logistics	• Prioritize multimodal links in Abidjan-Lagos, Mombasa-Kigali, and North-South corridors • Develop regional port community systems (PCS) • Ensure redundancy in key maritime routes	• Port turnaround time • Corridor dwell time • PCS transaction share • Corridor reliability index	• Transport ministries • Port authorities • Corridor management institutions

continued on next page

Table 2.3: continued

Table 2.3: Africa's Policy Roadmap			
Policy area	**Africa-specific levers**	**KPIs to track**	**Primary owner(s)**
Security and compliance	• Integrate BO data and AML frameworks into trade systems • Vet and license 'trusted corridor operators' • Joint border operations to reduce cargo theft and smuggling	• Seizures per risk flag • Corridor incident rate • Percent shipments via vetted operators	• Finance and justice ministries • Customs • Interior and security agencies

AfCFTA = African Continental Free Trade Area; RECs = Regional Economic Communities; ETG = Energy Transition Goods; SEZ = Special Economic Zone; AEO = Authorized Economic Operator; CBAM = Carbon Border Adjustment Mechanism; ISO/IEC = International Organization for Standardization / International Electrotechnical Commission; PPP = Public–Private Partnership; MRV = Measurement, Reporting, and Verification

Note: The Africa Policy Roadmap summarizes actionable policy levers and institutional roles drawn from AfCFTA, AU, AfDB, and World Bank–WTO frameworks. It is designed as a diagnostic and operational reference, rather than a prescriptive policy blueprint. Key Performance Indicators (KPIs) serve as indicative metrics for tracking progress across digital, sustainability, logistics, investment, and governance enablers.

2.16 Comparative Discussion and Prospects for Successful Integration

LAC and Africa stand at parallel crossroads in the reglobalization era. Both regions face a common structural test: shifting from commodity-dependent, low-complexity exports towards reliable, digitally enabled and low-carbon production fast enough to sustain growth, employment and investor confidence. Despite notable progress, participation in GVCs remains shallow, with most economies concentrated in low-productivity segments. New TiVA-based evidence confirms that while total participation rose markedly during 1995-2011, momentum has since weakened. From 2011 to 2022, backward linkages increased only modestly while forward linkages flattened, indicating consolidation rather than renewed expansion of integration. Evidence across this chapter – spanning diversification, upgrading and resilience – shows that while the geography of trade is broadening, the depth of inclusion remains limited. Apparent diversification often masks concentration: rerouted trade flows, particularly Chinese indirect value added to the US, benefit mainly established Asian economies such as Viet Nam, Chinese Taipei and Singapore, with limited spillovers to Africa or LAC. Spurious diversification persists, partner counts are rising, yet concentration and technological dependence remain high.

Three persistent gaps shape both regions' readiness for reglobalization. First, technological and digital readiness, though improving, still lags global benchmarks, constraining participation in data-driven and service-intensive GVCs. High fixed broadband costs and limited backbone infrastructure, evidenced in Nordås and Xu (2024), restrict the ability of firms to engage in digital segments of trade. Second, sustainability and energy resilience remain uneven: LAC leads in clean electricity generation and Africa in critical mineral endowments, but both need stronger alignment between trade, industrial and energy policies. Third, institutional and

geopolitical resilience, regulatory predictability, trade facilitation and risk management continue to define investor confidence and supply chain reliability. Together these gaps underpin a central finding of Chapter 2: integration alone is no longer sufficient. The TiVA patterns and firm-ownership diagnostics demonstrate that formal participation does not guarantee upgrading, domestic firms in both regions remain concentrated in low-complexity, assembly-intensive tasks dominated by foreign-controlled value capture. Economies must therefore be technologically, institutionally and climatically ready to compete in the next configuration of global production.

LAC possesses stronger modern services capabilities, more permissive data governance regimes and cleaner power systems, providing a platform for nearshoring and green manufacturing. If corridor reliability improves and digital bottlenecks are reduced, TiVA evidence suggests renewed backward linkage potential in sectors such as electronics, medical devices and digitally intensive manufacturing. With improved corridor reliability, standardized conformity-assessment procedures for ETGs and bankable green PPAs the region can position itself in reliability-priced sectors such as electronics, medical devices and digitally intensive manufacturing.

Africa, by contrast, combines rapid mobile technology and fintech diffusion with abundant renewable energy and mineral resources. Yet TiVA data show Africa's integration remains primarily forward-oriented – driven by raw material exports with limited domestic value capture – underscoring the need to expand processing and intermediate goods capabilities. Its opportunity lies in converting these endowments into processing, logistics and digital services hubs if grid reliability, traceability and contract bankability advance in sequence. Targeted corridor upgrades, standardized PPAs and the operationalization of AfCFTA digital trade and single window systems can move Africa from fragmented participation to integrated, higher-value engagement.

Across both regions, the practical agenda must be corridor-first and KPI-anchored, emphasizing measurable outcomes over aspirational commitments. Translating readiness into performance requires coordinated progress across four mutually reinforcing pillars.

- **Digital and data infrastructure**: Expand IXPs and enforce backbone service standards along major trade corridors. Deploy interoperable e-ID systems and universal digital ID coverage and promote SME adoption of cloud computing and AI.
- **Energy and sustainability readiness**: Fast-track substation and last-mile grid upgrades to strengthen reliability. Publish low- or zero-tariff lanes for ETGs under a harmonized-system list and align conformity assessment procedures with international standards to accelerate participation in clean technology value chains.
- **Trade facilitation and investment frameworks**: Operationalize trusted trader lanes through AEO mutual recognition, pre-arrival processing and e-payments. Establish one-stop investment windows with standardized PPP models, partial

credit guarantees and transparent project pipelines to attract and de-risk private capital.

- **Skills, enterprise upgrading and inclusion:** Scale targeted upskilling and supplier-development programs that enable micro, small, and medium-sized enterprises (MSMEs) to integrate into original equipment manufacturer (OEM) supply tiers and digital service networks. Strengthening absorptive capacity is essential to convert connectivity into competitiveness.

Progress across these pillars should be tracked through a compact readiness scorecard covering corridor uptime, IXP traffic, e-ID coverage, grid reliability (SAIDI/SAIFI), ETG tariff levels and certification times, AEO share of exports, licensing turnaround and MSME upgrading rates. To accelerate impact, governments should sequence reforms: (1) fix corridor and grid reliability on priority routes, (2) stand up digital trust enablers (IXPs, e-ID, single windows), (3) operationalize bankable PPAs and standardized ETG conformity, and (4) crowd in private capital via guaranteed platforms and pipeline transparency. Delivery should be owned by cross-ministerial "readiness units" with quarterly KPI reviews and sunset clauses for underperforming programmes. On the investor side, publishing corridor service-level agreements and green power availability maps can shorten time-to-investment and anchor OEM supplier upgrading.

Together these actions operationalize the chapter's central message that reglobalization is not a retreat but a rewiring. Economies that combine reliability, digital trust and low-carbon competitiveness will secure durable advantages in the new geography of trade. For LAC and Africa, success will hinge on converting endowments into bankable reliability, measured in hours of corridor uptime, cents per kilowatt-hour of certified clean power, minutes to clear customs and the share of MSME suppliers meeting OEM quality standards. Where these metrics move, TiVA will follow higher domestic value capture, deeper backward linkages, and more resilient participation in the next wave of sustainable, digitally driven growth.

Building on the comparative roadmap developed in Chapter 2, the next chapter turns to a live test case where reglobalization is already reshaping industrial geography: the global EV value chain. Chapter 3 traces this system end-to-end – from critical mineral extraction and processing to batteries, motors, electronics, charging infrastructure, recycling and software – and examines how value added and carbon burdens are being redistributed relative to internal combustion engine vehicles (ICEVs). Using life cycle analysis under varying power mix and efficiency scenarios, it quantifies emissions outcomes and identifies policy levers that reconcile competitiveness with decarbonization. Through a product space lens, the chapter maps where developing economies can enter, climb and diversify across EV-related segments of global production.

For policymakers in LAC and Africa, the implications are immediate and practical. The enabling conditions highlighted in Chapter 2 corridor-first digital reliability, bankable green PPAs, trusted trader lanes and predictable investment facilitation remain decisive. Within the EV ecosystem, opportunities lie in critical mineral processing, mid-stream battery components, motor and electronics niches and downstream services such as charging networks, data systems and circular economy solutions. The EV case provides a concrete template for translating Chapter 2's readiness levers into sector-specific strategies that price reliability, accelerate technological upgrading and deliver low-carbon growth. Chapter 3 applies this framework to quantify how these interventions can reshape participation, value capture and resilience across the next generation of reglobalized production networks.

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Annex 2.1: Latin America and the Caribbean (LAC) Readiness Indicators

This appendix presents the country-level data and composite rankings that underpin the readiness diagnostics for LAC discussed in Chapter 2.

Indicators are min-max normalized (0-1) and grouped into three composite pillars:

(1) Technology and connectivity
(2) Sustainability and energy
(3) Institutional and geopolitical Resilience

The tables report normalized indicator scores (0-1), composite pillar rankings and overall readiness scores for all LAC economies, enabling comparative benchmarking within the region and against global reference economies.

Annex Table 2.A.1: Pillar Ranking By Country Technology Readiness

Rank	Logistic Performance Index	Mobile Connectivity Index	ICT Capital Goods Imports Index	Human Capital	Digital Services Trade Restrictiveness Index	Digitally Deliverable Services Index	Government Promotion of Investments in Emerging	Global Cyber-security Index
1	Singapore	Singapore	Singapore	Singapore	Belize	United States	China	United States
2	Finland	Switzerland	United States	Israel	Laos	Ireland	Singapore	Estonia
3	Denmark	Denmark	Vietnam	Brunei	Cambodia	Germany	Luxembourg	United Kingdom
4	Germany	Australia	Malaysia	Iceland	Argentina	China	Israel	Singapore
5	Netherlands	Finland	Philippines	Denmark	Uruguay	Japan	Finland	South Korea
6	Switzerland	Norway	South Korea	Sweden	China	Netherlands	United States	Spain
7	Austria	Ireland	Mexico	Estonia	Indonesia	Switzerland	South Korea	Malaysia
8	Belgium	United States	Czechia	Malaysia	Poland	Luxembourg	Malaysia	Lithuania
9	Canada	United Kingdom	Hungary	United Kingdom	Colombia	France	France	Japan
10	Sweden	New Zealand	Ireland	New Zealand	Iceland	United Kingdom	Canada	Canada
11	France	Sweden	Thailand	Norway	Türkiye	Canada	Germany	France
12	Japan	Austria	Netherlands	Finland	Chile	Italy	Japan	Australia
13	Spain	Netherlands	Japan	Netherlands	Bolivia	Belgium	Sweden	Türkiye
14	South Korea	Iceland	Israel	Canada	Peru	Sweden	Brunei	Germany
15	United States	Luxembourg	Germany	South Korea	Brunei	South Korea	Netherlands	Luxembourg
16	Australia	Germany	Slovakia	Australia	Brazil	Spain	United Kingdom	Latvia
17	China	Canada	Poland	Uruguay	Latvia	Israel	Thailand	Portugal
18	Greece	France	Brazil	United States	South Korea	Finland	Indonesia	Netherlands
19	Italy	Japan	Laos	Greece	Austria	Austria	Ireland	Norway
20	Norway	Spain	Australia	Portugal	Singapore	Denmark	Switzerland	Brazil

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Annex Table 2.A.1: continued

Annex Table 2.A.1: Pillar Ranking By Country Technology Readiness								
Rank	Logistic Performance Index	Mobile Connectivity Index	ICT Capital Goods Imports Index	Human Capital	Digital Services Trade Restrictiveness Index	Digitally Deliverable Services Index	Government Promotion of Investments in Emerging	Global Cyber-security Index
21	United Kingdom	Estonia	Argentina	Luxembourg	Greece	Poland	Portugal	Belgium
22	Estonia	South Korea	Costa Rica	Ireland	Paraguay	Türkiye	Vietnam	Italy
23	Iceland	Belgium	Denmark	Japan	Slovenia	Australia	Austria	Finland
24	Ireland	Lithuania	Sweden	France	Israel	Brazil	Estonia	Indonesia
25	Israel	Slovenia	Finland	Slovenia	Hungary	Norway	New Zealand	Sweden
26	Luxembourg	Czechia	Indonesia	Austria	Czechia	Philippines	Australia	Vietnam
27	Malaysia	Israel	Austria	Poland	Belgium	Czechia	Lithuania	Greece
28	New Zealand	Italy	Canada	Germany	Vietnam	Malaysia	Türkiye	Austria
29	Poland	Slovakia	Portugal	Switzerland	Portugal	Mexico	Czechia	Poland
30	Latvia	Hungary	Iceland	Lithuania	Ireland	New Zealand	Laos	Denmark
31	Thailand	Portugal	Norway	Czechia	Thailand	Hungary	Iceland	China
32	Lithuania	China	Paraguay	Trinidad and Tobago	New Zealand	Portugal	Hungary	Slovakia
33	Portugal	Poland	United Kingdom	Latvia	Philippines	Indonesia	Slovenia	Hungary
34	Türkiye	Latvia	France	Spain	Italy	Argentina	Belgium	Israel
35	Czechia	Greece	New Zealand	Slovakia	Finland	Greece	Denmark	Switzerland
36	Philippines	Uruguay	Colombia	Italy	France	Slovakia	Norway	Thailand
37	Slovakia	Brazil	Latvia	Hungary	Germany	Costa Rica	Uruguay	Ireland
38	Slovenia	Chile	Estonia	Belgium	Spain	Panama	Philippines	New Zealand
39	Vietnam	Türkiye	Peru	Panama	Sweden	Thailand	Myanmar	Mexico
40	Brazil	Malaysia	Panama	Peru	Guatemala	Uruguay	Chile	Iceland
41	Hungary	Thailand	Trinidad and Tobago	Belize	Denmark	Slovenia	Spain	Philippines
42	Panama	Mexico	Chile	China	Lithuania	Estonia	Colombia	Uruguay
43	Chile	Brunei	Lithuania	Indonesia	Netherlands	Colombia	Poland	Dominican Republic
44	Indonesia	Panama	Nicaragua	Colombia	Estonia	Latvia	Latvia	Slovenia
45	Peru	Costa Rica	Italy	Bolivia	Luxembourg	Lithuania	Guyana	Czechia
46	Uruguay	Vietnam	Slovenia	Myanmar	Japan	Iceland	Mexico	Chile
47	Colombia	Indonesia	Türkiye	Brazil	Slovakia	Chile	Trinidad and Tobago	Costa Rica
48	Costa Rica	Colombia	Belgium	Guyana	Mexico	El Salvador	Italy	Colombia
49	Honduras	Argentina	Ecuador	Türkiye	Australia	Peru	Argentina	Paraguay
50	Mexico	Peru	Spain	Costa Rica	Norway	Vietnam	Costa Rica	Brunei
51	Argentina	Ecuador	Switzerland	Mexico	Switzerland	Dominican Republic	Jamaica	Peru
52	El Salvador	Paraguay	Greece	Chile	United Kingdom	Nicaragua	Dominican Republic	Argentina
53	Paraguay	Trinidad and Tobago	Uruguay	Vietnam	United States	Cambodia	Cambodia	Myanmar

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Annex Table 2.A.1: continued

Annex Table 2.A.1: Pillar Ranking By Country Technology Readiness								
Rank	Logistic Performance Index	Mobile Connectivity Index	ICT Capital Goods Imports Index	Human Capital	Digital Services Trade Restrictiveness Index	Digitally Deliverable Services Index	Government Promotion of Investments in Emerging	Global Cyber-security Index
54	Dominican Republic	Dominican Republic	Dominican Republic	Argentina	Costa Rica	Trinidad and Tobago	Slovakia	Panama
55	Guatemala	Philippines	Belize	Honduras	Ecuador	Ecuador	Panama	Jamaica
56	Jamaica	Belize	Luxembourg	Nicaragua	Dominican Republic	Honduras	Brazil	Suriname
57	Nicaragua	Bolivia	Guatemala	Thailand	Canada	Bolivia	Peru	Guyana
58	Trinidad and Tobago	Venezuela	Suriname	Dominican Republic	Malaysia	Laos	Belize	Venezuela
59	Bolivia	El Salvador	Jamaica	Suriname	Panama	Paraguay	Suriname	Ecuador
60	Cambodia	Suriname	Brunei	Philippines	Trinidad and Tobago	Venezuela	Venezuela	Trinidad and Tobago
61	Guyana	Guyana	Honduras	Venezuela	Guyana	Singapore	Ecuador	Laos
62	Laos	Guatemala	Bolivia	Jamaica	Jamaica	Brunei	Greece	Cambodia
63	Venezuela	Cambodia	Venezuela	Paraguay	El Salvador	Belize	Guatemala	Bolivia
64	Belize	Laos	Guyana	El Salvador	Nicaragua	Guyana	Paraguay	El Salvador
65	Brunei	Jamaica	Myanmar	Ecuador	Venezuela	Jamaica	Bolivia	Guatemala
66	Ecuador	Honduras	Cambodia	Guatemala	Honduras	Myanmar	El Salvador	Belize
67	Myanmar	Nicaragua	China	Laos	Myanmar	Guatemala	Honduras	Nicaragua
68	Suriname	Myanmar	El Salvador	Cambodia	Suriname	Suriname	Nicaragua	Honduras

Source: Authors' calculations using World Bank (Connecting to Compete: LPI 2023); GSMA (Mobile Connectivity Index 2023); UN Comtrade (2022 release); Oxford Insights (Government AI Readiness Index 2023); OECD (DSTRI and Digitally Deliverable Services data); Portulans Institute (Network Readiness Index 2023); and International Telecommunication Union (Global Cybersecurity Index, various years).

Conceptual framing and indicator grouping adapted from Estevadeordal, A., Kahn, T. and Werner, A. (2024) Latin America in the New Geometry of Global Supply Chains. Washington, DC: CAF – Georgetown Americas Institute.

Note: Higher values indicate stronger technological and digital readiness. Scores are min–max normalized (0–100) across all economies within the Latin America and Caribbean (LAC) region. Missing values are excluded from pillar averages.

Annex Table 2.A.2: Pillar Rankings By Country Sustainability Readiness								
Rank	Low Carbon Intensity Index	Renewable Energy Consumption Index	Trade In Energy Transition Goods Index	Protectionism in Energy Transition Goods Index	Critical Mineral Index	Biodiversity and Habitat Environmental Performance	Exposure to Natural Disasters Index	Vulnerability To Natural Disasters Index
1	Switzerland	Iceland	Panama	Venezuela	Australia	Germany	Czechia	Finland
2	Sweden	Paraguay	Chile	Brazil	Brazil	France	Hungary	Sweden
3	Costa Rica	Norway	Peru	Argentina	China	Thailand	Luxembourg	Luxembourg
4	Ireland	Uruguay	Australia	Cambodia	Indonesia	Belize	Paraguay	South Korea
5	Iceland	Costa Rica	Jamaica	Uruguay	Chile	Slovenia	Singapore	Iceland
6	Singapore	Sweden	Greece	Bolivia	Türkiye	Latvia	South Korea	Denmark
7	Denmark	Denmark	Brazil	Paraguay	Bolivia	Belgium	Austria	Türkiye
8	Panama	New Zealand	Hungary	Suriname	Argentina	Estonia	Denmark	Ireland
9	Paraguay	Brazil	Brunei	Guyana	United States	Laos	Switzerland	Japan
10	Uruguay	Austria	Luxembourg	Belize	Mexico	Singapore	Bolivia	Switzerland
11	France	Ecuador	South Korea	China	Peru	Czechia	Slovakia	Slovakia
12	Venezuela	Switzerland	Finland	Malaysia	Philippines	Austria	Estonia	Netherlands
13	United Kingdom	Finland	Laos	Laos	Canada	Lithuania	Laos	Austria
14	Colombia	El Salvador	Malaysia	Indonesia	Poland	Portugal	Finland	Estonia
15	Norway	Belize	Sweden	Chile	Germany	Netherlands	Iceland	Germany
16	Luxembourg	Honduras	Italy	Ecuador	Czechia	Australia	Trinidad and Tobago	Lithuania
17	Portugal	Latvia	Estonia	South Korea	Spain	Myanmar	Lithuania	Portugal
18	Italy	Portugal	Germany	Myanmar	Portugal	Bolivia	Latvia	Hungary
19	Latvia	Laos	Japan	Ireland	Norway	Iceland	Israel	Greece
20	Spain	Colombia	Czechia	Philippines	Austria	Denmark	Sweden	Belgium
21	Guatemala	Venezuela	Singapore	Luxembourg	Finland	Dominican Republic	Jamaica	Norway
22	Austria	Peru	Thailand	Estonia	Belgium	Brazil	Norway	New Zealand
23	El Salvador	Nicaragua	China	Thailand	Belize	Ecuador	Ireland	Czechia
24	Dominican Republic	Suriname	Lithuania	Slovakia	Brunei	Colombia	Uruguay	Italy
25	Peru	Canada	United States	Latvia	Cambodia	Italy	Poland	Singapore
26	Myanmar	Guatemala	Denmark	Netherlands	Colombia	Finland	Belgium	Slovenia
27	Nicaragua	Luxembourg	Iceland	Lithuania	Costa Rica	United Kingdom	Suriname	Spain
28	Netherlands	Cambodia	Portugal	Vietnam	Denmark	Philippines	Germany	Poland
29	Finland	Chile	Slovenia	Hungary	Dominican Republic	Malaysia	Netherlands	China
30	Germany	Spain	Poland	Jamaica	Ecuador	Greece	Belize	United Kingdom
31	Brazil	Lithuania	Netherlands	Slovenia	El Salvador	South Korea	Cambodia	United States
32	Hungary	Greece	Türkiye	Czechia	Estonia	Nicaragua	Guyana	Suriname
33	Belgium	Vietnam	Mexico	Greece	France	Costa Rica	United Kingdom	Canada
34	Estonia	Italy	Austria	Poland	Greece	Japan	France	Australia

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Annex Table 2.A.2: continued

Annex Table 2.A.2: Pillar Rankings By Country Sustainability Readiness								
Rank	Low Carbon Intensity Index	Renewable Energy Consumption Index	Trade In Energy Transition Goods Index	Protectionism in Energy Transition Goods Index	Critical Mineral Index	Biodiversity and Habitat Environmental Performance	Exposure to Natural Disasters Index	Vulnerability To Natural Disasters Index
35	New Zealand	Panama	Latvia	Finland	Guatemala	Sweden	Portugal	Chile
36	Philippines	Slovenia	Spain	Portugal	Guyana	Trinidad and Tobago	Guatemala	Uruguay
37	Slovenia	Ireland	Slovakia	Denmark	Honduras	Ireland	Brazil	France
38	Israel	Myanmar	Canada	Spain	Hungary	Chile	Dominican Republic	Guyana
39	Slovakia	United Kingdom	Belgium	Belgium	Iceland	Indonesia	El Salvador	Trinidad and Tobago
40	Argentina	Germany	Philippines	Italy	Ireland	Spain	Spain	Latvia
41	Mexico	Türkiye	Ecuador	Austria	Israel	Switzerland	Greece	Costa Rica
42	Honduras	Estonia	France	Sweden	Italy	Panama	Malaysia	Argentina
43	Greece	Philippines	Israel	France	Jamaica	Slovakia	Italy	Panama
44	Indonesia	Bolivia	United Kingdom	Germany	Japan	Canada	Honduras	Paraguay
45	Türkiye	China	Colombia	Türkiye	Laos	Norway	Türkiye	Laos
46	Chile	United States	Vietnam	Panama	Latvia	Cambodia	Costa Rica	Brazil
47	Guyana	Australia	Suriname	Trinidad and Tobago	Lithuania	Hungary	Slovenia	Belize
48	Ecuador	Mexico	Indonesia	United States	Luxembourg	New Zealand	Argentina	Malaysia
49	Bolivia	France	Switzerland	Dominican Republic	Malaysia	Paraguay	Chile	Israel
50	Japan	Japan	Norway	Australia	Myanmar	Brunei	Thailand	Dominican Republic
51	Czechia	Argentina	Costa Rica	Israel	Netherlands	Jamaica	Ecuador	Vietnam
52	United States	Netherlands	Dominican Republic	New Zealand	New Zealand	Peru	Panama	Venezuela
53	Poland	Slovakia	El Salvador	Colombia	Nicaragua	Luxembourg	Peru	Nicaragua
54	Thailand	Hungary	Uruguay	Mexico	Panama	Suriname	New Zealand	Bolivia
55	Jamaica	Malaysia	Cambodia	Nicaragua	Paraguay	Guyana	Nicaragua	Mexico
56	Belize	Thailand	Ireland	Honduras	Singapore	Argentina	Venezuela	El Salvador
57	South Korea	Dominican Republic	Guatemala	El Salvador	Slovakia	Israel	Myanmar	Jamaica
58	Cambodia	Belgium	Trinidad and Tobago	Guatemala	Slovenia	Venezuela	Canada	Honduras
59	Suriname	Indonesia	New Zealand	Japan	South Korea	Guatemala	Vietnam	Guatemala
60	Malaysia	Jamaica	Paraguay	United Kingdom	Suriname	Uruguay	Australia	Cambodia
61	Australia	South Korea	Argentina	Costa Rica	Sweden	El Salvador	Colombia	Thailand
62	Canada	Czechia	Honduras	Peru	Switzerland	Honduras	Indonesia	Ecuador
63	Lithuania	Guyana	Myanmar	Canada	Thailand	United States	Philippines	Peru
64	Laos	Israel	Nicaragua	Brunei	Trinidad and Tobago	Mexico	Japan	Indonesia

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Annex Table 2.A.2: continued

Annex Table 2.A.2: Pillar Rankings By Country Sustainability Readiness								
Rank	Low Carbon Intensity Index	Renewable Energy Consumption Index	Trade In Energy Transition Goods Index	Protectionism in Energy Transition Goods Index	Critical Mineral Index	Biodiversity and Habitat Environmental Performance	Exposure to Natural Disasters Index	Vulnerability To Natural Disasters Index
65	Vietnam	Poland	Bolivia	Iceland	United Kingdom	Türkiye	Mexico	Colombia
66	Brunei	Singapore	Guyana	Norway	Uruguay	Poland	China	Philippines
67	Trinidad and Tobago	Brunei	Belize	Singapore	Venezuela	Vietnam	Brunei	Myanmar
68	China	Trinidad and Tobago	Venezuela	Switzerland	Vietnam	China	United States	Brunei

Source: Authors' calculations using World Bank (World Development Indicators 2024, CO_2 intensity and renewable energy share); UN Comtrade (2022 exports and MFN tariffs); U.S. Department of Commerce (Executive Order 14017critical-goods list); U.S. Geological Survey (Mineral Commodity Summaries 2024); Yale University (Environmental Performance Index 2024); and WorldRisk Index 2024 (Bündnis Entwicklung Hilft & Ruhr University Bochum).

Conceptual framing and indicator grouping adapted from Estevadeordal, A., Kahn, T. and Werner, A. (2024) Latin America in the New Geometry of Global Supply Chains. Washington, DC: CAF – Georgetown Americas Institute.

Note: Higher values indicate stronger environmental and energy-transition readiness. Scores are min–max normalized (0–100) across all LAC economies. Countries with no mineral reserves receive 0 for that component.

Annex Table 2.A.3: Pillar rankings By Country Institutional And Geopolitical Resilience								
Rank	Export Similarity with China Index	Trade Bans Index	Security Threat Index	Trade with Sanctioned Countries Index	Political Distance from Trading Partners Index	Nonalignment in UN Voting Index	Ethnic Cohesion Index	Working Age Population Index
1	Czechia	United States	Portugal	Belize	Luxembourg	Germany	Denmark	Singapore
2	Vietnam	Brunei	Slovenia	Suriname	Iceland	Belgium	El Salvador	Jamaica
3	Germany	Laos	Iceland	Cambodia	Belgium	Denmark	Germany	South Korea
4	South Korea	Venezuela	Luxembourg	Laos	Austria	Lithuania	Ireland	Brazil
5	Italy	Belize	Singapore	Myanmar	Trinidad and Tobago	Luxembourg	Italy	Malaysia
6	Poland	Suriname	Denmark	Trinidad and Tobago	Denmark	Netherlands	Jamaica	Colombia
7	Thailand	Iceland	Slovakia	Australia	Portugal	Poland	Latvia	Trinidad and Tobago
8	France	Latvia	Austria	Canada	Jamaica	Slovakia	Lithuania	Thailand
9	Netherlands	Cambodia	Norway	Mexico	Slovakia	Slovenia	Norway	China
10	Austria	Guyana	Switzerland	Ireland	Ireland	Greece	Portugal	Costa Rica
11	Türkiye	Luxembourg	Japan	Chile	Sweden	Estonia	South Korea	Luxembourg
12	Japan	Bolivia	South Korea	Panama	Slovenia	Latvia	Sweden	Chile
13	Hungary	Honduras	New Zealand	Luxembourg	Latvia	Norway	Uruguay	Myanmar
14	Spain	Nicaragua	Estonia	New Zealand	France	Portugal	Czechia	Vietnam
15	Slovakia	Slovakia	Hungary	Philippines	Norway	Spain	Poland	Türkiye
16	Lithuania	Trinidad and Tobago	Netherlands	Peru	Czechia	Iceland	France	Indonesia
17	Portugal	Estonia	Poland	Bolivia	Netherlands	Czechia	Japan	Slovakia
18	Sweden	Paraguay	Czechia	Iceland	Spain	South Korea	Greece	Belize
19	Denmark	El Salvador	Finland	Dominican Republic	Estonia	Finland	Paraguay	Mexico
20	United States	Uruguay	Latvia	Nicaragua	Italy	Italy	Dominican Republic	Ecuador
21	Malaysia	Panama	Australia	Vietnam	Germany	Hungary	Finland	El Salvador
22	Singapore	Slovenia	Ireland	Jamaica	Laos	France	Austria	Poland
23	Slovenia	Jamaica	Sweden	Norway	Guyana	Austria	Costa Rica	Suriname
24	Mexico	Myanmar	Canada	Portugal	United Kingdom	Ireland	Chile	Iceland
25	Estonia	Guatemala	Lithuania	Guyana	Israel	New Zealand	Honduras	Spain
26	United Kingdom	Lithuania	Germany	United States	Lithuania	Sweden	Hungary	Austria
27	Belgium	Ecuador	Belgium	Colombia	Poland	Switzerland	Brazil	Switzerland
28	Latvia	Hungary	Israel	Malaysia	Bolivia	Japan	Netherlands	Honduras
29	Philippines	Peru	Spain	Singapore	Switzerland	United Kingdom	New Zealand	Peru
30	Finland	Costa Rica	Costa Rica	Israel	Belize	Australia	Venezuela	Hungary
31	Israel	Dominican Republic	France	Denmark	Costa Rica	Türkiye	Philippines	Dominican Republic

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Annex Table 2.A.3: continued

Annex Table 2.A.3: Pillar rankings By Country Institutional And Geopolitical Resilience								
Rank	Export Similarity with China Index	Trade Bans Index	Security Threat Index	Trade with Sanctioned Countries Index	Political Distance from Trading Partners Index	Nonalignment in UN Voting Index	Ethnic Cohesion Index	Working Age Population Index
32	Indonesia	Finland	United Kingdom	Indonesia	Panama	Canada	Mexico	Canada
33	Canada	Greece	Guyana	Switzerland	Finland	Brazil	Panama	Uruguay
34	Greece	Norway	Suriname	Austria	Colombia	Guatemala	Cambodia	Ireland
35	Luxembourg	Denmark	Vietnam	Sweden	Dominican Republic	Honduras	Nicaragua	Cambodia
36	Switzerland	China	Chile	Japan	Canada	Panama	Australia	Panama
37	Cambodia	Colombia	Uruguay	Uruguay	El Salvador	Colombia	Türkiye	Argentina
38	El Salvador	Czechia	Brunei	France	Paraguay	Myanmar	Slovenia	New Zealand
39	Brazil	New Zealand	Laos	Belgium	Ecuador	Uruguay	Argentina	Nicaragua
40	Ireland	Poland	Argentina	United Kingdom	Greece	Mexico	United Kingdom	Guyana
41	Guatemala	Austria	Italy	Germany	Mexico	Argentina	Slovakia	Australia
42	Dominican Republic	Ireland	Panama	Spain	Singapore	Costa Rica	Vietnam	Laos
43	Myanmar	Philippines	United States	Slovenia	Hungary	Dominican Republic	Colombia	United States
44	Colombia	Türkiye	Malaysia	Argentina	Malaysia	Chile	Thailand	Paraguay
45	Costa Rica	Sweden	China	Thailand	United States	Paraguay	Estonia	Norway
46	Peru	Switzerland	Indonesia	Netherlands	Suriname	Ecuador	Guatemala	Bolivia
47	New Zealand	Chile	Bolivia	Czechia	Argentina	Peru	Belgium	Netherlands
48	Norway	Israel	Greece	Brazil	Philippines	Guyana	United States	Philippines
49	Chile	Portugal	Nicaragua	Hungary	Guatemala	Suriname	Spain	Slovenia
50	Australia	Argentina	Paraguay	Costa Rica	Peru	Belize	Myanmar	Portugal
51	Honduras	Vietnam	Ecuador	South Korea	Indonesia	Jamaica	Ecuador	Venezuela
52	Laos	Indonesia	El Salvador	Ecuador	Honduras	El Salvador	Switzerland	Belgium
53	Argentina	Australia	Peru	Honduras	Brazil	Trinidad and Tobago	Canada	Lithuania
54	Ecuador	Malaysia	Brazil	Brunei	Myanmar	Venezuela	Malaysia	Germany
55	Paraguay	Belgium	Guatemala	Guatemala	Brunei	Thailand	Peru	Italy
56	Uruguay	Brazil	Cambodia	Paraguay	Cambodia	Singapore	China	Czechia
57	Trinidad and Tobago	Germany	Dominican Republic	Slovakia	Uruguay	Philippines	Trinidad and Tobago	United Kingdom
58	Iceland	Italy	Türkiye	Italy	Thailand	Vietnam	Bolivia	Greece
59	Brunei	Netherlands	Colombia	El Salvador	South Korea	Bolivia	Laos	Denmark
60	Jamaica	Spain	Venezuela	Poland	Chile	Malaysia	Israel	Estonia
61	Venezuela	Mexico	Belize	China	Australia	Brunei	Indonesia	Guatemala
62	Suriname	Thailand	Honduras	Venezuela	Türkiye	Laos	Luxembourg	Latvia
63	Bolivia	France	Jamaica	Finland	Japan	Indonesia	Iceland	Sweden
64	Panama	Singapore	Trinidad and Tobago	Latvia	New Zealand	Cambodia	Singapore	Finland

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Annex Table 2.A.3: continued

Annex Table 2.A.3: Pillar rankings By Country Institutional And Geopolitical Resilience								
Rank	Export Similarity with China Index	Trade Bans Index	Security Threat Index	Trade with Sanctioned Countries Index	Political Distance from Trading Partners Index	Nonalignment in UN Voting Index	Ethnic Cohesion Index	Working Age Population Index
65	Nicaragua	United Kingdom	Thailand	Estonia	Vietnam	Israel	Suriname	France
66	Guyana	Canada	Mexico	Greece	Venezuela	Nicaragua	Guyana	Israel
67	Belize	Japan	Myanmar	Lithuania	Nicaragua	China	Belize	Brunei
68	China	South Korea	Philippines	Türkiye	China	United States	Brunei	Japan

Source: Authors' calculations using World Bank (World Development Indicators, governance and demography); UN Comtrade (trade with sanctioned partners); Global Trade Alert (trade bans and restrictions); Freedom House (Freedom in the World); Erik Voeten (UN General Assembly Voting Data); Fund for Peace (Fragile States Index, security category); and Ethnic Power Relations (EPR) Dataset (ETH Zurich).

Conceptual framing and indicator grouping adapted from Estevadeordal, A., Kahn, T. and Werner, A. (2024) Latin America in the New Geometry of Global Supply Chains. Washington, DC: CAF – Georgetown Americas Institute.

Note: Higher values indicate stronger institutional, demographic, and political resilience. Scores are min–max normalized (0–100) within the LAC region. Composite rankings are equal-weighted averages across available indicators.

Annex 2.2: Indicator Definitions and Source Data (LAC)

Annex Table 2.A.4: Technology Indicators								
Country	Logistic Performance index	Mobile Connectivity index	ICT Capital Goods Imports index	Human Capital - AI Readiness index	Digital Services Trade Restrictiveness index	Digitally Deliverable Services index	Government Promotion of Investments in Emerging Techs index	Global Cybersecurity index
Argentina	0.560	0.668	0.197	0.349	0.660	0.640	0.349	0.501
Australia	0.740	0.906	0.204	0.754	0.939	0.709	0.512	0.975
Austria	0.800	0.868	0.176	0.707	0.798	0.745	0.537	0.939
Belgium	0.800	0.834	0.114	0.588	0.838	0.794	0.456	0.963
Belize	0.000	0.603	0.096	0.448	0.000	n/a	0.235	0.103
Bolivia	0.480	0.593	0.085	0.422	0.758	0.314	0.066	0.161
Brazil	0.640	0.762	0.226	0.401	0.777	0.707	0.284	0.966
Brunei	0.000	0.712	0.088	0.938	0.768	n/a	0.703	0.561
Cambodia	0.480	0.546	0.050	0.000	0.595	0.410	0.311	0.191
Canada	0.800	0.855	0.176	0.774	1.000	0.817	0.742	0.977
Chile	0.600	0.761	0.128	0.358	0.737	0.491	0.381	0.688
China	0.740	0.807	0.000	0.432	0.692	0.883	1.000	0.925
Colombia	0.580	0.678	0.152	0.425	0.701	0.551	0.379	0.637
Costa Rica	0.580	0.706	0.197	0.363	0.957	0.595	0.343	0.675
Czechia	0.660	0.823	0.411	0.663	0.837	0.692	0.492	0.744
Denmark	0.820	0.909	0.196	0.886	0.896	0.739	0.456	0.926
Dominican Republic	0.520	0.635	0.101	0.303	0.960	0.468	0.315	0.751
Ecuador	0.000	0.652	0.114	0.198	0.957	0.396	0.217	0.263
El Salvador	0.540	0.571	0.000	0.203	n/a	0.488	0.059	0.133
Estonia	0.720	0.844	0.151	0.866	0.917	0.558	0.519	0.995
Finland	0.840	0.905	0.188	0.803	0.877	0.759	0.831	0.958
France	0.780	0.846	0.164	0.720	0.877	0.860	0.748	0.976
Germany	0.820	0.860	0.249	0.697	0.877	0.912	0.734	0.974
Greece	0.740	0.785	0.106	0.739	0.816	0.626	0.178	0.940
Guatemala	0.520	0.550	0.092	0.163	0.895	n/a	0.089	0.131
Guyana	0.480	0.556	0.070	0.374	n/a	n/a	0.368	0.281
Honduras	0.580	0.513	0.088	0.343	n/a	0.364	0.022	0.022
Hungary	0.640	0.817	0.362	0.600	0.834	0.654	0.465	0.913
Iceland	0.720	0.866	0.170	0.906	0.733	0.502	0.469	0.798
Indonesia	0.600	0.679	0.178	0.427	0.693	0.642	0.604	0.949
Ireland	0.720	0.889	0.355	0.721	0.856	0.923	0.578	0.859
Israel	0.720	0.822	0.271	0.960	0.820	0.778	0.833	0.909
Italy	0.740	0.822	0.123	0.608	0.874	0.809	0.357	0.961
Jamaica	0.500	0.514	0.090	0.264	n/a	n/a	0.335	0.325
Japan	0.780	0.846	0.313	0.721	0.918	0.876	0.717	0.978
Laos	0.480	0.525	0.205	0.079	0.501	0.310	0.478	0.203
Latvia	0.700	0.798	0.152	0.658	0.777	0.551	0.373	0.973

Note: Numbers are min–max normalized to 0–1 and shown as provided. "N/A" = unavailable. Country-level indicator values are normalized within indicators and grouped by readiness pillar.

Annex Table 2.A.4: Technology Indicators								
Country	Logistic Performance index	Mobile Connectivity index	ICT Capital Goods Imports index	Human Capital - AI Readiness index	Digital Services Trade Restrictiveness index	Digitally Deliverable Services index	Government Promotion of Investments in Emerging Techs index	Global Cybersecurity index
Lithuania	0.680	0.833	0.127	0.669	0.896	0.528	0.506	0.979
Luxembourg	0.720	0.861	0.094	0.727	0.917	0.861	0.949	0.974
Malaysia	0.720	0.739	0.670	0.844	n/a	0.668	0.764	0.981
Mexico	0.580	0.717	0.469	0.363	0.921	0.657	0.368	0.817
Myanmar	0.000	0.475	0.056	0.413	n/a	n/a	0.384	0.364
Netherlands	0.820	0.868	0.314	0.776	0.896	0.874	0.666	0.971
New Zealand	0.720	0.878	0.163	0.813	0.860	0.657	0.516	0.840
Nicaragua	0.500	0.503	0.124	0.340	n/a	0.447	0.022	0.090
Norway	0.740	0.905	0.170	0.806	0.939	0.701	0.456	0.969
Panama	0.620	0.709	0.143	0.566	n/a	0.586	0.289	0.341
Paraguay	0.540	0.652	0.167	0.247	0.819	0.283	0.067	0.571
Peru	0.600	0.661	0.148	0.557	0.758	0.470	0.253	0.557
Philippines	0.660	0.630	0.560	0.275	0.873	0.695	0.392	0.770
Poland	0.720	0.801	0.229	0.705	0.697	0.738	0.379	0.939
Portugal	0.680	0.808	0.171	0.732	0.855	0.645	0.545	0.973
Singapore	0.860	0.931	1.000	1.000	0.800	n/a	0.996	0.985
Slovakia	0.660	0.820	0.243	0.633	0.920	0.601	0.300	0.924
Slovenia	0.660	0.830	0.115	0.708	0.819	0.562	0.459	0.749
South Korea	0.760	0.836	0.559	0.774	0.797	0.785	0.775	0.985
Spain	0.780	0.845	0.113	0.647	0.877	0.782	0.381	0.985
Suriname	0.000	0.571	0.091	0.282	n/a	n/a	0.235	0.312
Sweden	0.800	0.878	0.189	0.869	0.878	0.790	0.714	0.946
Switzerland	0.820	0.912	0.112	0.693	0.939	0.866	0.573	0.870
Thailand	0.700	0.738	0.341	0.306	0.859	0.580	0.644	0.865
Trinidad and Tobago	0.500	0.649	0.130	0.660	n/a	0.404	0.368	0.222
Türkiye	0.680	0.747	0.115	0.365	0.736	0.714	0.502	0.975
United Kingdom	0.740	0.879	0.165	0.833	0.939	0.856	0.665	0.995
United States	0.760	0.886	0.689	0.740	0.939	1.000	0.786	1.000
Uruguay	0.600	0.765	0.106	0.752	0.682	0.579	0.435	0.752
Venezuela	0.460	0.578	0.077	0.266	n/a	0.000	0.235	0.271
Vietnam	0.660	0.685	0.671	0.355	0.854	0.470	0.541	0.946

Note: Numbers are min–max normalized to 0–1 and shown as provided. "N/A" = unavailable. Country-level indicator values are normalized within indicators and grouped by readiness pillar.

Annex Table 2.A.5: Sustainability Indicators								
Country	Low Carbon Intensity index	Renewable Energy Consumption index	Trade in energy transition goods index	Protectionism in energy transition goods index	Critical Mineral index	Biodiversity and Habitat-Environmental Performance index	Exposure to Natural Disasters index	Vulnerability to Natural Disasters index
Argentina	0.729	0.115	0.017	0.096	0.343	0.491	0.885	0.789
Australia	0.438	0.124	0.456	0.831	1.000	0.837	0.688	0.854
Austria	0.851	0.421	0.144	0.788	0.001	0.855	0.998	0.923
Belgium	0.801	0.078	0.123	0.785	0.000	0.874	0.982	0.906
Belize	0.601	0.387	0.000	0.435	0.000	0.879	0.975	0.766
Bolivia	0.663	0.148	0.008	0.345	0.361	0.836	0.997	0.731
Brazil	0.814	0.447	0.271	0.077	0.658	0.781	0.936	0.768
Brunei	0.297	0.000	0.225	0.994	0.000	0.592	0.000	0.000
Cambodia	0.505	0.268	0.030	0.269	0.000	0.601	0.975	0.704
Canada	0.413	0.307	0.125	0.992	0.106	0.605	0.741	0.861
Chile	0.697	0.262	0.496	0.653	0.547	0.653	0.871	0.851
China	0.000	0.148	0.164	0.506	0.613	0.190	0.354	0.873
Colombia	0.884	0.359	0.104	0.874	0.000	0.768	0.685	0.533
Costa Rica	0.986	0.612	0.059	0.926	0.000	0.701	0.901	0.796
Czechia	0.637	0.029	0.168	0.779	0.023	0.857	0.999	0.899
Denmark	0.949	0.461	0.162	0.782	0.000	0.817	0.998	0.942
Dominican Republic	0.847	0.082	0.059	0.824	0.000	0.816	0.930	0.752
Ecuador	0.690	0.414	0.118	0.677	0.000	0.773	0.854	0.655
El Salvador	0.851	0.396	0.053	0.911	0.000	0.358	0.927	0.717
Estonia	0.801	0.164	0.170	0.760	0.000	0.870	0.996	0.923
Finland	0.826	0.407	0.209	0.780	0.001	0.755	0.995	0.966
France	0.936	0.119	0.111	0.790	0.000	0.883	0.973	0.835
Germany	0.819	0.193	0.170	0.792	0.055	0.888	0.980	0.923
Greece	0.719	0.228	0.392	0.779	0.000	0.726	0.918	0.911
Guatemala	0.858	0.290	0.024	0.911	0.000	0.413	0.957	0.709
Guyana	0.692	0.026	0.001	0.413	0.000	0.510	0.974	0.832
Honduras	0.727	0.379	0.013	0.899	0.000	0.345	0.912	0.710
Hungary	0.804	0.101	0.229	0.777	0.000	0.599	0.999	0.914
Iceland	0.960	1.001	0.160	1.000	0.000	0.820	0.995	0.950
Indonesia	0.712	0.076	0.079	0.566	0.550	0.632	0.601	0.569
Ireland	0.962	0.202	0.029	0.715	0.000	0.658	0.986	0.934
Israel	0.744	0.025	0.111	0.834	0.000	0.476	0.991	0.755
Italy	0.866	0.212	0.171	0.785	0.000	0.756	0.913	0.899
Jamaica	0.604	0.054	0.396	0.777	0.000	0.582	0.989	0.713
Japan	0.656	0.119	0.169	0.914	0.000	0.697	0.563	0.934
Laos	0.333	0.361	0.199	0.562	0.000	0.867	0.996	0.778
Latvia	0.865	0.373	0.132	0.763	0.000	0.875	0.992	0.804
Lithuania	0.383	0.231	0.164	0.773	0.000	0.855	0.994	0.922
Luxembourg	0.881	0.284	0.224	0.756	0.000	0.551	0.999	0.956
Malaysia	0.457	0.092	0.188	0.559	0.000	0.729	0.914	0.761

Note: Numbers are min–max normalized to 0–1 and shown as provided. "N/A" = unavailable. Country-level indicator values are normalized within indicators and grouped by readiness pillar.

Annex Table 2.A.5: Sustainability Indicators								
Country	Low Carbon Intensity index	Renewable Energy Consumption index	Trade in energy transition goods index	Protectionism in energy transition goods index	Critical Mineral index	Biodiversity and Habitat-Environmental Performance index	Exposure to Natural Disasters index	Vulnerability to Natural Disasters index
Mexico	0.728	0.121	0.145	0.879	0.145	0.310	0.499	0.718
Myanmar	0.837	0.197	0.009	0.714	0.000	0.837	0.776	0.439
Netherlands	0.828	0.112	0.151	0.770	0.000	0.840	0.978	0.926
New Zealand	0.801	0.452	0.021	0.870	0.000	0.596	0.820	0.905
Nicaragua	0.833	0.344	0.009	0.898	0.000	0.715	0.813	0.733
Norway	0.883	0.792	0.064	1.000	0.003	0.604	0.989	0.906
Panama	0.943	0.212	1.000	0.804	0.000	0.628	0.841	0.787
Paraguay	0.938	0.843	0.020	0.363	0.000	0.595	0.999	0.784
Peru	0.844	0.347	0.489	0.971	0.140	0.566	0.834	0.612
Philippines	0.777	0.149	0.121	0.755	0.118	0.730	0.600	0.452
Poland	0.615	0.022	0.153	0.779	0.056	0.209	0.983	0.876
Portugal	0.870	0.368	0.160	0.780	0.005	0.850	0.969	0.916
Singapore	0.950	0.008	0.168	1.000	0.000	0.864	0.999	0.899
Slovakia	0.735	0.105	0.128	0.761	0.000	0.626	0.997	0.933
Slovenia	0.776	0.208	0.158	0.777	0.000	0.876	0.900	0.889
South Korea	0.520	0.039	0.211	0.697	0.000	0.725	0.999	0.956
Spain	0.859	0.241	0.131	0.784	0.006	0.630	0.922	0.879
Suriname	0.473	0.328	0.091	0.370	0.000	0.530	0.982	0.867
Sweden	0.998	0.500	0.185	0.789	0.000	0.678	0.990	0.959
Switzerland	1.000	0.412	0.068	1.000	0.000	0.630	0.998	0.934
Thailand	0.615	0.088	0.165	0.760	0.000	0.880	0.857	0.695
Trinidad and Tobago	0.100	0.000	0.022	0.807	0.000	0.675	0.995	0.825
Türkiye	0.701	0.182	0.151	0.794	0.466	0.250	0.911	0.942
United Kingdom	0.890	0.195	0.107	0.916	0.000	0.751	0.974	0.870
United States	0.624	0.148	0.164	0.808	0.310	0.333	0.000	0.870
Uruguay	0.938	0.645	0.031	0.316	0.000	0.374	0.985	0.843
Venezuela	0.891	0.351	0.000	0.000	0.000	0.464	0.805	0.742
Vietnam	0.299	0.227	0.097	0.773	0.000	0.201	0.733	0.750

Note: Numbers are min–max normalized to 0–1 and shown as provided. "N/A" = unavailable. Country-level indicator values are normalized within indicators and grouped by readiness pillar.

Annex Table 2.A.6: Geopolitical Indicators								
Country	Export Similarity with China index	Trade Bans index	Security Threat index	Trade with sanctioned countries index	Political distance from trading partners index	Nonalignment in UN voting index	Ethnic Cohesion index	Working age population index
Argentina	0.138	0.155	0.570	0.838	0.578	0.421	0.689	0.506
Australia	0.153	0.121	0.790	0.982	0.359	0.758	0.706	0.499
Austria	0.779	0.207	0.860	0.906	0.915	0.852	0.865	0.560
Belgium	0.605	0.103	0.760	0.876	0.918	0.906	0.508	0.415
Belize	0.010	0.500	0.320	1.000	0.717	0.364	n/a	0.650
Bolivia	0.044	0.431	0.470	0.951	0.727	0.293	0.313	0.457
Brazil	0.326	0.086	0.380	0.809	0.498	0.630	0.765	0.817
Brunei	0.071	0.638	0.610	0.781	0.442	0.286	n/a	0.000
Cambodia	0.348	0.466	0.360	0.988	0.430	0.249	0.730	0.521
Chile	0.155	0.172	0.640	0.966	0.369	0.397	0.848	0.744
China	n/a	0.224	0.510	0.660	0.000	0.000	0.331	0.767
Colombia	0.233	0.224	0.330	0.926	0.690	0.481	0.588	0.805
Costa Rica	0.222	0.310	0.710	0.808	0.716	0.407	0.865	0.764
Czechia	0.999	0.224	0.800	0.819	0.822	0.882	0.981	0.391
Denmark	0.696	0.259	0.890	0.918	0.905	0.906	1.000	0.383
Dominican Republic	0.260	0.310	0.350	0.948	0.684	0.401	0.870	0.538
Ecuador	0.113	0.328	0.400	0.791	0.650	0.391	0.463	0.604
Canada	0.446	0.000	0.780	0.978	0.668	0.704	0.417	0.531
El Salvador	0.343	0.397	0.400	0.690	0.664	0.354	1.000	0.597
Estonia	0.618	0.414	0.830	0.386	0.775	0.892	0.527	0.363
Finland	0.531	0.293	0.800	0.479	0.709	0.879	0.869	0.252
France	0.819	0.017	0.710	0.879	0.833	0.869	0.953	0.220
Germany	0.922	0.069	0.770	0.849	0.770	0.909	1.000	0.407
Greece	0.442	0.293	0.450	0.168	0.634	0.896	0.941	0.384
Guatemala	0.296	0.345	0.380	0.765	0.563	0.616	0.514	0.339
Guyana	0.015	0.466	0.670	0.927	0.748	0.384	n/a	0.500
Honduras	0.150	0.431	0.320	0.782	0.533	0.562	0.830	0.546
Hungary	0.764	0.328	0.820	0.809	0.616	0.875	0.812	0.542
Iceland	0.085	0.483	0.960	0.949	0.921	0.886	n/a	0.585
Indonesia	0.465	0.138	0.480	0.916	0.544	0.263	0.209	0.699
Ireland	0.306	0.207	0.790	0.968	0.849	0.848	1.000	0.524
Israel	0.484	0.172	0.740	0.923	0.738	0.175	0.216	0.120
Italy	0.882	0.052	0.550	0.724	0.775	0.879	1.000	0.399
Jamaica	0.067	0.362	0.300	0.933	0.884	0.357	1.000	0.982
Japan	0.775	0.000	0.850	0.892	0.303	0.781	0.947	0.000
Laos	0.147	0.638	0.610	0.986	0.749	0.269	0.283	0.498
Latvia	0.591	0.483	0.800	0.389	0.834	0.892	1.000	0.324
Lithuania	0.725	0.345	0.780	0.106	0.734	0.906	1.000	0.412
Luxembourg	0.403	0.466	0.960	0.963	1.000	0.906	n/a	0.763
Malaysia	0.682	0.121	0.520	0.926	0.608	0.293	0.404	0.815

Note: Numbers are min–max normalized to 0–1 and shown as provided. "N/A" = unavailable. Country-level indicator values are normalized within indicators and grouped by readiness pillar.

Annex Table 2.A.6: Geopolitical Indicators								
Country	Export Similarity with China index	Trade Bans index	Security Threat index	Trade with sanctioned countries index	Political distance from trading partners index	Nonalignment in UN voting index	Ethnic Cohesion index	Working age population index
Mexico	0.626	0.034	0.170	0.974	0.628	0.438	0.735	0.650
Myanmar	0.242	0.362	0.090	0.986	0.454	0.468	0.478	0.737
Netherlands	0.784	0.052	0.820	0.827	0.806	0.902	0.760	0.453
New Zealand	0.176	0.224	0.840	0.955	0.300	0.845	0.758	0.503
Nicaragua	0.036	0.431	0.440	0.943	0.087	0.155	0.718	0.503
Norway	0.169	0.276	0.860	0.930	0.829	0.892	1.000	0.494
Panama	0.039	0.379	0.540	0.966	0.711	0.488	0.733	0.511
Paraguay	0.110	0.414	0.430	0.764	0.657	0.394	0.890	0.496
Peru	0.183	0.328	0.400	0.952	0.550	0.391	0.396	0.544
Philippines	0.542	0.207	0.090	0.955	0.575	0.327	0.743	0.450
Poland	0.867	0.224	0.820	0.683	0.728	0.902	0.965	0.592
Portugal	0.713	0.172	0.970	0.930	0.886	0.892	1.000	0.428
Singapore	0.649	0.017	0.960	0.925	0.625	0.343	n/a	1.000
Slovakia	0.735	0.431	0.880	0.738	0.859	0.902	0.668	0.657
Slovenia	0.645	0.379	0.970	0.846	0.840	0.902	0.691	0.429
South Korea	0.899	0.000	0.850	0.804	0.402	0.882	1.000	0.881
Spain	0.753	0.052	0.720	0.847	0.800	0.889	0.496	0.568
Suriname	0.056	0.500	0.660	0.999	0.588	0.374	n/a	0.588
Sweden	0.698	0.190	0.790	0.904	0.849	0.845	1.000	0.298
Switzerland	0.372	0.190	0.860	0.909	0.718	0.838	0.420	0.549
Thailand	0.825	0.034	0.200	0.828	0.407	0.350	0.559	0.782
Trinidad and Tobago	0.088	0.431	0.270	0.983	0.911	0.354	0.319	0.793
Türkiye	0.778	0.207	0.340	0.000	0.355	0.726	0.701	0.711
United Kingdom	0.614	0.017	0.710	0.863	0.740	0.778	0.674	0.388
United States	0.684	1.000	0.530	0.927	0.598	0.000	0.504	0.498
Uruguay	0.091	0.397	0.640	0.880	0.415	0.458	1.000	0.527
Venezuela	0.064	0.534	0.330	0.501	0.243	0.354	0.744	0.421
Vietnam	0.965	0.155	0.650	0.938	0.271	0.310	0.611	0.734

Note: Numbers are min–max normalized to 0–1 and shown as provided. "N/A" = unavailable. Country-level indicator values are normalized within indicators and grouped by readiness pillar.

Annex 2.3: Africa Readiness Indicators

This appendix presents the country-level data and composite rankings that underpin the readiness diagnostics for Africa, as discussed in Chapter 2.

Indicators are min-max normalized (0-1) and grouped into six composite pillars:

(1) Technology readiness
(2) Trade and investment readiness
(3) Sustainability and energy readiness
(4) Institutional and geopolitical readiness
(5) Financial readiness
(6) Business readiness

The tables report normalized indicator scores (0-1), composite pillar rankings and overall readiness scores for all African economies, enabling comparative benchmarking across subregions and against global reference economies.

Annex Table 2.A.7: Pillar Rankings By Country Technology Readiness			
Rank	Artificial Intelligence Preparedness Index (AIPI)	Internet Penetration Index	Mobile Connectivity Index
1	Denmark	Bahrain	Singapore
2	Singapore	United Arab Emirates	Switzerland
3	Netherlands	Iceland	Denmark
4	Estonia	Qatar	Australia
5	Finland	Kuwait	Finland
6	Switzerland	Saudi Arabia	Norway
7	New Zealand	Luxembourg	United Arab Emirates
8	Germany	Denmark	Ireland
9	Sweden	Norway	Netherlands
10	Luxembourg	Australia	United Kingdom
11	Japan	Switzerland	Germany
12	United Kingdom	United Kingdom	Sweden
13	Australia	Sweden	New Zealand
14	Austria	New Zealand	France
15	Israel	Oman	Canada
16	Canada	Ireland	Luxembourg
17	Norway	Singapore	Austria
18	Iceland	Spain	Belgium
19	France	Canada	Iceland
20	Ireland	Netherlands	Estonia
21	Belgium	Malaysia	Japan
22	Lithuania	Belgium	Spain
23	Malta	Finland	Lithuania
24	Spain	Austria	Portugal
25	Czechia	Germany	Qatar
26	Portugal	Estonia	Italy
27	China	Chile	Czechia
28	Slovenia	Latvia	Slovenia
29	Cyprus	Cyprus	China
30	Latvia	Israel	Latvia
31	Malaysia	Kazakhstan	Slovakia
32	United Arab Emirates	Malta	Hungary
33	Italy	Libya	Croatia
34	Poland	Slovakia	Cyprus
35	Slovakia	Hungary	Israel
36	Chile	Japan	Greece
37	Romania	Slovenia	Kuwait
38	Croatia	Morocco	Poland
39	Greece	Uruguay	Uruguay
40	Bulgaria	Belarus	Bulgaria
41	Saudi Arabia	Argentina	Bahrain

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Annex Table 2.A.7: continued

Annex Table 2.A.7: Pillar Rankings By Country Technology Readiness			
Rank	Artificial Intelligence Preparedness Index (AIPI)	Internet Penetration Index	Mobile Connectivity Index
42	Hungary	Azerbaijan	Malta
43	Kazakhstan	Lithuania	Brazil
44	Uruguay	France	Chile
45	Costa Rica	Seychelles	Saudi Arabia
46	Serbia	Poland	Romania
47	Thailand	Jordan	Malaysia
48	Qatar	Czechia	Thailand
49	Oman	Costa Rica	Mexico
50	Mexico	Lebanon	Serbia
51	Seychelles	Bhutan	Kazakhstan
52	Georgia	Romania	Moldova
53	Albania	Thailand	Costa Rica
54	Mauritius	Portugal	Oman
55	Indonesia	Serbia	Indonesia
56	Bahrain	Croatia	Panama
57	Ukraine	Brazil	Peru
58	Brazil	Greece	Georgia
59	Panama	Jamaica	Colombia
60	Philippines	Uzbekistan	Paraguay
61	South Africa	Ukraine	Vietnam
62	Armenia	Albania	Armenia
63	India	Italy	Ukraine
64	Peru	Armenia	South Africa
65	Colombia	Georgia	Azerbaijan
66	Mongolia	Mexico	Mauritius
67	Jordan	Paraguay	Seychelles
68	Vietnam	Bulgaria	Belarus
69	Moldova	Botswana	Albania
70	Argentina	Vietnam	Dominican Republic
71	Azerbaijan	South Africa	Argentina
72	Belarus	Panama	Philippines
73	Dominican Republic	Suriname	India
74	Tunisia	Fiji	Mongolia
75	Kuwait	China	Ecuador
76	Fiji	Mongolia	Jordan
77	Kenya	Colombia	Tunisia
78	Bhutan	Mauritius	Belize
79	Ecuador	Grenada	Libya
80	Rwanda	Peru	Morocco
81	Sri Lanka	Ecuador	Samoa

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Annex Table 2.A.7: continued

Annex Table 2.A.7: Pillar Rankings By Country Technology Readiness			
Rank	Artificial Intelligence Preparedness Index (AIPI)	Internet Penetration Index	Mobile Connectivity Index
82	Jamaica	Moldova	El Salvador
83	Morocco	Tunisia	Uzbekistan
84	Ghana	Algeria	Bolivia
85	Belize	Belize	Botswana
86	Namibia	Gabon	Fiji
87	Lebanon	Philippines	Bhutan
88	Suriname	Djibouti	Lebanon
89	Botswana	El Salvador	Guatemala
90	Paraguay	Indonesia	Suriname
91	Senegal	Namibia	Cambodia
92	El Salvador	Ghana	Sri Lanka
93	Guatemala	Cambodia	Jamaica
94	Bangladesh	Senegal	Ghana
95	Bolivia	Samoa	Nicaragua
96	Zambia	Myanmar	Algeria
97	Algeria	Guatemala	Nepal
98	Cambodia	Honduras	Bangladesh
99	Liberia	Nicaragua	Gabon
100	Pakistan	Tajikistan	Vanuatu
101	Tajikistan	Lesotho	Nigeria
102	Benin	Vanuatu	Honduras
103	Lesotho	India	Namibia
104	Uganda	Sri Lanka	Myanmar
105	Nepal	Cameroon	Kenya
106	Honduras	Angola	Cameroon
107	Cameroon	Bangladesh	Senegal
108	Malawi	Solomon Islands	Lesotho
109	Nigeria	Nigeria	Rwanda
110	Nicaragua	Zimbabwe	Pakistan
111	Myanmar	Mali	Papua New Guinea
112	Niger	Mauritania	Zambia
113	Guinea	Togo	Angola
114	Gabon	Kenya	Uganda
115	Djibouti	Zambia	Togo
116	Togo	Rwanda	Zimbabwe
117	Madagascar	Benin	Solomon Islands
118	Zimbabwe	Guinea	Mozambique
119	Sierra Leone	Guinea-Bissau	Benin
120	Mali	Papua New Guinea	Sierra Leone
121	Papua New Guinea	Pakistan	Mauritania

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Annex Table 2.A.7: continued

Annex Table 2.A.7: Pillar Rankings By Country Technology Readiness			
Rank	Artificial Intelligence Preparedness Index (AIPI)	Internet Penetration Index	Mobile Connectivity Index
122	Guinea-Bissau	Liberia	Tajikistan
123	Angola	Niger	Malawi
124	Mozambique	Sierra Leone	Guinea
125	Ethiopia	Mozambique	Ethiopia
126	Libya	Ethiopia	Liberia
127	Mauritania	Malawi	Madagascar
128	Grenada	Madagascar	Mali
129	Uzbekistan	Uganda	Guinea-Bissau
130	Samoa	Dominican Republic	Niger
131	Vanuatu	Bolivia	Grenada
132	Solomon Islands	Nepal	Djibouti

Source: Authors' calculations using International Monetary Fund (Artificial Intelligence Preparedness Index 2024); International Telecommunication Union (ITU DataHub); and GSMA (Mobile Connectivity Index 2024).
Note: Scores are min-max normalized (0-100). Higher values indicate greater technological and digital readiness across African economies.

Annex Table 2.A.8: Pillar Rankings By Country Trade and Investment Readiness			
Rank	Logistics Performance Index (LPI)	Trade to GDP Ratio Index	Tariff Restrictiveness Index (TRI)
1	Finland	Luxembourg	Algeria
2	Singapore	Singapore	Zimbabwe
3	Denmark	Djibouti	India
4	Germany	Ireland	Cameroon
5	Netherlands	Malta	Gabon
6	Switzerland	United Arab Emirates	Morocco
7	Austria	Slovakia	Ethiopia
8	Belgium	Cyprus	Nepal
9	Canada	Seychelles	Bangladesh
10	Sweden	Vietnam	Sierra Leone
11	United Arab Emirates	Belgium	Togo
12	France	Netherlands	Benin
13	Japan	Hungary	Liberia
14	Spain	Slovenia	Ghana
15	Australia	Estonia	Niger
16	China	Lithuania	Guinea
17	Greece	Bahrain	Guinea-Bissau
18	Italy	Lesotho	Mali
19	Norway	Latvia	Senegal
20	South Africa	Czechia	Nigeria
21	United Kingdom	Cambodia	Samoa
22	Estonia	Switzerland	Mauritania
23	Iceland	Malaysia	Solomon Islands
24	Ireland	Belarus	Grenada
25	Israel	Mongolia	Suriname
26	Luxembourg	Bulgaria	Belize
27	Malaysia	Libya	Madagascar
28	New Zealand	Denmark	Argentina
29	Poland	Thailand	Bhutan
30	Bahrain	Serbia	Mozambique
31	Latvia	Austria	Serbia
32	Qatar	Mozambique	Brazil
33	Thailand	Poland	Chile
34	India	Georgia	Mongolia
35	Lithuania	Croatia	Myanmar
36	Portugal	Nicaragua	Tajikistan
37	Saudi Arabia	Mauritius	China
38	Croatia	Honduras	Tunisia
39	Czechia	Tunisia	Zambia
40	Malta	Belize	Fiji
41	Oman	Guinea	Cambodia

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Annex Table 2.A.8: continued

Annex Table 2.A.8: Pillar Rankings By Country Trade and Investment Readiness			
Rank	Logistics Performance Index (LPI)	Trade to GDP Ratio Index	Tariff Restrictiveness Index (TRI)
42	Philippines	Sweden	Oman
43	Slovakia	Fiji	Uruguay
44	Slovenia	Armenia	Indonesia
45	Vietnam	Qatar	Philippines
46	Brazil	Oman	Qatar
47	Bulgaria	Mauritania	United Arab Emirates
48	Cyprus	Moldova	Pakistan
49	Hungary	Namibia	Belarus
50	Kuwait	Jamaica	Armenia
51	Romania	Portugal	Uganda
52	Botswana	Greece	Paraguay
53	Panama	Jordan	Libya
54	Chile	Kuwait	Vanuatu
55	Indonesia	Romania	Kenya
56	Peru	Ukraine	Kazakhstan
57	Uruguay	Morocco	Malawi
58	Benin	Gabon	Rwanda
59	Colombia	Panama	Thailand
60	Costa Rica	Finland	Azerbaijan
61	Honduras	Azerbaijan	Vietnam
62	Mexico	Iceland	Switzerland
63	Namibia	Botswana	Ecuador
64	Argentina	Germany	Angola
65	Rwanda	Mexico	Uzbekistan
66	Serbia	El Salvador	Costa Rica
67	Solomon Islands	Bhutan	Ukraine
68	Sri Lanka	Lebanon	Mexico
69	Belarus	Zambia	El Salvador
70	Djibouti	Albania	Colombia
71	El Salvador	Samoa	Honduras
72	Georgia	Norway	Sri Lanka
73	Kazakhstan	Vanuatu	Jamaica
74	Papua New Guinea	Paraguay	Dominican Republic
75	Paraguay	Solomon Islands	Nicaragua
76	Ukraine	Costa Rica	Jordan
77	Bangladesh	Ghana	Guatemala
78	Dominican Republic	Senegal	Japan
79	Guatemala	Spain	South Africa
80	Guinea-Bissau	Mali	Lesotho
81	Mali	Angola	Panama
82	Nigeria	France	United Kingdom

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Annex Table 2.A.8: continued

Annex Table 2.A.8: Pillar Rankings By Country Trade and Investment Readiness			
Rank	Logistics Performance Index (LPI)	Trade to GDP Ratio Index	Tariff Restrictiveness Index (TRI)
83	Uzbekistan	Philippines	Namibia
84	Albania	Canada	Botswana
85	Algeria	Chile	Albania
86	Armenia	United Kingdom	Australia
87	Bhutan	Italy	Malaysia
88	Ghana	Kazakhstan	New Zealand
89	Grenada	Tajikistan	Canada
90	Guinea	Uzbekistan	Peru
91	Jamaica	Madagascar	Papua New Guinea
92	Mauritius	Togo	Norway
93	Moldova	Rwanda	Israel
94	Mongolia	Saudi Arabia	Iceland
95	Nicaragua	South Africa	Seychelles
96	Tajikistan	Bolivia	Georgia
97	Togo	Israel	Mauritius
98	Zimbabwe	Zimbabwe	Singapore
99	Bolivia	Ecuador	Luxembourg
100	Cambodia	Uruguay	Ireland
101	Gabon	Benin	Netherlands
102	Liberia	Peru	Belgium
103	Fiji	Dominican Republic	Malta
104	Madagascar	New Zealand	Denmark
105	Mauritania	Guatemala	Djibouti
106	Angola	Guinea-Bissau	Austria
107	Cameroon	Algeria	Finland
108	Libya	Australia	Estonia
109	Suriname	Nepal	Sweden
110	Myanmar	India	Germany
111	Malawi	Sri Lanka	Slovakia
112	Morocco	Sierra Leone	Bahrain
113	Mozambique	Colombia	Lithuania
114	Belize	Indonesia	Latvia
115	Samoa	Japan	Slovenia
116	Senegal	Cameroon	Cyprus
117	Tunisia	Uganda	Spain
118	Nepal	China	Poland
119	Sierra Leone	Brazil	France
120	Zambia	Niger	Hungary
121	Ethiopia	Argentina	Greece
122	Niger	Kenya	Czechia
123	Vanuatu	Bangladesh	Italy

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Annex Table 2.A.8: continued

Annex Table 2.A.8: Pillar Rankings By Country Trade and Investment Readiness			
Rank	**Logistics Performance Index (LPI)**	**Trade to GDP Ratio Index**	**Tariff Restrictiveness Index (TRI)**
124	Azerbaijan	Ethiopia	Bulgaria
125	Lesotho	Pakistan	Croatia
126	Uganda	Suriname	Portugal
127	Pakistan	Myanmar	Kuwait
128	Kenya	Malawi	Saudi Arabia
129	Ecuador	Nigeria	Romania
130	Jordan	Grenada	Moldova
131	Seychelles	Liberia	Lebanon
132	Lebanon	Papua New Guinea	Bolivia

Source: Authors' calculations using World Bank (Connecting to Compete: LPI 2023); WTO Tariff Data; WITS Database; and World Bank (World Development Indicators).

Note: Higher values reflect stronger openness and trade efficiency. Tariff-related variables are inverted so that higher scores correspond to more open regimes.

Annex Table 2.A.9: Pillar Rankings By Country Sustainability And Energy Readiness			
Rank	Modern Renewables Share Index	CO_2 Intensity Index	Energy Infrastructure Index (EII)
1	Gabon	Libya	Iceland
2	Iceland	Mongolia	Norway
3	Norway	Kuwait	Bhutan
4	Sweden	Oman	Sweden
5	Uruguay	South Africa	Finland
6	Finland	China	Canada
7	Brazil	Bahrain	Switzerland
8	Latvia	Qatar	France
9	Albania	Uzbekistan	Paraguay
10	Paraguay	Seychelles	New Zealand
11	Malawi	Samoa	Albania
12	Tajikistan	Kazakhstan	Austria
13	Denmark	Saudi Arabia	Costa Rica
14	Estonia	United Arab Emirates	Belgium
15	Austria	Vanuatu	Ethiopia
16	Uganda	Vietnam	Nepal
17	Costa Rica	Algeria	Uruguay
18	Lithuania	Moldova	Slovakia
19	Croatia	Canada	Malawi
20	Madagascar	Malaysia	Sierra Leone
21	Portugal	Ukraine	Uganda
22	New Zealand	Jamaica	Tajikistan
23	Fiji	Australia	Brazil
24	Sri Lanka	India	Denmark
25	Belize	Jordan	Lesotho
26	Chile	Suriname	Spain
27	Switzerland	Belarus	Zambia
28	Sierra Leone	Zimbabwe	Kenya
29	Georgia	Morocco	Latvia
30	Romania	Solomon Islands	Georgia
31	Serbia	Tunisia	Portugal
32	Colombia	Estonia	Mozambique
33	Cambodia	Tajikistan	El Salvador
34	Canada	Azerbaijan	Namibia
35	Slovenia	Bolivia	Slovenia
36	Zambia	Mozambique	Croatia
37	Namibia	Bulgaria	Ecuador
38	Bulgaria	Liberia	Panama
39	Greece	Malawi	Hungary
40	Cameroon	Poland	United Kingdom
41	Luxembourg	Thailand	Angola

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Annex Table 2.A.9: continued

Annex Table 2.A.9: Pillar Rankings By Country Sustainability And Energy Readiness			
Rank	Modern Renewables Share Index	CO_2 Intensity Index	Energy Infrastructure Index (EII)
42	Peru	Czechia	Belize
43	Panama	Fiji	Netherlands
44	Thailand	Ecuador	Ireland
45	Italy	Indonesia	Lithuania
46	Spain	Mexico	Armenia
47	Germany	Japan	Guinea
48	Slovakia	Slovakia	Luxembourg
49	Ecuador	Botswana	Colombia
50	India	Honduras	Romania
51	Czechia	Cambodia	Ukraine
52	France	Senegal	Peru
53	Vietnam	Georgia	Guatemala
54	El Salvador	Argentina	Italy
55	Poland	Cyprus	Fiji
56	Mozambique	Mauritania	Germany
57	Hungary	Pakistan	Qatar
58	Honduras	Lesotho	Bulgaria
59	Cyprus	Namibia	United Arab Emirates
60	Nicaragua	Chile	Greece
61	Ireland	Philippines	Nicaragua
62	Papua New Guinea	New Zealand	Chile
63	Suriname	Papua New Guinea	Honduras
64	Togo	Armenia	Rwanda
65	Indonesia	Greece	Cameroon
66	Mexico	Israel	Suriname
67	Belgium	Mauritius	Estonia
68	Ghana	Nepal	Kuwait
69	Bhutan	Benin	Zimbabwe
70	China	Brazil	Argentina
71	Australia	Dominican Republic	Singapore
72	Philippines	Slovenia	Czechia
73	Argentina	Iceland	Belarus
74	Netherlands	Mali	Japan
75	Zimbabwe	El Salvador	Samoa
76	Angola	Myanmar	Oman
77	Armenia	Belgium	Australia
78	Jordan	Hungary	Mali
79	Mauritius	Peru	Gabon
80	Rwanda	Germany	Malta
81	Malta	Nicaragua	Cambodia
82	Guinea-Bissau	Croatia	Mexico

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Annex Table 2.A.9: continued

Annex Table 2.A.9: Pillar Rankings By Country Sustainability And Energy Readiness			
Rank	Modern Renewables Share Index	CO_2 Intensity Index	Energy Infrastructure Index (EII)
83	Japan	Angola	Vietnam
84	Belarus	Colombia	Pakistan
85	Ukraine	Gabon	Liberia
86	Benin	Ghana	Ghana
87	Pakistan	Zambia	Israel
88	Morocco	Djibouti	Madagascar
89	Mali	Finland	Saudi Arabia
90	Dominican Republic	Austria	Bolivia
91	Nepal	Lithuania	Lebanon
92	Jamaica	Nigeria	Sri Lanka
93	Guatemala	Italy	China
94	Myanmar	Netherlands	Cyprus
95	Malaysia	Togo	Mauritania
96	Lesotho	Guatemala	Seychelles
97	Nigeria	Spain	Vanuatu
98	Samoa	Albania	Papua New Guinea
99	Israel	Latvia	Nigeria
100	Senegal	Panama	Bahrain
101	Kenya	Romania	Jordan
102	South Africa	Bangladesh	Malaysia
103	Lebanon	Norway	Thailand
104	Guinea	United Kingdom	Jamaica
105	Ethiopia	Uruguay	Myanmar
106	Vanuatu	Portugal	Tunisia
107	Mongolia	Luxembourg	Senegal
108	Kazakhstan	Madagascar	Togo
109	Niger	Cameroon	Mauritius
110	Tunisia	France	Serbia
111	Azerbaijan	Paraguay	Algeria
112	Uzbekistan	Singapore	Morocco
113	Mauritania	Grenada	Azerbaijan
114	Grenada	Sri Lanka	Grenada
115	Singapore	Kenya	Moldova
116	Seychelles	Guinea	Poland
117	United Arab Emirates	Costa Rica	Guinea-Bissau
118	Liberia	Niger	Benin
119	Solomon Islands	Denmark	Indonesia
120	Bangladesh	Guinea-Bissau	South Africa
121	Algeria	Belize	Solomon Islands
122	Djibouti	Ireland	Bangladesh
123	Botswana	Sweden	Djibouti

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Annex Table 2.A.9: continued

Annex Table 2.A.9: Pillar Rankings By Country Sustainability And Energy Readiness			
Rank	Modern Renewables Share Index	CO_2 Intensity Index	Energy Infrastructure Index (EII)
124	Kuwait	Uganda	India
125	Saudi Arabia	Malta	Kazakhstan
126	Oman	Ethiopia	Libya
127	Bahrain	Switzerland	Mongolia
128	Libya	Rwanda	Botswana
129	Qatar	Sierra Leone	Uzbekistan
130	Bolivia	Bhutan	Philippines
131	Moldova	Serbia	Dominican Republic
132	United Kingdom	Lebanon	Niger

Source: Authors' calculations using International Renewable Energy Agency (Renewable Energy Statistics 2024); International Energy Agency (World Energy Balances 2024); World Bank (World Development Indicators); European Commission EDGAR; and Ember (Yearly Electricity Data 2024).

Note: Scores are min–max normalized (0–100). CO_2 intensity is inverted so that lower emissions per unit GDP yield higher readiness. Higher values indicate stronger energy-transition capacity.

Annex Table 2.A.10: Pillar Rankings By Country Institutional and Geopolitical Readiness			
Rank	Political Stability Index	Electrification Readiness Index (ERI)	Regulatory Quality Index
1	New Zealand	Lithuania	New Zealand
2	Singapore	Hungary	Singapore
3	Iceland	Netherlands	Denmark
4	Luxembourg	Austria	Georgia
5	Switzerland	Switzerland	United Kingdom
6	Samoa	Greece	Norway
7	Botswana	Australia	Sweden
8	Norway	Italy	Lithuania
9	Uruguay	Portugal	Malaysia
10	Grenada	South Africa	Mauritius
11	Japan	Brazil	Australia
12	Bhutan	Spain	United Arab Emirates
13	Sweden	Ireland	Estonia
14	Vanuatu	Qatar	Latvia
15	Malta	Chile	Finland
16	Canada	Belgium	Thailand
17	Czechia	Romania	Germany
18	Ireland	Norway	Canada
19	Denmark	Germany	Ireland
20	Australia	Slovenia	Kazakhstan
21	Portugal	Poland	Iceland
22	Finland	Bulgaria	Austria
23	Qatar	Iceland	Japan
24	Mauritius	Denmark	China
25	Austria	United Kingdom	Spain
26	Costa Rica	Ecuador	France
27	Netherlands	Colombia	Azerbaijan
28	Lithuania	Sweden	Israel
29	Hungary	New Zealand	Switzerland
30	Slovenia	Canada	Portugal
31	Fiji	Peru	Rwanda
32	Seychelles	Latvia	Slovenia
33	Estonia	Ukraine	Poland
34	United Arab Emirates	Croatia	Czechia
35	Croatia	Israel	Netherlands
36	Mongolia	Czechia	Bahrain
37	Germany	China	Serbia
38	Slovakia	Japan	Slovakia
39	Namibia	Sri Lanka	Belgium
40	Belgium	India	Armenia
41	Latvia	France	Moldova

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Annex Table 2.A.10: continued

Annex Table 2.A.10: Pillar Rankings By Country Institutional and Geopolitical Readiness			
Rank	Political Stability Index	Electrification Readiness Index (ERI)	Regulatory Quality Index
42	Poland	Pakistan	Belarus
43	Oman	Slovakia	Croatia
44	United Kingdom	Vietnam	Cyprus
45	Solomon Islands	Argentina	Hungary
46	Romania	Malaysia	Morocco
47	Italy	Philippines	Romania
48	Cyprus	United Arab Emirates	Kenya
49	Belize	Finland	Italy
50	Bulgaria	Kazakhstan	Chile
51	Spain	Thailand	Mexico
52	Suriname	Morocco	Bulgaria
53	France	Azerbaijan	Saudi Arabia
54	Jamaica	Saudi Arabia	India
55	Kuwait	Mexico	Ukraine
56	Panama	Luxembourg	Colombia
57	Dominican Republic	Uzbekistan	Oman
58	Greece	Indonesia	Uzbekistan
59	Albania	Estonia	Vietnam
60	Malaysia	Algeria	Jamaica
61	Chile	Bangladesh	Indonesia
62	Rwanda	Belarus	Luxembourg
63	Zambia	Cyprus	Costa Rica
64	Ghana	Kuwait	Jordan
65	Paraguay	Oman	Peru
66	Vietnam	Singapore	Qatar
67	Argentina	Mauritius	Tunisia
68	Cambodia	Botswana	Greece
69	Gabon	Costa Rica	Mongolia
70	Serbia	Bhutan	Albania
71	Senegal	Georgia	Kuwait
72	El Salvador	Malta	South Africa
73	Sierra Leone	Rwanda	Zambia
74	Malawi	Samoa	Panama
75	Nepal	Mongolia	Botswana
76	Jordan	Uruguay	Malta
77	Liberia	Serbia	Bhutan
78	Uzbekistan	Jamaica	El Salvador
79	Kazakhstan	Vanuatu	Nepal
80	Ecuador	Seychelles	Philippines
81	Lesotho	Fiji	Guatemala
82	Morocco	Panama	Togo

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Annex Table 2.A.10: continued

Annex Table 2.A.10: Pillar Rankings By Country Institutional and Geopolitical Readiness			
Rank	Political Stability Index	Electrification Readiness Index (ERI)	Regulatory Quality Index
83	Guatemala	Bahrain	Samoa
84	Peru	Albania	Sri Lanka
85	Benin	Moldova	Seychelles
86	Bolivia	Namibia	Fiji
87	Sri Lanka	Zambia	Uruguay
88	Georgia	Grenada	Namibia
89	China	Jordan	Tajikistan
90	Moldova	Armenia	Vanuatu
91	Guinea-Bissau	El Salvador	Pakistan
92	Thailand	Dominican Republic	Malawi
93	Brazil	Solomon Islands	Djibouti
94	Djibouti	Belize	Dominican Republic
95	Indonesia	Kenya	Ghana
96	Saudi Arabia	Ghana	Uganda
97	Bahrain	Nepal	Papua New Guinea
98	Madagascar	Tunisia	Lesotho
99	Nicaragua	Paraguay	Senegal
100	South Africa	Malawi	Brazil
101	Angola	Guatemala	Paraguay
102	Honduras	Senegal	Argentina
103	Belarus	Lesotho	Ecuador
104	Mauritania	Djibouti	Nigeria
105	Tajikistan	Tajikistan	Niger
106	Papua New Guinea	Cambodia	Honduras
107	Tunisia	Papua New Guinea	Belize
108	Armenia	Suriname	Solomon Islands
109	India	Togo	Mozambique
110	Mexico	Uganda	Zimbabwe
111	Uganda	Honduras	Nicaragua
112	Philippines	Nicaragua	Lebanon
113	Colombia	Benin	Cambodia
114	Azerbaijan	Bolivia	Grenada
115	Algeria	Sierra Leone	Mali
116	Guinea	Mauritania	Benin
117	Togo	Gabon	Bolivia
118	Zimbabwe	Zimbabwe	Mauritania
119	Bangladesh	Madagascar	Guinea
120	Kenya	Mozambique	Algeria
121	Israel	Liberia	Ethiopia
122	Mozambique	Guinea	Madagascar
123	Ukraine	Guinea-Bissau	Sierra Leone

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Annex Table 2.A.10: continued

Annex Table 2.A.10: Pillar Rankings By Country Institutional and Geopolitical Readiness			
Rank	Political Stability Index	Electrification Readiness Index (ERI)	Regulatory Quality Index
124	Cameroon	Niger	Suriname
125	Lebanon	Lebanon	Myanmar
126	Niger	Angola	Cameroon
127	Nigeria	Nigeria	Bangladesh
128	Myanmar	Cameroon	Gabon
129	Ethiopia	Ethiopia	Guinea-Bissau
130	Pakistan	Myanmar	Liberia
131	Libya	Mali	Angola
132	Mali	Libya	Libya

Source: Authors' calculations using World Bank (Worldwide Governance Indicators 2024); Energy Institute (Electricity Regulatory Index 2025), and World Bank (World Development Indicators).
Note: Higher scores denote more predictable, secure, and reliable institutional environments. ERI reflects the adequacy and resilience of national power systems.

Annex Table 2.A.11: Pillar Rankings By Country Financial Readiness			
Rank	Global Financial Readiness Index (GFRI)	Financial Depth Index	Financial Reserves Index
1	Finland	Japan	China
2	Iceland	China	Japan
3	Austria	Thailand	Switzerland
4	United Kingdom	Denmark	India
5	France	Australia	Saudi Arabia
6	Netherlands	Norway	Singapore
7	Lithuania	Cambodia	Germany
8	Estonia	Sweden	Brazil
9	Slovenia	Qatar	Italy
10	Denmark	Fiji	France
11	Norway	Malaysia	United Arab Emirates
12	Sweden	United Kingdom	Thailand
13	Japan	France	Mexico
14	Canada	Chile	Poland
15	Spain	Nepal	Israel
16	Switzerland	Finland	United Kingdom
17	Germany	Iceland	Indonesia
18	Ireland	Luxembourg	Czechia
19	Belgium	Austria	Canada
20	Australia	Netherlands	Malaysia
21	New Zealand	Jordan	Denmark
22	Malta	Honduras	Spain
23	Cyprus	Portugal	Philippines
24	Latvia	Samoa	Libya
25	Czechia	Brazil	Algeria
26	Slovakia	Spain	Vietnam
27	Portugal	Mauritius	Norway
28	Israel	Belgium	Netherlands
29	Greece	Georgia	Peru
30	Hungary	Bolivia	Romania
31	Italy	Armenia	South Africa
32	Chile	Malta	Sweden
33	Singapore	El Salvador	Colombia
34	Bahrain	Estonia	Australia
35	Ukraine	Italy	Qatar
36	Kenya	Slovakia	Kuwait
37	China	Cyprus	Hungary
38	Mongolia	Tunisia	Kazakhstan
39	Kuwait	Paraguay	Chile
40	Uruguay	Ecuador	Bulgaria
41	Croatia	Vanuatu	Ukraine

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Annex Table 2.A.11: continued

Annex Table 2.A.11: Pillar Rankings By Country Financial Readiness			
Rank	Global Financial Readiness Index (GFRI)	Financial Depth Index	Financial Reserves Index
42	Ghana	Grenada	Portugal
43	Brazil	Bhutan	Belgium
44	Senegal	Costa Rica	Uzbekistan
45	Serbia	Jamaica	Nigeria
46	Uganda	Philippines	Morocco
47	Saudi Arabia	Czechia	Austria
48	Kazakhstan	Greece	Lebanon
49	Bulgaria	Bulgaria	Serbia
50	Namibia	Croatia	Argentina
51	Poland	Colombia	Guatemala
52	Argentina	Belize	Cambodia
53	Georgia	Guatemala	New Zealand
54	United Arab Emirates	Indonesia	Jordan
55	Zambia	Lithuania	Bangladesh
56	South Africa	Bangladesh	Pakistan
57	Romania	Slovenia	Oman
58	Thailand	Mexico	Finland
59	Malaysia	Albania	Uruguay
60	Costa Rica	Poland	Greece
61	India	Uzbekistan	Slovakia
62	Oman	Botswana	Angola
63	Nigeria	Serbia	Costa Rica
64	Botswana	Hungary	Dominican Republic
65	Gabon	Dominican Republic	Azerbaijan
66	Togo	Uruguay	Ireland
67	Mauritius	Solomon Islands	Kenya
68	Vietnam	Nicaragua	Tunisia
69	Cameroon	Senegal	Belarus
70	Lesotho	Latvia	Mauritius
71	Azerbaijan	Moldova	Honduras
72	Moldova	Kazakhstan	Lithuania
73	Mali	Togo	Ecuador
74	Philippines	Azerbaijan	Panama
75	Liberia	Lesotho	Albania
76	Malawi	Ireland	Iceland
77	Peru	Djibouti	Nicaragua
78	Paraguay	Mali	Sri Lanka
79	Mozambique	Romania	Moldova
80	Benin	Rwanda	Mongolia
81	Panama	Algeria	Latvia
82	Uzbekistan	Benin	Bahrain

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Annex Table 2.A.11: continued

Annex Table 2.A.11: Pillar Rankings By Country Financial Readiness			
Rank	Global Financial Readiness Index (GFRI)	Financial Depth Index	Financial Reserves Index
83	Armenia	Mozambique	Georgia
84	Sierra Leone	Madagascar	Mozambique
85	Colombia	Suriname	Ethiopia
86	Zimbabwe	Argentina	El Salvador
87	Belize	Uganda	Armenia
88	Albania	Libya	Botswana
89	Sri Lanka	Pakistan	Namibia
90	Jordan	Guinea-Bissau	Croatia
91	Dominican Republic	Niger	Slovenia
92	Pakistan	Angola	Luxembourg
93	Bangladesh	Sierra Leone	Madagascar
94	Indonesia	Switzerland	Rwanda
95	Nepal	Germany	Cyprus
96	Bolivia	Canada	Estonia
97	Ecuador	Israel	Bolivia
98	Guinea	Singapore	Suriname
99	Cambodia	New Zealand	Fiji
100	Tajikistan	Saudi Arabia	Malta
101	Mexico	Ukraine	Lesotho
102	Morocco	India	Bhutan
103	Ethiopia	United Arab Emirates	Seychelles
104	Tunisia	Kuwait	Vanuatu
105	Madagascar	Ghana	Samoa
106	Honduras	Kenya	Belize
107	Libya	South Africa	Zimbabwe
108	Lebanon	Bahrain	Djibouti
109	El Salvador	Vietnam	Grenada
110	Mauritania	Peru	Ghana
111	Algeria	Mongolia	Zambia
112	Guatemala	Nigeria	Gabon
113	Nicaragua	Zambia	Cameroon
114	Niger	Oman	Nepal
115	Qatar	Belarus	Senegal
116	Belarus	Namibia	Liberia
117	Fiji	Gabon	Malawi
118	Luxembourg	Cameroon	Uganda
119	Jamaica	Morocco	Paraguay
120	Angola	Panama	Jamaica
121	Samoa	Liberia	Togo
122	Bhutan	Malawi	Mali
123	Rwanda	Lebanon	Benin

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Annex Table 2.A.11: continued

Annex Table 2.A.11: Pillar Rankings By Country Financial Readiness			
Rank	Global Financial Readiness Index (GFRI)	Financial Depth Index	Financial Reserves Index
124	Vanuatu	Sri Lanka	Guinea
125	Solomon Islands	Ethiopia	Tajikistan
126	Grenada	Guinea	Solomon Islands
127	Suriname	Tajikistan	Sierra Leone
128	Seychelles	Zimbabwe	Guinea-Bissau
129	Djibouti	Seychelles	Mauritania
130	Guinea-Bissau	Mauritania	Niger
131	Myanmar	Myanmar	Myanmar
132	Papua New Guinea	Papua New Guinea	Papua New Guinea

Source: Authors' calculations using World Bank (World Development Indicators); IMF (International Financial Statistics 2024), and World Bank (Global Findex Database 2025).

Note: Higher values indicate deeper financial systems, greater inclusion, and stronger external buffers. All indicators equally weighted within the composite.

Annex Table 2.A.12: Pillar Rankings By Country Business Readiness			
Rank	Firm Capacity Index (FCI)	Global Integration Index (GII)	Business Climate Index (BCI)
1	Liberia	Luxembourg	India
2	Seychelles	Slovenia	Lithuania
3	Samoa	Czechia	Benin
4	Ireland	Estonia	Bulgaria
5	Finland	Tunisia	Colombia
6	Iceland	Belgium	Czechia
7	Cyprus	Latvia	Finland
8	Mauritius	Austria	France
9	Gabon	Denmark	Israel
10	Luxembourg	Greece	Morocco
11	Belgium	Jordan	Rwanda
12	Chile	Italy	Samoa
13	Malta	Serbia	Zambia
14	Costa Rica	Croatia	Bangladesh
15	Solomon Islands	Bulgaria	Belize
16	Hungary	Mauritania	Bhutan
17	El Salvador	Finland	Canada
18	Estonia	Lithuania	Chile
19	New Zealand	Togo	Dominican Republic
20	Slovenia	Spain	Ethiopia
21	Denmark	Germany	Georgia
22	Czechia	Lesotho	Ghana
23	Portugal	Sweden	Greece
24	Italy	Lebanon	Jamaica
25	Lesotho	Belize	Jordan
26	Brazil	Belarus	Kazakhstan
27	Germany	Albania	Latvia
28	Croatia	Bahrain	Lesotho
29	Spain	Djibouti	Malawi
30	Paraguay	Iceland	Malaysia
31	Uruguay	Mauritius	Malta
32	Togo	Malta	Mexico
33	Philippines	Nigeria	Mozambique
34	Guinea-Bissau	Solomon Islands	Namibia
35	Bahrain	Fiji	New Zealand
36	Senegal	Morocco	Niger
37	Sweden	El Salvador	Suriname
38	Austria	Portugal	Uzbekistan
39	Lithuania	Mozambique	Armenia
40	Canada	Kenya	Azerbaijan
41	Rwanda	Georgia	Bahrain
42	Sierra Leone	Cyprus	Belgium

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Annex Table 2.A.12: continued

Annex Table 2.A.12: Pillar Rankings By Country Business Readiness			
Rank	Firm Capacity Index (FCI)	Global Integration Index (GII)	Business Climate Index (BCI)
43	France	France	Bolivia
44	Namibia	Canada	Botswana
45	Myanmar	Moldova	Cambodia
46	Jordan	Hungary	China
47	Ecuador	Costa Rica	Costa Rica
48	Greece	Romania	Croatia
49	Ghana	Cambodia	Cyprus
50	Colombia	Singapore	Denmark
51	Peru	Malaysia	Djibouti
52	Georgia	Bangladesh	Ecuador
53	Bolivia	Bolivia	El Salvador
54	Papua New Guinea	Nepal	Estonia
55	Guatemala	India	Gabon
56	Botswana	Ireland	Germany
57	Mauritania	New Zealand	Guinea
58	Tajikistan	Saudi Arabia	Guinea-Bissau
59	Romania	Armenia	Ireland
60	Latvia	Pakistan	Kenya
61	Nicaragua	Vanuatu	Liberia
62	Bhutan	Benin	Luxembourg
63	Albania	Ethiopia	Madagascar
64	Cambodia	Ghana	Mali
65	Nepal	Paraguay	Mauritius
66	Cameroon	Senegal	Nicaragua
67	Mozambique	Chile	Nigeria
68	Tunisia	Suriname	Paraguay
69	Dominican Republic	Malawi	Philippines
70	Armenia	Seychelles	Poland
71	Honduras	Gabon	Portugal
72	Poland	Namibia	Saudi Arabia
73	Kazakhstan	Cameroon	Senegal
74	Bulgaria	Botswana	Singapore
75	Moldova	Vietnam	Solomon Islands
76	Belarus	Papua New Guinea	Spain
77	Azerbaijan	Uruguay	Sweden
78	Serbia	Grenada	Tajikistan
79	Angola	Argentina	Togo
80	Mexico	Peru	Tunisia
81	Singapore	South Africa	Uganda
82	Thailand	Guatemala	Vanuatu
83	Morocco	Honduras	Zimbabwe

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Annex Table 2.A.12: continued

Annex Table 2.A.12: Pillar Rankings By Country Business Readiness			
Rank	Firm Capacity Index (FCI)	Global Integration Index (GII)	Business Climate Index (BCI)
84	Vietnam	Samoa	Albania
85	Israel	Dominican Republic	Angola
86	Malaysia	Ecuador	Argentina
87	China	Israel	Belarus
88	Jamaica	Myanmar	Brazil
89	Guinea	Niger	Cameroon
90	Niger	Bhutan	Grenada
91	Mali	Zambia	Guatemala
92	Argentina	Indonesia	Honduras
93	Zambia	Zimbabwe	Hungary
94	Kenya	Thailand	Iceland
95	Benin	Azerbaijan	Indonesia
96	Uzbekistan	Poland	Italy
97	Indonesia	Colombia	Moldova
98	Sri Lanka	Jamaica	Mongolia
99	Mongolia	China	Myanmar
100	Panama	Rwanda	Nepal
101	Bangladesh	Sri Lanka	Pakistan
102	Ethiopia	Panama	Panama
103	Vanuatu	Guinea-Bissau	Papua New Guinea
104	Djibouti	Mali	Romania
105	Madagascar	Mongolia	Seychelles
106	Nigeria	Madagascar	Sierra Leone
107	Malawi	Sierra Leone	South Africa
108	Fiji	Uganda	Sri Lanka
109	Pakistan	Philippines	Thailand
110	Grenada	Brazil	Uruguay
111	India	Nicaragua	Vietnam
112	Zimbabwe	Liberia	Austria
113	South Africa	Kazakhstan	Fiji
114	Suriname	Guinea	Lebanon
115	Belize	Uzbekistan	Mauritania
116	Lebanon	Tajikistan	Serbia
117	Saudi Arabia	Mexico	Slovenia
118	Uganda	Angola	Peru
119	Algeria	Algeria	Algeria
120	Australia	Australia	Australia
121	Japan	Japan	Japan
122	Kuwait	Kuwait	Kuwait
123	Libya	Libya	Libya
124	Netherlands	Netherlands	Netherlands

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Annex Table 2.A.12: continued

Annex Table 2.A.12: Pillar Rankings By Country Business Readiness			
Rank	Firm Capacity Index (FCI)	Global Integration Index (GII)	Business Climate Index (BCI)
125	Norway	Norway	Norway
126	Oman	Oman	Oman
127	Qatar	Qatar	Qatar
128	Slovakia	Slovakia	Slovakia
129	Switzerland	Switzerland	Switzerland
130	Ukraine	Ukraine	Ukraine
131	United Arab Emirates	United Arab Emirates	United Arab Emirates
132	United Kingdom	United Kingdom	United Kingdom

Source: Authors' calculations using World Bank (Enterprise Surveys 2024); World Bank (B-READY Program 2024), and OECD (SME and Entrepreneurship Outlook Database, comparative benchmark for selected economies).

Note: Higher values represent stronger firm-level capability, innovation, and participation in global value chains. Scores are normalized (0-100) and averaged with equal weights.

Annex 2.4: Indicator Definitions and Source Data (Africa)

Table 2.A.13: Normalized Indicators Technology, Trade & Investment, Sustainability, Institutional and Geopolitical, Financial and Business Readiness																			
			Technology Readiness			Trade & Investment Readiness			Sustainability Readiness			Institutional & Geopolitical Readiness			Financial Readiness			Business Readiness		
Economy	Region	Income Group	Artificial Intelligence Preparedness Index (AIPI)	Internet Penetration Index	Mobile Connectivity Index	Logistics Performance Index (LPI)	Trade to GDP Ratio Index	Tariff Restrictiveness Index (TRI)	Modern Renewables Share Index	CO_2 Intensity Index	Energy Infrastructure Index (EII)	Regulatory Quality Index	Political Stability Index	Electrification Readiness Index (ERI)	Financial Depth Index	Financial Reserves Index	Global Financial Readiness Index (GFRI)	Firm Capacity Index (FCI)	Global Integration Index (GII)	Business Climate Index (BCI)
Albania	OECD	Upper middle income	0.527	0.754	0.696	0.250	0.176	0.728	0.853	0.951	0.780	0.714	0.640	0.823	0.652	0.373	0.402	0.641	0.354	0.333
Algeria	AFRICA	Upper middle income	0.370	0.662	0.529	0.250	0.097	0.318	0.031	0.874	0.428	0.428	0.425	0.190	0.554	0.627	0.226	N/A	N/A	N/A
Angola	AFRICA	Lower middle income	0.260	0.341	0.404	0.083	0.154	0.602	0.534	0.945	0.675	0.319	0.491	0.591	0.425	0.451	N/A	0.578	0.006	0.333
Argentina	LAC	Upper middle income	0.474	0.850	0.691	0.375	0.058	0.411	0.538	0.924	0.587	0.584	0.592	0.101	0.512	0.524	0.588	0.538	0.120	0.333
Armenia	OECD	Upper middle income	0.493	0.739	0.713	0.250	0.223	0.511	0.529	0.931	0.655	0.816	0.450	0.579	0.769	0.316	0.417	0.617	0.184	0.500
Australia	OECD	High income	0.727	0.957	0.990	0.750	0.096	0.736	0.552	0.885	0.543	0.916	0.811	0.549	0.895	0.596	0.978	N/A	N/A	N/A
Austria	OECD	High income	0.725	0.914	0.937	0.875	0.273	N/A	0.810	0.948	0.780	0.879	0.791	0.798	0.815	0.542	0.996	0.743	0.640	0.167
Azerbaijan	OECD	Upper middle income	0.471	0.847	0.707	N/A	0.191	0.573	0.200	0.901	0.417	0.849	0.429	0.287	0.608	0.440	0.468	0.589	0.093	0.500
Bahrain	OECD	High income	0.515	1.000	0.847	0.667	0.373	N/A	0.000	0.809	0.476	0.838	0.498	0.190	N/A	0.346	0.794	0.747	0.345	0.500
Bangladesh	OECD	Lower middle income	0.384	0.333	0.518	0.292	0.056	0.377	0.065	0.954	0.383	0.374	0.393	0.192	0.662	0.492	0.381	0.493	0.206	0.667
Belarus	OECD	Upper middle income	0.471	0.862	0.705	0.333	0.315	0.504	0.499	0.894	0.581	0.813	0.483	0.000	N/A	0.404	N/A	0.596	0.358	0.333
Belgium	OECD	High income	0.672	0.922	0.936	0.875	0.433	N/A	0.567	0.941	0.768	0.823	0.727	0.035	0.780	0.558	0.981	0.885	0.675	0.500
Belize	LAC	Upper middle income	0.423	0.651	0.627	N/A	0.240	0.405	0.746	0.971	0.670	0.531	0.699	0.716	0.671	0.116	0.404	0.325	0.374	0.667
Benin	AFRICA	Lower middle income	0.363	0.207	0.344	0.417	0.113	0.380	0.496	0.937	0.406	0.485	0.522	0.460	0.550	N/A	0.428	0.532	0.179	0.833

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Annex Table 2.A.13: continued

Table 2.A.13: Normalized Indicators Technology, Trade & Investment, Sustainability, Institutional and Geopolitical, Financial and Business Readiness																			
			Technology Readiness			Trade & Investment Readiness			Sustainability Readiness			Institutional & Geopolitical Readiness			Financial Readiness			Business Readiness		
Economy	Region	Income Group	Artificial Intelligence Preparedness Index (AIPI)	Internet Penetration Index	Mobile Connectivity Index	Logistics Performance Index (LPI)	Trade to GDP Ratio Index	Tariff Restrictiveness Index (TRI)	Modern Renewables Share Index	CO_2 Intensity Index	Energy Infrastructure Index (EII)	Regulatory Quality Index	Political Stability Index	Electrification Readiness Index (ERI)	Financial Depth Index	Financial Reserves Index	Global Financial Readiness Index (GFRI)	Firm Capacity Index (FCI)	Global Integration Index (GII)	Business Climate Index (BCI)
Bhutan	OECD	Lower middle income	0.442	0.809	0.590	0.250	0.182	0.415	0.562	N/A	0.897	0.689	0.827	0.696	0.733	0.180	N/A	0.642	0.103	0.667
Bolivia	OECD	Lower middle income	0.377	N/A	0.599	0.208	0.127	N/A	N/A	0.901	0.505	0.475	0.521	0.505	0.771	0.254	0.346	0.698	0.203	0.500
Botswana	AFRICA	Upper middle income	0.413	0.723	0.596	0.500	0.190	0.721	0.025	0.919	0.277	0.692	0.845	0.126	0.647	0.310	0.494	0.677	0.128	0.500
Brazil	LAC	Upper middle income	0.501	0.786	0.842	0.542	0.067	0.440	0.867	0.938	0.733	0.585	0.503	0.878	0.797	0.765	0.643	0.777	0.056	0.333
Brunei	ASEAN	High income	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Bulgaria	OECD	High income	0.577	0.726	0.848	0.542	0.302	N/A	0.691	0.906	0.616	0.778	0.698	0.021	0.713	0.563	0.605	0.605	0.482	0.833
Burkina Faso	AFRICA	Low income	0.312	0.058	0.250	0.167	0.142	0.385	0.188	0.945	0.422	0.470	0.237	0.282	0.612	N/A	0.409	0.258	0.001	0.333
Burundi	AFRICA	Low income	0.295	0.023	0.173	N/A	0.052	0.537	0.231	0.961	0.633	0.401	0.306	0.392	N/A	N/A	N/A	0.463	0.129	0.333
Cambodia	ASEAN	Lower middle income	0.370	0.534	0.566	0.208	0.328	0.481	0.720	0.921	0.528	0.506	0.588	0.643	0.887	0.497	0.332	0.637	0.216	0.500
Cameroon	AFRICA	Lower middle income	0.341	0.359	0.464	0.083	0.078	0.321	0.680	0.959	0.602	0.391	0.285	0.649	N/A	N/A	0.479	0.636	0.131	0.333
Canada	OECD	High income	0.713	0.928	0.939	0.875	0.148	0.820	0.720	0.876	0.840	0.892	0.814	0.082	N/A	0.664	0.983	0.736	0.238	0.667
Chad	AFRICA	Low income	0.234	0.037	0.172	N/A	0.192	0.319	0.172	0.958	0.412	0.253	0.295	0.268	N/A	N/A	0.265	0.576	0.034	0.500
Chile	LAC	High income	0.586	0.895	0.842	0.458	0.144	0.440	0.745	0.926	0.610	0.787	0.630	0.691	0.853	0.565	0.826	0.883	0.141	0.667
China	CHINA	Upper middle income	0.635	0.699	0.898	0.750	0.073	0.468	0.559	0.805	0.500	0.867	0.510	0.156	0.968	1.000	0.763	0.557	0.085	0.500
Colombia	LAC	Upper middle income	0.489	0.694	0.729	0.417	0.082	0.682	0.722	0.945	0.645	0.750	0.431	0.691	0.680	0.598	0.408	0.703	0.090	0.833
Costa Rica	LAC	High income	0.540	0.812	0.756	0.417	0.162	0.649	0.798	0.966	0.774	0.737	0.787	0.789	0.729	0.451	0.510	0.871	0.223	0.500

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Annex Table 2.A.13: continued

Table 2.A.13: Normalized Indicators Technology, Trade & Investment, Sustainability, Institutional and Geopolitical, Financial and Business Readiness																				
			Technology Readiness			Trade & Investment Readiness			Sustainability Readiness			Institutional & Geopolitical Readiness			Financial Readiness			Business Readiness		
Economy	Region	Income Group	Artificial Intelligence Preparedness Index (AIPI)	Internet Penetration Index	Mobile Connectivity Index	Logistics Performance Index (LPI)	Trade to GDP Ratio Index	Tariff Restrictiveness Index (TRI)	Modern Renewables Share Index	CO_2 Intensity Index	Energy Infrastructure Index (EII)	Regulatory Quality Index	Political Stability Index	Electrification Readiness Index (ERI)	Financial Depth Index	Financial Reserves Index	Global Financial Readiness Index (GFRI)	Firm Capacity Index (FCI)	Global Integration Index (GII)	Business Climate Index (BCI)
Croatia	OECD	High income	0.582	0.793	0.887	0.583	0.255	N/A	0.791	0.943	0.689	0.802	0.752	0.750	0.711	0.306	0.692	0.773	0.485	0.500
Cyprus	OECD	High income	0.632	0.890	0.886	0.542	0.444	N/A	0.605	0.924	0.496	0.799	0.703	0.561	0.751	0.259	0.956	0.893	0.242	0.500
Czech Republic	OECD	High income	0.646	0.818	0.901	0.583	0.337	N/A	0.646	0.911	0.582	0.843	0.814	0.009	0.716	0.684	0.911	0.818	0.718	0.833
Denmark	OECD	High income	0.779	0.983	0.992	0.917	0.287	N/A	0.832	0.967	0.727	0.978	0.812	0.790	0.912	0.654	0.986	0.824	0.627	0.500
Djibouti	AFRICA	Lower middle income	0.319	0.586	N/A	0.333	0.767	N/A	0.028	0.947	0.383	0.606	0.503	0.170	0.587	0.080	N/A	0.470	0.333	0.500
Dominican Republic	LAC	Upper middle income	0.469	N/A	0.695	0.292	0.110	0.687	0.479	0.938	N/A	0.599	0.651	0.479	0.642	0.446	0.395	0.618	0.107	0.667
Ecuador	LAC	Upper middle income	0.442	0.674	0.666	N/A	0.116	0.601	0.658	0.912	0.687	0.564	0.543	0.670	0.743	0.379	0.338	0.718	0.107	0.500
El Salvador	LAC	Upper middle income	0.390	0.568	0.600	0.333	0.185	0.680	0.639	0.940	0.703	0.678	0.579	0.664	0.762	0.317	0.245	0.830	0.273	0.500
Estonia	OECD	High income	0.764	0.904	0.931	0.708	0.383	N/A	0.815	0.900	0.592	0.907	0.765	0.726	0.758	0.259	0.989	0.829	0.684	0.500
Ethiopia	AFRICA	Low income	0.254	0.095	0.311	N/A	0.042	0.367	0.312	0.975	0.758	0.419	0.194	0.491	N/A	0.319	0.273	0.482	0.179	0.667
Fiji	OECD	Upper middle income	0.449	0.707	0.594	0.167	0.227	0.478	0.762	0.911	0.623	0.621	0.773	0.706	0.877	0.233	N/A	0.438	0.289	0.167
Finland	OECD	High income	0.758	0.917	0.974	0.958	0.194	N/A	0.873	0.947	0.864	0.901	0.805	0.033	0.832	0.475	1.000	0.900	0.464	0.833
France	OECD	High income	0.698	0.842	0.944	0.833	0.154	N/A	0.643	0.960	0.813	0.850	0.681	0.013	0.861	0.750	0.992	0.733	0.242	0.833
Gabon	AFRICA	Upper middle income	0.323	0.643	0.515	0.208	0.195	0.326	0.941	0.945	0.532	0.374	0.587	0.777	N/A	N/A	0.494	0.887	0.137	0.500
Georgia	OECD	Upper middle income	0.530	0.738	0.733	0.333	0.259	0.913	0.729	0.922	0.714	0.954	0.514	0.723	0.780	0.335	0.586	0.702	0.244	0.667
Germany	OECD	High income	0.753	0.906	0.959	0.917	0.190	N/A	0.664	0.942	0.621	0.894	0.749	0.647	N/A	0.779	0.982	0.776	0.426	0.500

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Annex Table 2.A.13: continued

Table 2.A.13: Normalized Indicators Technology, Trade & Investment, Sustainability, Institutional and Geopolitical, Financial and Business Readiness																				
			Technology Readiness			Trade & Investment Readiness			Sustainability Readiness			Institutional & Geopolitical Readiness			Financial Readiness			Business Readiness		
Economy	Region	Income Group	Artificial Intelligence Preparedness Index (AIPI)	Internet Penetration Index	Mobile Connectivity Index	Logistics Performance Index (LPI)	Trade to GDP Ratio Index	Tariff Restrictiveness Index (TRI)	Modern Renewables Share Index	CO_2 Intensity Index	Energy Infrastructure Index (EII)	Regulatory Quality Index	Political Stability Index	Electrification Readiness Index (ERI)	Financial Depth Index	Financial Reserves Index	Global Financial Readiness Index (GFRI)	Firm Capacity Index (FCI)	Global Integration Index (GII)	Business Climate Index (BCI)
Ghana	AFRICA	Lower middle income	0.425	0.552	0.537	0.250	0.159	0.382	0.566	0.945	0.512	0.599	0.615	0.545	N/A	N/A	0.647	0.705	0.169	0.667
Greece	OECD	High income	0.582	0.786	0.855	0.750	0.209	N/A	0.681	0.931	0.612	0.725	0.642	0.653	0.716	0.458	0.867	0.715	0.590	0.667
Grenada	LAC	Upper middle income	N/A	0.678	N/A	0.250	N/A	0.398	0.155	0.962	0.417	0.500	0.836	0.260	0.736	0.100	N/A	0.424	0.123	0.333
Guatemala	LAC	Upper middle income	0.390	0.469	0.584	0.292	0.102	0.694	0.455	0.950	0.630	0.638	0.525	0.525	0.667	0.505	0.220	0.690	0.110	0.333
Guinea	AFRICA	Lower middle income	0.324	0.182	0.317	0.250	0.238	0.383	0.313	0.965	0.651	0.440	0.423	0.448	N/A	N/A	0.334	0.554	0.032	0.500
Guinea-Bissau	AFRICA	Low income	0.265	0.182	0.260	0.292	0.098	0.383	0.502	0.967	0.412	0.347	0.507	0.466	0.458	N/A	N/A	0.750	0.068	0.500
Haiti	LAC	Lower middle income	0.268	0.344	0.402	0.083	0.073	0.670	0.376	0.946	0.450	0.310	0.346	0.405	0.300	0.286	N/A	N/A	N/A	N/A
Honduras	LAC	Lower middle income	0.342	0.463	0.506	0.417	0.242	0.682	0.607	0.919	0.610	0.543	0.490	0.608	0.803	0.394	0.259	0.614	0.110	0.333
Hungary	OECD	High income	0.563	0.868	0.888	0.542	0.410	N/A	0.616	0.941	0.683	0.799	0.780	0.027	0.644	0.569	0.848	0.831	0.231	0.333
Iceland	OECD	High income	0.700	0.998	0.933	0.708	0.191	0.907	1.000	0.939	0.974	0.883	0.915	0.989	0.829	0.371	1.000	0.898	0.325	0.333
India	OECD	Lower middle income	0.493	0.384	0.673	0.625	0.092	0.320	0.652	0.889	0.377	0.763	0.449	0.237	N/A	0.832	0.508	0.381	0.192	1.000
Indonesia	ASEAN	Upper middle income	0.516	0.567	0.740	0.458	0.081	0.484	0.569	0.912	0.391	0.743	0.500	0.498	0.665	0.690	0.379	0.523	0.095	0.333
Iraq	OECD	Upper middle income	0.270	0.619	0.523	0.208	0.146	N/A	0.163	0.840	0.410	0.370	0.060	0.262	0.497	0.647	0.387	0.406	0.050	0.000
Ireland	OECD	High income	0.693	0.933	0.964	0.708	0.609	N/A	0.597	0.972	0.660	0.892	0.813	0.622	0.599	0.440	0.982	0.913	0.192	0.500
Israel	OECD	High income	0.725	0.885	0.883	0.708	0.125	0.846	0.407	0.933	0.510	0.849	0.363	0.448	N/A	0.722	0.876	0.567	0.107	0.833

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Annex Table 2.A.13: continued

Table 2.A.13: Normalized Indicators Technology, Trade & Investment, Sustainability, Institutional and Geopolitical, Financial and Business Readiness																				
			Technology Readiness			Trade & Investment Readiness			Sustainability Readiness			Institutional & Geopolitical Readiness			Financial Readiness			Business Readiness		
Economy	Region	Income Group	Artificial Intelligence Preparedness Index (AIPI)	Internet Penetration Index	Mobile Connectivity Index	Logistics Performance Index (LPI)	Trade to GDP Ratio Index	Tariff Restrictiveness Index (TRI)	Modern Renewables Share Index	CO_2 Intensity Index	Energy Infrastructure Index (EII)	Regulatory Quality Index	Political Stability Index	Electrification Readiness Index (ERI)	Financial Depth Index	Financial Reserves Index	Global Financial Readiness Index (GFRI)	Firm Capacity Index (FCI)	Global Integration Index (GII)	Business Climate Index (BCI)
Italy	OECD	High income	0.621	0.753	0.906	0.750	0.141	N/A	0.666	0.949	0.629	0.792	0.716	0.651	0.757	0.753	0.837	0.806	0.496	0.333
Jamaica	LAC	Upper middle income	0.434	0.775	0.540	0.250	0.215	0.686	0.472	0.884	0.467	0.744	0.681	0.470	0.721	N/A	N/A	0.556	0.087	0.667
Japan	OECD	High income	0.733	0.867	0.927	0.833	0.080	0.702	0.500	0.916	0.565	0.868	0.835	0.052	0.971	0.897	0.984	N/A	N/A	N/A
Jordan	OECD	Lower middle income	0.483	0.823	0.659	N/A	0.207	0.693	0.518	0.891	0.476	0.734	0.551	0.501	0.807	0.494	0.396	0.719	0.529	0.667
Kazakhstan	OECD	Upper middle income	0.552	0.880	0.771	0.333	0.141	0.542	0.234	0.839	0.358	0.892	0.547	0.284	0.616	0.568	0.609	0.609	0.038	0.667
Kenya	AFRICA	Lower middle income	0.445	0.231	0.483	N/A	0.058	0.537	0.362	0.963	0.716	0.796	0.384	0.504	N/A	0.416	0.764	0.534	0.247	0.500
Latvia	OECD	High income	0.632	0.892	0.897	0.667	0.338	N/A	0.854	0.952	0.715	0.903	0.727	0.798	0.628	0.349	0.943	0.654	0.674	0.667
Lebanon	OECD	Lower middle income	0.418	0.812	0.586	N/A	0.179	N/A	0.341	N/A	0.505	0.513	0.264	0.406	N/A	0.536	0.247	0.317	0.385	0.167
Lesotho	AFRICA	Lower middle income	0.355	0.407	0.443	N/A	0.350	0.711	0.429	0.925	0.726	0.590	0.543	0.548	0.602	0.186	0.473	0.778	0.411	0.667
Liberia	AFRICA	Low income	0.370	0.143	0.295	0.208	N/A	0.381	0.084	0.907	0.518	0.347	0.550	0.257	N/A	N/A	0.447	1.000	0.046	0.500
Libya	AFRICA	Upper middle income	0.245	0.875	0.620	0.000	0.298	0.524	0.000	0.717	0.346	0.190	0.086	0.138	0.492	0.639	0.251	N/A	N/A	N/A
Lithuania	OECD	High income	0.665	0.845	0.913	0.625	0.381	N/A	0.795	0.948	0.657	0.922	0.783	0.740	0.663	0.386	0.990	0.738	0.452	1.000
Luxembourg	OECD	High income	0.735	0.984	0.938	0.708	1.000	N/A	0.673	0.958	0.649	0.743	0.871	0.664	0.818	0.288	N/A	0.887	1.000	0.500
Madagascar	AFRICA	Low income	0.305	0.078	0.294	0.167	0.133	0.409	0.783	0.958	0.506	0.415	0.496	0.672	0.527	0.288	0.260	0.461	0.066	0.500
Malawi	OECD	Low income	0.340	0.086	0.318	N/A	N/A	0.542	0.849	0.907	0.741	0.612	0.569	0.806	N/A	N/A	0.446	0.444	0.138	0.667
Malaysia	ASEAN	Upper middle income	0.632	0.927	0.816	0.708	0.322	0.745	0.431	0.879	0.475	0.921	0.639	0.448	0.875	0.661	0.544	0.565	0.211	0.667

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Annex Table 2.A.13: continued

Table 2.A.13: Normalized Indicators Technology, Trade & Investment, Sustainability, Institutional and Geopolitical, Financial and Business Readiness																			
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Mali	AFRICA	Low income	0.296	0.260	0.289	0.292	0.156	0.383	0.480	0.939	0.539	0.493	0.074	0.504	0.580	N/A	0.458	0.541	0.068	0.500
Malta	OECD	High income	0.659	0.879	0.845	0.583	0.603	N/A	0.504	0.973	0.532	0.690	0.818	0.515	0.765	0.221	0.961	0.879	0.322	0.667
Mauritania	AFRICA	Lower middle income	0.233	0.253	0.325	0.167	0.221	0.394	0.184	0.924	0.495	0.466	0.482	0.308	N/A	N/A	0.237	0.667	0.482	0.167
Mauritius	AFRICA	Upper middle income	0.525	0.690	0.707	0.250	0.245	0.966	0.515	0.935	0.438	0.921	0.793	0.484	0.782	0.400	0.486	0.893	0.323	0.500
Mexico	LAC	Upper middle income	0.532	0.734	0.783	0.417	0.188	0.668	0.568	0.913	0.525	0.784	0.447	0.059	0.656	0.730	0.307	0.578	0.009	0.667
Moldova	OECD	Upper middle income	0.481	0.671	0.761	0.250	0.221	N/A	N/A	0.875	0.416	0.814	0.508	0.416	0.627	0.356	0.462	0.603	0.232	0.333
Mongolia	OECD	Upper middle income	0.484	0.699	0.673	0.250	0.313	0.449	0.248	0.778	0.345	0.716	0.752	0.287	N/A	0.356	0.703	0.511	0.068	0.333
Morocco	AFRICA	Lower middle income	0.429	0.866	0.620	N/A	0.196	0.345	0.490	0.897	0.421	0.799	0.527	0.462	N/A	0.547	0.303	0.568	0.288	0.833
Mozambique	AFRICA	Low income	0.257	0.096	0.347	N/A	0.272	0.416	0.630	0.904	0.705	0.524	0.348	0.660	0.539	0.320	0.431	0.635	0.248	0.667
Myanmar	ASEAN	Lower middle income	0.327	0.471	0.486	N/A	N/A	0.450	0.454	0.940	0.466	0.401	0.196	0.459	N/A	N/A	N/A	0.730	0.106	0.333
Namibia	AFRICA	Lower middle income	0.420	0.554	0.495	0.417	0.216	0.716	0.698	0.925	0.700	0.620	0.728	0.699	N/A	0.307	0.600	0.732	0.137	0.667
Nepal	OECD	Lower middle income	0.351	N/A	0.527	N/A	0.095	0.375	0.476	0.936	0.750	0.647	0.552	0.586	0.832	N/A	0.378	0.637	0.198	0.333
Netherlands	OECD	High income	0.766	0.928	0.962	0.917	0.414	N/A	0.536	0.949	0.663	0.840	0.785	0.602	0.810	0.623	0.992	N/A	N/A	N/A
New Zealand	OECD	High income	0.754	0.944	0.947	0.708	0.110	0.808	0.764	0.928	0.787	1.000	0.920	0.773	N/A	0.495	0.977	0.827	0.188	0.667
Nicaragua	LAC	Lower middle income	0.331	0.426	0.530	0.250	0.246	0.687	0.601	0.942	0.611	0.515	0.496	0.605	0.629	0.366	0.198	0.643	0.047	0.500

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Annex Table 2.A.13: continued

Table 2.A.13: Normalized Indicators Technology, Trade & Investment, Sustainability, Institutional and Geopolitical, Financial and Business Readiness																				
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Economy	Region	Income Group	Artificial Intelligence Preparedness Index (AIPI)	Internet Penetration Index	Mobile Connectivity Index	Logistics Performance Index (LPI)	Trade to GDP Ratio Index	Tariff Restrictiveness Index (TRI)	Modern Renewables Share Index	CO_2 Intensity Index	Energy Infrastructure Index (EII)	Regulatory Quality Index	Political Stability Index	Electrification Readiness Index (ERI)	Financial Depth Index	Financial Reserves Index	Global Financial Readiness Index (GFRI)	Firm Capacity Index (FCI)	Global Integration Index (GII)	Business Climate Index (BCI)
Niger	AFRICA	Low income	0.326	0.130	0.219	N/A	0.067	0.382	0.234	0.966	N/A	0.551	0.263	0.234	0.446	N/A	0.210	0.551	0.106	0.667
Nigeria	AFRICA	Lower middle income	0.336	0.295	0.507	0.292	N/A	0.387	0.426	0.948	0.478	0.552	0.200	0.447	N/A	0.551	0.503	0.449	0.304	0.500
Norway	OECD	High income	0.706	0.979	0.973	0.750	0.172	0.834	0.933	0.954	0.977	0.937	0.842	0.951	0.893	0.625	0.985	N/A	N/A	N/A
Oman	OECD	High income	0.533	0.941	0.743	0.583	0.222	0.481	0.007	0.784	0.547	0.749	0.724	0.223	N/A	0.476	0.508	N/A	N/A	N/A
Pakistan	OECD	Lower middle income	0.369	0.155	0.416	N/A	0.052	0.503	0.495	0.924	0.523	0.614	0.183	0.043	0.463	0.477	0.382	0.430	0.184	0.333
Panama	LAC	High income	0.501	0.712	0.737	0.500	0.195	0.714	0.672	0.952	0.687	0.698	0.669	0.678	N/A	0.378	0.418	0.510	0.076	0.333
Papua New Guinea	OECD	Lower middle income	0.290	0.169	0.415	0.333	N/A	0.829	0.596	0.929	0.482	0.596	0.472	0.550	N/A	N/A	N/A	0.698	0.125	0.333
Paraguay	LAC	Upper middle income	0.410	0.728	0.729	0.333	0.167	0.514	0.853	0.960	0.803	0.585	0.614	0.833	0.747	N/A	0.433	0.769	0.148	0.500
Peru	LAC	Upper middle income	0.491	0.678	0.737	0.458	0.111	0.820	0.673	0.941	0.633	0.729	0.525	0.657	N/A	0.623	0.439	0.703	0.119	0.000
Philippines	ASEAN	Lower middle income	0.498	0.617	0.681	0.583	0.151	0.497	0.550	0.927	N/A	0.641	0.434	0.550	0.721	0.652	0.448	0.761	0.057	0.500
Poland	OECD	High income	0.597	0.833	0.854	0.708	0.265	N/A	0.639	0.909	0.416	0.844	0.725	0.550	0.651	0.726	0.590	0.612	0.091	0.500
Portugal	OECD	High income	0.646	0.798	0.907	0.625	0.212	N/A	0.775	0.957	0.710	0.846	0.811	0.749	0.803	0.560	0.901	0.813	0.272	0.500
Qatar	OECD	High income	0.535	0.998	0.907	0.667	0.223	0.499	0.000	0.809	0.621	0.729	0.794	0.248	0.881	0.584	N/A	N/A	N/A	N/A
Romania	OECD	High income	0.584	0.807	0.821	0.542	0.202	N/A	0.726	0.952	0.644	0.798	0.718	0.075	0.581	0.615	0.560	0.663	0.223	0.333
Rwanda	AFRICA	Low income	0.437	0.211	0.428	0.375	0.132	0.551	0.510	0.979	0.608	0.846	0.627	0.550	0.580	0.273	N/A	0.736	0.084	0.833
Samoa	OECD	Upper middle income	N/A	0.505	0.618	N/A	0.176	0.392	0.413	0.838	0.560	0.630	0.860	0.472	0.800	0.118	N/A	0.949	0.109	0.833

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Annex Table 2.A.13: continued

Table 2.A.13: Normalized Indicators Technology, Trade & Investment, Sustainability, Institutional and Geopolitical, Financial and Business Readiness																				
			Technology Readiness			Trade & Investment Readiness			Sustainability Readiness			Institutional & Geopolitical Readiness			Financial Readiness			Business Readiness		
Economy	Region	Income Group	Artificial Intelligence Preparedness Index (AIPI)	Internet Penetration Index	Mobile Connectivity Index	Logistics Performance Index (LPI)	Trade to GDP Ratio Index	Tariff Restrictiveness Index (TRI)	Modern Renewables Share Index	CO_2 Intensity Index	Energy Infrastructure Index (EII)	Regulatory Quality Index	Political Stability Index	Electrification Readiness Index (ERI)	Financial Depth Index	Financial Reserves Index	Global Financial Readiness Index (GFRI)	Firm Capacity Index (FCI)	Global Integration Index (GII)	Business Climate Index (BCI)
Saudi Arabia	OECD	High income	0.577	0.987	0.831	0.625	0.131	N/A	0.008	0.839	0.506	0.772	0.500	0.207	N/A	0.799	0.620	0.314	0.188	0.500
Senegal	AFRICA	Lower middle income	0.396	0.512	0.453	N/A	0.159	0.386	0.402	0.921	0.461	0.588	0.583	0.425	0.629	N/A	0.635	0.745	0.145	0.500
Serbia	OECD	Upper middle income	0.537	0.797	0.772	0.375	0.277	0.425	0.726	N/A	0.436	0.834	0.585	0.610	0.648	0.527	0.635	0.582	0.492	0.167
Seychelles	AFRICA	High income	0.531	0.835	0.707	N/A	0.443	0.912	0.137	0.835	0.495	0.624	0.772	0.280	N/A	0.160	N/A	0.961	0.138	0.333
Sierra Leone	AFRICA	Low income	0.298	0.117	0.342	N/A	0.088	0.377	0.740	0.978	0.739	0.412	0.574	0.740	0.283	N/A	0.411	0.735	0.062	0.333
Singapore	ASEAN	High income	0.801	0.932	1.000	1.000	0.840	0.997	0.146	0.960	0.587	0.991	0.932	0.322	N/A	0.780	0.806	0.572	0.213	0.500
Slovakia	OECD	High income	0.592	0.871	0.892	0.583	0.464	N/A	0.662	0.917	0.745	0.832	0.741	0.008	0.753	0.453	0.910	N/A	N/A	N/A
Slovenia	OECD	High income	0.634	0.867	0.900	0.583	0.409	N/A	0.706	0.938	0.700	0.846	0.779	0.029	0.661	0.290	0.987	0.826	0.725	0.167
Solomon Islands	OECD	Lower middle income	N/A	0.321	0.365	0.375	0.167	0.394	0.067	0.897	0.388	0.528	0.719	0.196	0.632	N/A	N/A	0.840	0.297	0.500
South Africa	AFRICA	Upper middle income	0.497	0.715	0.710	0.750	0.130	0.704	0.356	0.792	0.391	0.704	0.492	0.481	N/A	0.604	0.568	0.350	0.119	0.333
Spain	OECD	High income	0.648	0.932	0.919	0.833	0.158	N/A	0.666	0.950	0.722	0.867	0.691	0.108	0.794	0.653	0.983	0.773	0.439	0.500
Sri Lanka	OECD	Lower middle income	0.436	0.378	0.552	0.375	0.091	0.682	0.756	0.962	0.502	0.626	0.520	0.654	N/A	0.366	0.400	0.513	0.079	0.333
Sudan	AFRICA	Low income	0.233	0.202	0.227	0.208	0.000	0.313	0.714	0.913	N/A	0.371	0.167	0.714	N/A	N/A	N/A	0.616	0.134	0.500
Suriname	LAC	Upper middle income	0.418	0.708	0.568	N/A	N/A	0.404	0.575	0.891	0.596	0.412	0.684	0.583	0.520	0.235	N/A	0.342	0.140	0.667
Sweden	OECD	High income	0.748	0.946	0.955	0.875	0.230	N/A	0.913	0.972	0.893	0.928	0.819	0.062	0.887	0.599	0.985	0.744	0.388	0.500
Switzerland	OECD	High income	0.757	0.951	0.993	0.917	0.323	0.596	0.742	0.975	0.826	0.847	0.870	0.055	N/A	0.867	0.983	N/A	N/A	N/A

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Annex Table 2.A.13: continued

Table 2.A.13: Normalized Indicators Technology, Trade & Investment, Sustainability, Institutional and Geopolitical, Financial and Business Readiness																				
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Tajikistan	OECD	Lower middle income	0.366	0.426	0.322	0.250	0.141	0.467	0.837	0.900	0.734	0.618	0.480	0.796	N/A	N/A	0.330	0.665	0.015	0.500
Thailand	ASEAN	Upper middle income	0.536	0.801	0.788	0.667	0.287	0.562	0.669	0.909	0.474	0.900	0.506	0.591	0.919	0.732	0.559	0.570	0.094	0.333
Togo	AFRICA	Low income	0.316	0.249	0.375	0.250	0.133	0.379	0.573	0.949	0.452	0.633	0.420	0.525	0.613	N/A	0.491	0.764	0.452	0.500
Tonga	OECD	Upper middle income	N/A	0.546	0.598	N/A	0.185	0.510	0.190	N/A	0.442	0.620	0.850	0.291	0.689	0.088	N/A	0.925	0.075	0.667
Tunisia	AFRICA	Lower middle income	0.465	0.669	0.635	N/A	0.241	0.471	0.221	0.897	0.464	0.729	0.455	0.319	0.749	0.409	0.273	0.631	0.680	0.500
Uganda	OECD	Low income	0.354	0.037	0.382	N/A	0.075	0.513	0.807	0.972	0.739	0.599	0.437	0.779	0.502	N/A	0.634	0.082	0.060	0.500
Ukraine	OECD	Upper middle income	0.512	0.762	0.711	0.333	0.198	0.657	0.499	0.880	0.639	0.751	0.292	0.014	N/A	0.563	0.779	N/A	N/A	N/A
United States	USA	High income	0.771	0.907	0.968	0.792	0.043	0.691	0.558	0.906	0.669	0.958	0.614	0.035	0.972	0.867	0.967	N/A	N/A	N/A
Uruguay	LAC	High income	0.549	0.863	0.851	0.458	0.116	0.483	0.906	0.956	0.747	0.621	0.841	0.843	0.637	0.471	0.693	0.765	0.125	0.333
Uzbekistan	OECD	Lower middle income	N/A	0.765	0.600	0.292	0.139	0.619	0.188	0.820	0.220	0.747	0.549	0.201	0.649	0.557	0.418	0.528	0.022	0.667
Vanuatu	OECD	Lower middle income	N/A	0.386	0.510	N/A	0.171	0.530	0.263	0.861	0.493	0.615	0.819	0.355	0.737	0.137	N/A	0.482	0.184	0.500
Vietnam	ASEAN	Lower middle income	0.482	0.720	0.722	0.583	0.435	0.578	0.641	0.866	0.525	0.746	0.600	0.595	N/A	0.627	0.483	0.568	0.126	0.333
Zambia	OECD	Lower middle income	0.371	0.224	0.413	N/A	0.178	0.472	0.706	0.945	0.717	0.702	0.617	0.710	N/A	N/A	0.573	0.538	0.098	0.833
Zimbabwe	AFRICA	Lower middle income	0.305	0.285	0.374	0.250	0.119	0.275	0.536	0.896	0.590	0.516	0.396	0.558	N/A	0.113	0.405	0.360	0.095	0.500

Note: Numbers are min-max normalized to 0-1 and shown as provided. "N/A" = unavailable. Country-level indicator values normalized by indicators and grouped by readiness pillar.

3

Global Electric Vehicle Value Chains: Paradigm Shifts and New Opportunities for Developing Economies

Ran Wang, Bo Meng, Yunfeng Yan, Norihiko Yamano, Ming Ye, Yang Zhou, Aodong Jiao, Sida Chen, Zhi Wang, and Jinjun Xue

3.1 Introduction

Since 2018, the global electric vehicle (EV) market has experienced rapid growth, with an average annual sales growth rate of 45.5%. By 2023, global EV sales reached 13.7 million units, accounting for 18% of total vehicle sales. With the continued decline in battery costs and the introduction of incentive policies in various economies, this share is expected to rise to 20% by 2024 (IEA, 2024a). The development of EVs is reshaping the traditional automotive industry ecosystem. The importance of engine manufacturing has diminished, while the roles of EV batteries, electric motors, electronic control systems and automotive chips have been elevated (Safari, 2018; Rísquez Ramos and Ruiz-Gálvez, 2024). Moreover, EVs have driven the rapid growth of emerging sectors such as battery manufacturing, charging infrastructure, software integration and battery recycling, along with advancements in related technologies like smart grids, autonomous driving, vehicle connectivity and energy storage. This process not only injects new vitality into the global economy but also helps reduce fossil fuel consumption in the transportation sector, supporting progress towards achieving carbon neutrality in transport (Li et al., 2024; Song et al., 2025).

The production centres of internal combustion engine vehicles (ICEVs) remain relatively fixed, primarily in the United States (US), Germany and Japan, where these countries have

Note: This chapter was jointly led by the Research Institute for Global Value Chains – University of International Business and Economics (RIGVC-UIBE) and the Institute of Developing Economies – Japan External Trade Organization (IDE-JETRO). The views expressed are those of the authors and do not necessarily reflect the views of RIGVC-UIBE and IDE-JETRO.

maintained production advantages for many years (Dowlah, 2018). Developing economies have generally only been able to participate in automotive production networks through assembly or by engaging in peripheral processing activities, such as the manufacture of car interiors, tyres and glass. However, the EV production network has been extended due to the complexity of battery manufacturing and now encompasses the entire supply chain – from critical mineral extraction to the installation of charging infrastructure and automotive chip development. As a result, the EV industry has fostered cross-sectoral development, as evidenced by companies such as consumer electronics companies Xiaomi and Huawei entering the automobile market, and vehicle maker BYD also producing mobile phones.

EVs, owing to their structural advantages in batteries and automotive chips, are inherently more conducive to deep integration with the digital economy (Liu et al., 2024). On the one hand, their high-efficiency and large-capacity power batteries free them from the energy efficiency bottlenecks and mechanical constraints of internal combustion engines. On the other, the number of onboard chips has risen substantially – 1,600 to 3,000 per EV, compared with 600 to 700 in per ICEV (IBE, 2024) – providing the hardware foundation for high-speed network access, real-time big data processing and other applications such as autonomous driving. Higher-level autonomous driving and intelligent cockpit technologies are also quickly advancing in EVs thanks to ongoing improvements in chip precision and processing power. Consequently, vehicles are evolving from means of transportation into lifestyle platforms more akin to smart terminals, which are deeply interconnected with personal data and digital services. This trend not only reshapes the structure of the automotive industry but also drives the digital transformation of global production and consumption (Llopis-Albert et al., 2021).

The EV-related production process creates significant value added but also places additional emissions reduction pressures on participants, particularly developing economies that supply raw materials and those that manufacture batteries (Franzò and Nasca, 2021; Hu et al., 2024). Research consistently shows that EVs generate higher carbon emissions during the production phase compared to ICEVs (ICCT, 2021). However, from a lifecycle perspective, EVs begin to demonstrate clear carbon reduction advantages after reaching a certain mileage. These advantages become increasingly pronounced with longer driving distances and the transition to cleaner energy sources (Qiao et al., 2020; Chen et al., 2024). For example, Farzaneh and Jung (2023) indicate that the life cycle carbon footprint of EVs in the US is approximately 22.6% lower than that of ICEVs. Mapping carbon emission flows and the carbon footprint distribution in EV production is crucial for fostering low-carbon EV manufacturing through international collaboration and unlocking their full emissions reduction potential.

The production of electric vehicles, particularly EV batteries, is highly dependent on critical raw materials such as lithium, cobalt and nickel. This creates unprecedented development opportunities for resource-rich developing economies. By directly engaging in or indirectly participating through foreign direct investment (FDI) in the mining, smelting and processing of these key minerals, these economies can not only integrate

into core segments of the global EV supply chain but also leverage this opportunity to drive domestic industrial upgrading and technological advancement. Companies from developed economies can also actively pursue collaboration with resource-rich economies through FDI, technology partnerships and other means to secure supply chains and tap into emerging markets. Such EV supply chain-driven cooperation models can help reduce global EV production costs, promote the inclusive development of clean energy technologies and foster a more inclusive global value chain.

In the next section, we first provide an overview of the current development of EVs, as well as the production and trade of core EV components and raw materials. In Section 3, we construct an EV-ICIO (inter-country input-output) model that distinguishes between EVs and ICEVs, which enables us to illustrate the differences in the creation, transfer and distribution of value added and carbon emissions along global EV and ICEV supply chains. Based on life cycle emissions, this section also estimates the emissions reduction potential of EVs relative to ICEVs. In Section 4, drawing on the product space model, we analyse the development pathways of different segments of the EV supply chain and discuss how developing economies can leverage their comparative advantages to seize new opportunities for participating in global EV supply chains. Finally, we review the main findings of this chapter and offer some policy recommendations.

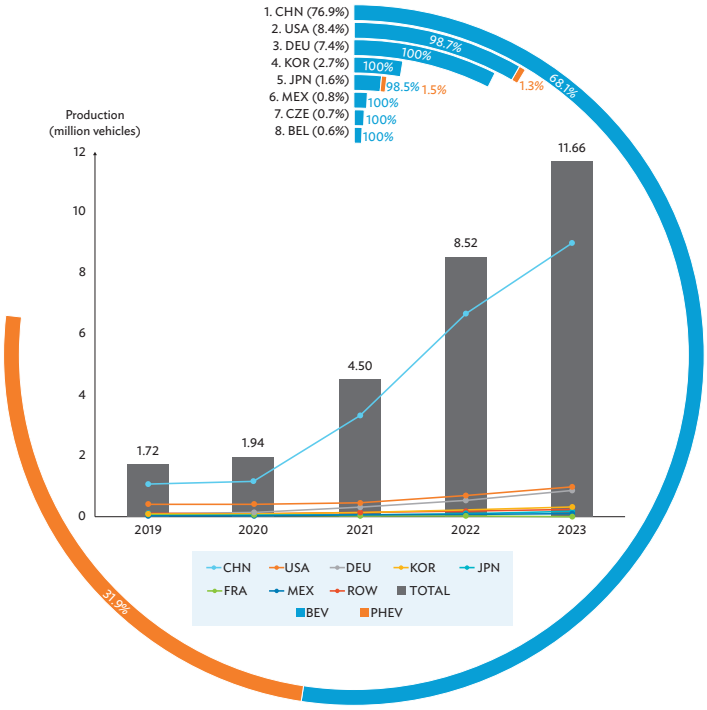
3.2 Overview of the Electric Vehicle Supply Chain

3.2.1 The Production and Trade of Electric Vehicles

From 2019 to 2023, China maintained its position as the world's largest producer of EVs, accounting for 76.9% of the global total in 2023 – far exceeding the US, Germany and South Korea (Figure 3.1). While China maintained steady growth from an already high base, South Korea and Germany experienced the fastest growth in EV production, with average annual growth rates of 130% and 119% respectively over the period. In terms of EV types produced, in 2023, 68.1% of China's output comprised battery electric vehicles (BEVs), and 31.9% were plug-in hybrid electric vehicles (PHEVs). In contrast, other economies focused almost exclusively on BEVs, with 98.7% of EV production in the US being BEVs and 1.3% PHEVs, while 98.5% of Japan's production was BEVs and 1.5% PHEVs.

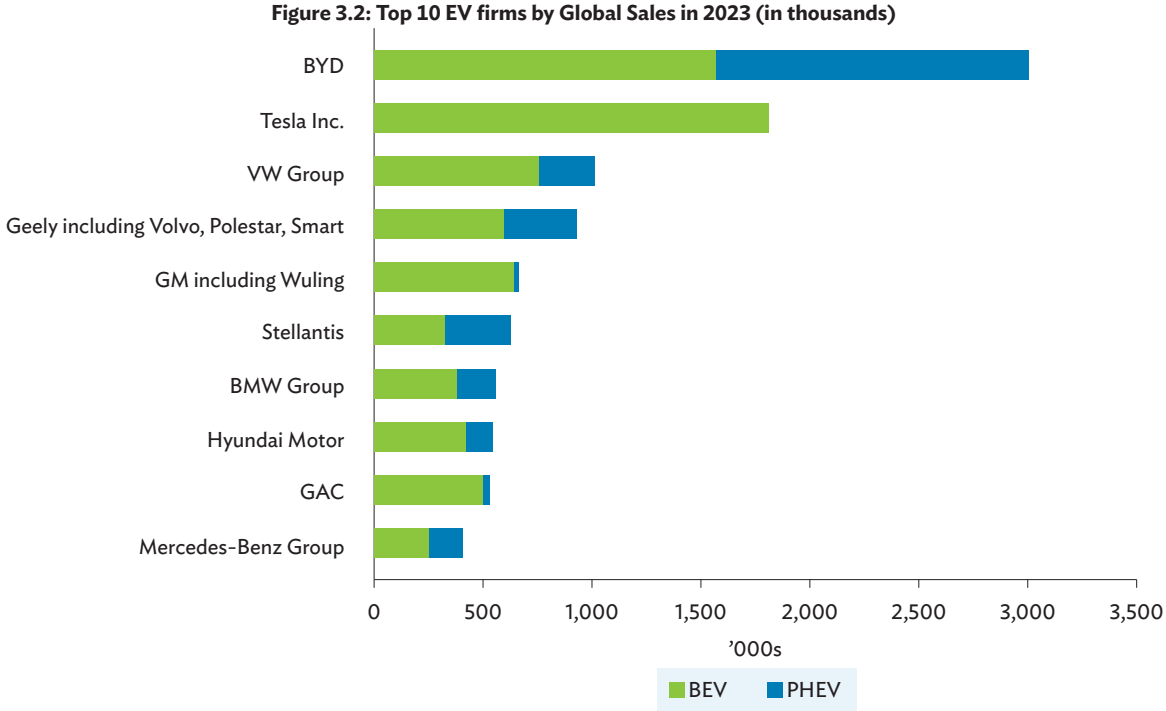
By automaker, BYD and Tesla led the global EV market by a significant margin in 2023 (Figure 3.2). BYD ranked first worldwide with nearly 3 million units sold, showing particularly strong performance in the PHEV segment. Meanwhile, Tesla focused exclusively on BEVs, with its Model Y achieving 1.2 million units in sales, making it the best-selling vehicle globally. Other Chinese automakers – including Geely, which also owns Volvo, Polestar and Smart; General Motors (GM), including Wuling; and Guangzhou Automobile Group Motor Co., Ltd (GAC) – also ranked among the top 10, highlighting the rapid rise of Chinese firms in the global EV sector. Germany had four companies on the list – VW Group, Stellantis, BMW Group and Mercedes-Benz Group – while South Korea's Hyundai Motor also emerged as a notable player in the EV industry.

Figure 3.1: Production of Electric Vehicles, 2019-2023



Note: This result is based on a territory-based principle. For example, EVs produced by Tesla's factory located in China are counted as China's domestic production.
Source: Global Vehicles Production in Global NEVS (2024)

Figure 3.2: Top 10 EV firms by Global Sales in 2023 (in thousands)



Source: Global EV Sales for 2023 in EV Volumes (2024)

The global EV export landscape in 2023 exhibited a hierarchically structured network centred around a few dominant economies, which function either as global or regional export hubs (Figure 3.3). Using export value (in USD) as the primary measure of centrality, we classify economies into global hubs, regional hubs and peripheral nodes based on both the magnitude and geographical breadth of their EV exports, with China and Germany considered as the two main global hubs. China emerged as a top global player with EV exports totalling $34.1 billion, corresponding to 1.6 million units. Its export destinations spanned Europe, Southeast Asia, Latin America and Australia, reflecting a highly diversified and global reach. China's central position in the network is bolstered not only by its dominant output but also by its expanding influence in emerging markets through competitively priced models (about $21,313 per unit) from automakers like BYD and SAIC Motor. Germany, with an even higher EV export value of $40.1 billion (approximately 786,000 units), also qualifies as a global hub. Despite a slightly lower volume, Germany's exports unit price for EVs is more than twice as high as China's (about $51,020 per unit), attributed to its premium vehicle brands such as BMW, Mercedes-Benz and Audi. Major destinations included the Netherlands, France, the United Kingdom (UK) and the US – reflecting both intra-European strength and transatlantic ties. Together, China and Germany accounted for over 49% of global EV export value in 2023 and formed the dual cores of the global EV trade network, which is characterized by high outflows and extensive connectivity across continents.

South Korea, Japan and Belgium could be regarded as regional hubs. South Korea exported EVs worth $11.98 billion (418,881 units) in 2023, predominantly to the US, Canada and parts of Europe. Its position as a regional hub stems from strong North American linkages, driven by Hyundai and Kia's strategic positioning in the SUV segment, and while the geographic coverage was narrower than that of China or Germany, the export scale was regionally significant. Japan exported EVs valued at $5.74 billion (approximately 149,091 units), marking a sharp 246% increase on previous years. Key markets for Japan included the US, Australia, China and Thailand, and although Japan's EV exports remain modest in absolute terms, the diversification of its destinations indicates potential to evolve into a more global node. Meanwhile Belgium, with $8.09 billion in EV exports (157,306 units), plays a unique role as not only a producer but also a logistics re-export hub. It acts as a key distribution node within Europe, re-exporting vehicles manufactured in neighbouring Germany and France to other European markets such as the Netherlands and the UK.

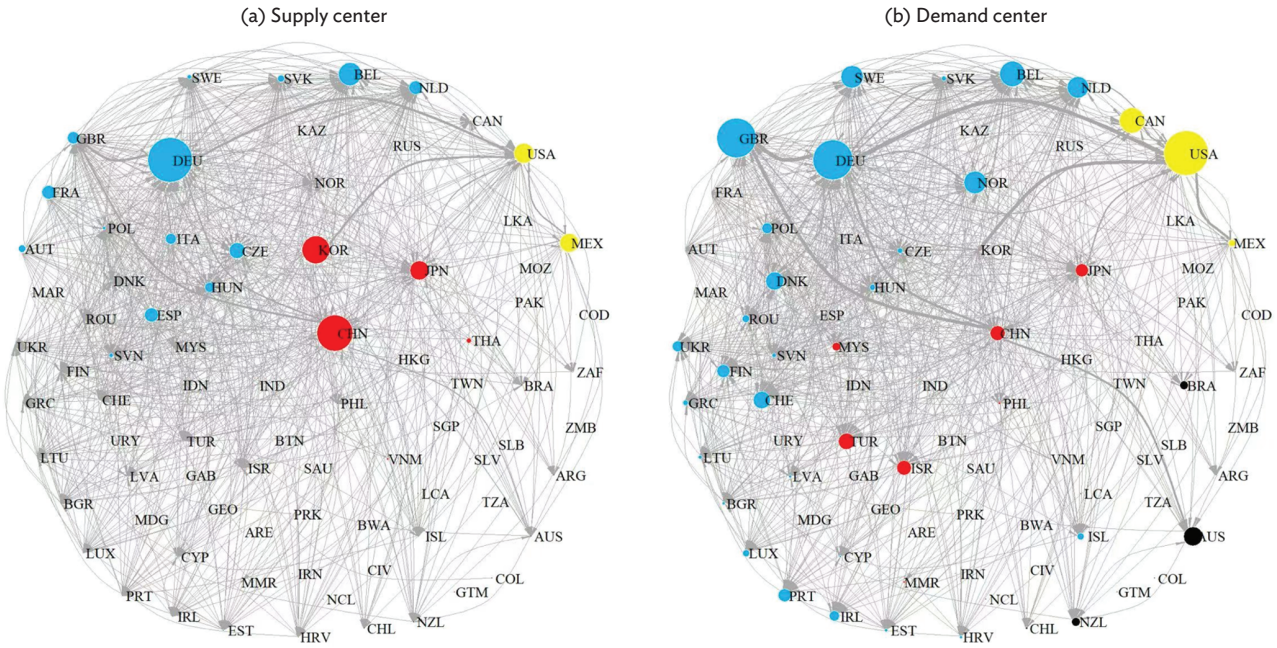
The US, despite being a major EV manufacturer, exported only $6.27 billion worth of EVs (approximately 129,546 units) in 2023, with Canada and Mexico as its dominant destinations. Its export network remains regionally confined within North America, constrained by domestic consumption focus and regulatory complexity. Mexico, while lacking detailed EV-specific export breakdowns, functioned as a manufacturing node for global brands like Tesla and BMW. Estimated EV exports reached $5.51 billion (137,750 units), primarily to the US and Latin America. As part of North American

value chains, Mexico's network role is more embedded and original equipment manufacturer (OEM)-dependent, rather than autonomous.

In 2023, the global EV import network revealed a strongly asymmetrical and regionally layered structure, with a few dominant consumer markets absorbing the bulk of global EV exports. The US emerged as the world's largest EV importer, with an import value of approximately $19.00 billion, sourcing primarily from Germany, South Korea and Japan. Germany itself, while being a major exporter, also stood out as a substantial importer with $15.27 billion in EV imports, mainly from China and Korea. This dual role reflects Germany's intricate supply chain integration within the European Union (EU) and its reliance on Asian suppliers for specific segments, particularly battery-driven models. Other significant importers included the UK ($14.79 billion), Belgium ($6.42 billion) and Canada ($6.40 billion), with each playing critical roles within the intra-European trade system and often functioning as logistical hubs or regional redistribution centres.

The import network, when mapped by trade value, displays a pattern of dense bilateral flows between a handful of high-income demand centres and a smaller group of producer economies. It is more consumption-centric than the export network and less centralized, with a relatively wider spread of mid-tier importers. However, most import links converge on key suppliers such as China, underscoring the growing concentration

Figure 3.3: Electric Vehicle Trade Network in 2023



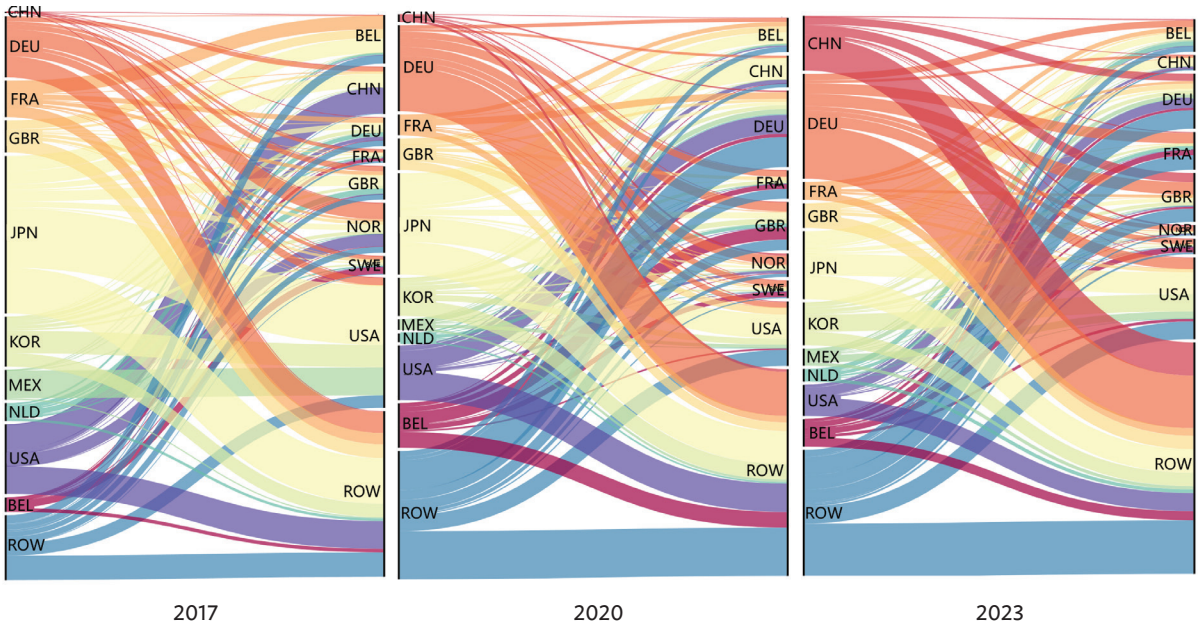
Notes: The network consists of nodes (countries or regions) and edges (trade flows). The node colors represent different regions, where red indicates Asia, blue represents Europe, yellow denotes North America, and black signifies other regions. The size of each node indicates its relative importance in terms of supply and demand, and the direction and size of edges (trade flows) indicate the trade direction and relationship strength, respectively. The topology of the network reveals core-periphery structures, hubs and linkages, which define the dynamics of global trade of EVs and their key parts.

Source: Meng et al. (2025) based on the OECD BTDIxE (2023) and IDE-JETRO's GVC Visualization Database.

in EV manufacturing. Regional clusters – such as Western Europe and North America – exhibit high internal connectivity and diversified sourcing, while regions like ASEAN remain more peripherally connected with asymmetric dependencies. These structural patterns are also driven by a mix of policy incentives (such as subsidies and emissions targets), industrial readiness and consumer market maturity, revealing how global EV trade is increasingly shaped by geopolitical alignment, regional integration and the evolving economics of decarbonization.

The export structure of EVs (passenger cars) by country from 2017 to 2023 is illustrated in Figure 3.4. China's share in the global EV market has progressively risen, with its share of global EV exports increasing from 0.2% to 10.4% over the period. Germany's share also increased from 11.4% to 19.9%. However, market shares of both Japan and the US both declined, with Japan's share falling from 29.5% to 12.9%, and the US from 13.0% to 5.8%, indicating a significant weakening in their competitiveness in EV exports. This is primarily due to the development of the EV industries in China and Germany, which squeezed Japan's market in other economies and reducing their demand for imports. For instance, from 2017 to 2023, the proportion of EVs imported by Germany from Japan decreased from 11.6% to 5.5%. Meanwhile, in the rest of the world, the shares of imports from China and Germany increased by 14% and 10%, respectively, while those from Japan and the US declined by 17% and 9%, respectively.

Figure 3.4: Trade Structure of Major Electric Vehicles-Exporting Countries from 2017 to 2023

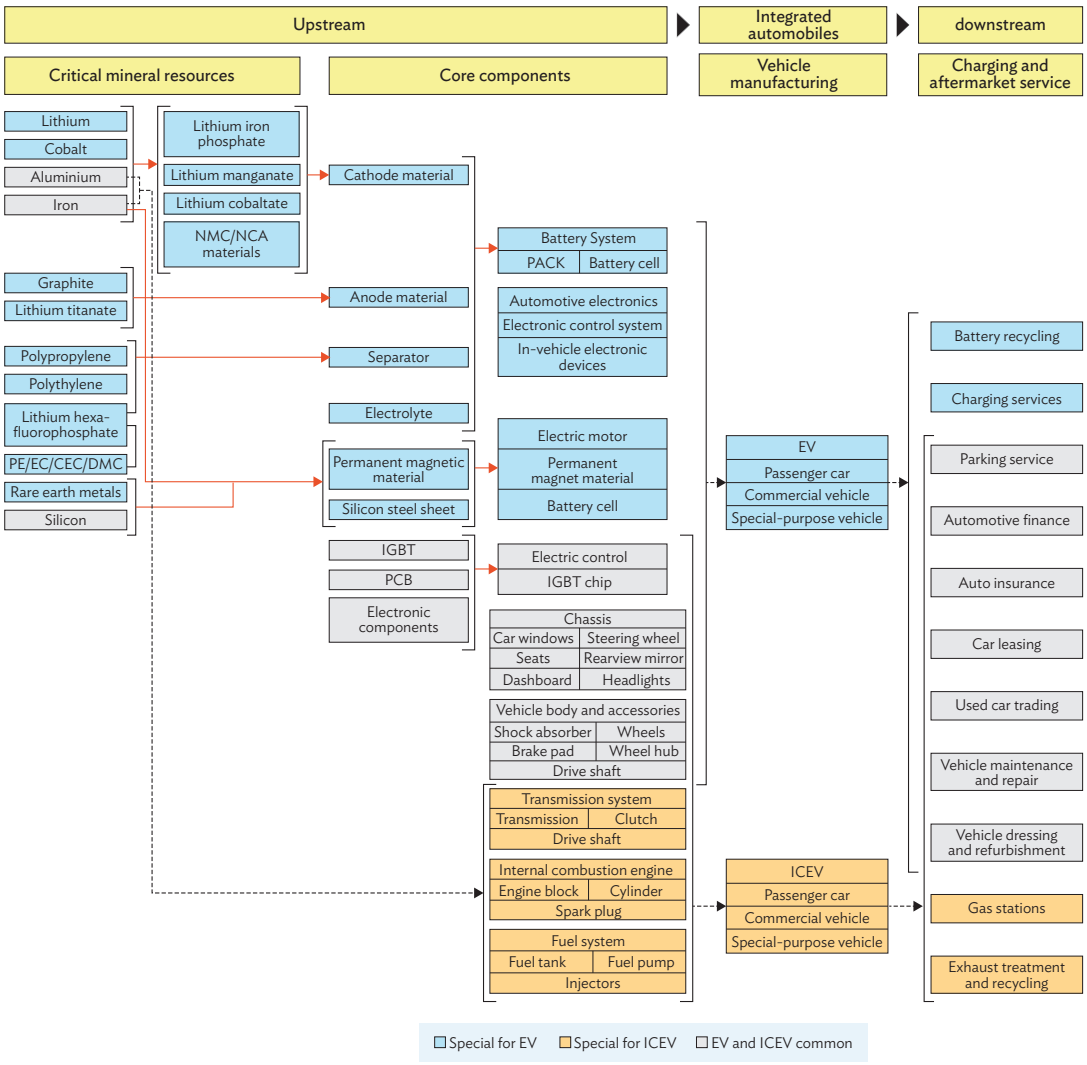


Notes: BEV (HS 870380), PHEV (870360 and 870370).
Source: UN Comtrade

3.2.2 The Production and Trade of Electric Vehicle-Related Minerals and Components

The EV supply chain can be divided into three main segments: upstream, integrated automobiles and downstream (Figure 3.5). At the upstream stage, the industry relies on a variety of critical mineral resources, including silicon, graphite, rare earth metals, magnesium, copper and cobalt, which are fundamental to the production of key components such as batteries and motors. At the same time, key chemical materials – including cathode and anode materials, magnetic materials and other functional chemicals, as well as a range of metallic materials used in vehicle bodies and battery structures – are also essential. Auxiliary materials, such as rubber, plastics, glass fibres and adhesives, provide important support for the manufacturing and assembly of various components.

Figure 3.5: Diagram of EV and ICEV Supply Chains



Source: Authors

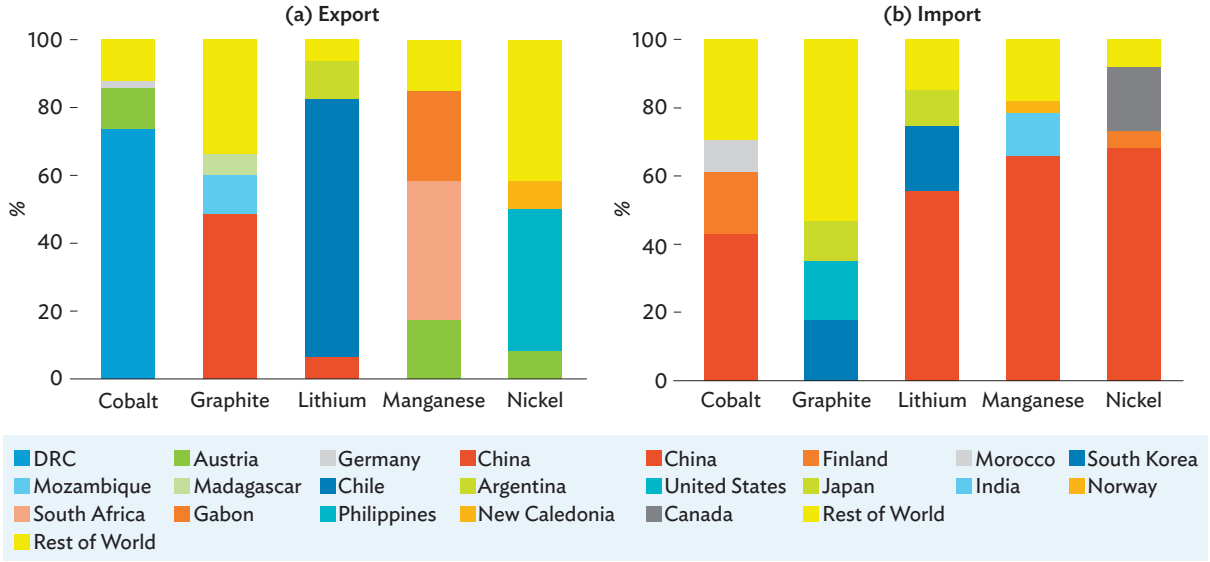
Moving into the core components segment, the supply chain covers automotive chips, various electronic parts, electric control systems, motors, battery systems and body and assembly modules. Automotive chips and electronic devices lay the technological foundation for EV intelligence and power control, while electric control and motor systems ensure power output and operational safety. The battery system serves as the core energy source and is crucial to vehicle performance, while the body and assembly relate to the structural integrity and functional realization of the vehicle. In the integrated automobiles segment, the focus is on vehicle manufacturing, which includes different types such as BEV and PHEV. This segment is responsible for the integration of all upstream components into a complete vehicle, ready for the market. The downstream segment centres on charging infrastructure and battery recycling. The development of charging facilities supports the large-scale adoption of EVs, while the recycling and cascade utilization of used batteries not only promotes resource circulation and environmental protection but also provides strong momentum for the industry's sustainable development.

Driven by high levels of investment in the previous five years, in 2024, annual battery demand surpassed 1 terawatt-hour (TWh) (IEA, 2025b). More batteries mean extracting and refining greater quantities of critical raw materials, particularly lithium, cobalt and nickel. Battery demand for lithium stood at around 140 kiloton (kt) in 2023, accounting for 85% of total lithium demand, while for cobalt, demand for batteries was up 15% to 150 kt, marking 70% of the total demand. Battery demand for nickel stood at almost 370 kt in 2023, accounting for over 10% of total demand (IEA, 2024b).

Figure 3.6a illustrates the export distribution of five key minerals closely associated with EVs in 2023: cobalt, graphite, lithium, manganese and nickel. Cobalt exports are highly concentrated, with the Democratic Republic of the Congo (DRC) holding a dominant position. Graphite exports are highly controlled by China and lithium exports are predominantly concentrated in Chile, while manganese exports mainly originate from South Africa, Gabon and other countries. Nickel exports are more widely distributed, with the Philippines being the primary supplier. In general, the key minerals essential for EV production exhibit significant regional concentration within the global supply chain, particularly for resources such as cobalt, graphite and lithium. This concentration might lead to supply vulnerability, leaving the global EV industry highly dependent on specific regions.

As shown in Figure 3.6b, China is the primary importer of key minerals for EVs, with the exception of graphite. This is largely because China serves as both the world's largest processing hub for raw materials and a major producer of both electric vehicles and EV batteries. Other significant importing countries, such as the US, Japan and Germany, also play crucial roles in EV production. As demand for EVs continues to rise, the need for raw materials in these countries has similarly increased. Consequently, these nations must be vigilant about potential risks to the supply of key minerals and consider strategies such as diversifying import sources to enhance the resilience of their raw material supply chains.

Figure 3.6: Trade of EV-Related Key Minerals in 2023

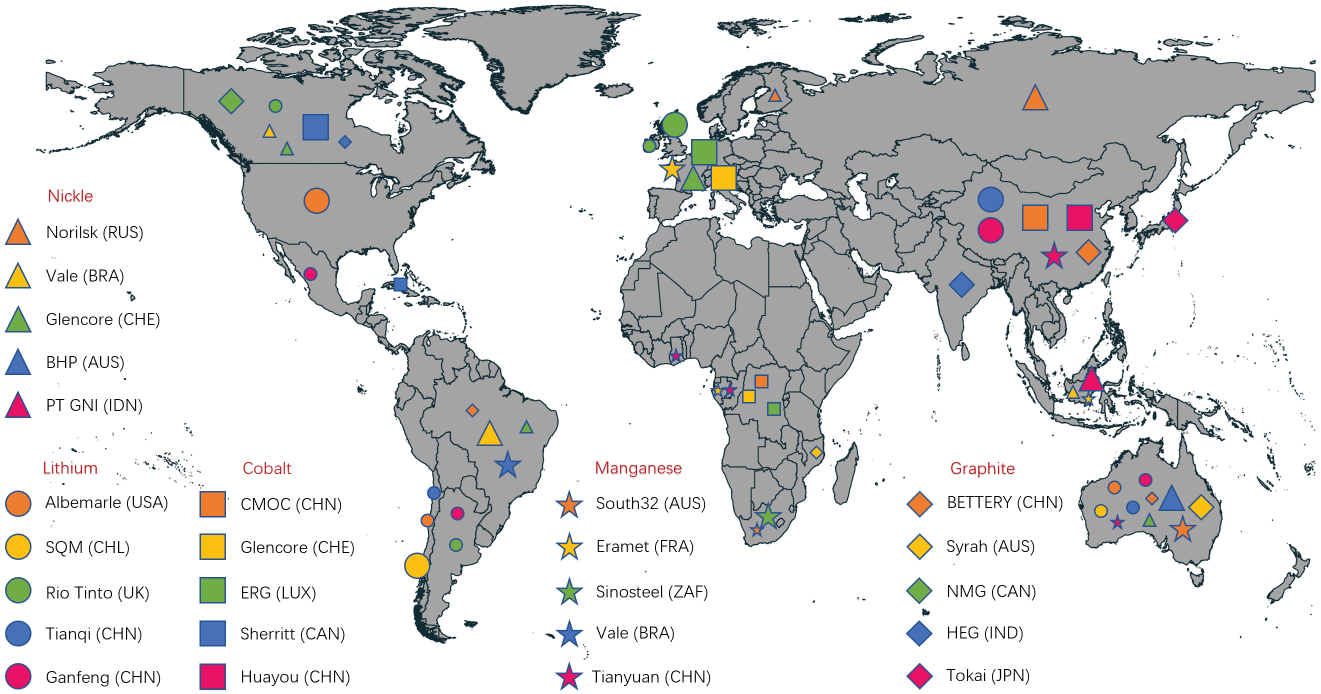


Notes: Cobalt (HS 260500), graphite (HS 250410, 250490), lithium (HS 283691), manganese (HS 260200), and nickel (HS 260400). DRC=Democratic Republic of Congo. For each mineral, the top three exporting/importing economies are shown, while all other regions are aggregated as the rest of the world.
Source: CEPII BACI database

Although critical mineral resources are controlled by only a few countries, the origins of multinational enterprises (MNEs) engaged in related industries are widely distributed, which reduces the risks associated with EV battery production (Figure 3.7). Regionally, Australia has a comprehensive endowment across nearly all critical minerals; Chinese firms demonstrate strong global competitiveness and extensive control, particularly in lithium, cobalt and graphite; European companies, despite having limited domestic reserves, leverage their globally distributed extraction networks; Africa is rich in cobalt and manganese, though extraction activities are largely dominated by foreign firms; South American lithium is concentrated in Chile and Argentina and primarily developed by external actors; and North America, while resource diverse, lacks a dominant position in any single mineral. At the mineral level, lithium is concentrated in South America and Australia; cobalt centred in the DRC; manganese in Africa; and graphite primarily controlled by China and Japan, while nickel is more widely distributed.

The EV battery accounts for approximately 30% of the total vehicle cost, yet manufacturing of such batteries is concentrated in only a few countries (Figure 3.8). China contributed over 80% of the global EV battery production capacity in 2023, with a total capacity of 1,783 gigawatt-hour (GWh), followed by Europe (7.5%), the US (6.6%), South Korea (2.4%) and Japan (1.9%). From the perspective of the national origin of production capacity, Chinese manufacturers dominate with a total capacity of 1,600 GWh, which is 3.9 times that of the second-ranked South Korean manufacturers. However, South Korean manufacturers have a more globally distributed production footprint, accounting for 74% of total EV battery production capacity in Europe, 29% in the US and 10% in China. In contrast, Chinese manufacturers predominantly concentrate their production domestically, with only a small proportion located in Japan and Europe.

Figure 3.7: Distribution of Multinational Enterprises Engaged in the Extraction of Critical Minerals

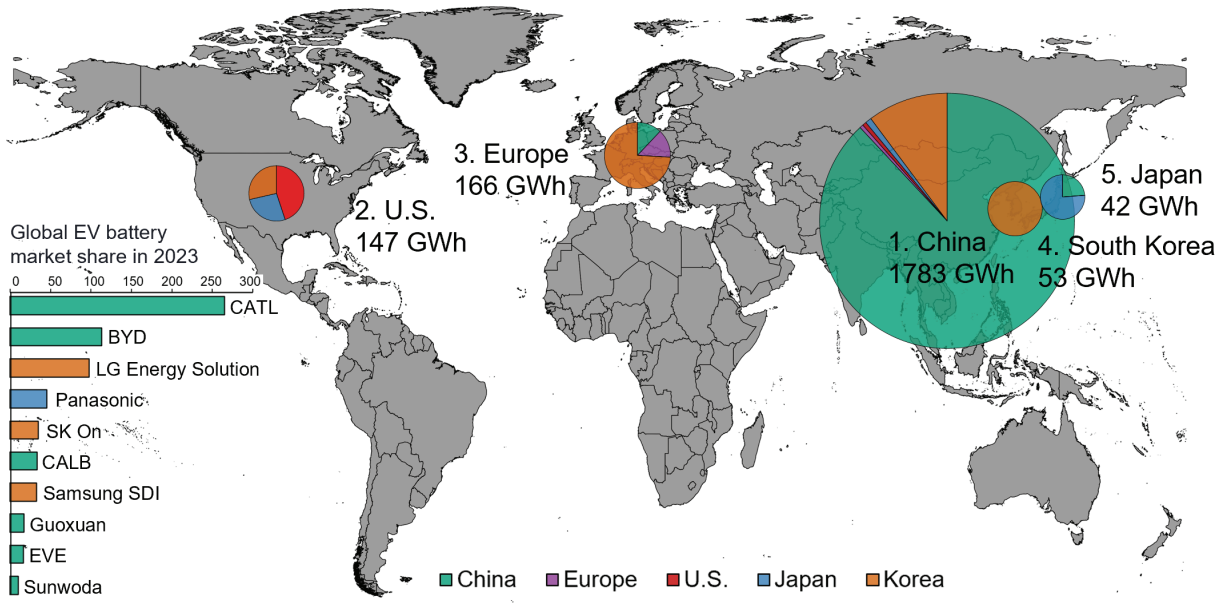


Notes: Different shapes and colours represent specific minerals and firms, with larger symbols indicating company headquarters and smaller ones denoting major mining sites.
Source: Data collected by the author from online news articles.

This concentration of production capacity mirrors the market's consolidation, where a few leading companies dominate. In 2023, 10 manufacturers collectively accounted for 93% of the global EV battery market share. China's dominance is underpinned by its technological leadership, large-scale production capabilities and robust government support for EV policies. Among the top 10 manufacturers, six are Chinese companies, with Contemporary Amperex Technology Co. Ltd. (CATL) commanding the largest market share at 36.8%. Meanwhile, leveraging advanced technology and global market strategies, South Korea's LG Energy Solution, SK On and Samsung SDI ranked third, fifth and seventh, respectively. Japan's Panasonic also secured a position in the global top 10 EV battery suppliers, placing fourth.

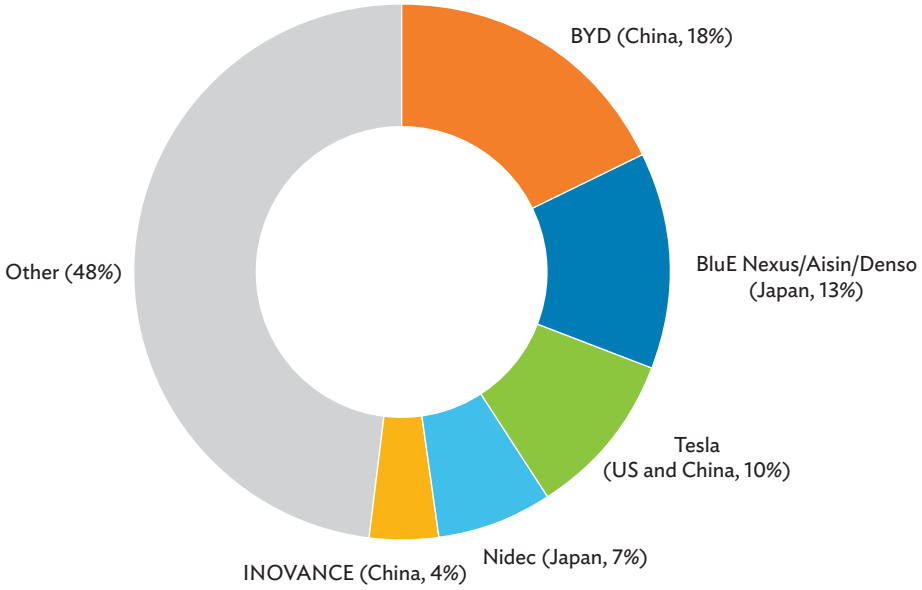
Compared to the EV battery sector, the electric motor market exhibits a more diversified competitive landscape (Figure 3.9). BYD leads the market, ranking first with an 18% share. The Japanese consortium of BluE Nexus, Aisin and Denso collectively holds a 13% share, securing second place. Tesla's electric motor production across its factories in the US and China accounts for 10% of the global market, placing it third. Japan's Nidec commands 7% of the market, followed closely by China's Inovance Technology (Inovance), which holds a 4% share. Other companies collectively account for the remaining 48% of the market.

Figure 3.8: Regional EV Battery Manufacturing Capacity By Manufacturer Headquarters and Global EV Battery Market Share in 2023



Source: IEA (2024a) and Annual Cumulative Global Battery Usage for EV in SNE (2024)

Figure 3.9: Global EV Electric Motor Market Share in 2022



Source: Analysis Report: EV/HV Drive Motor in Marklines (2024)

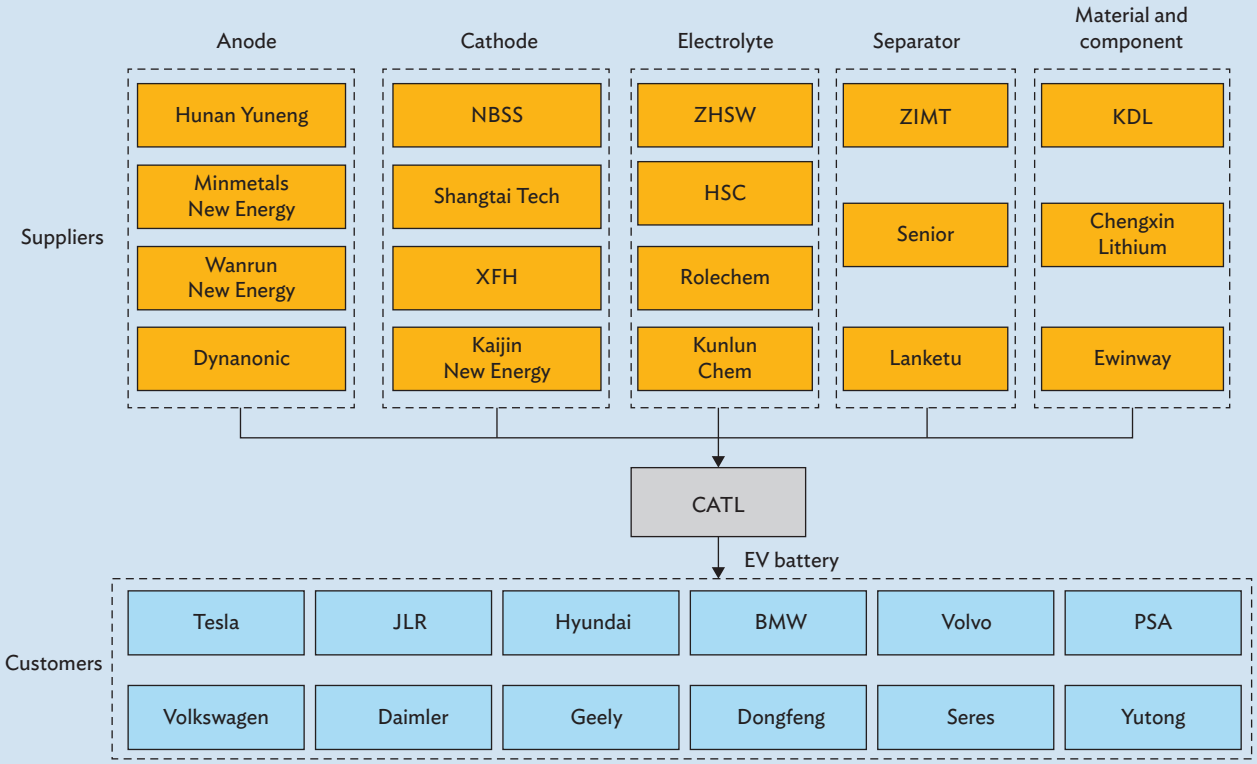
Box 3.1: Global Leader in the EV Battery Industry: CATL

Contemporary Amperex Technology Co., Ltd. (CATL) is the global leader in the production of EV batteries. According to SNE Research, the company held a 36.8% share in the EV battery market in 2023, maintaining its position as the leader for the seventh consecutive year. From 2017 to 2023, its annual average growth rate of EV battery sales reached 60.5%, driven by its continuous technological innovation and policies aimed at building a resilient supply chain.

CATL engages in deep collaboration with suppliers in crucial upstream areas such as cathode, anode, separator and electrolyte, as well as key components through mechanisms like technology licensing, long-term agreements and joint ventures. This strategy ensures the security of supply for critical raw materials and equipment while keeping costs under control. Additionally, the company collaborates with its suppliers to advance technological research and development (R&D), creating a supply chain system with sustained global competitiveness.

CATL's clientele includes numerous domestic Chinese automakers such as SAIC, Geely, Yutong, BAIC, Dongfeng, XPeng and Seres. Internationally, CATL has established partnerships with prominent global automotive brands, supplying EV battery products to BMW, Daimler, Hyundai, Jaguar Land Rover, PSA, Volkswagen and Volvo. This extensive customer base strategy effectively mitigates the negative impact of market demand fluctuations on the company's sales revenue, enhancing its stability and competitiveness in the global EV market.

Figure B 3.1.1: The Industrial Chain Distribution of CATL



Notes: NBSS: Ningbo Shanshan Co., Ltd. XFH: Shanghai XFH Technology Co., Ltd. ZHSW: Zhuhai Smoothway Electronic Materials Co., Ltd. HSC: Jiangsu Hsc New Energy Materials Co., ltd. ZIMT: Shenzhen ZTE New Materials Technology Co., Ltd. Senior: Shenzhen Senior Technology Material Co., Ltd. Lanketu: Qingdao Lanketu Membrane Materials Co., Ltd. KDL: Shenzhen Kedali Industry Co., Ltd. Ewinway: Jiangxi Yunwei New Material Co., Ltd.

Source: Wind, annual report of CATL 2024

3.3 Structure Change of Value Added Creation and Carbon Emissions Along Global EV and ICEV Supply Chains

Drawing on the EV-ICIO model developed by Meng et al. (2025)[1], this section analyses how value added and carbon emissions are created and distributed along global supply chains in response to the production of EVs and ICEVs across six key automotive-producing countries: China, Germany, Japan, South Korea, Mexico and the US, which together accounted for 66.4% of global automotive production in 2023 (OICA, 2025).

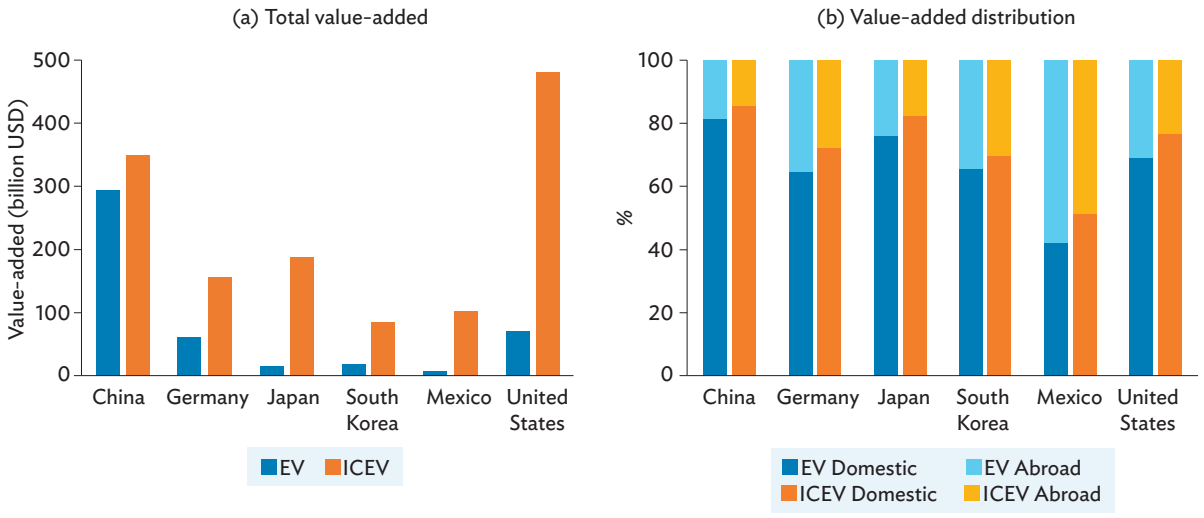
3.3.1 Value-Added Induced By the Production of EV and ICEV

Figure 3.10a presents the absolute level of value added embedded in the production of EVs and ICEVs. In 2023, China and the US were the largest automobile-producing countries, manufacturing 30.2 million and 10.6 million vehicles (OICA, 2025), respectively, thereby generating the highest levels of value added. However, the gap in value added between the two countries was relatively modest, with China generating $643 billion and the US making $552 billion. This narrower gap primarily results from the higher domestic value added coefficient of automotive-related sectors within the US, and the average vehicle price in the US is roughly 2.3 times that of China.

Driven by vertically integrated battery production, vehicle assembly and material refining capacity, China holds a commanding lead in the EV sector. EV production in China generated $294 billion in value added. Benefiting from a large internal market and accelerating investment in domestic EV manufacturing infrastructure, the US ($70 billion) and Germany ($61 billion) ranked just behind China in terms of EV-related value added, though substantial gap remains compared with the ICEV-related value added. For example, in the US, the former accounted for only 14.6% of the latter. This reflects that traditional automotive manufacturing powerhouses may not necessarily be able to maintain their comparative advantages, given the significant differences in intermediate inputs and required production technologies between EVs and ICEVs. EVs impose higher demands on R&D capabilities and supply chain integration, especially in batteries, electronics and electric motors.

[1] The EV-ICIO model disaggregates the automotive sector in the OECD ICIO system into three subsectors: EVs, ICEVs and vehicle parts and components. The development of this model is based on the latest OECD ICIO tables (Yamano et al. 2023) as the control total, the OECD BTDIxE, detailed product level merchandise trade statistics (UN Comtrade), and the information of structural differences in technological input requirements between EVs and ICEVs estimated using a combination of firm-level surveys, expert interviews (for details, see Meng et al. 2025).

Figure 3.10: Value Added Induced By EV and ICEV Production, 2023



Source: Authors' calculation using an EV-ICIO model based on the OECD ICIO data (Meng et al., 2025).

Japan and South Korea possess advantages in battery and semiconductor technologies. However, the scale of their EV assembly remains relatively limited, resulting in a comparatively modest level of value added. Meanwhile, Mexico – traditionally a major assembly base for ICEVs – has yet to transition to large-scale EVs assembly, reflecting constraints in EVs demand, supply chain integration and technology adaptation.

Figure 3.10b illustrates the proportion of domestic and foreign value added, highlighting the more inclusive and globalized nature of EV supply chains. Compared with ICEVs, EVs involve more cross-border stages and external inputs, resulting in a higher share of foreign value added and enabling a wider range of economies to participate in the EV supply chains by leveraging their comparative advantages. For example, resource-rich economies such as the DRC have become important global suppliers of raw materials for EV batteries due to their abundant cobalt reserves – a role they can scarcely play in the ICEVs value chain. Similarly, countries like Indonesia and Chile, which are endowed with significant nickel and lithium resources, have emerged as key links in the EV supply chains.

The completeness of a country's domestic supply chain determines the share of value added that is retained domestically. China, Japan and the US all lead in terms of domestic value added shares. For China, 81.5% of the value added in EV production is retained domestically – only four percentage points lower than for ICEVs – mainly due to China's strong capabilities in battery manufacturing and vehicle assembly. However, it is worth noting that China still depends on foreign suppliers for automotive chips and critical minerals required for battery production. The US shows the inverse profile: relatively strong retention in ICEVs (76.6%) and a moderately lower share in EVs (68.9%). Although the US maintains significant control over chip manufacturing, vehicle design and vehicle assembly, it relies heavily on the Chinese supply chain

for EV batteries and critical mineral processing. This structural asymmetry results in a significantly lower share of domestic value added captured by the US in the EV production compared to ICEVs.

Germany and South Korea retain domestic value added shares of approximately 64.7% and 65.5% in EV production, respectively. Germany demonstrates strong capabilities in mechanical components but is highly reliant on battery supplies from Asia. South Korea has robust production capacities in batteries and semiconductors, yet still imports processed mineral products for battery manufacturing. Mexico exhibits the lowest domestic value added share, with only 42.3% for EVs and 51.5% for ICEVs, further highlighting its downstream position in the automotive supply chain and its limited control over high-value components.

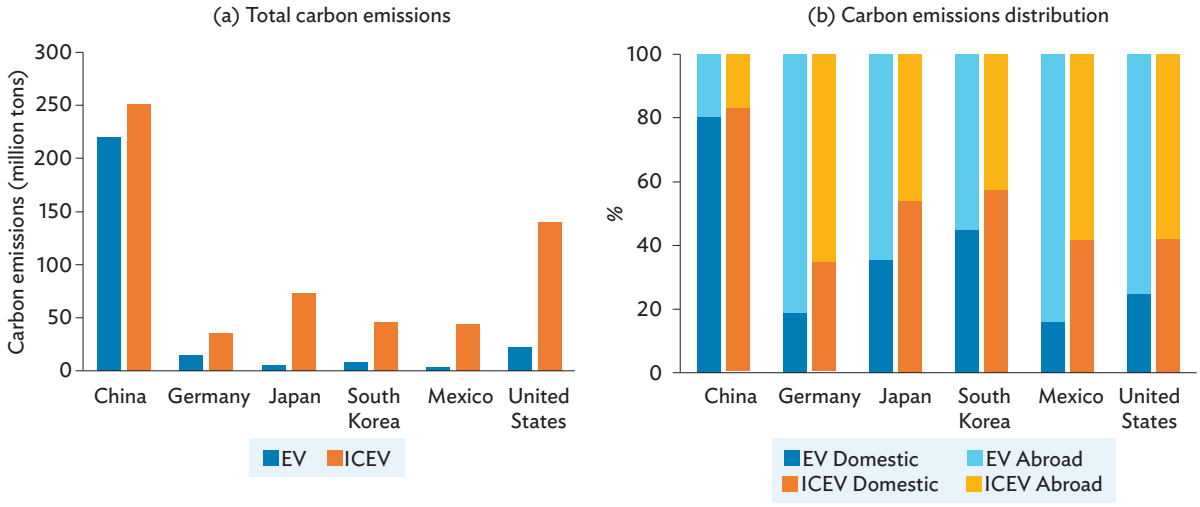
3.3.2 Carbon Emissions Induced by the Production of EVs and ICEVs

Based on the EV-ICIO model, it is also possible to quantify the differences in carbon emissions from the production of EV and ICEV across selected economies. Figure 3.11a illustrates the total carbon emissions generated from the production of EV and ICEV by economy. Owing to higher production volumes and ongoing reliance on carbon-intensive internal combustion engine manufacturing, ICEV production is associated with greater overall emissions. Meanwhile, the total emissions associated with EV production should not be overlooked either, as the battery supply chain generates substantial emissions.

At the national level, China's high degree of localization in the automotive supply chains, combined with its coal-dependent energy mix, results in the country leading the world in carbon emissions from both EV and ICEV production, reaching 220 million tons and 251 million tons, respectively. In contrast, the US benefits from a relatively cleaner domestic energy mix, with an average carbon intensity that is just 23% of China's (World Bank, 2025). Consequently, carbon emissions from ICEV production in the US are only 55.7% of those in China, totalling 162 million tons.

Figure 3.11b presents the share of carbon emissions between domestic and foreign sources. Similar to value added, the more open and globalized EV supply chains lead to a greater share of foreign carbon emissions, though this proportion varies significantly across economies. In China, strong domestic supply chains and high carbon intensity result in 80.2% of EV-related and 83.2% of ICEV-related carbon emissions remaining within the country. Although South Korea and Japan are also major producers of EV batteries, a large share of the upstream mineral processing required for their battery produciton is imported from China. As a result, their domestic carbon emissions embodied in EV production are higher than in the US and Germany, but lower than in China.

Figure 3.11: Carbon Emissions Induced By EV and ICEV Production, 2023



Source: Authors' calculation using an EV-ICIO model based on the OECD ICIO data (Meng et al., 2025). The carbon emissions information is derived and estimated from sectoral production-related emissions (Yamano et al., 2024).

The US and Germany have relatively limited domestic capacity for EV battery production and primarily rely on imports from countries like South Korea, Japan and China, while participating less in carbon-intensive battery manufacturing. According to estimates, battery supply chains account for roughly 60% of total EV production emissions (McKinsey, 2023). Consequently, in both economies, over 70% of carbon emissions associated with EV production originate from abroad.

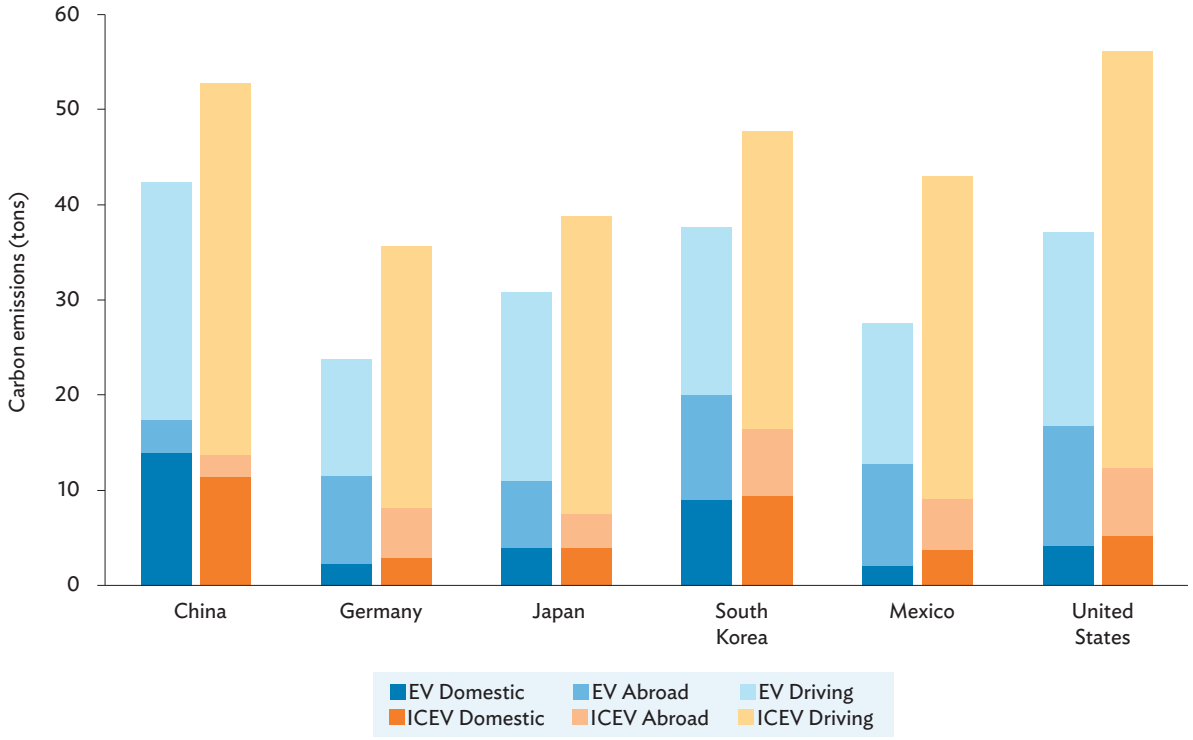
For ICEV production, traditional manufacturing economies typically have established stable global supply chains. Most ICEV-related industries in China are concentrated domestically. Partly because developed economies such as Germany, Japan, South Korea and the US have adopted relatively strict emissions regulations, they often outsource carbon-intensive production processes, resulting in a larger share of their carbon emissions occurring abroad. Notably, Germany records the highest share of ICEV-related carbon emissions occurring abroad – 65.0% – reflecting its deep integration within the EU's internal production network. As a country primarily focused on vehicle assembly, Mexico exhibits relatively low shares of foreign carbon emissions in the EV and ICEV production.

3.3.3 Life Cycle Carbon Emissions of EVs and ICEVs

As the primary pathway for decarbonizing the transport sector, EVs exhibit significantly lower life cycle emissions than ICEVs (TEI, 2022) (Figure 3.12). Emissions associated with the EV battery supply chain result in the production of an EV generating 2 to 4 tons more carbon emissions than an ICEV. For example, producing an EV in the US generates 16.8 tons of carbon dioxide (tCO_2) of carbon dioxide emissions, compared to only 12.3 tCO_2 emissions for an ICEV. However, over the vehicle's lifetime, EVs show

a clear advantage in emission reductions. In China, the driving emissions of an EV are about 25.1 tCO_2, while those of an ICEV reach 39.0 tCO_2. Similar trends are observed in other economies: in Germany, Japan and South Korea, the driving emissions for EVs are 12.3, 19.8 and 17.6 tCO_2, respectively, which are significantly lower than those of ICEVs (27.6, 31.4, and 31.3 tCO_2, respectively).

Figure 3.12: Life Cycle Carbon Emissions per EV and ICEV



Notes: The vehicle lifetime is set at 200,000 km (Nguyen-Tien et al., 2025).
Source: Authors' calculation using an EV-ICIO model based on the OECD ICIO data (Meng et al., 2025). The carbon emissions information is derived and estimated from sectoral production-related emissions (Yamano et al., 2024).

The ongoing transition to cleaner electricity, combined with continued improvements in vehicle efficiency, will enable EVs to achieve even greater environmental benefits over their entire lifetime (Yang et al., 2021). We set up three scenarios to examine how improvements in the energy mix and advances in battery technology affect the time required for EVs to achieve net emission reductions relative to ICEVs. Scenario 1 assumes a cleaner national energy mix, characterized by a higher share of renewable energy (Table 3.1). Scenario 2 assumes more efficient electric driving system, meaning that less electricity is needed to drive the same distance (Table 3.2). Scenario 3 combines both factors – that is, assuming that the share of renewables and electric driving system efficiency is increased by the same proportion (Table 3.3).

Under the current energy mix and technological conditions, it takes only 1.7 years for EVs in the US to reach life cycle emission parity with ICEVs, while the corresponding periods are 5.7 years for China and 7.6 years for Japan. This outcome is mainly

determined by differences in average driving distances and the engine displacements of ICEVs. In the US, the average daily driving distance is 61 km, compared with only 25 km in China and 22 km in Japan. Moreover, ICEVs in the US have larger engine displacements compared to those in Japan and China, which means that switching from ICEVs to EVs results in greater annual emission reductions in the US, i.e., EVs in the US require less time to offset the higher production emissions through lower driving emissions.

Table 3.1: Simulation Results of Scenario 1 (cleaner energy mix)

	Baseline	5%	10%	15%	20%	25%	30%
China	5.7	5.5	5.4	5.2	5.1	4.9	4.7
Germany	3.7	3.6	3.5	3.3	3.2	3.1	3.0
Japan	7.6	7.3	7.1	6.9	6.6	6.4	6.1
South Korea	3.5	3.4	3.3	3.2	3.2	3.1	3.0
Mexico	3.3	3.2	3.1	3.0	2.9	2.8	2.7
United States	1.7	1.6	1.6	1.5	1.5	1.4	1.4

Source: Authors' calculation using an EV-ICIO model based on the OECD ICIO data (Meng et al., 2025).

Table 3.2: Simulation Results of Scenario 2 (more efficient electric driving system)

	Baseline	5%	10%	15%	20%	25%	30%
China	5.7	5.6	5.2	4.9	4.6	4.4	4.2
Germany	3.7	3.7	3.7	3.6	3.5	3.5	3.4
Japan	7.6	7.2	6.9	6.5	6.2	6.0	5.7
South Korea	3.5	3.4	3.2	3.0	2.9	2.8	2.6
Mexico	3.3	3.2	3.1	3.0	2.9	2.9	2.8
United States	1.7	1.6	1.6	1.6	1.5	1.5	1.4

Source: Authors' calculation using an EV-ICIO model based on the OECD ICIO data (Meng et al., 2025).

Table 3.3: Simulation Results of Scenario 3 (cleaner energy mix and more efficient electric driving system)

	Baseline	5%	10%	15%	20%	25%	30%
China	5.7	5.4	4.9	4.5	4.1	3.8	3.5
Germany	3.7	3.6	3.4	3.2	3.1	2.9	2.8
Japan	7.6	7.0	6.4	5.9	5.5	5.0	4.6
South Korea	3.5	3.3	3.1	2.8	2.6	2.5	2.3
Mexico	3.3	3.1	2.9	2.8	2.6	2.5	2.3
United States	1.7	1.6	1.5	1.4	1.3	1.3	1.2

Source: Authors' calculation using an EV-ICIO model based on the OECD ICIO data (Meng et al., 2025).

As the energy mix improves, the time required for EVs to achieve net emission reductions decreases significantly. For example, if the share of renewable energy increases by 15%, the payback period for EVs in Japan drops from 7.6 years to 6.9 years, and in China from 5.7 years to 5.2 years. In the US, only 1.5 years are needed to

achieve net emission reductions. This is because the expansion of renewable energy leads to a more substantial reduction in electricity-related emissions, benefiting both the production and driving phase of EVs, while the emissions associated with gasoline/diesel consumption in ICEVs remain unchanged.

Improvements in electric driving system efficiency help reduce the energy-related emissions of EVs during the operation phases. When electric driving system efficiency increases by 15%, the carbon payback period for EVs in Japan shortens from 7.6 years to 6.5 years, and in the US drops to 1.6 years. However, compared with improvements to the energy mix, increasing electric driving system efficiency poses greater technological challenges. When both the energy mix and electric drive efficiency improve by 15%, the emission reduction potential of EVs is further enhanced, with the carbon payback period for EVs in Japan declining to about 5.9 years to achieve life cycle emission parity with ICEVs.

Based on the above analysis, an efficient global EV supply chain design places low-emission, technologically advanced economies at the helm of battery and core-component manufacturing, as well as of end-of-life circular activities, while resource-rich developing economies supply critical minerals and undertake mineral processing. This specialization leverages comparative advantages, deepens technology–resource complementarities and accelerates the EV sector's low-carbon transition worldwide.

3.4 New Opportunities for a More Inclusive Global EV Supply Chains: A Study Based on Product Space Evolution

The development of EV supply chains is profoundly redefining the landscape of the global automotive industry. EV-related industries have become a strategic priority not only for traditional automotive powerhouses but also for numerous emerging market and developing economies (EMDEs), which view the EV sector as a pivotal future development track and are exploring avenues for integration into the global supply chain. In 2024, EV sales in Asia, Africa and Latin America surged by 40% year-on-year, capturing a 4% market share. Notably, sales in Indonesia and Vietnam tripled and doubled, respectively, while Costa Rica and Uruguay achieved high penetration rates of 15% and 13% (IEA, 2025b). This growth opens new avenues for developing economies to enter the EV value chain, fostering economic growth through industrial upgrading and diversification.

3.4.1 Product Space Network of EV Supply Chains

The product space network is an outcome-based framework for measuring linkages between products (Hidalgo et al., 2007). Its core logic is that if the production of two

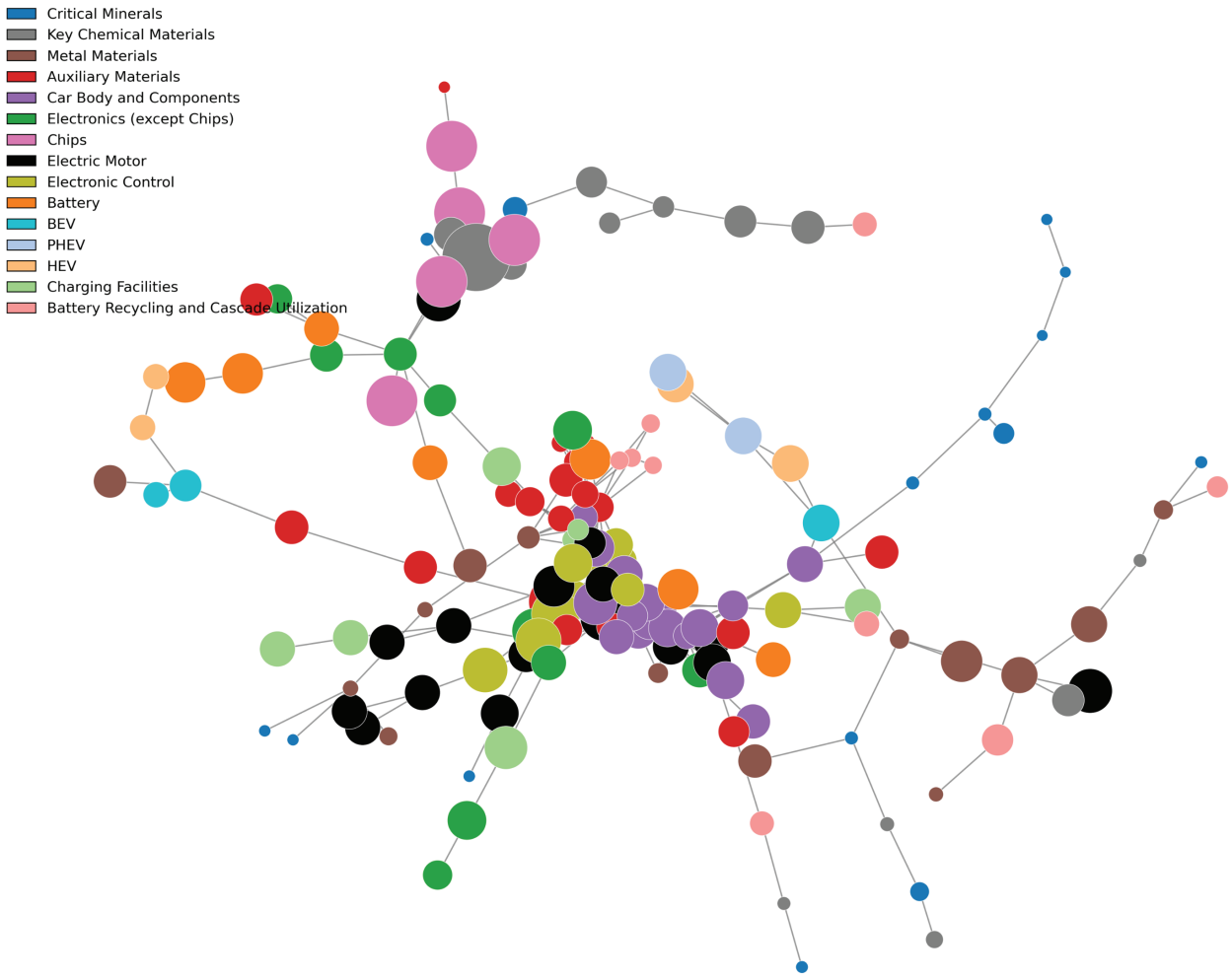
goods requires similar institutions, infrastructure, factor inputs or technology, etc., they are likely to be co-produced. This linkage is quantified as "proximity", which formalizes the idea that a country's ability to produce a product is dependent on its ability to produce other, related products. For instance, a country capable of exporting apples likely possesses most conditions needed for exporting pears (e.g., suitable soil, climate and cold-chain logistics), as the capabilities are highly transferable. In contrast, these capabilities would be largely irrelevant for producing goods like copper wires or home appliances.

Based on this logic, a product space network for EV supply chains was constructed. The network was developed by first identifying EV-related products according to industry classifications from the WTO (2024) and IEA (2024a), which categorize 155 products into four segments: raw materials, upstream, midstream and downstream. The raw materials category encompasses key chemical materials, metals and auxiliary materials. The upstream segment consists of six product groups: chips, other electronics, electronic control systems, electric motors and batteries, as well as car bodies and components. The midstream segment covers EV manufacturing, including both BEVs and PHEVs. The downstream segment includes charging infrastructure, battery recycling and cascade utilization.

The resulting EV product space exhibits a distinct core-periphery structure (Figure 3.13). Products located in the core demonstrate high technical versatility and complementarity. They are densely interconnected, enabling agglomeration effects and economies of scale through technology sharing and transfer. For instance, production factors related to electronic control systems (yellow), car bodies and components (purple) and auxiliary materials (red) can be readily applied across different EV subsystems. In contrast, peripheral products occupy relatively isolated positions in the product space. While their technological pathways are less extendable from existing products, they still fulfill indispensable roles within the EV supply chain.

Peripheral products can be broadly classified into two types. The first category comprises resource-intensive products, such as key mineral resources including lithium, cobalt and nickel. The development of these products is largely dependent on a country's natural resource endowment. Although they involve relatively low levels of technological sophistication, they form the foundational support for EV manufacturing and represent the starting point of the supply chain. The second category consists of key components with high technical barriers, such as chips (pink) and batteries (orange). The R&D and manufacturing of these products rely heavily on original innovation and industrial ecosystems, presenting significant entry barriers and strong industrial control.

Figure 3.13: Global EV Supply Chain Product Space, 2017-2023



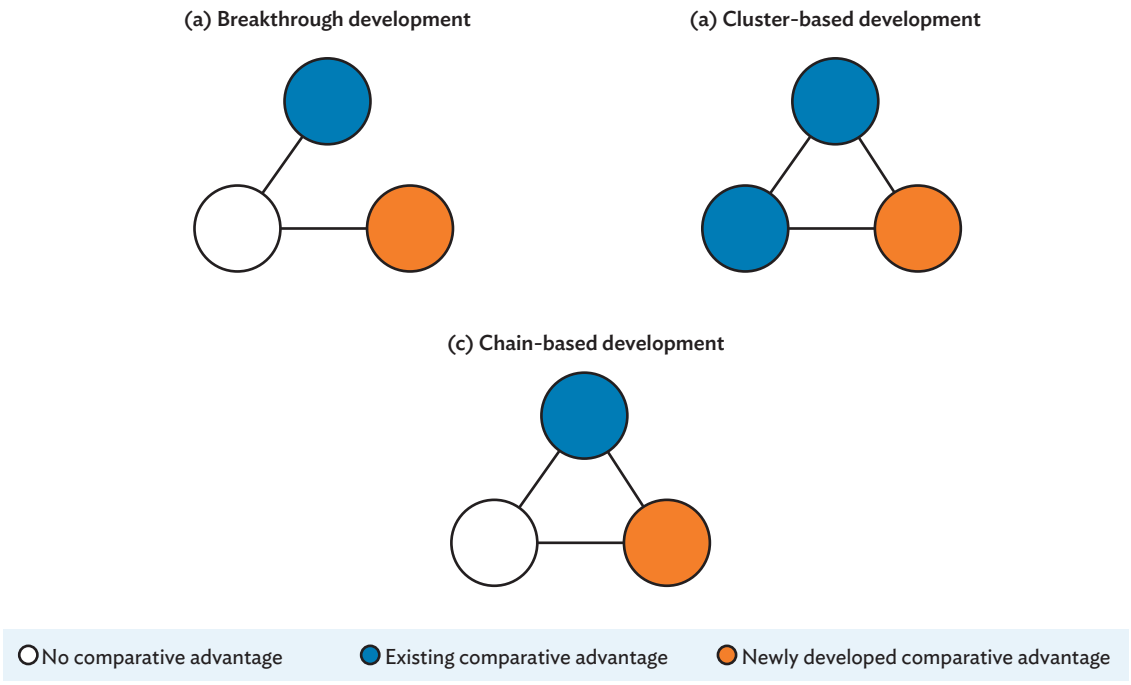
Note: The node size corresponds to the product complexity, node colour represents categories in the EV supply chain.
Source: Authors' calculation based on UN Comtrade data (2017-2023)

3.4.2 Evolutionary Pattern of the Global EV Supply Chain

The evolutionary pathways of countries within the EV supply chain can be categorized into three types: breakthrough, cluster-based and chain-based. Using each country's set of competitive products in 2017 as the benchmark, we define any product newly added between 2018 and 2023 as a "new product".

A product is classified as following a breakthrough pattern if it has no direct network connection to any product in the benchmark (Figure 3.14a). It is considered cluster-based if the new product forms a triadic closure with existing products in the benchmark (Figure 3.14b). If it is connected to a benchmark product but does not form a triadic closure, the evolution is labelled 'chain based'. Both the chain-based and cluster-based patterns are considered path-dependent, as they build upon existing competitive products.

Figure 3.14: Schematic Diagram of Evolutionary Patterns



Source: Compiled by the author

The evolution diagram of the main countries in EV supply chains is shown in Figure 3.15. On the left side of this diagram are the evolutionary patterns of 15 EV supply chain categories. Raw materials categories mainly follow a breakthrough pattern, lacking links with pre-existing products. For example, among 22 new critical mineral products (2017–2023), 18 are breakthrough; in key chemical materials, 16 of 20; in metal materials, 18 of 30; and in auxiliary materials, 15 of 46.

Most upstream categories exhibit strong path dependencies: among 21 new electronics products, six are cluster-based and 10 chain-based; in electronic control, eight cluster-based and 11 chain-based (out of 23); in electric motors, eight cluster-based and 10 chain-based (out of 29); in batteries, three cluster-based and two chain-based (out of eight); and in body and components, 21 cluster-based and 11 chain-based (out of 37). An exception is chips, where three of six new products are breakthroughs.

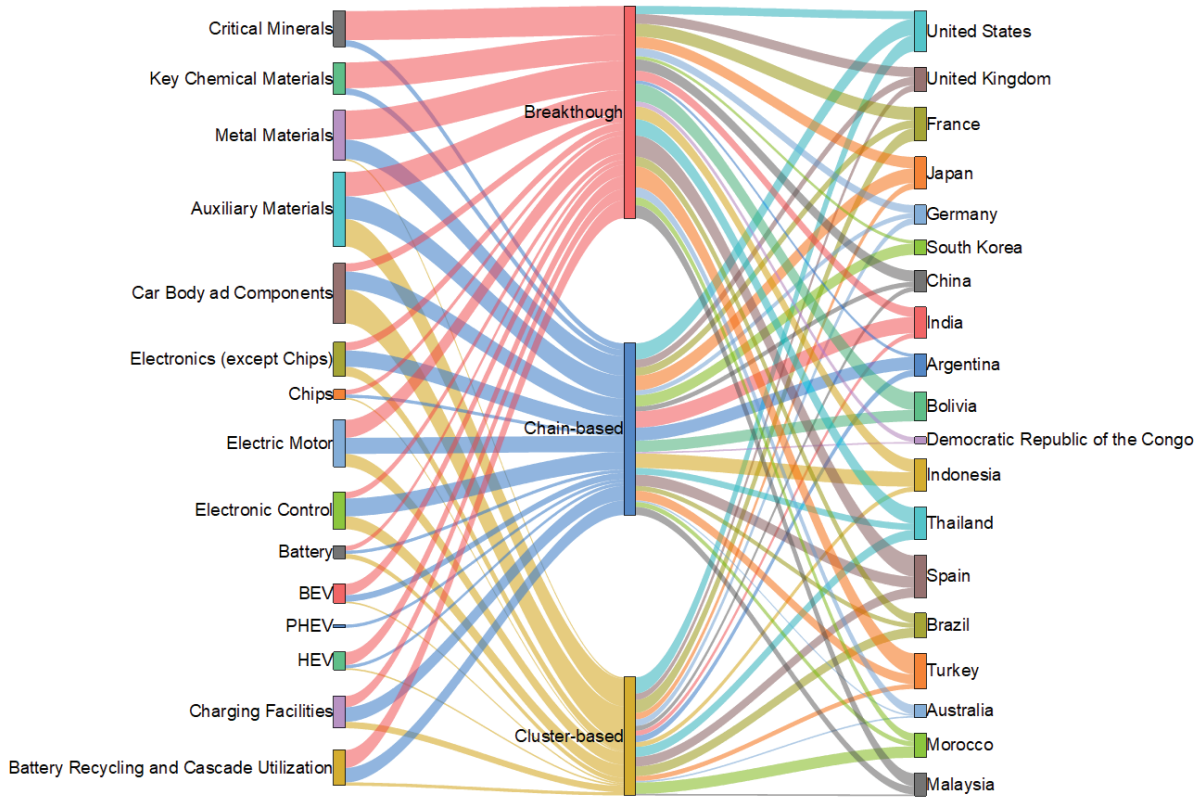
Most midstream categories also follow the breakthrough pattern, with 15 of 25 new BEV, PHEV and HEV products being breakthroughs. In downstream categories, half of the products (seven in charging facilities and 11 in battery recycling) are breakthroughs and half are chain-based.

The right side of Figure 3.15 allows for a cross-country comparison of evolutionary pathways within the EV supply chain. Most developed countries follow strong path dependencies, adopting chain-based or cluster-based patterns. In the US, 10 products

are cluster-based and 10 chain-based among 25 new products. The UK, Japan and South Korea mainly follow chain-based patterns with five, nine and seven products, respectively, while France and Germany lean towards cluster-based patterns with eight and four products. These developed economies build on existing technological strengths, particularly in electronics, electric motors and electronic control, leading to chain-based evolution without major shifts from traditional internal combustion engine industries, except in advanced technologies such as power batteries.

In contrast, developing economies display more varied patterns. China mainly follows a breakthrough pattern, with seven of 13 new products unrelated to existing ones. Thailand, Spain, and Türkiye also follow breakthrough patterns, whereas India shows a chain-based path dependency. Resource-rich countries such as Argentina (lithium) and Indonesia (nickel) mainly evolve in a chain-based manner. Bolivia presents a mixed case, with eight breakthrough and nine chain-based products. Brazil and Morocco, on the other hand, show a tendency towards cluster-based evolution.

Figure 3.15: Evolutionary Patterns of 15 Categories in the EV Supply Chain (Typical Economies)



Source: Authors' calculation based on UN Comtrade data (2017–2023)

3.4.3 Evolutionary Patterns of Typical Products in the EV Supply Chain

The evolution of six representative product categories within the EV supply chain was analysed at the product level, covering chips, electronics (excluding chips), electronic controls, electric motors, batteries and EV manufacturing. Their specific evolutionary pathways are illustrated in Figure 3.16.

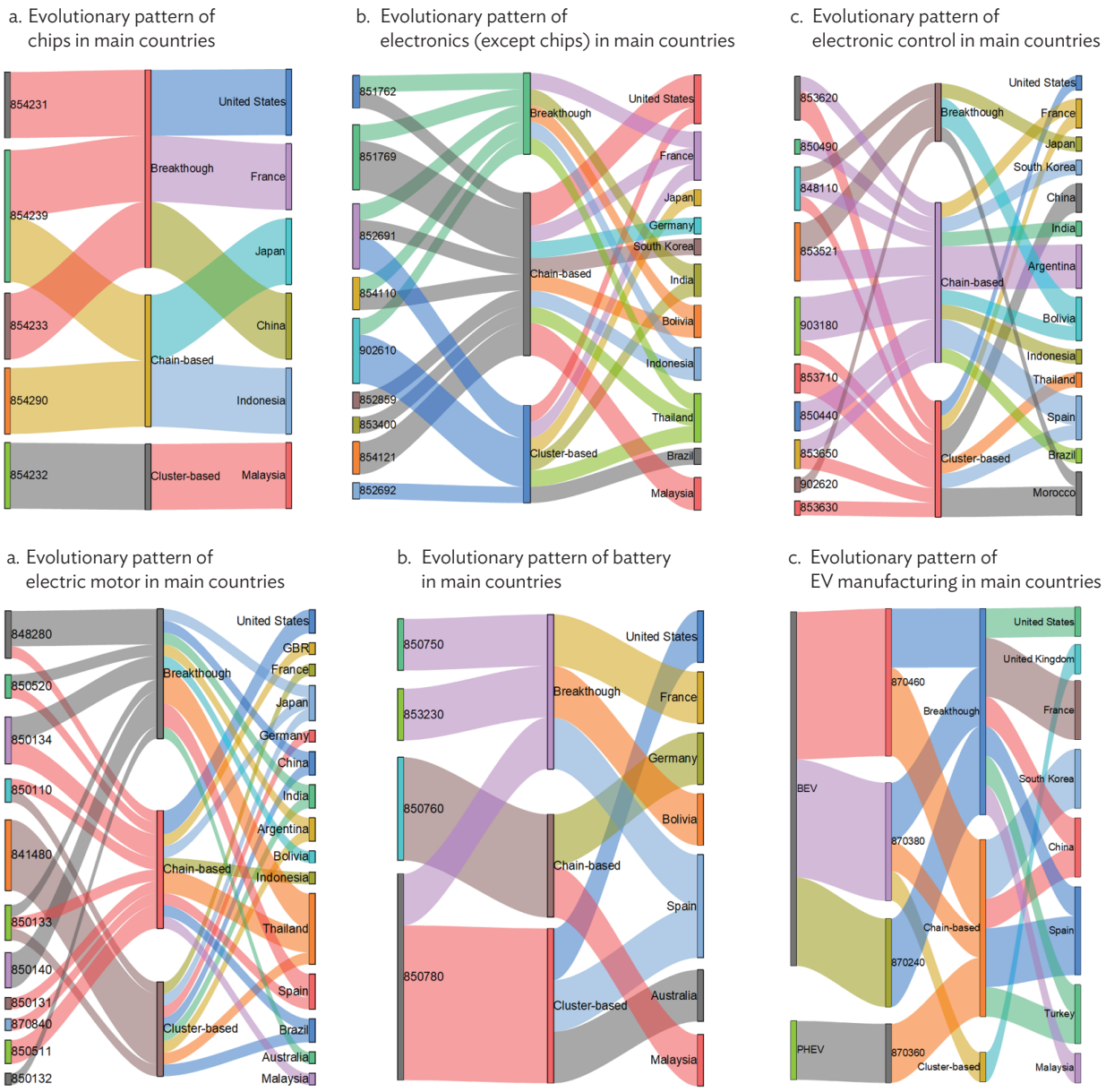
In the chips category, evolutionary patterns are highly diverse (Figure 3.16a). Processor and controller integrated circuits (HS 854231) and amplifier integrated circuits (HS 854233) predominantly follow a breakthrough pattern. In contrast, parts of integrated circuits (HS 854290) evolve in a chain-based manner, reflecting reliance on pre-existing electronic component industries. Memory integrated circuits (HS 854232) exhibit a cluster-based pattern, indicating strong linkages with existing products and the formation of triadic closures. Only six countries – the US, France, Japan, China, India and Malaysia – developed comparative advantages in new chip products and entered the global EV supply chain product space between 2017 and 2023, half of which followed the breakthrough pattern.

For electronics (excluding chips), the chain-based evolutionary pattern is dominant (Figure 3.16b). Among the 21 new electronic products that revealed comparative advantage (RCA) and entered the EV supply chain product space, 10 followed a chain-based pattern – including two products each from the US and Malaysia. Most electronic products, such as monitors other than cathode ray tubes (HS 852859), printed circuit boards (HS 853400), and unipolar transistors (HS 854121), follow the chain-based evolutionary patterns, indicating that they tend to develop based on existing technological and industrial foundations.

Electronic control products show strong path dependence, with most following chain-based or cluster-based patterns (Figure 3.16c). Of the 23 new electronic control products, 11 evolved in a chain-based manner – including three from Argentina and two from Spain – while eight followed a cluster-based pattern, with two products each from China and Morocco. Products such as automatic circuit breakers (HS 853620, HS 853521), static converters (HS 850440), electrical switches (HS 853650) and circuit protection devices (HS 853630) typically entered the EV product space via chain-based or cluster-based pathways, indicating reliance on technological extensibility or industrial agglomeration, indicating that electronic control products tend to develop based on their technological extensibility or technological clusters.

For electronic control, it displays evolutionary patterns across three paths (Figure 3.16d). Among 29 new electronic control products, eight are cluster-based, 10 are chain-based and 11 products follow the breakthrough evolutionary pattern. However, there are differences among products: the cluster-based evolutionary pattern is primarily concentrated in products such as micro motors (HS 850110), compressors

Figure 3.16: Evolutionary Pattern of Six Typical Products in the EV Supply Chain Across Selected Countries



Source: Authors' calculation based on UN Comtrade data (2017–2023)

(HS 841480) and DC motors/generators (HS 850133), while the products with chain-based and breakthrough evolutionary patterns are more widely distributed.

Battery evolution reveals significant technological lock-in effects (Figure 3.16e). Between 2017 and 2023, the US, France, Bolivia, Spain, Australia and Malaysia developed new RCA battery products, mostly following breakthrough or chain-based patterns. All power batteries (HS 850760) evolved in a chain-based manner, reflecting high dependence on existing lithium battery systems and manufacturing capabilities. In contrast, nickel-metal hydride (NiMH) batteries (HS 850750) and capacitors

(HS 853230) mainly followed breakthrough patterns, suggesting greater potential in alternative technology pathways. Other batteries (HS 850780) followed a cluster-based pattern, likely due to agglomeration in niche applications.

In EV manufacturing products, most countries follow the breakthrough evolutionary pattern (Figure 3.16f). Most BEV products (HS 870380, HS 870460, HS 870240) follow the breakthrough pattern, and their development requires policy incentives. In contrast, PHEVs (HS 870360) exhibit stronger path dependence, mainly following the chain-based pattern, due to their higher reliance on existing automotive industrial systems.

3.4.4 EV Product Space Network and Its Evolution in Typical Economies

The evolutionary patterns of countries within the EV supply chain can be visualized using a product space network diagram. We hold the product space of a country in 2023 fixed and studied the dynamics of products within it. To illustrate these patterns, seven representative countries have been selected, with their specialization evolution depicted in Figures 3.5-3.7. Products in which a country holds a revealed comparative advantage (RCA>1) are represented by coloured circles.

Evolutionary Pattern of Traditional ICEV Economies

Figure 3.17 shows the evolutionary pattern of the traditional ICEV countries (the US, Japan and Germany) in the global EV supply chain product space.

The US had an RCA in 71 EV supply chain products in 2023 (Figure 3.17a). It occupied the core cluster of the EV supply chain product space, primarily associated with products in electronic control, electric motors, body and components, and auxiliary materials. It also participated in 12 peripheral products, such as chips, metal materials and electronics. The evolutionary patterns of the US in the EV supply chain tend to be path-dependent. From 2017 to 2023, the US developed 25 new advantageous products, 10 of them following the cluster-based pattern and 10 following the chain-based pattern. Most products in the core cluster (such as polymers in auxiliary materials, NiMH batteries and circuit breakers in electric motors) followed the cluster-based pattern, and most products in the periphery (such as refined copper in metal materials, and diodes in electronics) followed the chain-based pattern.

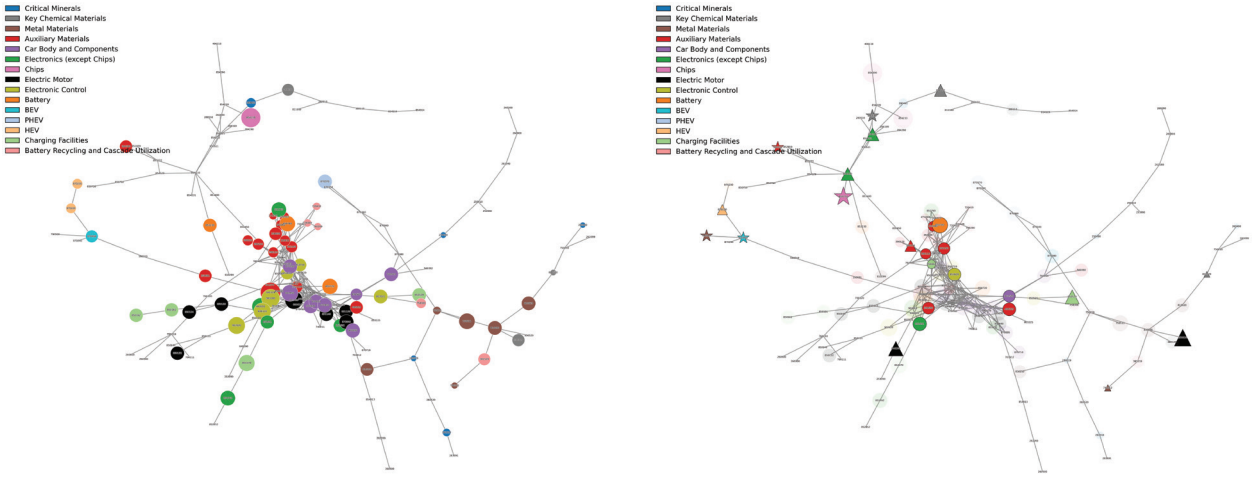
Japan occupies both the core cluster and periphery of the EV supply chain product space (Figure 3.17b), and it has more products with comparative advantages in the periphery than the US. In the core cluster, Japan has RCA in electric motors (HS 850300, HS 850152, HS 851140, etc.), electronic control (HS 903180, HS 853580), body and components products. In the periphery, Japan has RCA in chips (HS 854232, HS 854239, HS 854290), batteries (HS 853222, HS 850750, HS 853230, HS 853225), electronics (HS 854129, HS 854110, HS 853400) and key chemical materials (HS 284169, HS 282690, HS 284690). The evolutionary pattern of Japan in the EV supply

chain product space tends towards chain-based and breakthrough patterns due to its technological advantage. From 2017 to 2023, Japan developed 20 new advantageous products, nine of them following the chain-based pattern, including other chips (HS 854239), heat exchangers (HS 841950), electric motors (HS 850110), polyvinyl chloride (HS 390330), and paints and varnishes (HS 321000), etc.

Germany mainly occupies the core cluster in the EV supply chain product space (Figure 3.17c), with products in the categories of body and components, electric motors and electronic control. In 2023, Germany had 71 RCA products, with 16 in body and components, 11 in electric motors, and seven in electronic control. Germany follows a cluster-based evolutionary pattern in the EV supply chain product space due to its scale advantage.

Figure 3.17: EV Supply Chain Product Space of the US, Japan and Germany in 2023 and their Evolutionary Patterns

a. The US



b. Japan

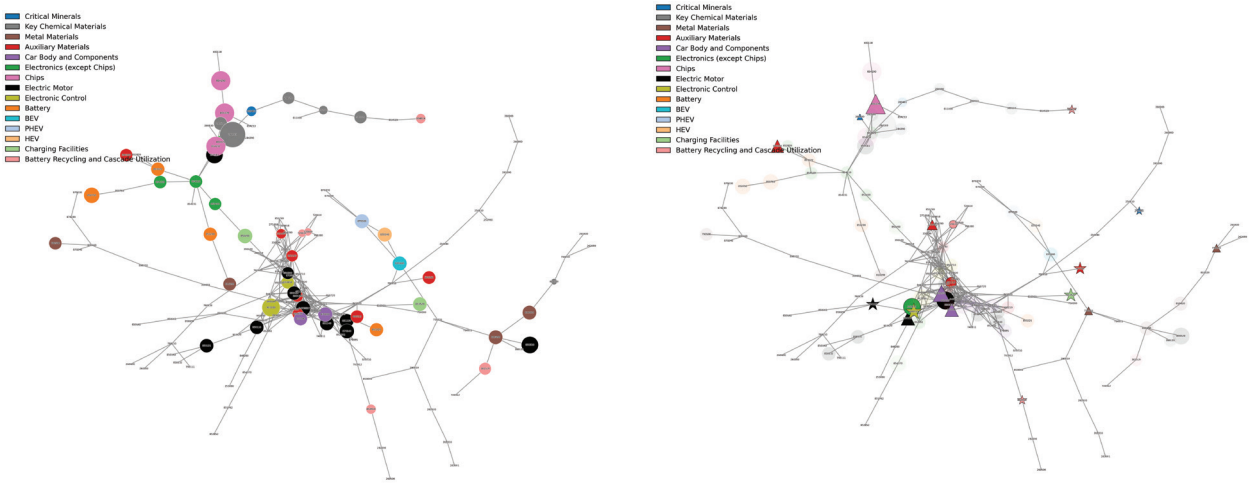


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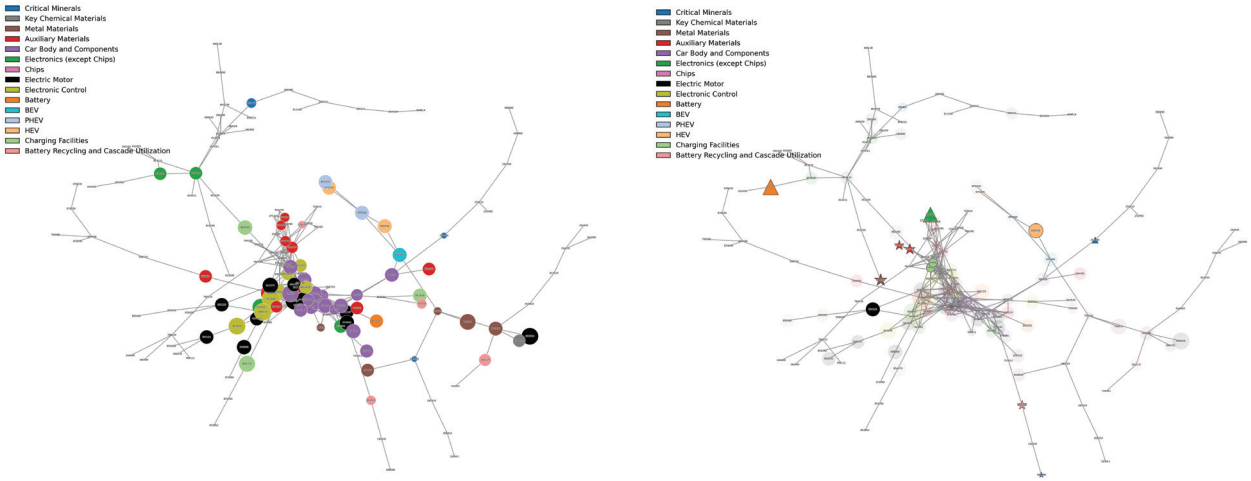
Figure 3.17: continued

c. Germany



Notes: Left, the product space of countries in 2023. Right, the evolution between 2007 and 2023. The shapes of star, circle and triangle represent the evolutionary pattern of breakthrough, cluster-based and chain-based, respectively (the same below).
Source: Authors' calculation based on UN Comtrade data (2017-2023)

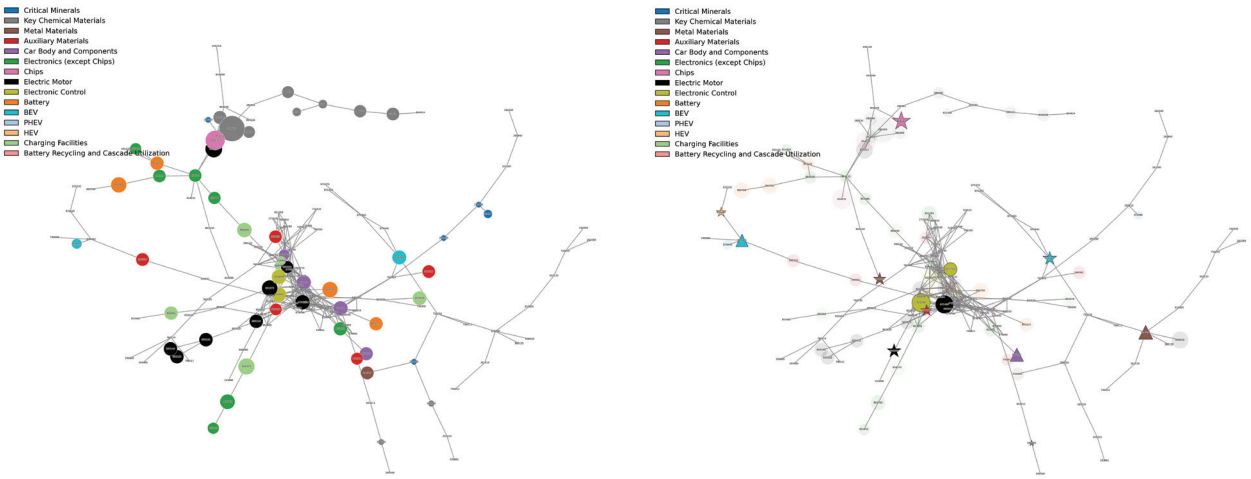
Evolutionary Pattern of Market-Driven Economies

China's products with RCA are distributed in the core cluster and the periphery of the EV supply chain product space (Figure 3.18a). In 2023, China had RCA in 56 EV supply chain products, 20 of them located in the core cluster of the EV supply chain product space and the others distributed in the periphery. China mainly follows the breakthrough evolutionary pattern in the EV supply chain product space. From 2017 to 2023, China developed 13 new advantageous products, seven of them following the breakthrough pattern. The breakthrough pattern indicates that China develops high-complexity products without establishing linkages with present products, which often rely on indigenous R&D, technology importation and industrial policy support.

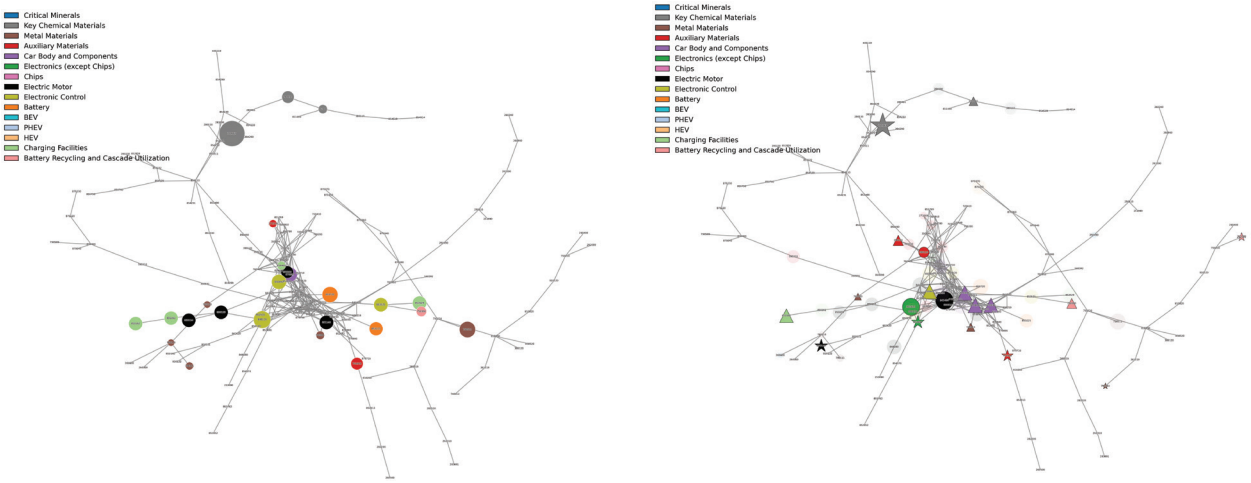
India also has its RCA products in the core cluster and the periphery of the EV supply chain product space (Figure 3.18b). In 2023, India had 25 RCA products in the EV supply chain, most of them in the periphery. In the periphery, India has RCA in key chemical materials (HS 284169, HS 284690, HS 282010). In the core cluster, India has RCA in electric motors (HS 850134, HS 850133, HS 850300, HS 851140), batteries (HS 850720, HS 853225), and electronic control (HS 848110, HS 850490, HS 853521). India mainly follows the evolutionary pattern of breakthrough and chain-based development. From 2017 to 2023, India developed 19 new advantageous products, six of them following the breakthrough pattern and 10 of them following the chain-based pattern. India remains in the early development stage of the EV supply chain, with its advantageous products distributed in the periphery of the product space, which makes it hard to form an interconnected and complementary supply chain ecosystem.

Figure 3.18: EV Supply Chain Product Space of China and India in 2023, and Their Evolutionary Patterns

a. China



b. India



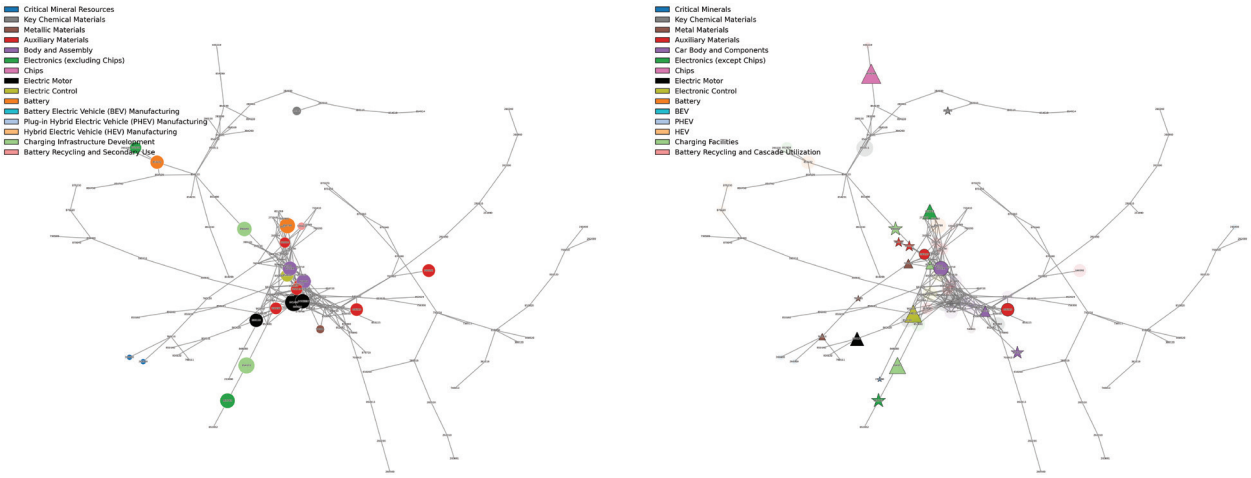
Source: Authors' calculation based on UN Comtrade data (2017–2023)

Evolutionary Patterns of Resource-Abundant Economies

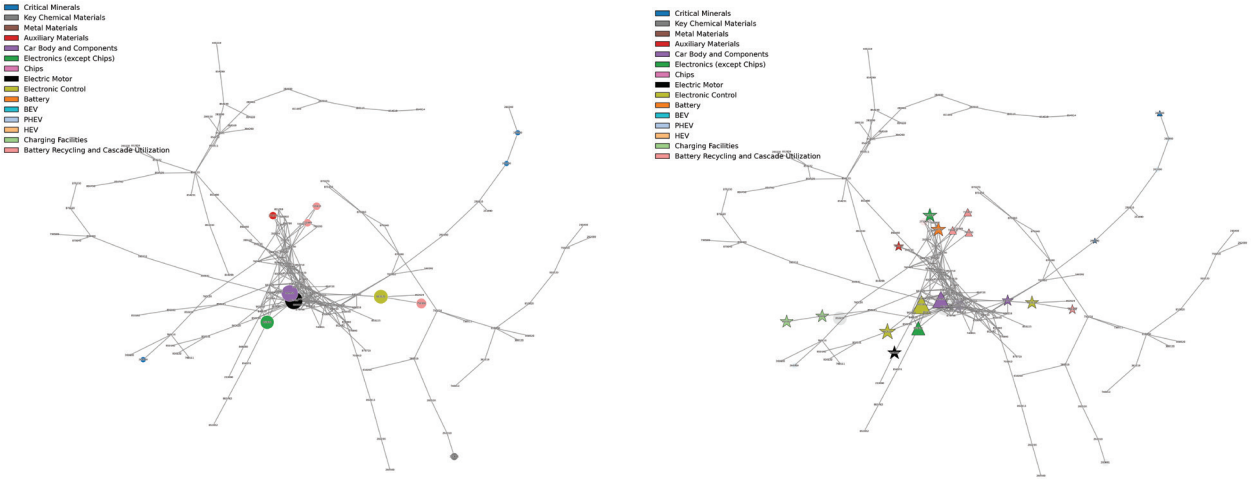
Indonesia mainly occupies the core cluster of the EV supply chain product space (Figure 3.19a). In 2022, Indonesia had 23 RCA products, with two critical materials (HS 260300, HS 260600), one key chemical material (HS 811100) and one metal material (HS 740811). Indonesia follows the chain-based and breakthrough evolutionary patterns in the EV supply chain product space. From 2017 to 2022, Indonesia developed 20 new advantageous products, nine of them (HS 854290, HS 850131, HS 848110, HS 854370, HS 851769, HS 854442, HS 940120, HS 760410, HS 760110) following the chain-based pattern, eight following the breakthrough pattern and three following the cluster-based pattern. Indonesia holds the world's largest nickel reserves, but it lacks RCA in raw materials in the EV supply chain product space, due to the implementation of an export ban on unprocessed mineral ores (including bauxite and nickel) in 2014.

Figure 3.19: EV Supply Chain Product Space of Indonesia and Bolivia, and Their Evolutionary Patterns

a. Indonesia in 2022



b. Bolivia in 2023



Source: Authors' calculation based on UN Comtrade data (2017-2023)

Bolivia had 12 RCA products in the EV supply chain in 2023 (Figure 3.19b), with three of them being critical materials (HS 260900, HS 260300, HS 261590). From 2017 to 2023, Bolivia developed 18 new advantageous products, 11 of them following the breakthrough pattern. The South American country gained its advantage in the transition from ICEV vehicles to EVs due to its natural endowments. In the ICEV vehicles era, Bolivia's lithium-rich salt flats – characterized by high impurity levels and unfavourable locations – remained untapped. However, the global shift to EVs, coupled with rising lithium prices, has transformed these deposits into strategic assets and helped Bolivia enter the global EV supply chain.

3.4.5 Opportunities for Different Economies

For economies with established technological or scale advantages in ICEV manufacturing, it is crucial to leverage their traditional strengths while embracing new EV technology trends. By enhancing innovation in core components such as batteries and chips, these countries can occupy a high value added position in the EV supply chain. Given the significant similarities in production factors, technology and institutional frameworks between EVs and ICEVs, countries with a strong ICEV base should adopt a cluster-based development model to systematically build EV supply chain capabilities rooted in their existing ICEV foundation.

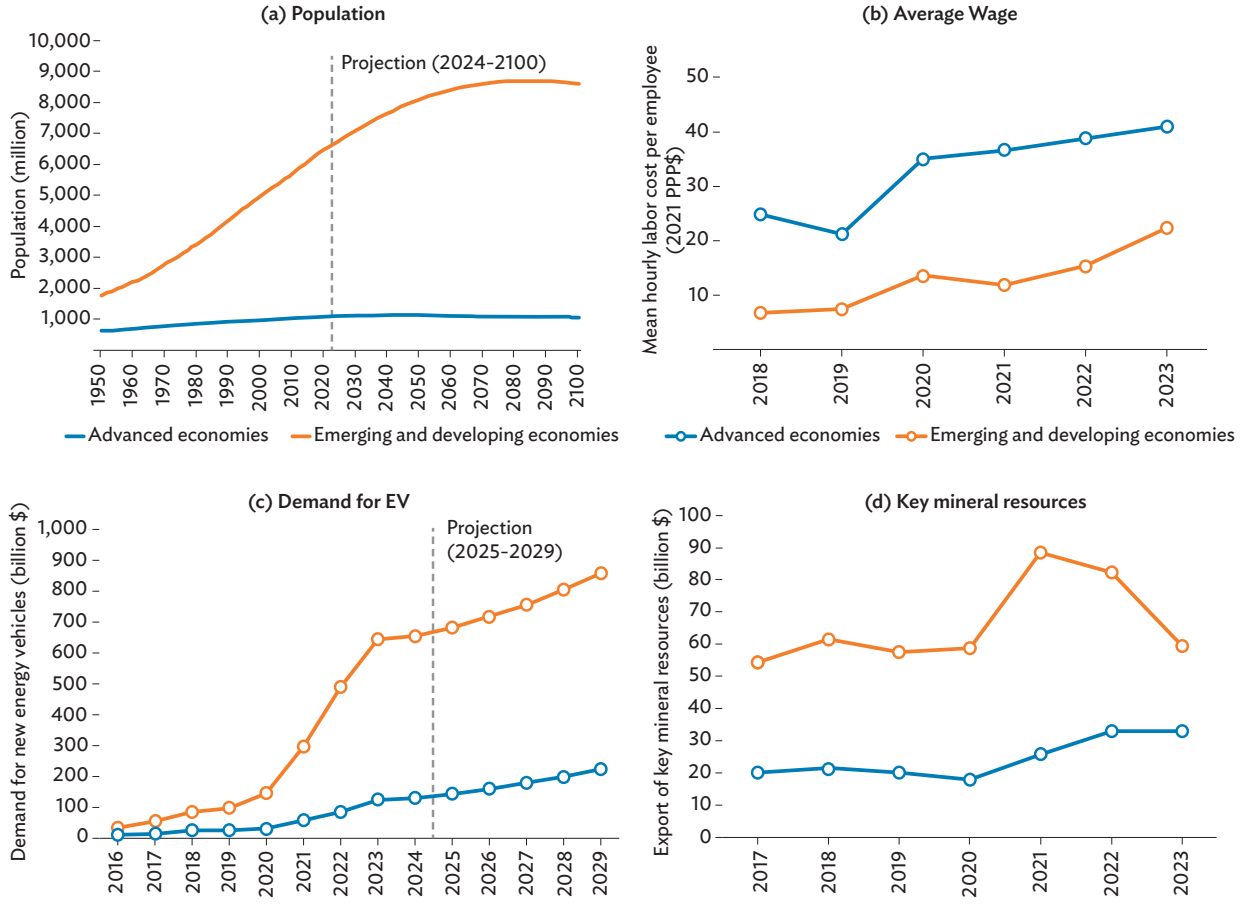
For economies with market advantages in the EV supply chains, it is important that they combine incentives with localization, construct special economic zones and use "market for technology" to attract foreign investment. A case in point is VinFast in Vietnam, which partnered with GM and LG Chem to license EV platforms and battery technology, capitalizing on local labour costs and market potential. Foreign enterprises with EV-related technologies can help these economies build an EV industry, which will help these economies foster a cluster-based and chain-based development ecosystem.

Resource-rich economies can draw lessons from Indonesia and Bolivia. Indonesia's success hinges on policy coherence, forced localization and strategic FDI attraction. For example, Indonesia implemented a ban on unprocessed nickel ore exports in 2014 as part of a policy to promote greater domestic processing of mineral resources. This policy attracted giants such as CATL, LG Energy Solution and BYD to build smelters and battery plants. Estimates show that developing economies play a dominant role in the export of critical mineral resources, supplying more than 60% of global demand and consolidating their indispensable position in the production of EV batteries and the broader supply chain.

Beyond mineral reserves, developing economies also possess significant labour and market advantages (Figure 3.20). They account for more than 60% of the world's working-age population, while labour costs are only about 39% of those in advanced economies, providing an unparalleled foundation for efficient, low-cost manufacturing and large-scale industrial expansion. These countries are not only key production centres but also the main drivers of demand growth, contributing nearly 80% of global EV market demand – a trend fuelled by rapid urbanization, rising disposable incomes and increasing acceptance of sustainable mobility solutions. As a result, developing economies are well-positioned to leverage their unique strengths to integrate into the global EV value chain, thereby achieving both economic growth and industrial upgrading.

The preceding sections have shown that the restructuring of global EV value chains is reflected in shifting trade patterns, evolving input-output linkages and dynamic product-space trajectories. But from the perspective of firms themselves, this transformation is not merely an aggregate pattern – it is an unfolding process taking place in real time

Figure 3.20: The Resource Advantages of Developing Economies



Source: Population data and average wage data are obtained from United Nations (1950-2100, medium scenario) and the International Labour Organization (ILO) separately (2018-2023). Data on EV demand is sourced from Statista Market Insights (2016-2029). Key mineral resources data is derived by the authors from UN Comtrade (2017-2023).

within firms and industries. Electrification, accelerated innovation cycles, rising capital requirements and increasingly interventionist policy environments are reshaping how automotive companies compete, organize production and manage risk. To complement the empirical evidence and analytical results presented in this chapter, the following box provides an industry-level, firm-side perspective on how global automotive companies interpret and navigate these structural shifts. This business viewpoint offers additional context for understanding the strategic and organizational adjustments that accompany the quantitative patterns documented above.

Box 3.2: The View from Global Business

Introduction – The New Architecture of Competition

The rise of EVs has triggered the most profound shake-up of the global automotive industry since Henry Ford first adopted the moving assembly line for mass production in 1913 (Nevins and Hill, 1954). What essentially began as a technological pivot towards electrification has evolved into a systemic transformation of the sector's economics, supply chains and organizational culture. The industry is being redrawn along new fault lines – not just between geographies, but between industrial models: old versus new, slow versus fast, linear versus integrated.

Across the world's major production hubs, the industry is confronting four major challenges defining this new phase of automotive globalization: 1) the reconfiguration of value chains, 2) the accelerating pace of innovation, 3) the escalating cost of the transition, and 4) the growing organizational gap between legacy and entrant firms. We discuss each in turn, particularly from the industry perspective. This box complements Chapter 3's quantitative analysis of EV value chain restructuring, critical mineral dependencies and opportunities for developing economies.

1. Value Chain Reconfiguration

The shift currently playing out, from ICEVs to EVs, has redistributed value creation across entirely new supply chains, altering both the geography and governance of the automotive industry. Batteries, semiconductors and software platforms have displaced engines, transmissions and exhaust systems as the principal nodes of competitive advantage (McKinsey, 2023; IEA, 2024). This transformation has empowered upstream actors – from mining firms in Australia, Chile and the DRC to battery giants such as CATL, LG Energy Solution and Panasonic – while leaving traditional OEMs increasingly dependent on suppliers they were previously in a position to dictate outcomes to (IEA, 2023; ICCT, 2023).

Some incumbents, such as Volkswagen and Stellantis, are responding through vertical integration, investing directly in cell manufacturing and critical mineral partnerships (Volkswagen AG, 2024; Stellantis, 2024). Others, including Hyundai and VinFast, are embedding entire EV ecosystems within national industrial strategies – leveraging state support and coordinated infrastructure investment to attract supply chain partners (OECD, 2024; UNCTAD, 2024; Vingroup, 2024).

2. Speed and Agility of Innovation

EV-first manufacturers have completely up-ended traditional automotive product development and iteration cycles. Whereas legacy OEMs would typically take up to five or even seven years to bring a new model to market, EV makers such as Tesla, BYD and NIO have successfully and dramatically compressed these cycles through the use of digital twins, software-defined vehicle architectures and over-the-air update capabilities (NIO, 2024; Jacobides et al., 2023; ISACA, 2023). Today, these digital design and simulation tools have enabled continuous product and design iterations, a much faster time-to-market, and tighter feedback loops between engineering, production and user experience.

As analyst Michael Dunne notes, "Chinese automakers develop new cars in half the time of traditional automakers in the West," reflecting an organizational model optimized for speed and integration rather than sequential development (Dunne, 2024a). Firms like BYD illustrate this shift vividly: their 1,300-member smart driving R&D team is developing proprietary autonomous and connectivity systems "in double-quick time," bypassing legacy dependencies on external suppliers (KR Asia, 2025).

In contrast, incumbent automakers remain constrained by functionally siloed structures and sequential engineering processes that make it difficult to achieve comparable agility. As Jacobides and colleagues observe, "incumbent OEMs have historically taken a function-by-function approach to developing software.. integrating across these functional silos is a difficult task" (Jacobides et al., 2023).

The result is a widening strategic gap. Traditional manufacturers such as Ford and Hyundai are experimenting with modular platforms and co-locating software and hardware teams to emulate digital-native competitors (Ramachandran, 2025; ISACA, 2023).

3. Cost and Capital Pressures

For most EV-focused firms, particularly newer entrants, profitability remains elusive and is often treated as a secondary objective. At this stage of the industry's evolution, the priority lies in capturing market share and establishing a defensible position within a fast-moving and capital-intensive ecosystem. Growth and scale, rather than short-term returns, have become the dominant strategic imperatives (IEA, 2024; Reuters, 2025).

Analysts estimate that the transition to EVs demands 30-50% more upfront investment per vehicle platform than comparable ICEV programmes, owing to the cost of battery plants, new software architectures and retooled manufacturing lines (McKinsey & Company, 2020; RMI, 2023). Despite record levels of investment, profitability remains elusive for most players; Ford's Model e division reported a $4.7 billion operating loss in 2023, while China's hypercompetitive EV market continues to compress margins even for leading brands (IEA, 2024; Reuters, 2025).

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Box 3.2: continued

Profitable entrants such as Tesla and BYD have achieved cost advantages through scale, vertical integration and proprietary battery production, whereas established automakers must reconfigure legacy assets – retooling factories, retraining workforces and maintaining dual ICEV and EV production systems during the transition (IEA, 2024; McKinsey & Company, 2020). This has led to a wave of strategic partnerships and joint ventures – including Ford-SK On (BlueOval SK) in Kentucky and Tennessee, Stellantis-Samsung SDI (StarPlus Energy) in Indiana, and Honda-LG Energy Solution in Ohio – designed to secure supply, share capital costs and localize production in line with evolving industrial policy frameworks (SK On, 2022; Stellantis, 2023; Honda, 2023).

Automakers are also seeking policy alignment, leveraging incentives under the US Inflation Reduction Act and the EU Battery Regulation (2023/1542) to offset transition costs and de-risk investment (CRS, 2024; European Commission, 2024; EUR-Lex, 2023).

4. Organizational Adaptation and Cultural Change

Perhaps the most subtle yet decisive challenge lies within the firms themselves. The shift to electrification demands not only new technologies but fundamental organizational transformation – embracing cross-functional decision-making, agile iteration and digital-first engineering cultures (McKinsey & Company, 2023; Deloitte, 2024). Automakers such as Hyundai and Volvo have restructured around software-defined vehicle (SDV) units to unify hardware and software development, enabling faster product cycles and over-the-air updates (Hyundai Motor Group, 2023; Volvo Cars, 2024).

In parallel, firms are expanding their internal technology capabilities, hiring large cohorts of software engineers, data scientists and systems architects. Volkswagen, for instance, now employs more than 6,000 software developers, while Ford has established a dedicated technology hub in Detroit in the US (Reuters, 2024).

Leading automakers are building in-house software capabilities, reducing reliance on suppliers and improving speed-to-market (McKinsey & Company, 2025). Scholarly studies also show that the most adaptive firms are integrating scaled agile methods across software and hardware domains, creating continuous feedback loops between design, testing and deployment (Ågren et al., 2022).

By contrast, traditional manufacturers including GM and Toyota continue to grapple with the complexity of managing overlapping ICEV and EV product lines and extensive legacy supplier relationships – issues that inevitably slow innovation and dilute strategic focus (IEA, 2024; Bain & Company, 2023). The contest is therefore no longer defined by geography – East versus West – but by organizational learning speed. Companies capable of simultaneously integrating digital, mechanical and cultural change are emerging as the true winners of the EV transition, while those constrained by inherited structures risk being left behind (Bain & Company, 2023; McKinsey & Company, 2023).

Conclusion – Adapting to Compete in an Era of Systemic Change

The transformation under way in the global automotive industry is neither cyclical nor incremental – rather it is profoundly systemic. Electrification has set off a once-in-a-century reconstruction of the industry's architecture, in which scale, speed and systems integration now define competitiveness more than brand heritage or existing market share. The companies that thrive will be those capable of reimagining themselves as technology platforms and ecosystem orchestrators, rather than as manufacturers alone.

In this new order, value creation no longer flows down linear supply chains but circulates within networks linking mining, software, batteries and mobility services. Financial endurance and strategic patience have become as important as engineering excellence. Governments are no longer neutral referees but active participants shaping outcomes through industrial policy and energy transition mandates.

For the business community, the implications are clear. Surviving this phase will require organizational agility, disciplined capital deployment and the ability to learn faster than technological change. Firms that can align product, policy and digital strategy within a coherent framework will not only endure the transition but define the next industrial paradigm – one where the boundaries between automaker, technology company and energy provider are dynamically intertwined.

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Box 3.2: continued

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Note: This box was authored by Simon Lacey (formerly with the World Economic Forum, currently with Belt Road Capital Management). The views expressed herein are those of the author and do not necessarily reflect those of the affiliated institutions.

3.5 Conclusion

The rapid expansion of EVs is fundamentally restructuring traditional automotive value chains. The importance of conventional ICE manufacturing has diminished, giving way to core EV components such as batteries, electric motors and electronic control systems. This transition has not only raised the overall technological complexity but also led to a concentration of manufacturing capacity – particularly in battery production, which is dominated by China, and in semiconductors, which are controlled by a limited number of economies. Such geographic and corporate concentration introduces vulnerabilities and potential disruptions, especially for key raw materials like lithium, cobalt and nickel, which are not only geographically scarce but also exposed to geopolitical uncertainties. Although EV production initially generates higher carbon emissions than conventional vehicles – mainly due to energy-intensive battery manufacturing – life cycle assessments confirm substantial carbon reduction benefits over time. These advantages are further amplified by the adoption of cleaner energy and ongoing technological progress. For resource-rich developing economies, the EV transition offers a pathway to integrate into higher-value segments of global supply chains, enabling industrial upgrading through targeted policies, strategic foreign investment and international cooperation. Ultimately, fostering inclusive and sustainable growth in the global EV market will depend on coordinated policy incentives, diversified supply chain partnerships and enhanced international collaboration.

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4

Towards Greener and Inclusive Global Value Chains – Insights From Environmental Policy

Bo Meng, Ankai Xu, Meng Li, and Sunghun Lim

4.1 Introduction

The proliferation of global value chains (GVCs) over the past two decades has been propelled by declining cross-border transportation and communication costs – driven by technological advances and the progressive reduction of tariff and non-tariff barriers under the World Trade Organization (WTO) and various regional trade agreements. Despite the recent shocks and uncertainties to GVCs caused by escalating geopolitical tensions, the nature of GVCs – characterized by geographically fragmented production enabled by the expansion of international trade and foreign direct investment (FDI) – continues to play a fundamental role in enabling countries to leverage their comparative advantages and gain value added (WTO, 2023, also see Chapter 1). However, the globalization of production has also been accompanied by a marked increase in greenhouse gas (GHG) emissions (e.g., carbon dioxide, or CO_2, emissions) embodied in cross-border supply chains, as production processes span multiple borders with varying emission intensities (Meng et al., 2023). In response – and aligned with the global community's climate goals of carbon neutrality and reducing carbon leakage (IPCC, 2021) – policymakers are increasingly engaging both upstream suppliers and downstream customers to advance green transition strategies. Table 4.1 provides an illustrative list of climate mitigation policy instruments. These initiatives aim not only to improve environmental performance across value chains, but also to generate economic value, enhance corporate reputation and build long-term environmental competitiveness.

Note: This chapter was led by the Institute of Developing Economies – Japan External Trade Organization (IDE-JETRO). The views expressed are those of the authors and do not necessarily reflect the views of IDE-JETRO.

Table 4.1: Climate Mitigation Policy Instruments	
Category	**Examples of Policy Instruments**
Explicit carbon pricing	– Carbon taxes – Emissions trading systems
Implicit carbon pricing	– Fuel excise taxes – Fuel subsidies (negative carbon prices) – Value-added tax differential for fuels
Mitigation crediting	– Carbon crediting mechanisms – Voluntary carbon markets
Incentive-based policies for technologies, efficiency, and other mitigation-related activities	– Vehicle feebates – Tradable fuel efficiency standards – Feed-in tariffs – Electricity excise taxes and subsidies – Emissions-based vehicle taxes – Tradable renewable portfolio standards – Tradable renewable fuel standards – Technological deployment subsidies – Electric vehicle incentives – Energy efficiency tax credits – Certain industrial and agricultural subsidies
Standards (non-tradable) and other regulations	– Air pollution standards – Greenhouse gas emissions intensity standards – Clean energy standards – Technology mandates or polluting product bans – Fertilizer regulations – Energy efficiency building codes – Fuel efficiency regulations – Energy market reform – (Non-tradable) renewable share mandates
Investment and other policies	– Public investment (e.g., public transportation, enabling infrastructure for innovation) – Information policies (product labelling/rating, certification, information disclosure) – Other electric vehicle policies – Research and development policies

Note: Emissions trading systems (ETSs) take two main forms: mass-based systems, such as cap-and-trade programs that differ in how allowances are allocated; and rate-based systems, such as tradable emission performance standards, output-based pricing systems, and low-carbon fuel standards. Rate-based ETSs limit the intensity but not total amount of emissions; trading results in a price for incremental emissions but benchmark allocations limit the average pricing of emissions, much as with output-based allocation in cap-and-trade regimes or output-based rebating of emission taxes. Under rate-based systems, total emissions fluctuate with economic activity, but to a lesser extent than with carbon taxes. Flexibility mechanisms under cap-and-trade systems also allow emissions to vary but help promote price stability. Thus, subtle but important distinctions exist among the policies that can be blurred in practice. Not all international organizations categorize rate-based ETSs as explicit carbon pricing. When all trading occurs bilaterally or on secondary markets, the resulting emissions price may not be observable.
Source: WTO, OECD, IMF, UN, World Bank (2024)

Given the structural complexity and international interdependence embedded in GVCs, and the reality that climate policies are primarily designed and implemented at the national level – shaped by domestic priorities, institutional capacities and economic structures – there is a pressing need for both domestically effective and globally coherent environmental governance.[1]

[1] Fragmentation of climate change mitigation policies is costly and could lead to the introduction of complementary policies which could come with trade frictions (Bekkers et al., 2024).

This chapter aims to explore why, how and to what extent well-designed and internationally balanced environmental policies can contribute to the decarbonization of GVCs. A necessary foundation for this analysis is the development of a consistent accounting framework that enables the systematic tracing of both value added and GHG emissions (here proxied by CO_2 emissions) along GVCs. This chapter first introduces a novel GVC-based emissions accounting system capable of capturing both production- and consumption-based emissions at multiple levels of resolution – by country, sector, production stage – through the channels of both trade and FDI.

Drawing from this accounting framework, this chapter demonstrates that emissions reductions must occur across both domestic and international segments of GVCs. GVCs are deeply rooted in domestic production systems yet operate through cross-border production sharing; hence, effective climate mitigation requires action across all nodes of the chain. To illustrate this point, the subsequent section takes China's emissions trading system (ETS) as an example to first show how a carefully designed place-based carbon pricing mechanism, considering balanced regulatory coverage and firm-ownership heterogeneity, can support China to peak CO_2 emissions, lower emissions intensity and green its export structure. Using the WTO Environmental Database (EDB), section 4.3 demonstrates that trade-related environmental policies can shape green GVCs (trade of environment-friendly products and reshape of comparative advantage) through their impact on innovation and technological change. In addition, this chapter also explores how the carbon border adjustment mechanism (CBAM) may influence GVC decarbonization and reshape trade and investment activities undertaken across different types of firm ownership, particularly for countries without robust domestic carbon mitigation policies. While various environmental policies exist, they represent one facet of the broader environmental externalities associated with GVC expansion. Some negative impacts – such as biodiversity loss, occupational heat exposure, pollution, waste etc. – have also intensified alongside the rise of globalized production, yet are less amenable to market mechanisms, which is discussed at the end of the chapter. Our analytical results show that:

(1) GVCs are firmly embedded in domestic production systems while simultaneously operating through cross-border production sharing. This duality implies that effective emissions reduction must address both domestic and international segments of GVCs: meaningful climate mitigation requires action across all nodes of the chain.
(2) National ETSs can play a pivotal role in GVC decarbonization if they are in an appropriately designed manner. Evidence from China's case study suggests that expanding carbon pricing to achieve broader firm coverage and more equitable green financial access can enhance emissions efficiency while minimizing gross domestic product (GDP) losses.
(3) Trade-related environmental policies also influence GVCs by shaping green innovation and technological change. Measures that stimulate green innovation – such as research and development (R&D) subsidies, intellectual property

reforms and market-based instruments that reward low-emission technologies – can accelerate firms and sectors towards the green technological frontier. Over time, such policies may induce structural shifts in competitiveness, enabling some countries to capture higher value added segments of environmental goods production.

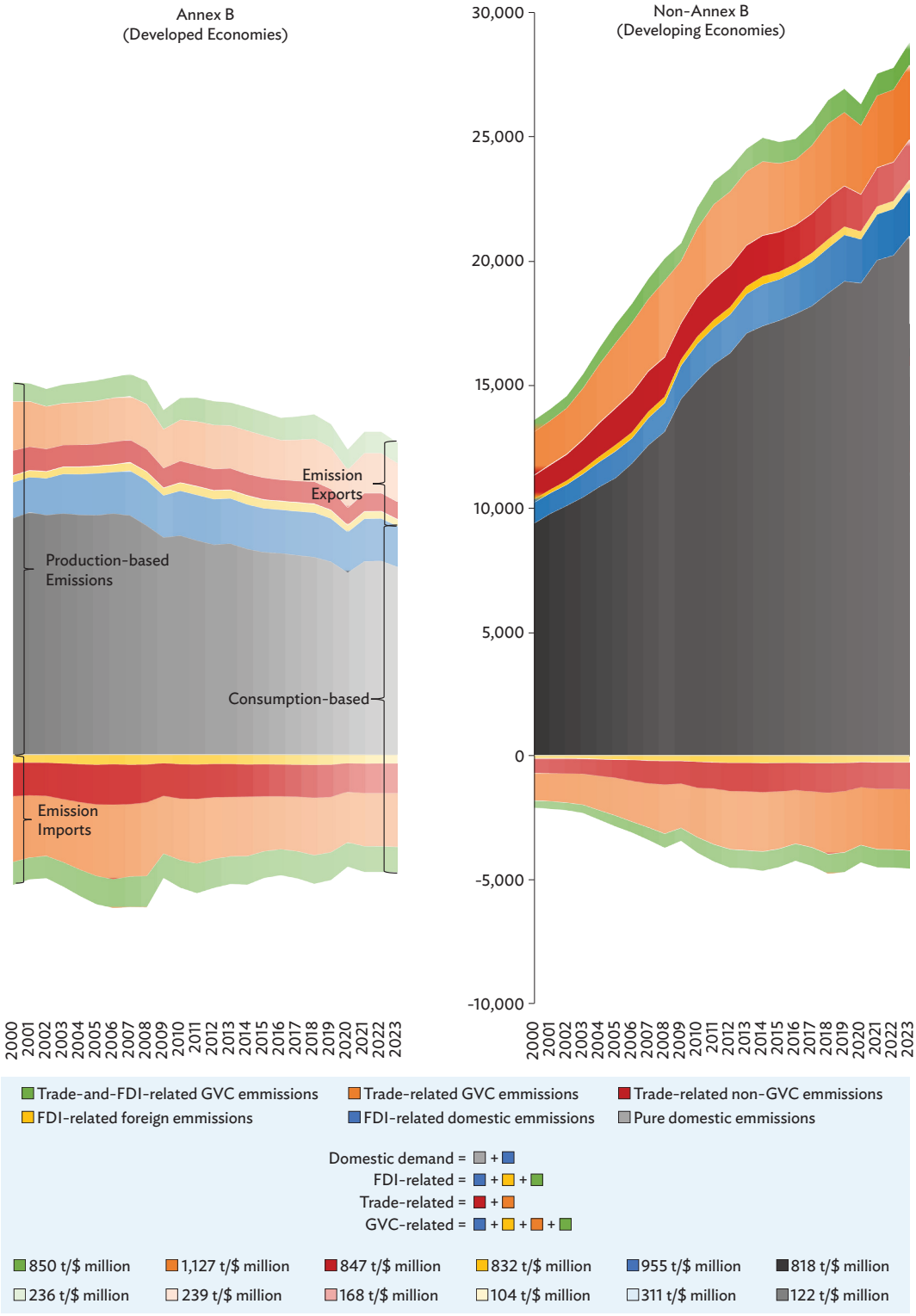
(4) CBAMs – such as the EU's CBAM – when implemented with sufficient sectoral coverage and transparency, can mitigate carbon leakage and create positive spillovers by encouraging trading partners to adopt or strengthen domestic carbon pricing. However, they also generate uneven impacts across countries and different types of firm ownership.

(5) Beyond carbon, this chapter also highlights the broader structural environmental externalities embedded in GVCs. These externalities are rarely reflected in product prices and remain inadequately governed under existing trade and climate frameworks. Internalizing non-carbon externalities in GVCs requires complementary regulatory approaches, internationally recognized standards and stronger cooperative governance mechanisms.

4.2 Tracing CO_2 Emissions along GVCs

Regarding the connection between GVCs and carbon emissions, Meng et al. (2018) integrate the trade in value added (TiVA) and carbon emissions footprint in a unified GVC accounting (Koopman et al., 2014), thus enabling both value added and emissions to be systematically traced at the country, sector and bilateral levels through various trading routes in GVCs. Building upon those pioneering works, Li et al. (2022) update the conventional GVC-based approach following Wang et al. (2021) with explicit consideration of both cross-border production sharing and multinational enterprises' (MNEs) FDI activities in GVCs, and show clearly which (country, sector, firm) emits CO_2 emissions for whom via which type of route in GVCs (see Annex 4.1 for technical details).

Figure 4.1: Tracing CO_2 Emissions of Annex B and Non-Annex B Economy Groups, 2000-2023



Source: Authors' estimation based on Li et al. (2022).

Note: Data for 2000-2020 is sourced from OECD-activity of multinational enterprises (AMNE) and OECD's carbon dioxide (CO2) emissions embodied in international trade (TECO2) database; Emissions for 2021-2023 are imputed based on IEA CO_2 emissions and World Bank GDP data; CO_2 emission intensities (emissions per unit of value-added) are estimated in constant 2015 prices; The Annex B economy group as defined in Kyoto Protocol.

Figure 4.1 presents a comparative overview of production- and consumption-based CO_2 emissions, emission exports and emission imports for developed (defined here as economies listed in Annex B of the Kyoto Protocol) and developing (defined here as economies not listed in Annex B) economy groups, disaggregated by GVC linkages. The figure reveals a pronounced divergence in emissions trajectories between the two groups over the past two decades.

For developed economies, both production- and consumption-based CO_2 emissions have declined steadily. Production-based emissions increased slightly between 2002 and 2007, peaking in 2007, before falling to 12.5 gigatons (Gt) in 2023 – below their 2000 level of 15.0 Gt. Consumption-based emissions followed a similar pattern, decreasing from 16.2 Gt in 2000 to 13.9 Gt in 2023. These declines were primarily driven by reductions in domestic emissions (-20.4%), alongside notable declines in trade-related non-GVC emissions[2] (-30.2%) and trade-related GVC emissions (-20.9%). In contrast, FDI-related domestic and FDI-and-trade-related emissions increased by 13.2% and 8.2%, respectively. The decrease in consumption-based emissions was also supported by an 11.4% reduction in non-GVC trade emissions and an 18.4% reduction in GVC-related trade emissions.

In contrast, developing economies experienced a substantial increase in emissions over the same period. Production-based emissions rose from 13.6 Gt in 2000 to 28.8 Gt in 2023. Between 2000 and 2023, pure domestic emissions and FDI-related domestic emissions increased by 123.6% and 131.2%, respectively. Consumption-based emissions also surged, from 12.3 Gt in 2000 to 27.5 Gt in 2023 – an increase of 104.1%. The scale of this growth far exceeds the emissions reductions observed in developed economies and has become the dominant driver of the net increase in global CO_2 emissions.

In terms of emissions composition in 2023, domestic value chains accounted for 73.4% of total production-based emissions in developed economies and 79.5% in developing ones. Within these shares, pure domestic and FDI-related domestic emissions represented 60.4% and 13.0% for developed economies, and 72.8% and 6.7% for developing economies. The remaining production-based emissions were attributable to cross-border flows: in developed economies, FDI-related foreign emissions accounted for 2.1%, trade-related non-GVC emissions for 5.5%, trade-related GVC emissions 12.5%, and trade-and-FDI-related emissions 6.5%. In developing economies, these shares were 1.2%, 5.6%, 10.5%, and 3.2%, respectively. Emissions linked to GVC-related activities – including FDI-related domestic and foreign emissions, trade-related GVC emissions and trade-and-FDI-related emissions – comprised 34.1% of total production-based emissions in developed economies, compared to 21.6% in developing economies. This indicates a higher degree of GVC integration in developed economies but also suggests a growing trend of emissions relocation and GVC-driven environmental interdependence across both economy groups.

[2] Non-GVC emissions refer to trade-related emissions that are not linked to trade in intermediate goods or foreign direct investment (FDI). For technical details, see Annex 4.1.

In short, developed economies have demonstrated a clear downward trend in both production-based and consumption-based CO_2 emissions across most segments of GVCs. These reductions are observed not only in emissions for final demands but also for exports, reflecting broad-based decarbonization. Notably, this decline has occurred even as these economies operate at already relatively low carbon intensity levels, with continued improvements in emissions efficiency – i.e., a significantly lower volume of emissions per $1 of value added (as indicated by the colour intensity). By contrast, the trajectory in developing economies has been markedly different. Not only has the decline in carbon intensity been modest – their pace of decline between 2000 and 2023 was only about 60% of that of developed economies – but this limited progress has been accompanied by substantial absolute increases in emissions across all channels. Particularly concerning is the carbon cost of GVC participation: for every additional $1 of value added generated through GVCs, developing economies emit roughly 3.6-4.7 times more CO_2 than their developed counterparts. This gap largely reflects the rapid growth of South-South trade in energy-intensive intermediates and the structural position of developing economies in GVCs, where they are concentrated in upstream, manufacturing-heavy and carbon-intensive activities[3]. This widening disparity in emissions performance also raises serious concerns for both the achievement of the United Nations (UN) Sustainable Development Goals (SDGs) and the feasibility of meeting the Intergovernmental Panel on Climate Change (IPCC) target of limiting global warming to 1.5°C. Without more ambitious and inclusive climate policy responses that address the structural asymmetries embedded in global production systems, both environmental sustainability and equitable development may be at risk.

4.3 How an Emissions Trading System Can Help Decarbonize the Domestic Segments of GVCs

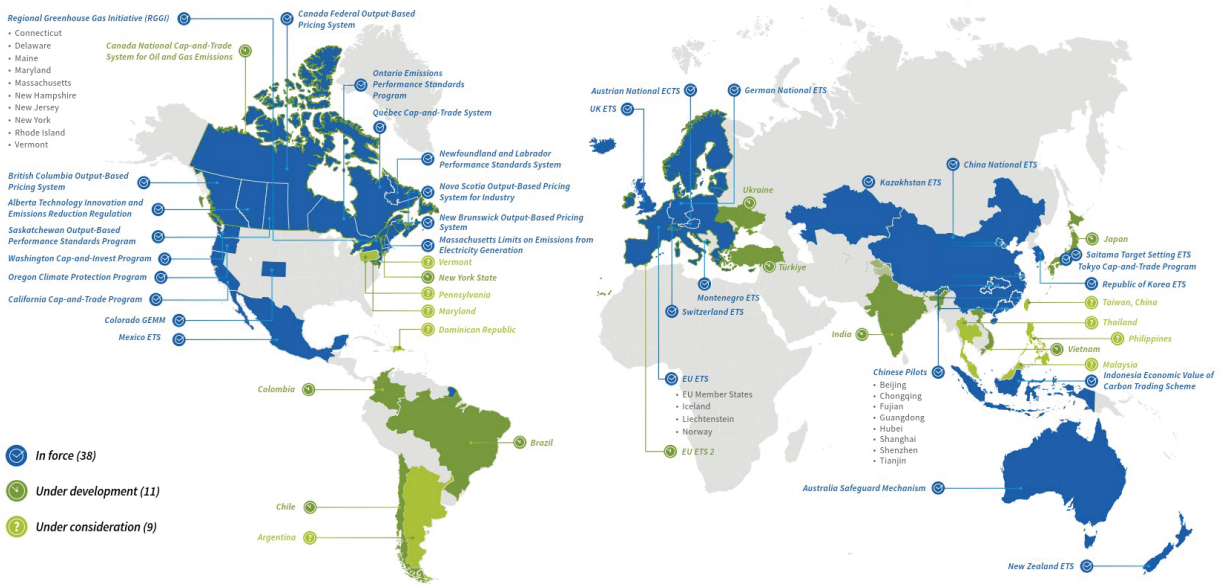
As shown in the previous section, almost all emissions embodied in GVCs ultimately originate from domestic production processes[4]. In other words, unless upstream domestic emissions are effectively mitigated, it will not be possible to substantially reduce the embodied carbon content of downstream exports. This challenge is particularly pronounced in developing economies, where the scale and growth rate of emissions embedded in internationally traded goods are exceptionally high. These economies often exhibit relatively weaker environmental regulatory frameworks and limited adoption of explicit carbon pricing mechanisms. Against this backdrop,

3 Over the past three decades, trade liberalization has played a critical role in fostering the expansion of GVCs. However, it has also contributed to the increased cross-border movement of carbon-intensive intermediate goods – particularly in the form of rising South-South trade flows in recent years (Meng et al., 2018). These developments highlight the need to incorporate environmental considerations into the design of trade policies. For instance, recent studies suggest that trade liberalization in energy-related environmental goods (EREGs) and environmentally preferable products (EPPs) has the potential to yield dual benefits: reducing carbon emissions while simultaneously enhancing GDP (Bacchetta et al., 2023).

4 Whether emissions embodied in international transportation services (e.g., cargo shipping) are attributed to domestic production could depend on whether those services are operated by domestic or foreign entities.

achieving global climate targets – such as the 1.5°C or 2°C goals outlined by the IPCC, which calls for cutting emissions by one-quarter to one half in this decade (Parry et al., 2021) – requires urgent policy interventions. Among the available instruments, the introduction of a well-designed, locally tailored ETS stands out as a key market-based solution.

Figure 4.2: The Current State of Play in Emissions Trading



Note: The above ETS world map depicts emissions trading systems currently in force, under development or under consideration. As of January 2025, there are 38 ETSs in force. Another 11 are under development and expected to be in operation in the next few years. These include ETSs in Colombia, Türkiye and Vietnam. Nine jurisdictions are also considering the role an ETS can play in their climate change policy mix. If a jurisdiction has multiple systems in force, it is depicted in blue, with the borders of the jurisdiction representing the layered systems (e.g. Germany and Guangdong). If, however, it has a system in force while an additional one is under development, it is depicted in blue but also features a green border (e.g. the EU).
Source: ICAP (International Carbon Action Partnership) ETS Map.

Over the past two decades, ETSs have become a widely implemented approach to reducing greenhouse gas (GHG) emissions in a cost-effective and flexible manner (see Figure 4.2 for the detailed ETS country coverage). By assigning a price to carbon and allowing regulated firms to trade emissions allowances, ETSs create economic incentives for cleaner production and technological upgrading (Ellerman et al., 2010; Teixidó et al., 2019; Evro et al., 2024; Shobande et al., 2024).

The EU ETS, launched in 2005, is the most mature and institutionally developed carbon market globally. It covers approximately 45% of EU emissions, spanning energy-intensive sectors such as power generation, industry and aviation. In recent years, the EU ETS exhibits some of the highest carbon prices, reaching up to about \$87.8 per metric ton of CO_2 emissions (tCO_2e) in February 2025. Through a series of regulatory reforms – such as the introduction of the Market Stability Reserve, a progressively tightening emissions cap and expanded sectoral coverage – the EU ETS

has demonstrated tangible progress in emissions mitigation while preserving economic competitiveness (Joltreau and Sommerfeld, 2018; Verde, 2020; Pahle et al., 2025).

In contrast, the United States (US) has not adopted a federal-level ETS, but subnational initiatives like California's Cap-and-Trade Program and the Regional Greenhouse Gas Initiative (RGGI) provide valuable policy experimentation. These systems have delivered measurable results within their jurisdictions, though their influence on GVC emissions is limited due to their fragmented and localized nature (Caron et al., 2015; Lessmann and Kramer, 2024; Yan, 2021).

China's national ETS, launched in 2021, represents a landmark advancement in climate policy for developing economies. Initially covering the power sector, it applies intensity-based benchmarks rather than absolute emission caps, which may constrain its ability to deliver systemic reductions (Qi and Cheng, 2018; Goulder et al., 2019). Additional concerns include monitoring, reporting and verification (MRV) mechanisms and limited sectoral coverage (Liu et al., 2022a; Huang et al., 2022; Liu et al., 2022b).

In short, while ETSs are not a panacea, they play an increasingly critical role in reducing emissions and supporting the decarbonization of GVCs. Following sections 4.2.1 and 4.2.2 provide an in-depth analysis of China's ETS, demonstrating that the relevant policy should be tailored to local conditions.

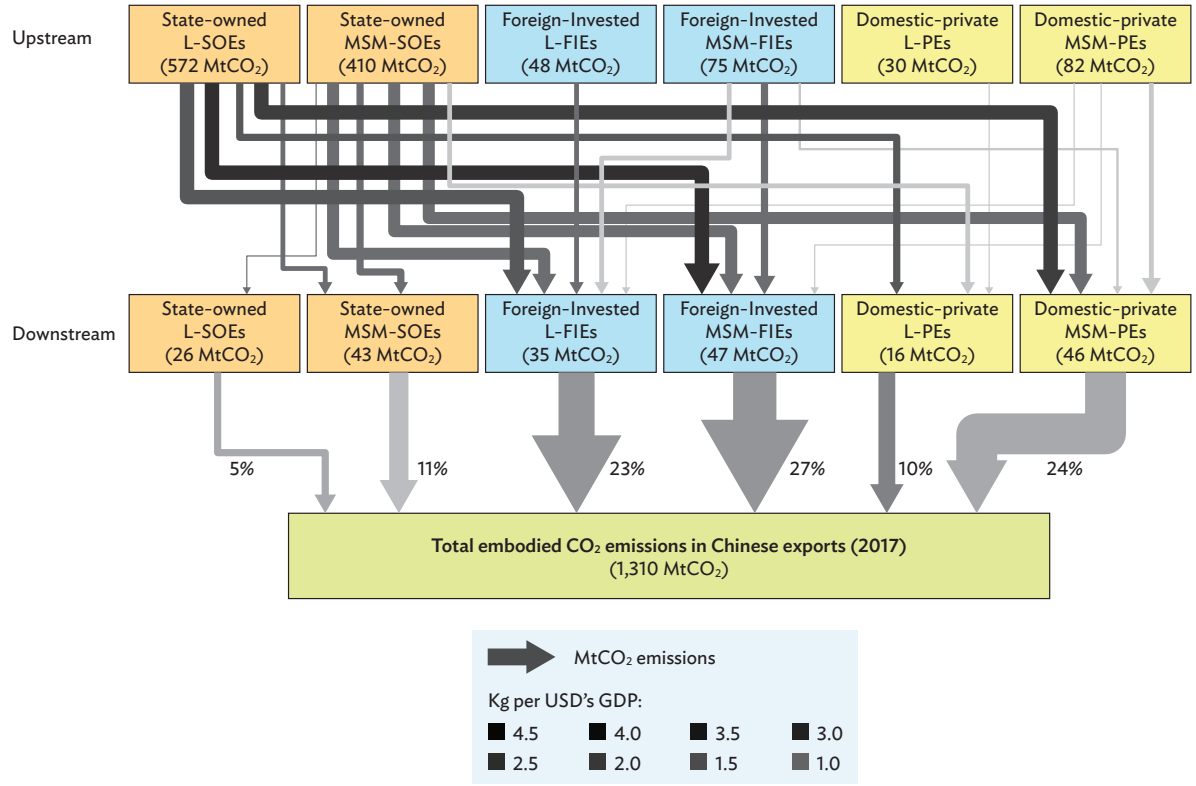
4.3.1 Challenges in Designing Effective Environmental Policies in China

Under market-based instruments, such as an ETS, emitters can follow two basic strategies to meet emission regulations: either adjust their input structure on the production technology frontier or invest in energy technology to shift said frontier.

Whether China's ETS can effectively motivate firms to decarbonize depends critically on two country-specific conditions:

(1) **Comprehensive coverage, including more emitting firms**
For the ETS to function efficiently, it must encompass a broad range of emitting firms –particularly micro, small and medium-sized enterprises (MSMEs). Otherwise, substantial carbon leakage may occur as firms face heterogeneous costs of adjusting their input structures to reduce emissions. Although China's regional ETS pilots have been in operation for over a decade, they have primarily covered a limited number of sectors and large, high-carbon emitters. However, in reality, since 2010 more than half of China's CO_2 emissions have originated from MSMEs. In 2017, MSME exports accounted for approximately 62% of China's total embodied emissions in trade, over 55% of which stemmed from upstream MSMEs (see Figure 4.3). Yet most of these firms remain outside the current ETS framework. Consequently, the "low-hanging fruit" for emission reductions – large, regulated emitters – has largely been exhausted. The

Figure 4.3: Tracing China's Emissions Embodied in Exports from Upstream to Downstream



Note: L: Large sized; MSM: micro, small and medium sized; SOEs: state-owned enterprises; FIEs: foreign-invested enterprises; PEs: private enterprises.
Source: Authors' estimates and Dr. Meichen Zhang (UIBE)'s estimation based on Meng et al. (2018).

marginal effectiveness of existing policy instruments is diminishing, while the costs of further abatement are rising. Without a well-designed mechanism to regulate MSME emissions, achieving both national emission peaking and the decarbonization of China's GVCs will remain a difficult task.

(2) **Reducing disparities in green financing and regulatory burdens across firm types**

Firms within the same industry but differing in ownership structure and size often face very different costs of green financing. State-owned enterprises (SOEs), typically subject to emission regulation yet enjoying preferential credit access, are more inclined to invest in upgrading production technologies and equipment. In contrast, other regulated emitters – especially large private firms – often rely on substituting energy inputs with other factors due to relatively higher financing costs. Unregulated emitters, mainly MSMEs, are generally disincentivized from cutting emissions because of low energy prices, limited access to affordable credit and weaker enforcement of environmental regulations. This fragmented regulatory landscape generates wide variation in the marginal abatement cost of CO_2 emissions across firms, reducing the overall efficiency of emission reduction. Moreover, the uneven distribution of green

investment not only lowers the average efficiency of decarbonization but also crowds out other productive fixed-capital investments, thereby constraining long-term economic growth.

The above two conditions for China are also mutually reinforcing, as gains from green investment (innovation) increase only if such innovation can allow emissions to be more fairly priced (Fischer, 2008). Given the above discussion, this section takes China's ETS as a case study to show that place-based and market-oriented policy design (using national ETS as a proxy here[5]), with more firm coverage and equalized green financial supports for different types of companies, can not only help China peak its emissions around 2030 with less GDP loss but also help Chinese firms become greener participants in GVCs. To do so, this section employs a dynamic computable general equilibrium (CGE) model[6] with explicit consideration of firm heterogeneity (size and ownership) and differential treatments of financing conditions across firms.

4.3.2 Impacts of Place-Based ETS Design on China's Emission Reduction

The dynamic CGE model used accounts for heterogeneous firm types, differentiated policy regulation and endogenous energy-technology investment. The model is calibrated to 2017 as the base year based on a newly estimated Chinese input-output table with 42 sectors and six types of firms in terms of their three ownerships – state-owned, foreign-invested or domestic private – and two sizes (large, non-large: MSMEs) as shown in Table 4.2.

Regarding scenario setting, the total intensity target is set to decrease China's CO2 emissions per unit of GDP by 4% per year beginning in 2017. This target assures that China will meet the commitment made in its intended nationally-determined contributions (INDCs) to decrease the carbon intensity by 60% from 2005 levels and peak China's emissions in 2030. The benchmark for cross-scenario comparison is the business-as-usual (BAU) scenario in which mandatory intensity targets are enforced for certain types of firms to fulfil an exogenously determined total intensity target that meets China's commitment in the INDC. In the BAU scenario, the climate regulations cover only SOEs and large private firms, and only SOEs have much easier access to preferential financial terms. The unbalanced regulatory structure is shown in Table 4.3. In the partial-coverage scenarios, only SOEs and large private firms are regulated by emission constraints and can participate in emission trading; in the full-coverage scenarios, all firms are equally regulated and are able to trade their emissions in an integrated carbon market. In the various financial condition scenarios, the endogenous

5 A national ETS is used as a policy proxy; in practice, an ETS combined with a carbon or energy tax should also be considered as an alternative policy option (Zou et al., 2020).

6 The CGE model used in this section is a recursive dynamic model based on the structure of Rutherford (1995), with modification in the settings for energy technologies following Otto et al. (2008). Future periods are simulated based on the outcomes of the preceding period. The model assumes neo-classical macro closure, that is, it assumes full use and employment of capital and labour.

subsidy (or financial interest) for green investment is provided for SOEs as in the BAU scenario, while in the equalized scenarios, the subsidy is eliminated.

Table 4.2: Firm Size and Ownership

Firm size	Firm ownership		
	State-owned enterprises	Foreign-invested enterprises	Private enterprises
Large enterprises	L-SOE	L-FIE	L-PE
MSMEs	MSM-SOE	MSM-FIE	MSM-PE

Note: Regulated firm types are shaded, with the darker shading indicating access to preferential financial conditions.

Table 4.3: Scenarios under ETS with Different Firm Coverage and Financial Conditions

Financial condition (subsidy as a proxy)	Regulation coverage (ETS as a proxy)	
	Partial coverage	Full coverage
Differentiated	ETS_P_D	ETS_F_D
Equalized	ETS_P_E	ETS_F_E

The main simulation results are presented in Figure 4.4a-d. In the model setting, this section assumes that China fulfils its climate commitment by reducing carbon intensity by at least 60% from 2005 levels and peaking total CO_2 emissions by 2030. Under these assumptions, the model projects that emissions will peak in 2030, corresponding to a 28.5% reduction relative to the counterfactual null scenario, which represents a future without any mitigation policy interventions. Although the emissions trajectories are aligned across policy scenarios, the economic impacts – measured in terms of GDP loss – vary significantly. Compared to the null scenario, average annual GDP growth under the BAU scenario is projected to be 0.15% lower, resulting in a 2.1% GDP loss by 2030. Introducing an ETS with the regulatory design (ETS_P_D) mitigates GDP loss in the early years; however, its economic cost accelerates after 2026 and eventually exceeds that of the BAU scenario. In contrast, scenarios that either expand regulatory coverage to all firm types (ETS_F_D) or eliminate distortions in green finance (e.g., balanced subsidies for green investments in ETS_P_E) result in smaller GDP losses throughout the simulation period. The most favourable outcome is observed under the ETS_F_E scenario, which combines full coverage with a balanced financial structure. This scenario yields a GDP loss approximately 0.8% lower than the null scenario, highlighting the efficiency gains from comprehensive and financially neutral policy design.

Figure 4.4: ETS Scenario Results With Different Firm Coverage and Financial Conditions

Figure 4.4a: GDP loss

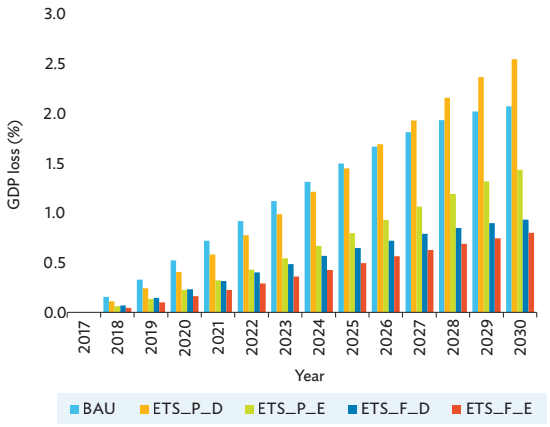


Figure 4.4b: Green investment needed

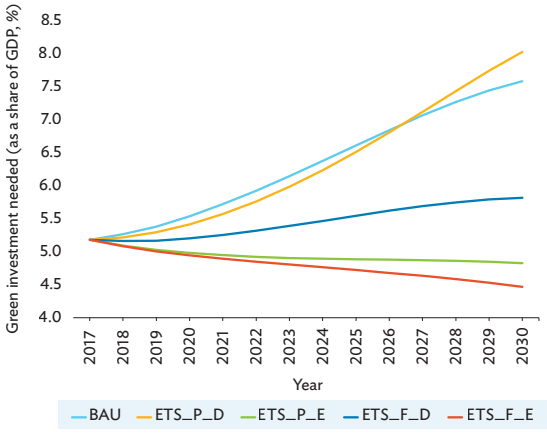


Figure 4.4c: Green investment efficiency

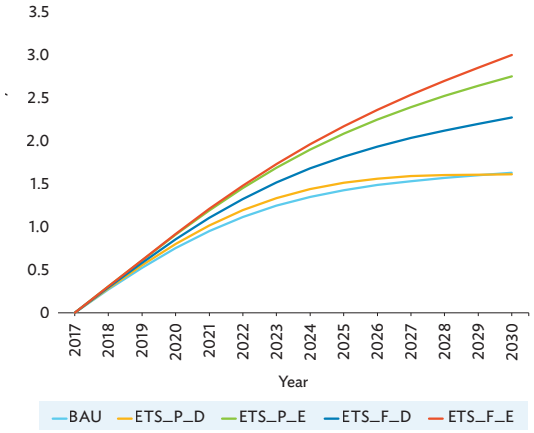
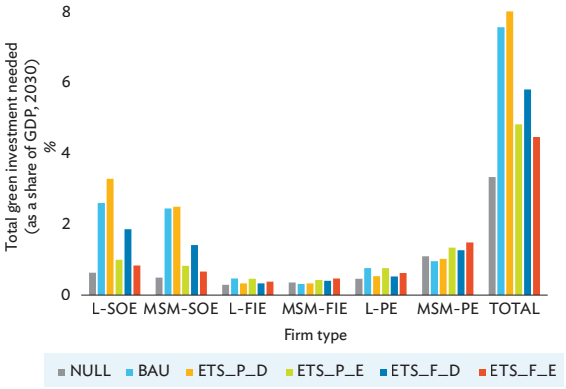


Figure 4.4d: Total green investment needed



Source: Authors' estimation.
Note: BAU denotes the business-as-usual scenario. ETS_P_D represents an ETS with partial firm coverage under differentiated financial conditions; ETS_P_E indicates partial firm coverage under equalized financial conditions; ETS_F_D refers to full firm coverage under differentiated financial conditions; and ETS_F_E denotes full firm coverage under equalized financial conditions.

Different policy scenarios could impact green investment allocation and efficiency in very different ways. The partial regulation increases the incentives for green investments in regulated firms, and furthermore, the preferential financial conditions further distort green investments towards SOEs. Theoretically, the concentration of green investments in regulated firms, especially subsidized SOEs, leads to unequal marginal revenues across firms and decreases the national average efficiency of green investments. Aside from that, the higher demand for green investments is competing with other fixed capital investments, which will further affect the long-term economic growth. Figure 4.4b-c shows the trajectory of total green investment and its efficiency to illustrate the argument mentioned above. In the BAU and ETS_P_D scenarios, green investment increases quickly as the emission targets tighten. The total amount of accumulated green investment through 2030 for BAU and ETS_P_D accounts for about 7.6% and 8.0% of GDP. However, the efficiency of green investment, defined as the change in emissions intensity from the null scenario divided by the amount of green investment per unit of energy input, decreases dramatically over time. Both expanding the coverage of regulation (ETS_F_D) and elimination of the subsidy for SOE green investment (ETS_P_E) lower the total demand for green investments, while at the same time, its

efficiency is significantly increased. In the ETS_P_E scenario, the accumulated green investment accounts for 4.8% of GDP in 2030 and 5.8% in the ETS_F_D scenario, while their efficiency rates in 2030 are 69% and 39% higher than that of BAU. With the full regulation coverage and equalized financial condition (ETS_F_E), total green investment accounts for 4.5% of GDP in 2030, which is the lowest among the various scenarios. At the same time, green investment efficiency under ETS_F_E is the highest among the scenarios considered, which is 84% higher than that for the BAU level.

Figure 4.4d illustrates the distribution of green investment by firm type in 2030 across the different policy scenarios. Under the ETS_F_E scenario – which ensures both comprehensive coverage and the elimination of financial distortions – the total volume of green investment amounts to approximately 4.5% of GDP in 2030. Notably, private MSMEs account for the largest share, comprising nearly one-third of total green investment. This reflects a more efficient and inclusive allocation of capital, where investment decisions are driven by marginal abatement costs rather than regulatory privilege. However, when MSMEs are excluded from emissions regulation, as in scenarios with partial coverage, their incentives to invest in energy-efficient technologies are significantly weakened. At the same time, increased demand for green technologies from regulated firms – particularly large SOEs – drives up technology costs, further crowding out MSMEs from the green investment space. This distortion is clearly observed in the ETS_P_E scenario, where the share of green investment by regulated firms increases, while the share by unregulated MSMEs declines. The situation is even more pronounced under the ETS_P_D scenario, which combines partial coverage with preferential financial treatment for SOEs. In this case, green investment by SOEs increases substantially, while investment from all other non-SOE firms declines. The disproportionate expansion of SOE investment effectively overwhelms the reductions observed in other sectors, leading to resource misallocation. Under both the BAU and ETS_P_D scenarios – characterized by dual distortions in both regulatory coverage and financial support – the total amount of green investment reaches approximately 8% of GDP by 2030. However, more than 67% of this investment is concentrated in SOEs, signalling a highly skewed distribution that undermines overall investment efficiency and reduces the effectiveness of green finance in supporting broad-based industrial transformation.

From GVC perspectives, our model findings carry important implications beyond domestic policy. Since almost all emissions embodied in GVCs ultimately originate from domestic production processes, mitigating upstream emissions is a necessary condition for reducing the embodied carbon in downstream exports. In the absence of effective domestic decarbonization – particularly in intermediate goods and upstream industrial inputs – efforts to green GVCs will remain limited in scope and impact. A place-based national ETS design in China, featuring broader firm coverage and neutral financial treatment across ownership types, can play a pivotal role in addressing this challenge. Such a system would not only enable China to achieve its 2030 emissions peak with reduced macroeconomic costs but also improve the carbon competitiveness

of its firms engaged in global production networks. By enhancing incentives for cleaner production across SOEs, private firms and MSMEs alike, a balanced carbon pricing can support a more inclusive transition towards low-carbon industrial upgrading via efficient green investment. In turn, this would strengthen China's position in a future trade environment increasingly shaped by carbon-based regulations, such as the EU's CBAM (which will be discussed later), and contribute meaningfully to the global effort to decarbonize GVCs. The above results indicate that China's case study also can serve as an important reference for other developing economies seeking to establish or strengthen their own carbon pricing, while considering their specific domestic circumstances and constraints in addressing climate change.

4.4 Trade-Related Environmental Policies: Impacts on GVCs and Green Innovation

The previous section focused on how market-oriented domestic policies can help decarbonize GVCs; this section turns to trade-related environmental policies. To better understand the scope and effects of environmental policies, Bellelli and Xu (2024) map trade-related environmental measures using the WTO's Environmental Database (EDB), which compiles more than 13,000 environment-related measures based on notifications submitted by WTO members. Compared with other environmental measures databases, the EDB comprises policy measures that bear direct or indirect implications for trade. It has a wider country coverage, including information from over 160 economies, notified since 2009. Through systematic processing of the notifications, Bellelli and Xu (2024) identify the number of measures in effect, which has been steadily increasing over time (Figure 4.5). Furthermore, the data reveals a correlation between the number of trade-related environmental measures and economies' income levels (Figure 4.6).[7]

4.4.1 Trade-Related Environmental Policies and GVCs

Environmental policies are increasingly shaping the structure and geography of GVCs. As countries pursue climate goals and adopt a wide array of environmental measures, these policies are beginning to influence where, how and by whom goods and services are produced and traded.

The implications for GVCs are multifaceted, reflecting both short-term cost adjustments and longer-term shifts in comparative advantage and technological capabilities. The potential trade and environmental impacts of environmental policies can be conceptualized as follows (see Figure 4.7).

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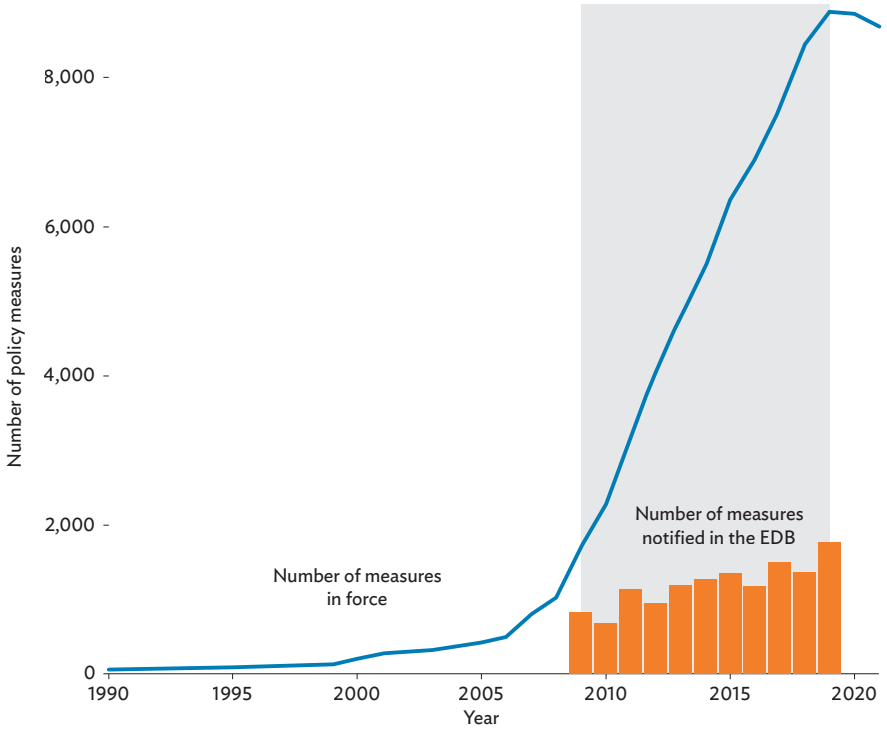
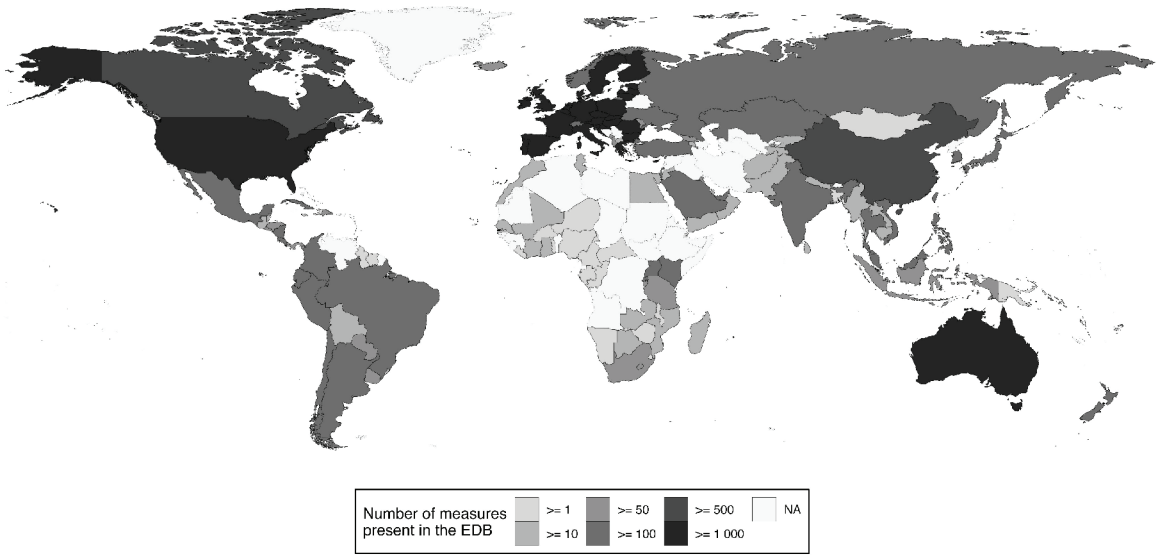
7 Information based on notifications may be subject to reporting bias. Such as bias may stem from two sources: first, high-income countries are more likely to have the institutional capacity to notify their measures; second, the database records the number of measures rather than their magnitude (e.g., financial value or regulatory stringency), meaning it reflects the presence rather than the intensity of policy activity.

Figure 4.5: Number of Active Environmental Measures in the EDB



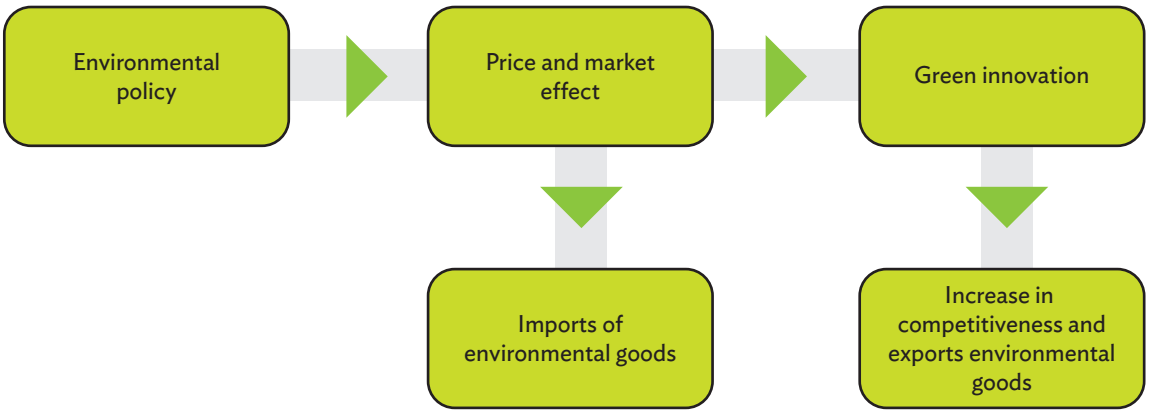
Source: Bellelli and Xu (2024).
Notes: The figure depicts the increase in active environment-related measures notified to the WTO. The line indicates "active measures" based on the implementation periods extracted from the EDB. The bar plot illustrates the number of measures by year of notification. The notification period covered by the EDB is highlighted in grey.

Figure 4.6: Number of Notified Trade-Related Environmental Measures By Economy



Source: Bellelli and Xu (2024).
Notes: The map displays the number of notified measures by economy. A darker filling indicates that a larger number of measures were notified. Economies with white borders are states for which the EDB contains no notified measures.

Figure 4.7: Potential Effects of Environmental Policies



Source: Bellelli and Xu (2024).

One of the most direct ways in which environmental policies impact GVCs is through their effect on relative production costs. Supportive policies such as subsidies, tax credits or preferential procurement can reduce the costs of production for firms engaged in environmental goods and services. When these policies are targeted at specific, environmentally friendly sectors, they can improve the competitiveness of domestic producers in these sectors. This may lead to a repositioning of countries or firms within GVCs, as they gain comparative advantage in cleaner or more innovative segments of the value chain.

In contrast, regulatory measures such as carbon taxes, emissions caps and environmental standards may raise operational costs, especially for carbon-intensive or resource-intensive activities. As compliance costs increase, firms may be incentivized to shift production to jurisdictions with more lenient environmental regulations, or to relocate specific segments of their value chains to optimize cost efficiency. These pressures can alter the global allocation of production stages, with potentially significant implications for the distribution of value added across countries (Koźluk and Timiliotis, 2016; Duan et al., 2021).

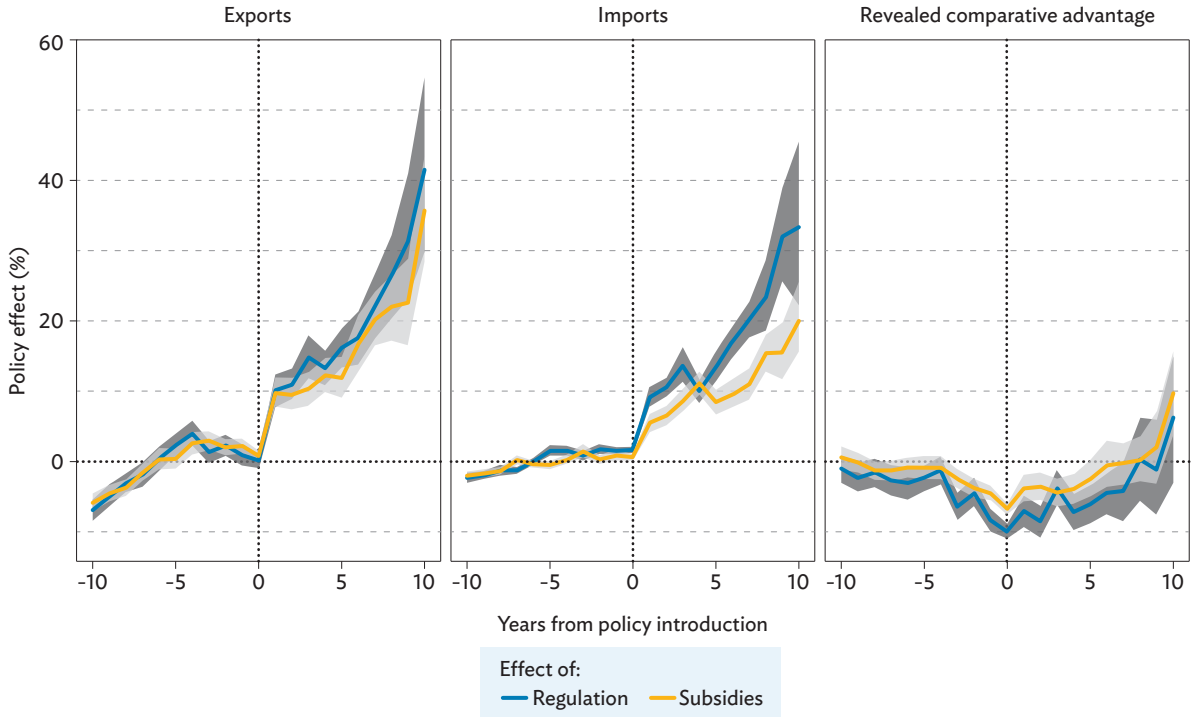
Beyond cost-based effects, environmental policies can also shape GVCs through their impact on innovation and technological change. Policies that encourage green innovation, such as R&D subsidies, intellectual property reforms or market-based instruments designed to reward low-emission technologies, can push firms and sectors up the technological frontier. Over time, this may result in structural shifts in competitiveness, enabling some countries to capture high-value added segments of environmental goods production. In this way, environmental policy not only addresses externalities but also acts as an industrial policy tool, shaping the direction of technical change and the composition of international trade.

This mechanism aligns with the literature of directed technical change first articulated in Acemoglu et al. (2012, 2014). In their model, a final good is produced using either clean or dirty technologies. If clean sectors offer greater profit opportunities, perhaps due to environmental policy incentives, they will attract more innovation, increase productivity and generate comparative advantage in trade.

4.4.2 Empirical Evidence on the Trade and Innovation Effects of Environmental Policies

Understanding the impact of environmental policies, particularly in a globalized world, is essential to facilitate a successful transition to a more sustainable future. Bellelli and Xu (2024) empirically assess these effects using a synthetic counterfactual methodology. Their analysis estimates the average treatment effect of implementing environmental measures on trade flows and innovation outcomes. They distinguish between policies that increase firms' compliance costs ("regulations") and those that lower the cost of production or innovation ("subsidies").

Figure 4.8: Potential Effects of Environmental Policy on Trade

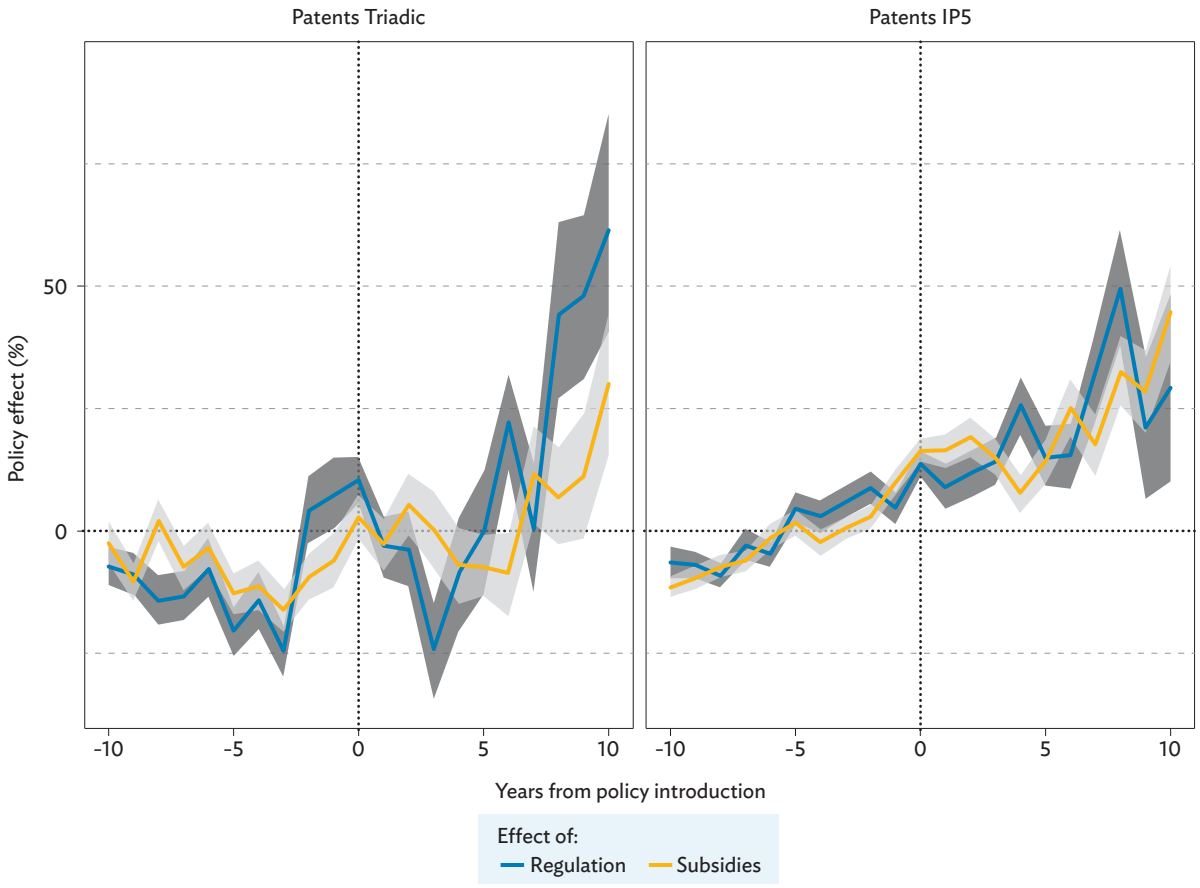


Noted: Shaded area are bootstrapped 95 confidence intervals.

Source: Bellelli and Xu (2024).
Notes: The figure displays the estimation results of a synthetic counterfactual to illustrate the effects of environmental policies on (1) exports of environmental goods, (2) imports of environmental goods and, (3) revealed comparative advantage in environmental goods exports. The horizontal axis represents the years around the implementation of an environmental policy, while the vertical axis indicates the percentage change in the trade in the economy implementing an environmental policy compared with trade in the same sector in the counterfactual countries with no policy. The shaded area represents bootstrapped 95% confidence interval.

As shown in Figure 4.8, the empirical findings show that environmental policies are associated with significant increases in both exports and imports of environmental goods. The effects of these policies gradually increase over time following their implementation, resulting in up to a 40% increase in exports and a 30% increase in imports of environmental goods relative to the synthetic counterfactual approximately 10 years after the environmental measures are enacted. Moreover, regulations and support policies display subtle differences in their trade effects: while both types of policies strongly affect the exports of environmental goods, regulations tend to boost imports slightly more. When measured by the revealed comparative advantage (RCA) of environmental exports, the effects do not appear as pronounced. The implementation of an environmental policy does not seem to be associated with an increase in the comparative advantage of an economy's exports in the initial years of the policy's implementation, and a positive effect on the RCA only becomes visible 8-10 years after a policy is enacted.

Figure 4.9: Potential Effects of Environmental Policy on Green Innovation



Noted: Shaded area are bootstrapped 95 confidence intervals.

Source: Bellelli and Xu (2024).

Notes: The figure displays the estimation results of synthetic counterfactual to illustrate the effects of environmental policies on environmental patents within the triadic family and IP5 family. The horizontal axis represents the years around the implementation of an environmental policy, while the vertical axis indicates the percentage change in patents in the economy implementing an environmental policy compared with patents in the same sector in the counterfactual countries with no policy. The shaded area represents bootstrapped 95% confidence interval.

In terms of green innovation, the analysis shows a statistically significant rise in environmental patent filings following policy implementation. While the patent counts in the triadic family – where patents are filed in different national patent offices – seem to display some fluctuations, the patent counts in the IP5 family – a forum of the world's five largest intellectual property offices – appear to show a steady increase after the implementation of an environmental policy (see Figure 4.9). Both regulatory instruments and subsidy measures contribute to this outcome, though their temporal effects differ. Subsidies appear to have more immediate impacts, while regulations are associated with longer-term innovation responses.

Their work complements a broader literature examining the effects of environmental policies on trade and innovation. A growing body of research highlights the positive impact of environmental policies on innovation. A few sector-specific studies show that well-designed environmental regulations can stimulate clean technology development across a range of industries, including automobiles (Aghion et al., 2016), wind turbines (Dechezleprêtre and Glachant, 2014) and solar photovoltaics (Peters et al., 2011). Firm-level evidence also suggests that the EU ETS has encouraged low-carbon innovation (Calel and Dechezleprêtre, 2016). More broadly, studies find that properly structured environmental regulations can enhance both innovation and firm competitiveness (Ambec et al., 2013; Dechezleprêtre and Sato, 2017). Taking a more holistic view, Pugliese et al. (2019) examine the co-evolution of countries' scientific, technological and productive capabilities, concluding that technological strength is the strongest predictor of industrial and scientific performance.

4.5 Carbon Border Adjustment Mechanisms and Their Impacts on Carbon Leakage in GVCs

If more carbon-intensive countries were to adopt domestic ETSs and, ideally, establish linkages with existing regional or international carbon markets, the risk of carbon leakage through trade and investment could be significantly reduced in theory. In such a harmonized global framework, the differential in carbon pricing between jurisdictions would narrow, thereby weakening incentives for firms to relocate emissions-intensive activities across borders. However, the current global landscape remains fragmented, with substantial variation in carbon pricing coverage, design and stringency across countries (Black et al., 2022). In response to this asymmetry, economies with more ambitious climate policies and lower carbon intensities have either implemented or proposed CBAMs as a mean to level the playing field and prevent leakage. While CBAMs are a second-best solution from a global coordination perspective, they reflect the practical difficulties of achieving synchronized international carbon mitigation policies and may become more prevalent if convergence on such policies remain elusive.

This section builds on the existing literature by first evaluating the potential effectiveness of CBAMs in reducing cross-border carbon leakage. It further examines limitations in current approaches, particularly the limited treatment of GVC structures and firm-level heterogeneity – such as differences in technology adoption, emissions intensity and market exposure between MNEs and local firms. Using a novel GVC-based CGE model, this section analyses the implications of a CBAM similar to the scheme proposed by the EU for emissions, GVCs and economic welfare.

4.5.1 The Potential Effectiveness of CBAMs in Reducing Cross-Border Carbon Leakage

CBAMs are climate policy instruments that can complement existing domestic carbon pricing mechanisms, such as the EU ETS in its early phase. Under the EU's CBAM framework, importers are required to purchase certificates reflecting the embedded emissions in imported products, with prices linked to the ETS[8]. Currently in its transitional phase, the EU CBAM represents the most advanced implementation of cross-border carbon pricing to date. Proposals for CBAM measures in other countries (e.g., Canada, the US) have also been evaluated through CGE models and macroeconomic simulations.

Modelling studies for the EU's CBAM find a substantial drop in leakage rates once import carbon tariffs are applied. For example, Bellora and Fontagné (2023) show that the EU's planned CBAM would curtail leakage compared to a scenario with no border measures. OECD (2025) simulations indicate that, the CBAM effectively prevents carbon leakage by redirecting EU imports from less carbon-efficient countries to more carbon-efficient countries. Further investigation considering supply chains (Dechezleprêtre et al., 2025) shows the CBAM can effectively prevent carbon leakage. However, it only partially mitigates the negative effects of higher carbon prices and free allowances removal on the value added of CBAM-protected industries and negatively affects downstream EU industries.

As pointed out by Fischer and Fox (2012), design choices critically influence leakage outcomes. A key feature is whether CBAMs include export adjustments. Ambec et al. (2024) find that theoretically a CBAM only levels the playing field domestically and may lead to an autarky equilibrium (a no-trade equilibrium occurs when carbon tariffs render foreign firms uncompetitive domestically, and at the same time, domestic firms are unable to compete internationally). To reverse carbon leakage, a CBAM must be complemented with export rebates. In addition, the EU CBAM covers a limited set of

8 Under the EU Regulation, CBAM has a transitional (report-only) period from 1 October 2023 to 31 December 2025. The definitive regime applies from 1 January 2026. As amended by Regulation (EU) 2025/2083, Member States sell CBAM certificates in 2027 for emissions embedded in goods imported in 2026, and the first annual surrender for 2026 is due by 30 September 2027. The amendment also introduces a de minimis, single mass-based threshold of 50 tonnes per importer per calendar year; importers at or below this threshold are exempt from CBAM obligations for that year.

emissions-intensive sectors, which constrains its aggregate leakage mitigation effect and may leave competitiveness gaps. A recent study (Qian et al., 2025) shows that EU CBAM with extended emission scope and industry coverage can lower carbon leakage more effectively.

Empirical research suggests that CBAMs can be effective in mitigating carbon leakage, particularly when they are comprehensively designed and embedded within broader cooperative climate strategies. However, important trade-offs remain. Notably, most existing CBAM-related simulations do not explicitly account for GVC linkages or firm-level heterogeneity. In particular, the distinction between MNEs and domestically owned firms is often overlooked, despite their markedly different production structures, emission intensities and exposure to trade policies. This omission risks misestimating the true impact of CBAMs on both carbon leakage and industrial competitiveness. For example, Ortiz et al. (2022) find that MNEs' foreign affiliates disproportionately invest in emission-intensive manufacturing sectors, resulting in greater contributions to host-country CO_2 emissions than to value added. Incorporating firm heterogeneity and GVC structures into future modelling efforts is therefore essential for more accurately capturing the distributional effects of CBAMs – both across firms and between countries.

4.5.2 A GVC-based CGE Analysis for CBAMs Considering Firm Heterogeneity

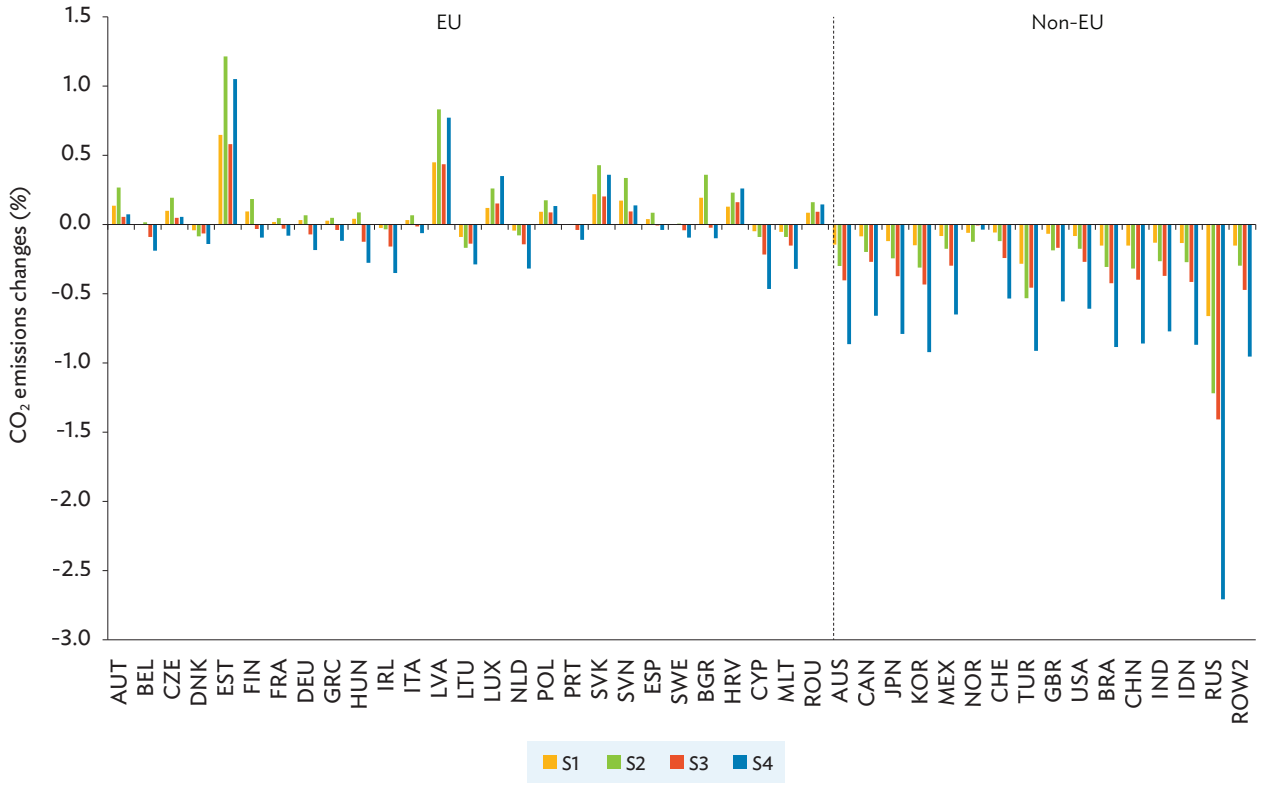
Thanks to the recent development of GVC accounting for emissions (Meng et al., 2018, 2023) and GVC-based CGE modelling (Koopman et al., 2014; Cai et al., 2015; Meng et al., 2025), as well as the OECD inter-country input-output (ICIO) data with consideration of MNEs' activities via FDI, detailed simulation analysis about how and to what extent a CBAM implemented by the EU impacts emissions and welfare via GVCs becomes available.

This section considers the CBAM scenarios for the EU from two dimensions in our GVC-based CGE model.[9] The first dimension is carbon tax rate, which is set at two levels, one is \$50 per tCO2e and another one is \$100 per tCO_2e. The second dimension is sector coverage and this section also assumes two types of sector coverage: one covers five key sectors (cement, iron and steel, aluminium, fertilizers and electricity) that is proposed in the current EU's CBAM and another one covers all sectors. Table 4.4 provides a summary of four scenarios used in this paper.

9 This section uses a revised version of DREAM to study the impacts of CBAM on GVCs. DREAM is originally developed from the GTAP-E model and has been used to study the carbon pricing issues (Qian et al., 2018). Unlike DREAMs used in previous studies that the international trade patterns are modelled indirectly by using the Globe method (McDonald et al., 2007; Wu et al., 2022a, b; Tang et al., 2022). Our model is based on the OECD's Activity of MNEs (AMNE) ICIO table in which MNEs (the main players of GVCs) and local firms are split at the sector level. In addition, the relevant bilateral and sectoral FDI flow and stock data is from Meng et al. (2022)'s estimation which is based on official statistics of several international organizations as well as GTAP database.

Table 4.4: A CBAM CGE Model Scenario Setting			
		CBAM tax rate	
		$50 per tCO_2e	$100 per tCO_2e
Sector coverage	Key sectors	Scenario 1 (S1)	Scenario 2 (S2)
	All sectors	Scenario 3 (S3)	Scenario 4 (S4)

Figure 4.10: Simulation Results of an EU CBAM's Impact on CO_2 Emissions



Source: Authors' estimation based on Qian et al. (2025).

Figure 4.10 presents the simulated effects of an EU CBAM on global and regional CO_2 emissions across four policy scenarios: S1 ($50 per tCO_2e applied to key sectors), S2 ($100 per tCO_2e on key sectors), S3 ($50 per tCO_2e on all sectors) and S4 ($100 per tCO_2e on all sectors). At the global level, CO_2 emissions are projected to decline by 0.12%, 0.23%, 0.36%, and 0.69% under scenarios S1 through S4, respectively. Notably, expanding the CBAM's sectoral coverage from a limited set of key industries to the entire economy results in a CO_2 reduction effect approximately 1.5 times larger than that achieved by doubling the carbon price from $50 to $100 per tCO2e. This indicates that the breadth of sectoral application has a greater marginal impact on emissions abatement than increasing the carbon price alone.

From a policy implementation perspective, a CBAM limited to key sectors offers clear administrative advantages. It reduces compliance complexity and costs by narrowing the scope to a smaller set of easily identifiable, carbon-intensive intermediate goods.

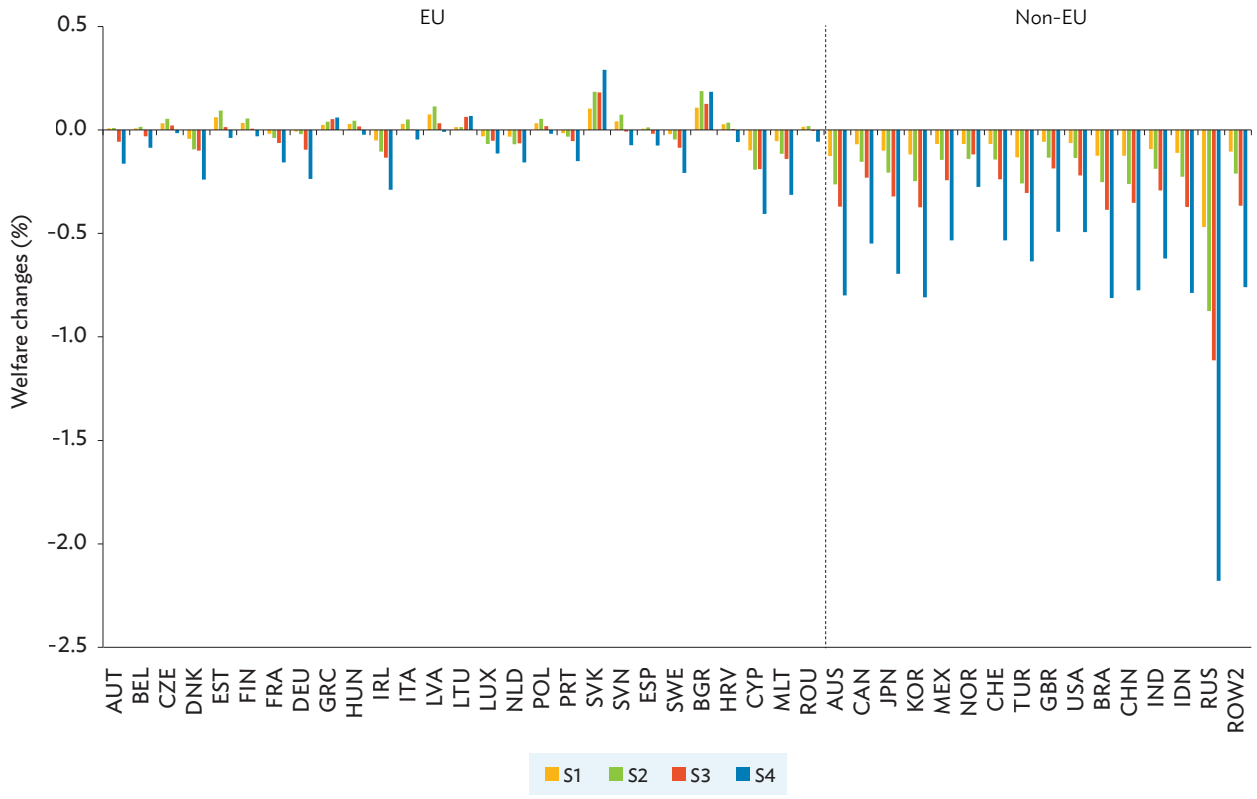
However, this approach may fall short in addressing emissions embodied in complex products with deep and geographically dispersed supply chains. For example, in the case of producing electric vehicles, about half of all emissions (see Chapter 3) occur upstream during the production of power batteries, rather than in final assembly. As such, expanding CBAM coverage across more sectors enhances the policy's effectiveness by allowing carbon price signals to travel further upstream in the value chain, thereby influencing emissions-intensive production stages more comprehensively.

One of CBAMs' central policy objectives is to reduce the risk of carbon leakage – whereby production shifts to countries with laxer climate regulations, undermining the efficacy of domestic climate policy. Simulation results suggest that this goal is largely met, as under scenario S4, CO_2 emissions in non-EU countries decline by nearly 1% on average, reflecting the deterrent effect of a CBAM on emissions outsourcing.

However, the intra-EU impact of a CBAM is far from uniform. While some member states, particularly in Western Europe, experience slight emissions reductions, others – especially in Eastern Europe – record increases. Under scenario S4, more than half of EU countries see emissions rise by an average of 0.7%, whereas certain Western European economies observe modest declines of around 0.2%.

Several structural mechanisms explain this heterogeneity. First of all, by increasing the cost of imported carbon-intensive goods, a CBAM enhances the relative competitiveness of domestically produced alternatives. In Eastern European countries, where industries tend to be more carbon-intensive, this substitution effect leads to increased domestic production – and consequently, higher emissions – even though these products are cleaner than their imported counterparts. Secondly, a CBAM alters intra-EU production dynamics. Facing higher costs for non-EU imports, Western European countries may shift emissions-intensive production to Eastern European member states, where production remains cost-effective and CBAM duties do not apply. This adjustment reduces external leakage but redistributes emissions within the EU. Notably, such reallocation may help Western countries like Germany lower their domestic carbon intensity, contributing to observed emissions reductions, albeit partly through geographic displacement rather than technological improvement. Thirdly, a CBAM indirectly raises energy prices across the EU by increasing the costs of carbon-intensive goods. This elevates the shadow price of carbon and strengthens incentives for firms to adopt cleaner energy sources and invest in energy efficiency. Countries with high energy dependency are particularly responsive to these price signals, driving gradual improvements in energy use and emissions intensity. This mechanism partly accounts for the modest emissions decline observed in some Western European economies under the more stringent CBAM scenarios.

Figure 4.11: Simulation Results of an EU CBAM's Impact on Welfare



Source: Authors' estimation based on Qian et al. (2025).

Figure 4.11 provides a detailed estimation of the distributional effects of CBAM by presenting welfare change (based on the equivalent variation) rates across countries and policy scenarios. Consistent with the pattern observed in emissions changes, welfare impacts also exhibit clear regional asymmetries. Non-EU countries generally experience welfare losses, as measured by the income required to restore pre-CBAM levels of well-being, due to reduced competitiveness in the EU market resulting from higher entry barriers on carbon-intensive exports.

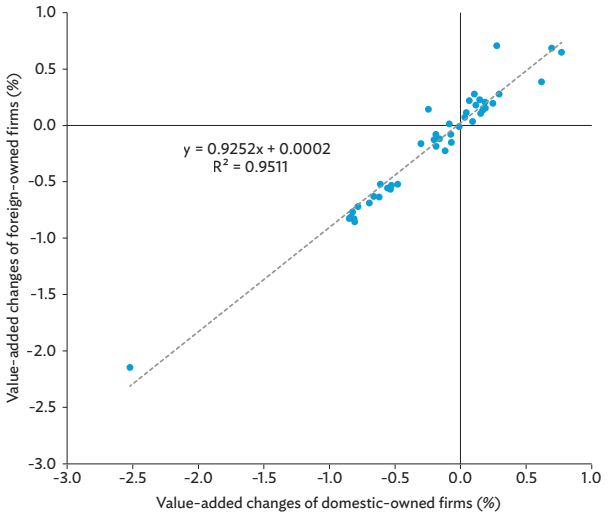
Within the EU, the welfare effects are more nuanced. Eastern European countries, whose domestic production is relatively more carbon-intensive, tend to benefit from a CBAM in terms of welfare gains. As imported high-carbon goods become less competitive due to the adjustment mechanism, domestic substitutes – especially those produced within the EU and thus exempt from CBAM – gain market share. This shift enhances production activity and utility levels in these countries, resulting in positive welfare changes.

Conversely, many Western European countries experience welfare losses under a CBAM regime. This is primarily due to increased costs of imported carbon-intensive intermediate inputs, which raise the production costs of final goods across the EU supply chain. Western European economies, characterized by relatively lower carbon intensity in their industrial structure, are less likely to benefit from the substitution

effect that favours domestic carbon-intensive production. As a result, they are more exposed to the negative utility effects of higher consumer prices without offsetting gains in production competitiveness. The burden of CBAM-induced price adjustments thus falls more heavily on final consumption in these countries, leading to a net welfare decline.

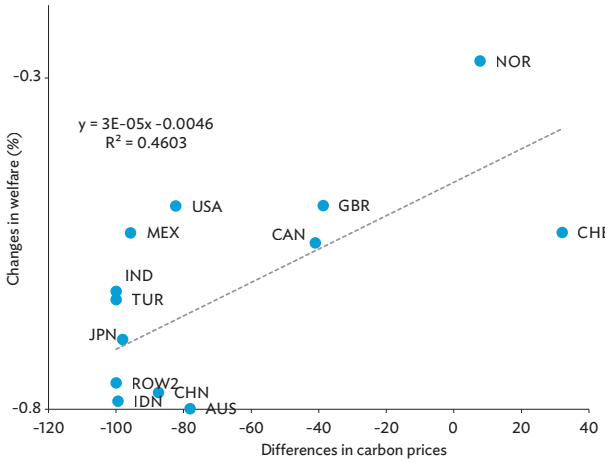
In short, while a CBAM appears effective in reducing global emissions and curbing carbon leakage, it also induces significant structural shifts in production and emissions patterns both within and outside the EU. These heterogeneous effects underscore the need for careful consideration of intra-EU equity and coordination in the design and implementation of carbon border measures. These heterogeneous impacts underscore a critical tension within CBAM frameworks: while the policy effectively reduces global emissions and internalizes carbon costs at the border, its economic burden is unevenly distributed – particularly between EU and non-EU countries, and among EU member states themselves. This highlights the importance of complementary domestic measures and policy coordination mechanisms between the EU and non-EU countries, to ensure a just and politically sustainable transition towards carbon neutrality.

Figure 4.12: Simulation Results of an EU CBAM's Impact on GVCs By Firm Ownership



Note: Based on Scenario 4 (for all sectors and \$100 per tCO_2e)
Source: Authors' estimation based on Qian et al. (2025).

Figure 4.13: The Relationship Between Welfare Changes and the Difference in Carbon Prices for Non-EU Economies

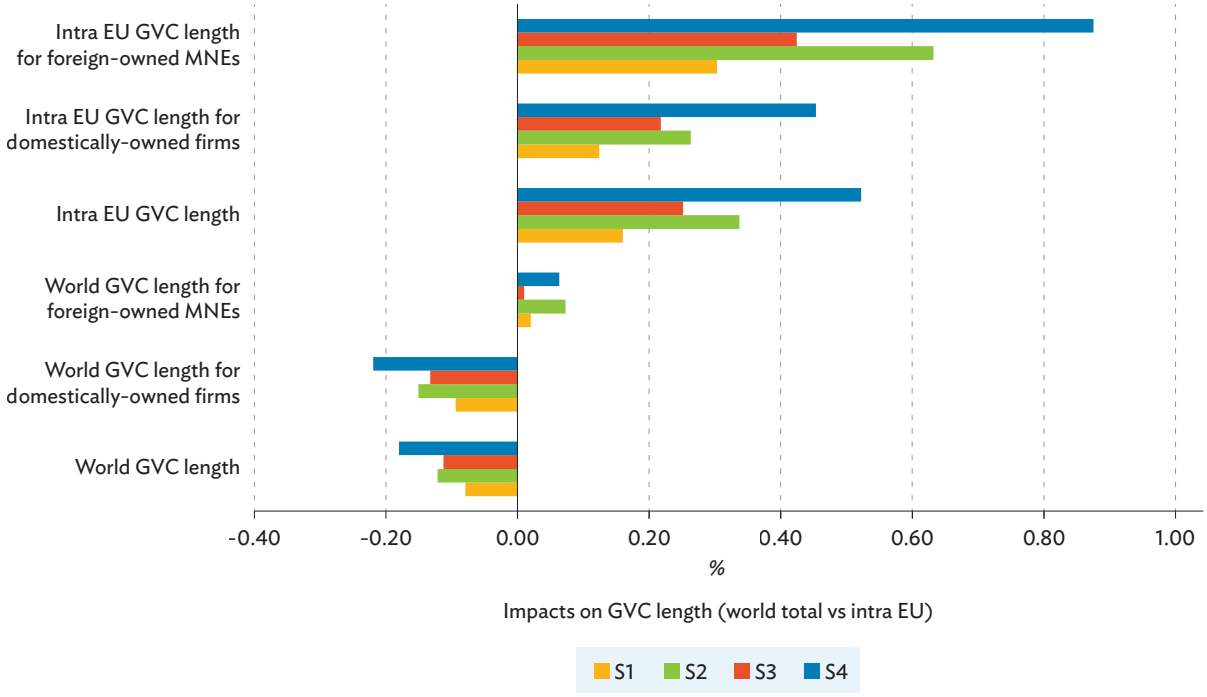


Note: Based on Scenario 4 (for all sectors and \$100 per tCO_2e)
Source: Authors' estimation based on Qian et al. (2025).

An important nuance in a CBAM's impact lies in the differential responses between MNEs and domestically owned firms. Figure 4.12 compares GDP changes under Scenario S4 and reveals that MNEs are less adversely affected than domestic firms. This outcome reflects MNEs' greater operational flexibility, broader geographic footprints and experience managing GVCs, which enable them to adapt more effectively to external shocks such as CBAM-induced price shifts. MNEs can reallocate production or adjust sourcing to minimize carbon cost exposure, while also leveraging advanced

compliance systems. In contrast, domestically owned firms, often with limited supply chain flexibility and concentrated market operations, are more vulnerable to rising input costs and thus suffer larger output losses.

Figure 4.14: Simulation Results of the EU CBAM's Impact on the Length of GVCs



Source: Authors' estimation based on Qian et al. (2025).

Furthermore, Figure 4.13 shows that non-EU countries with relatively high domestic carbon prices experience smaller welfare losses under an EU CBAM regime. This outcome is intuitive: when exporters offer goods of similar price and quality, those from countries with higher domestic carbon prices are more competitive, as their products are subject to a lower adjustment under a CBAM. This finding aligns with the conclusions of Mehling et al. (2019), suggesting that an EU CBAM may create positive spillover effects by encouraging trade partners to implement or strengthen domestic carbon pricing mechanisms.

The above firm-level implications are further substantiated by changes in GVC length under a CBAM, as illustrated in Figure 4.14. Drawing on the methodology proposed by Wang et al. (2017), this section computes GVC length – proxied by the upstreamness index – for both global and intra-EU production networks. The upstreamness index captures the average number of production stages that a unit of value added in a specific sector passes through before reaching final demand.

The results reveal two contrasting trends. At the global level, CBAM implementation leads to a shortening of GVC length, particularly in segments dominated by domestically owned firms. This suggests a contraction or simplification of international supply chains, likely driven by rising costs associated with carbon-intensive imports and reduced competitiveness of non-EU suppliers. Conversely, intra-EU GVCs become more extended under a CBAM, with the lengthening most pronounced among MNEs. This pattern underscores MNEs' heightened sensitivity to carbon-adjusted import prices and their capacity to restructure production across EU member states. It also reflects their superior capability to maintain complex supply chains by relocating stages of production previously conducted in non-EU regions back within the EU, thereby avoiding CBAM tariffs while preserving operational efficiency.

Together, these findings reinforce the earlier conclusion that while a CBAM similar to the EU's proposed scheme can curb carbon leakage, it may also reinforce structural inequalities between globally integrated firms and domestic producers. Policy measures supporting domestically owned firms' low-carbon transitions are necessary to ensure a more balanced and inclusive adjustment process.

While a CBAM represents a significant innovation in the global carbon pricing landscape, it also faces practical challenges. These include the verification of embedded emissions, administrative complexity, potential inconsistencies with WTO rules and distributional concerns for developing economies. Moreover, interactions with existing carbon pricing mechanisms abroad may lead to overlapping regulation or unintended double taxation, adding to the burden on international trade partners (WTO, 2022). Nordhaus (2015) argues that multilateral "climate clubs" with harmonized carbon pricing and border measures can better address free riding and global emissions. Overland and Huda (2022) emphasize that unilateral CBAMs risk raising trade tensions and achieving only limited global adoption, whereas coordinated efforts enhance legitimacy and impact. Böhringer et al. (2022) note that CBAM can reduce leakage through competitiveness channels but is vulnerable to retaliation and policy gaps. Together, these studies suggest that a CBAM, while useful under fragmented climate governance, is only a partial solution. Greater international coordination through climate clubs or the carbon pricing framework proposed by the WTO (Bekkers et al., 2024), which emphasizes global coverage, equity and fairness, protection for vulnerable groups and flexibility in implementation, is essential for more effective global emissions control.

4.6 Addressing GVC-Driven Environmental Externalities

GVCs have fundamentally reshaped international trade and production, fostering deep economic interdependence among nations. While the expansion of GVCs has generated notable gains in productivity and economic growth, it has also externalized significant environmental costs. The fragmentation and globalization of production have not only

redistributed but also often amplified environmental burdens, extending beyond the GHG emissions previously discussed to include various forms of pollution and public health risks. These externalities are frequently shifted towards countries with weaker regulatory capacity or ecologically fragile regions, where enforcement mechanisms are limited and environmental resilience is low. For example, the spatial fragmentation inherent in GVCs enables pollution-intensive production stages to be relocated to jurisdictions with relatively lax environmental standards. This phenomenon, commonly referred to as the "pollution haven" effect, enables high-income economies to import lower-cost goods while displacing pollution, toxic releases and associated health risks to less regulated regions (Copeland et al., 2004; Levinson and Taylor, 2008; Shapiro and Walker, 2018). Consequently, the market prices of traded goods fail to capture their full environmental costs, perpetuating a geographic disconnect between the sites of consumption and pollution generation. Cost competition within GVCs also creates strong incentives for environmental under-regulation, especially in developing and emerging economies. Environmental standards may be under-enforced or circumvented entirely, leading to unchecked pollutant discharges, land degradation and public health risks (Prakash and Potoski, 2006; Kellenberg, 2009). Furthermore, the multi-tiered and opaque nature of GVCs dilutes accountability, making it difficult to trace responsibility or incentivize upstream investment in pollution control technologies.

4.6.1 Environmental Externalities in Manufacturing GVCs

Manufacturing GVCs have dispersed production across borders to exploit cost advantages, while simultaneously externalizing a wide range of environmental burdens. Beyond the well-documented issue of carbon leakage, manufacturing value chains are also major sources of local pollution. Export-oriented industrial zones in East and South Asia release high concentrations of sulphur dioxide (SO_2), nitrogen oxides (NO_x), fine particulates ($PM_{2.5}$) and volatile organic compounds, all of which degrade air quality and threaten public health. In the context of China's export boom, these emissions were linked to increased incidences of respiratory and cardiovascular illnesses (Wang et al., 2017; Bombardini and Li, 2020). In textile manufacturing hubs such as Bangladeshi capital Dhaka and the Indian city of Tiruppur, the discharge of untreated dye effluents has severely contaminated local water bodies, decimating aquatic ecosystems and posing severe risks to human consumption (Al-Tohamy et al., 2022; Subramanian and Baskar, 2022; Masum et al., 2025).

An often-overlooked dimension of manufacturing externalities is the intensification of occupational heat exposure among workers in developing countries. As climate change accelerates, the incidence and severity of extreme heat events have risen. A recent study by Li et al. (2025) shows that between 1995 and 2020, trade-related labour exposure to extreme heat rose by 89%, from 221.5 to 419.0 billion person-hours. Crucially, low- and lower-middle-income countries accounted for 72% of the exposure burden but received only 6.7% of global labour compensation. This discrepancy reveals how trade redistributes climate risk and labour hardship across countries. Workers

in heat-prone regions, particularly those integral to global supply chains, require enhanced protection through climate adaptation infrastructure and labour safeguards.

4.6.2 Environmental Externalities in Agricultural GVCs

Agriculture and agribusiness have also become increasingly globalized through value chains (Lim, 2023), generating significant environmental costs, chiefly via land-use change and agrochemical inputs. Rising global demand for commodities such as soy, palm oil, cocoa and beef has driven extensive land use change. In Brazil's Amazon and Cerrado regions, export-oriented expansion of soybean cultivation and cattle ranching has led to accelerated deforestation (Carreira et al., 2024), triggering carbon release, biodiversity loss and hydrological disruption (Lenzen et al., 2012; Chaudhary et al., 2016; Wilting et al., 2021). Empirical evidence suggests that trade liberalization under regional agreements often coincides with forest conversion, as newly profitable cropland replaces native ecosystems (Abman and Lundberg, 2020).

Excessive use of fertilizers and pesticides in export-oriented agriculture represents another major externality. To meet stringent international standards for yield and quality, farmers frequently over-apply agrochemicals, leading to nutrient runoff, groundwater contamination and eutrophication, with an increased load of nutrients. China, for example, consumes nearly one-third of global fertilizer output and continues to experience serious non-point source pollution (Ren et al., 2021; Wang et al., 2023). Similar patterns are observable globally, including the formation of "dead zones" in the Gulf of Mexico due to nutrient loading from export-oriented corn and soybean farming in the Mississippi Basin (Secchi et al., 2011; Rabotyagov et al., 2014). Pesticide overuse contributes further to the degradation of soil quality, pollinator populations and aquatic ecosystems.

Export-oriented agriculture also depletes natural capital. Monoculture production accelerates soil nutrient loss and organic matter depletion, imposing intergenerational costs on local farming communities. Water-intensive exports, such as cotton, almonds and avocados, have caused widespread groundwater over-extraction in arid regions (Cerasoli and Porporato, 2023), echoing historical ecological collapses such as the Aral Sea basin (Micklin, 2007). These "virtual water" exports exacerbate local water stress without internalizing the associated environmental and social costs (Hoekstra and Hung, 2005).

The human cost of agricultural GVCs is equally concerning. Empirical studies document elevated rates of chronic kidney disease among sugarcane workers in Central America and tea labourers in India – linked to recurrent dehydration and prolonged exposure to agrochemicals (García-Trabanino et al., 2015; Venugopal et al., 2021). Pesticide applicators and residents likewise face serious long-term health risks without access to compensation or legal recourse against multinational actors.

Additionally, integration into global food value chains has contributed to dietary transitions in low- and middle-income countries. Drawing on two decades of cross-country data, Hashad et al. (2024) find that deeper backward participation in GVCs is positively correlated with rising obesity rates among women, particularly in urban areas, driven by greater access to processed, energy-dense foods. These findings illustrate how the structure of global food systems not only externalizes environmental harms but also propagates adverse health outcomes. Addressing these multi-dimensional risks calls for integrated policy frameworks that internalize environmental, health and labour externalities across the full length of agricultural GVCs.

4.7 Conclusion and Discussion

This chapter has examined the environmental implications of GVCs through the lens of carbon emissions, the effectiveness of policy instruments and broader ecological externalities. A consistent finding is that while GVCs have enhanced economic integration and efficiency, they have simultaneously externalized significant environmental costs – ranging from embodied carbon leakage to biodiversity loss, ecosystem degradation and occupational health risks. Our analysis shows that environmental burdens are unequally distributed across borders, firm types and social groups. Low-income countries often bear the brunt of upstream emissions, toxic exposure and ecological degradation, while capturing a relatively small share of value-added. Similarly, MSMEs – despite being key contributors to employment and production – are frequently excluded from decarbonization support mechanisms.

These findings collectively reaffirm the need to make GVCs not only greener, but also more inclusive.

To advance greener and more inclusive GVCs, we propose the following policy priorities:

(1) **Broaden and harmonize carbon pricing frameworks or similar policies** in more developing economies, with explicit place-based design to include diverse firm types with equalized green finance treatment. This means extending coverage to more sectors and MSMEs and ensuring that carbon markets provide level playing fields regardless of firm ownership or size. Where possible, ETSs should be linked across borders to facilitate convergence in carbon pricing and reduce arbitrage incentives.

(2) **Coordinate environmental policies internationally.** Fragmented policy landscapes introduce regulatory frictions in GVCs. When countries adopt different environmental regulations (e.g., divergent product standards, carbon pricing mechanisms), this can introduce border adjustment complexities, disrupt economies of scale for firms operating across multiple jurisdictions and

create a need for "regulatory hedging" strategies, where firms adjust production to serve specific regulatory markets.

(3) **Internalize non-carbon externalities in GVCs** by integrating environmental and health criteria into trade and investment rules. This includes binding standards on agrochemical use, land-use change, waste discharge and occupational health – especially in sectors most exposed to ecological harm.

(4) **Promote inclusive climate transitions through multilateral cooperation,** with a focus on strengthening regulatory capacity in developing countries, incentivizing clean technology adoption and embedding equity safeguards in international climate-trade interfaces.

Ultimately, achieving green and inclusive GVCs will require aligning climate ambition with trade openness, industrial competitiveness with social equity and firm-level incentives with collective environmental responsibilities. International cooperation, policy coherence and transparent institutional arrangements will be critical to ensuring that global trade not only sustains prosperity but also safeguards planetary and human health for generations to come.

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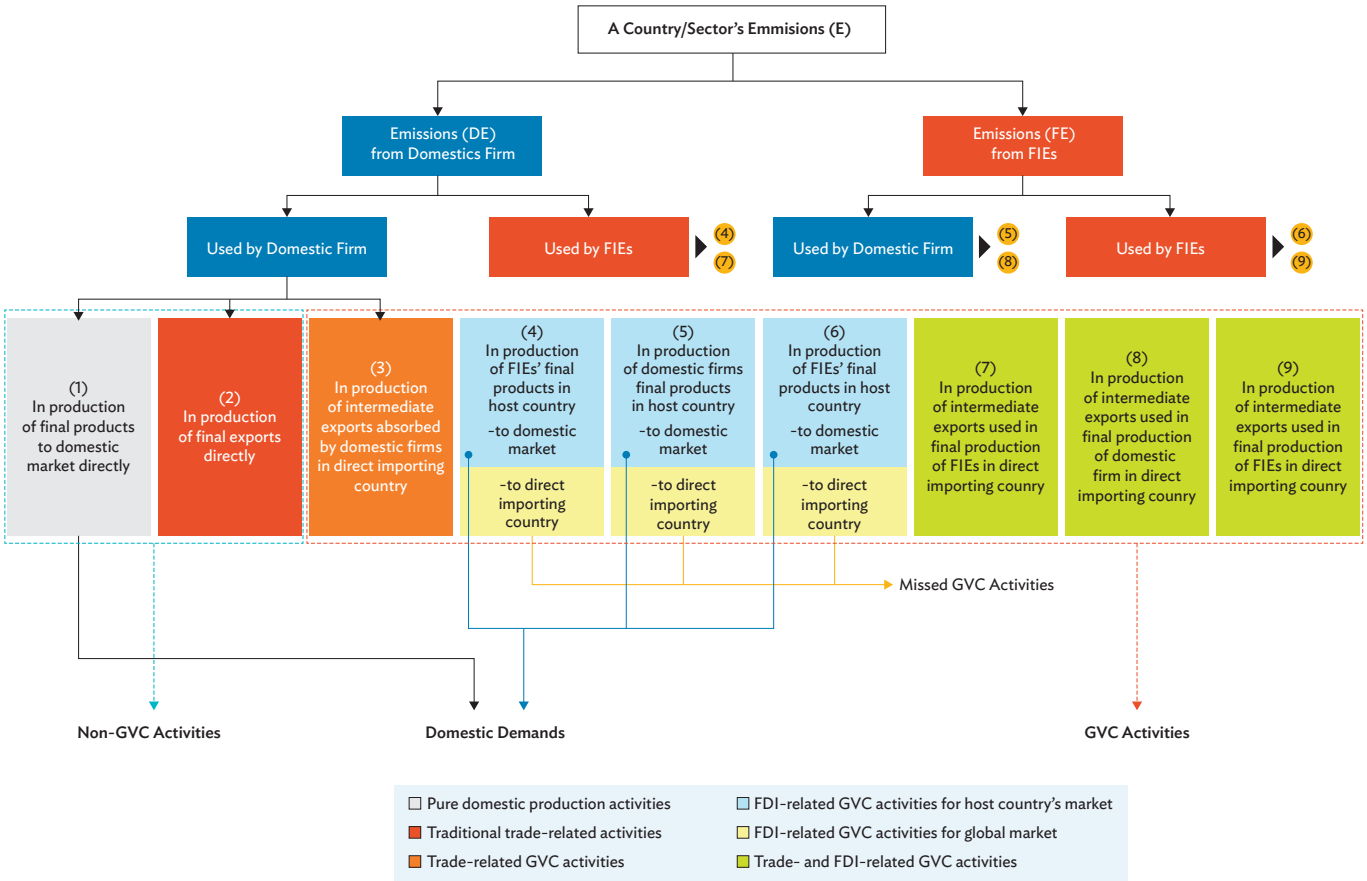
Annex 4.1: Updated Accounting for Tracing CO_2 Emissions along GVCs

Meng et al. (2018) integrate the trade in value added and emissions footprint in a GVC accounting (Koopman et al., 2014), thus enable both value added and emissions to be systematically traced at the country, sector and bilateral levels through various routes in GVCs. However, one problem remains unresolved in Meng et al. (2018): this accounting relies heavily on territory-based measures (the border of the country) rather than the ownership or controlling power of firms. This may lead to misunderstandings in the identification of carbon leakages and emission responsibility sharing at the firm level. For example, numerous MNEs sold considerable amounts of products that were "made" or "assembled" in developing economies through FDI channels, to those economies' domestic consumers, but conventional accountings do not count such sales and associated emissions as a part of GVCs and GVC related carbon transfer. Therefore, all the responsibility of emissions embodied in those domestic transactions belongs to those developing economies, regardless a production-based or consumption-based approach is followed.

Figure 4.15: Accounting for Tracing Emissions Along GVCs



Source: Li et al. (2022).

Given the above challenges, Li et al. (2022) propose a novel multi-tiered framework to systematically trace a country's sectoral emissions from upstream production stages to downstream final use along GVCs, enabling a more granular understanding of their sources (production-based emissions), transmission (emission transfer or emission export/import) and absorption (consumption-based emissions).

As shown in Figure 4.15, Tier 2 disaggregates these emissions by ownership structure of the producers, distinguishing between domestic enterprises (DEs) and foreign-invested enterprises (FIEs), including affiliates of MNEs. This distinction can help capture the firm heterogeneity in production behaviour, technological capacity and environmental performance. Tier 3 introduces the intermediate-user perspective by classifying emissions according to who uses those goods and services produced by different types of firms. Tier 4 further distinguishes emissions into nine distinct trade and investment routes, which are ultimately grouped into the following six categories based on the final market they serve emissions associated with:

(1) Emissions embodied in purely domestic production
(2) Emissions embodied in traditional trade (Ricardian-type trade of final goods)
(3) Emissions embodied in trade-related GVC activities
(4) Emissions embodied in FDI-related GVC activities serving the host country's domestic market
(5) Emissions embodied in FDI-related GVC activities serving global export markets
(6) Emissions embodied in GVC activities involving both trade and FDI (hybrid routes)

Those emissions could further be linked into two types of firm activities in Tier 5: non-GVC activities, where no cross-border production sharing or FDI is involved, and GVC-related activities involving trade in intermediate goods or FDI-linked production arrangements.

This decomposition enables a detailed characterization of how emissions are embedded and transmitted through various channels in the global production networks, accounting not only for trade but also for investment linkages. It is important to highlight the "missed GVC activities", which are often overlooked in conventional emissions accounting frameworks. These include, for example: 1) final goods produced by FIEs for the domestic or global market (e.g., Tesla (Shanghai) Co., Ltd. manufacturing electric vehicles for both Chinese consumers and export to countries like Japan), and 2) final goods produced by domestic firms using intermediate inputs sourced from FIEs (e.g., Chinese automakers integrating electronic control units produced by Bosch (China) Investment Ltd.). Under traditional accounting systems, such activities are typically classified as either domestic production or Ricardian-type final good trade (i.e., French wine in exchange for English cloth), thereby failing to capture the embedded GVC characteristics. This leads to an underestimation of the emissions footprints and international interdependence of GVCs.

By systematically incorporating these nuanced production and ownership linkages, our framework provides a more accurate and policy-relevant representation of emissions along GVCs, laying the groundwork for more targeted and effective environmental interventions.

5

Industrial Policy in a Strategically Contested Global Economy

Robert Koopman[1], and Shaopeng Huang[2]

5. 1 Introduction – Industrial Policy In An Evolving Global Economy

Governments across a wide range of economies have returned to industrial policy in recent years as a central feature of their economic strategies. Unlike the interventionist policies of earlier decades, which were often justified by developmental concerns or framed around infant industry protection, today's industrial policies are being deployed in response to a broader set of structural and strategic challenges. These include decarbonization, concerns over technological dependence, supply chain resilience and the rising role of economic security in shaping international economic relations.

This renewed interest in state-led economic interventions is unfolding within a global economy that is deeply integrated through cross-border production networks. China's expanding use of industrial subsidies – accelerating after the launch of "Made in China 2025" plan in 2015, and the 2018 trade conflict with the United States (US) – illustrates how domestic support policies now shape global production and export structures. Modern global value chains (GVCs) link firms, suppliers and buyers across national boundaries, often with strong interdependence in inputs and technologies.

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Note: The work on this chapter was led by Dr. Robert B. Koopman, and Shaopeng Huang of the University of International Business and Economics

In this context, policies aimed at domestic restructuring or sectoral support can influence trade and investment patterns well beyond national borders. While the instruments may look familiar – subsidies, tax incentives, investment screening mechanisms – their operation within these tightly connected systems creates new analytical and governance challenges.

The IMF (2024b) and the OECD (2023) note that contemporary industrial policy is increasingly anchored within national fiscal and financial frameworks. Instruments once managed by sectoral ministries, such as targeted credit, procurement or research and development (R&D) incentives, are now more systematically coordinated with macro-stabilization, climate investment and technology finance agendas. This institutionalization marks a transition from episodic, project-based intervention towards sustained policy coordination across industrial, financial and environmental domains (Baquie et al., 2025; Benitez and Bisbey, 2021). As a result, industrial policy functions simultaneously as a mechanism of structural transformation and as a core element of fiscal architecture, linking production upgrading with long-term investment and climate objectives.

Recent work by Evenett and colleagues (2024) helps clarify the character of the current wave of industrial policy. Drawing on a database of policy announcements since early 2023, they document a notable increase in targeted measures across more than 75 jurisdictions. These measures span clean energy technologies, semiconductors, digital infrastructure and the upstream inputs needed to support them, such as critical minerals. The stated objectives of these policies go beyond traditional economic upgrading and increasingly emphasize security, resilience and climate transition. Their analysis also reveals clear variation across income levels. Advanced economies tend to rely on direct financial transfers, R&D support and public procurement, while emerging markets and developing economies (EMDIs) more often use tax incentives, trade-related measures and state-directed finance. These differences likely reflect variation in fiscal space and administrative capacity but also highlight a broader shift in the policy landscape.

Although attention has often focused on the number of industrial policy interventions being introduced, some analysts have cautioned against assuming that simple counts correlate with significance. Dadush (2022) notes that many interventions are modest in financial scale and unlikely to meaningfully distort trade. He points to cases such as development bank lending or small-scale state aid programmes where the grant-equivalent value is negligible relative to broader macroeconomic aggregates. While he acknowledges the importance of monitoring industrial policy for transparency and dialogue, he warns that relying on numerical tallies of interventions may exaggerate their systemic effects (see Table 5.1). This perspective highlights the importance of distinguishing between large-scale strategic interventions and routine support measures that may have limited cross-border relevance.

Table 5.1: Harmful Interventions by Country – Economic Impact vs. Reported Numbers				
Country/ Region	**Period**	**GTA reported interventions**	**Actual economic impact**	**Key Dadush findings**
China	2009-2023	Increased number nearly every year since 2009; largest presence in Global Trade Alert (GTA) database listings	**Substantial but overstated:** ~1.73% of GDP (2019), ~$300bn annually	• Only substantive case of large-scale trade-distorting subsidies • However, aggregate welfare impact on trading partners uncertain • State-owned enterprises (SOEs) account for only ~7% of China's exports • Many subsidies may benefit trading partners through lower prices
France	2019	79 harmful interventions (55 subsidies); majority from European Investment Bank (EIB)	**Minimal:** Grant element ~€140m (~0.02% of gross fixed investment)	• EIB source of 46/55 subsidies • EIB loans have market-rate conditions • Real grant element "equivalent to measurement error" • Explosion in reported numbers masks trivial economic impact
US	Pre-2019	Declining subsidy interventions after Global Financial Crisis through 2019	**Minimal:** SBA assets <$17bn; Ex-Im Bank loans ~$8bn (2019)	• Portfolios "minuscule compared to US trade flows" • Two main agencies have very modest budgets • Declining trend contradicts perception of increasing interventions
US	Post-2021	Massive increase in industrial subsidies	**Substantial:** $805bn across the Infrastructure Act, the Inflation Reduction Act (IRA), and the CHIPS Act	• EV subsidies with discriminatory local content provisions • "Single most important signal" of US retreat from rules-based system • Subsidies may exceed China's as share of GDP
EU	2009-2019	Large and increasing numbers reported by GTA	**Limited:** Mostly development/environmental loans through EIB	• Despite strict state aid rules, appears as major subsidy user in GTA • Most interventions are EIB development finance • Grant elements minimal due to market-rate lending conditions
All Countries	2018-2023	Subsidies rose to ~80% of harmful interventions (2020-21), fell to 64.4% (2023)	**Context-dependent:** Pandemic crisis interventions vs. normal industrial policy	• Pandemic subsidies were "necessary policy response in crisis" • Should be "targeted and temporary" • Normal-times industrial subsidies historically small as % of GDP

Note: Scale and scope of recent industrial policy interventions are unprecedented in both advanced and emerging economies, reflecting not only competitiveness concerns but also geopolitical, climate, and security imperatives (see Box 5.1).
Source: Based on data and analysis in Dadush (2022).

As this new generation of industrial policy gains traction, the implications for global production are not yet fully understood. Most existing analytical frameworks were developed in earlier periods, when production was organized more nationally and spillovers were easier to isolate. Evaluating the effectiveness and consequences of industrial policy today requires analytical approaches that are better attuned to inter-sectoral linkages, firm-level heterogeneity and international feedback effects within globally integrated value chains. Several recent empirical and modelling contributions, discussed in later sections of this chapter, help address these gaps. They provide evidence on how industrial policy affects productivity convergence, supply chain reconfiguration and cross-border investment dynamics across strategically significant sectors.

These developments also raise questions about the adequacy of existing multilateral rules and institutional mechanisms. The World Trade Organization's (WTO) framework for managing subsidies and countervailing measures remains in place, but enforcement limitations, notification gaps and the broader breakdown in dispute settlement have reduced its effectiveness. At the same time, efforts by institutions such as the International Monetary Fund (IMF), the Organisation for Economic Co-operation and Development (OECD), the World Bank and the WTO to improve data and transparency – through mechanisms like the Joint Subsidy Platform – are emerging as important complementary tools. Some academic and policy proposals, including the idea of a modular transparency platform (Koopman, 2025), have sought to address these challenges by offering alternative frameworks for monitoring and dialogue.

This chapter sets out to provide a structured, evidence-based and neutral review of the emerging landscape. It draws together empirical findings, modelling insights and institutional developments to help clarify how industrial policy is evolving, how it interacts with GVCs, and how researchers and policymakers are responding. The sections that follow examine the conceptual foundations of industrial policy in an open economy, survey recent trends in its design and implementation, and assess available evidence on its economic and strategic effects. The chapter concludes with a discussion of current efforts to improve transparency and coordination, without making normative judgments about the legitimacy or desirability of specific policy approaches.

5. 2 Conceptual Background and Analytical Considerations

Industrial policy has long been a contested concept in both economic theory and applied policy (Rodrik, 1995; Juhász et al., 2024). While definitions vary (Aiginger and Rodrik, 2020), a common understanding refers to targeted government efforts to influence the allocation of resources across sectors to support specific developmental, strategic or social objectives. Historically, the focus was on promoting industrialization through infant industry protection or through policies designed to encourage the accumulation of capital, learning and scale economies in manufacturing. Over time, as global trade became more liberalized and integrated, enthusiasm for active industrial policy diminished, in part due to concerns over inefficiency, rent seeking and poor targeting.

As production has become globally fragmented, the classical frameworks of industrial policy have come under renewed scrutiny. Recent cross-country studies drawing on newly compiled datasets tracking industrial policy measures, such as Evenett et al. (2004) and Baquie et al. (2025) show that governments are using a far wider mix of instruments ranging from R&D subsidies and carbon-related incentives, to strategic public procurement to steer structural change. More generally, building on earlier second-best logic (Rodrik, Grossman, and Norman, 1995; Baldwin and Krugman, 1988), recent empirical and theoretical studies apply it to globally networked production

systems in which spillovers cross borders through trade, investment and knowledge flows. As a result, modern industrial policy is understood less as a national corrective and more as a coordination process operating within complex value chain ecosystems.

The analytical frameworks that shaped the earlier consensus on industrial policy were built on models of domestic distortions and welfare optimization. The seminal contributions of Bhagwati and Ramaswami (1963) and Corden (1957) fundamentally transformed the understanding of optimal policy interventions by establishing the principle that the most efficient remedy for a specific market distortion is a targeted instrument – typically a production or consumption subsidy – rather than a trade barrier. These frameworks also emphasized that protectionist measures, including tariffs and quotas, generally impose efficiency costs that exceed their potential benefits, except in very specific cases when addressing distortion precisely at its source.

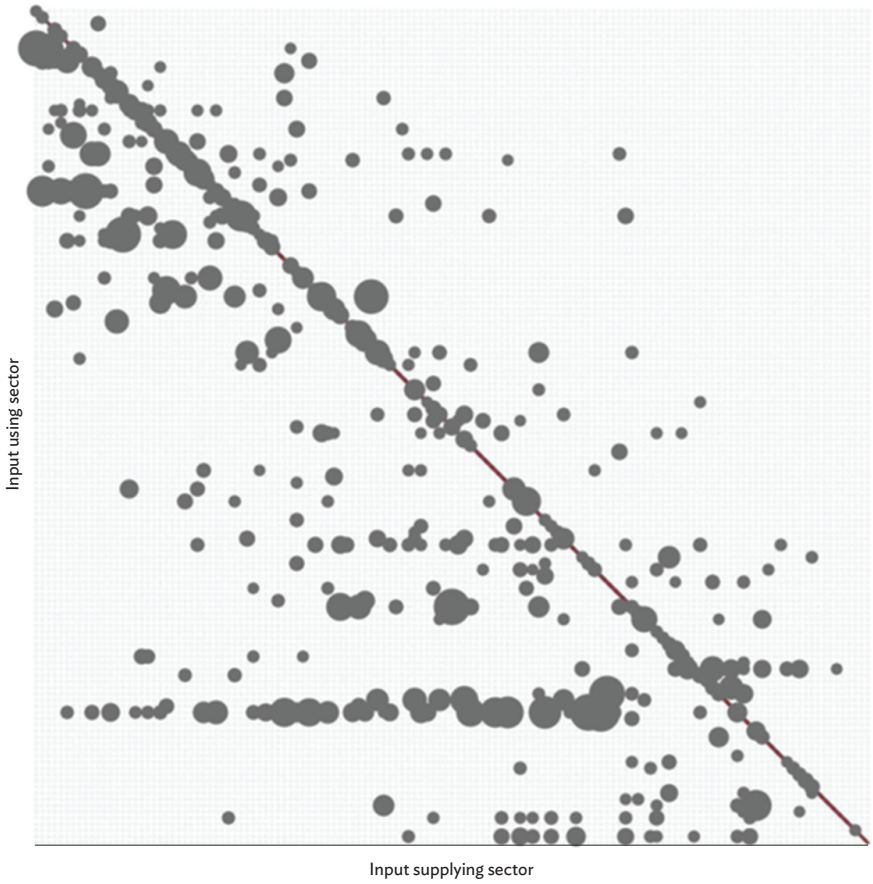
However, much of this work was developed under conditions that abstracted from international production fragmentation, cross-border investment flows and knowledge spillovers. With the rise of GVCs over the past three decades, the analytical environment in which industrial policy operates has changed considerably. Today, trade in intermediate goods accounts for more than half of world trade, with firms regularly sourcing inputs and organizing production across multiple jurisdictions. In such a setting, the effects of industrial policy depend not only on the internal conditions of the targeted sector, but also on its position and connectivity within broader production networks.

Recent empirical and theoretical work has responded to this shift. One relevant contribution is Liu (2019), who shows how industrial policies can generate cascading spillovers when targeted at sectors with extensive upstream and downstream linkages. Liu (2019) demonstrates that subsidies directed at upstream sectors amplify productivity and competitiveness throughout production chains (see Figure 5.1), a result confirmed by Zhang et al. (2024) and Rotunno (2024), who trace similar spillover effects across domestic and cross-border networks. Ma et al. (2024) show that participation in GVCs through imported inputs raises firm productivity by fostering learning and supplier upgrading, suggesting that industrial policy can indirectly strengthen these channels.

Together, these studies contribute to an emerging strand of literature that grounds industrial policy evaluation in firm-level and network-based metrics, moving beyond traditional partial equilibrium analysis and illuminating how policy interventions ripple through production networks. This suggests that the effectiveness of industrial policy cannot be evaluated without reference to inter-sectoral and international linkages.

In related work, Lashkaripour and Lugovskyy (2023) develop a general equilibrium model with scale economies and monopolistic competition, showing that well-targeted industrial policy can yield global efficiency gains and transformative welfare

Figure 5.1: The Input-Output Demand Matrices of China in 2007



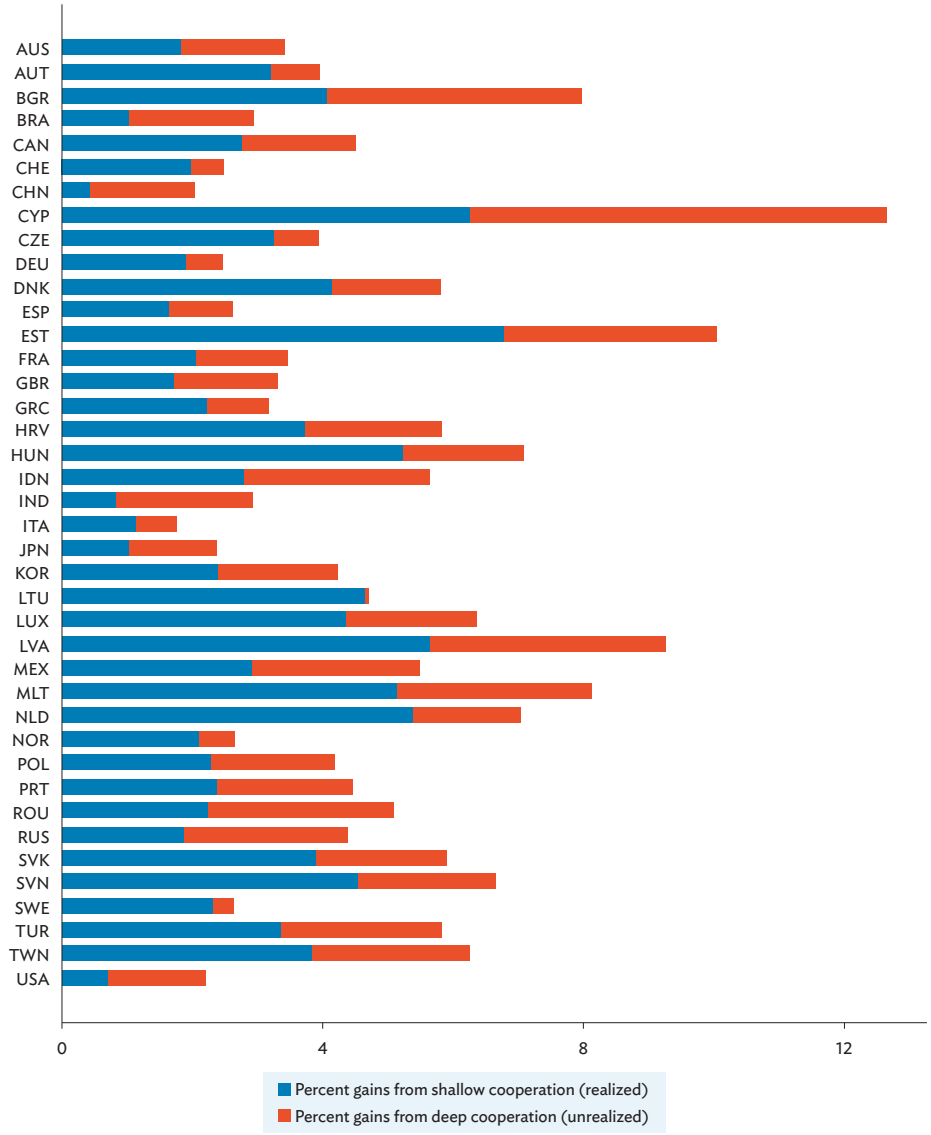
Note: The figure visualizes China's 2007 input-output demand matrix, with rows denoting input-using industries, and columns denoting input-supplying industries. The size of *i j*-th entry in the figure reflects the share of industry *j*'s output supplied to industry *i*, with only linkages of 5% or more shown. Industries are ranked by the sector's distortion centrality, placing the upstream sectors towards the top. The dense area below the diagonal indicates a hierarchical production structure in which inputs flow primarily from upstream to downstream sectors. This pattern underscores Liu's finding that in such hierarchical networks, distortions and policy effects accumulate through backward demand linkages so that subsidies to upstream sectors can generate amplified spillovers throughout the value chain.

Source: Figure III, right panel ("The IO Demand Matrices of China Are Hierarchical") in Liu (2019).

improvements under certain conditions, particularly when subsidies are coordinated internationally in sectors characterized by technological complementarity and underinvestment (see Figure 5.2).

Other recent work has turned to the political economy and institutional dimensions of industrial policy. Juhász and Lane (2024) argue that industrial policy outcomes often hinge less on economic fundamentals than on institutional design and coalition dynamics. They emphasize that the ability to sustain effective industrial strategies depends on the presence of bureaucratic competence, clear accountability mechanisms and durable political coalitions. Their historical survey, and related scholarship, contrasts cases where these conditions were met, such as postwar France or contemporary South Korea, with others where fragmentation or political capture led to limited results (see Table 5.2).

Figure 5.2: Welfare Gains from Deep and Shallow Cooperation



Note: This figure illustrates how international coordination magnifies the welfare effects of industrial policy in economies characterized by scale economies and profit-generating markups. Using data from the 2014 World Input-Output Database, the authors compute welfare changes under three benchmark scenarios: (i) the status quo; (ii) shallow cooperation, in which countries refrain from overt protectionism but act unilaterally; and (iii) deep cooperation, in which governments coordinate corrective Pigouvian subsidies across sectors. The figure reports the percentage change in real income relative to the status quo equilibrium for various economies. The results highlight that unilateral or shallow forms of policy coordination yield limited or even negative welfare effects once terms-of-trade tensions are considered, whereas deep cooperation – mutual alignment of industrial subsidies – produces transformative global gains. The figure suggests that the welfare consequences of modern industrial policy depend less on its scale than on the degree of cross-country coordination. Effective governance of industrial policy therefore requires "deep" agreements capable of internalizing cross-border spillovers and mitigating subsidy races, rather than isolated national interventions.

Source: Figure 5 ("Welfare Gains from Industrial Policy under Increasing Returns") in Lashkaripour and Lugovskyy (2023)

These institutional considerations are particularly relevant in evaluating the capacity of countries to design, monitor, adjust or phase out industrial policy instruments over time. The ability to implement industrial policy effectively may depend less on the theoretical merits of the intervention than on its institutional coherence, consistent oversight and the operational autonomy of implementing agencies.

Table 5.2: Comparisons of Industrial Policy Cases from Various Studies						
Economies	Period	Institutional context	Sector(s)	Policy tools	Outcome	Source(s)
South Korea	1960s-1980s	Strong bureaucratic competence, clear accountability, stable political coalitions	Steel, shipbuilding, electronics	Targeted credit, export discipline, SOEs, performance monitoring	Successful industrial upgrading and export dominance	Rodrik (2008); Juhász, Lane & Rodrik (2024)
Chinese Taipei	1970s-1990s	Flexible bureaucratic institutions, coordinated industrial planning	ICT, machinery, semiconductors	R&D subsidies, SME support, flexible industrial planning	Sustained tech upgrading and diversified manufacturing base	Rodrik (2007)
Brazil	1970s-1980s	Fragmented implementation, weak bureaucratic control, vulnerability to capture	Manufacturing (general)	State-owned enterprises (SOEs), protective tariffs, subsidized investment	Initial capability gains followed by inefficiency and stagnation	Rodrik (2008); Juhász, Lane and Rodrik (2024)
India	1950s-1980s	Fragmented institutions, weak coherence, frequent political capture	Heavy industry, general manufacturing	Licence system, SOEs, import substitution	Low productivity growth, limited export orientation	Rodrik (2008); Juhász, Lane and Rodrik (2024)
Argentina	1950s-1970s	Highly protectionist, politically driven state interventions	Consumer goods, general import substitution industries (ISI)	Protectionist tariffs, state-led development	Chronic macro instability, limited industrial deepening	Rodrik (2007, 2008); Juhász, Lane and Rodrik (2024)
France	Post-WWII-1980s	Not specified	Not specified	Centralized planning ('Plan Calcul'), elite-driven policy	Limited success due to weak feedback and rigid structures	Estrin and Holme (1983); Cohen (2007); Klebaner and Voy-Gillis (2023)

Note: Authors' compilation from cited sources, drawing on Rodrik's (2007, 2008) synthesis of works by Evans (1995), Amsden (2001), Wade (1990) and related works.

Multilateral institutions have begun to integrate some of these evolving considerations into their own policy frameworks. Recent IMF and OECD initiatives have begun to incorporate industrial policy within broader fiscal and governance frameworks. Section 6 discusses these institutional responses and the emerging transparency and coordination tools in greater depth.

The analytical challenge going forward is to bring these strands of research and institutional practice into a more coherent evaluative framework. The rise of GVCs and the heightened geopoliticization of technology and security policy have altered the assumptions that underpinned earlier analyses. Modern industrial policies are increasingly justified on grounds that they transcend conventional economic rationales and often produce both positive and negative spillovers across borders. Understanding when and how these effects arise requires tools capable of capturing intricate cross-sector linkages, firm-level heterogeneity and state-capacity constraints. Equally critical is enhancing transparency and fostering shared understanding across jurisdictions, particularly where overlapping industrial support from multiple governments coexists in the same sectors, which heightens the risk of friction and inefficiency in global markets.

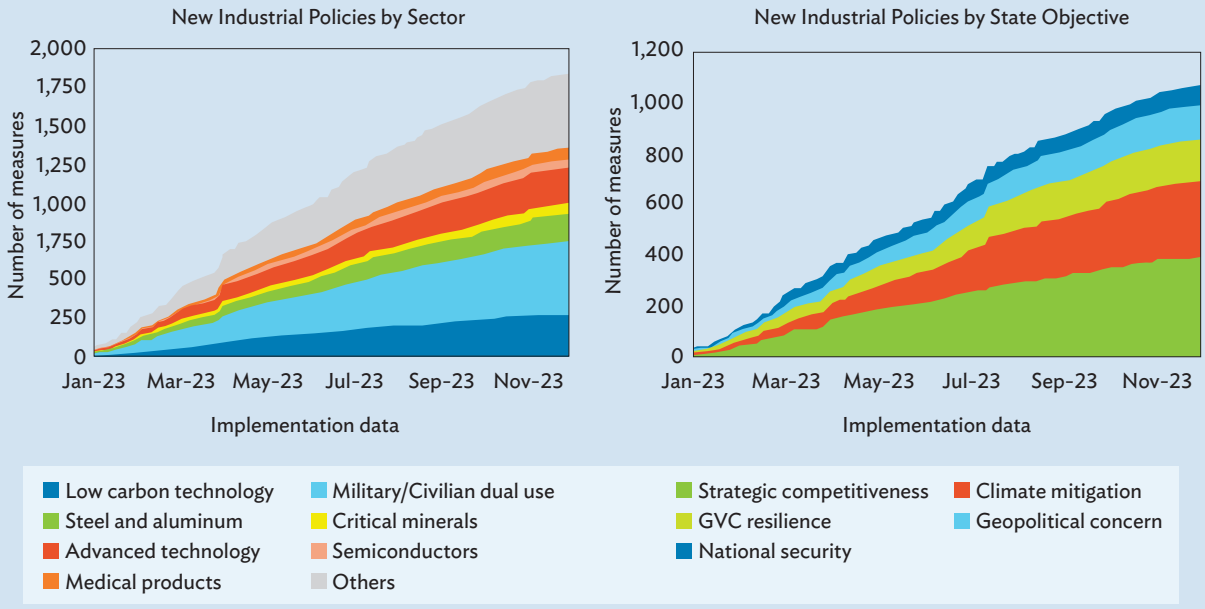
The sections that follow draw on empirical and theoretical work aimed at clarifying these intricate dynamics. While the effectiveness of industrial policy remains context-specific, the available evidence helps identify the conditions under which particular types of interventions are more likely to generate learning, technological upgrading, productivity growth or resilience. At the same time, recent research has warned of the potential pitfalls, subsidy races, retaliatory measures and unintended distortions – especially when transparency is low and policy coordination is weak. These issues are developed further in subsequent sections.

Box 5.1: The Rise of New Industrial Policies

The resurgence of industrial policy reflects a shift in government strategies to address economic and non-economic challenges, including climate change and geopolitical tensions, often through subsidies and trade restrictions. While industrial policy can help address market failures to promote structural transformation and resilience, overall economic impacts remain mixed, and its effectiveness depends on sectoral dynamics and policy design. This note summarizes recent developments and policy lessons from the analysis of industrial policy, the IMF's approach to covering industrial policy in surveillance and international collaboration on data gaps and policy coordination.

Industrial policy (IP) refers to government efforts to shape the structure of the economy through targeted measures on specific domestic industries, firms or economic activities to achieve certain economic or non-economic objectives. Challenges related to climate change and increased geopolitical rivalry have contributed to governments taking a more active role in guiding the structural transformation in the recent wave of IP. This is evidenced by governments' stated motives and the sectors targeted. Besides economic motives like competitiveness, new motives such as climate mitigation, geopolitical and national security concerns, and supply chain resilience have emerged. Sectors targeted include low-carbon technologies, military/civilian dual use products and other advanced technologies, as well as their upstream inputs, such as critical minerals (Figure B 5.1.1).

Figure B 5.1.1: New Industrial Policy Measures
(Cumulative, based on announcements since Jan 2023; sample of 75 jurisdictions)



Source: Evenett, Jakubik, Martin and Ruta (2024)

Policy tools deployed in pursuit of industrial policy objectives vary, depending on countries' fiscal, institutional and administrative capacity, and often discriminate between domestic and foreign producers. Most of the recent IPs have been implemented through different types of subsidies – advanced economies (AEs) tend to rely on direct financial grants, state loans, and other forms of state aid, while emerging markets and developing economies (EMDEs) opt for state loans, tax relief and capital injections. Trade restrictions on

continued on next page

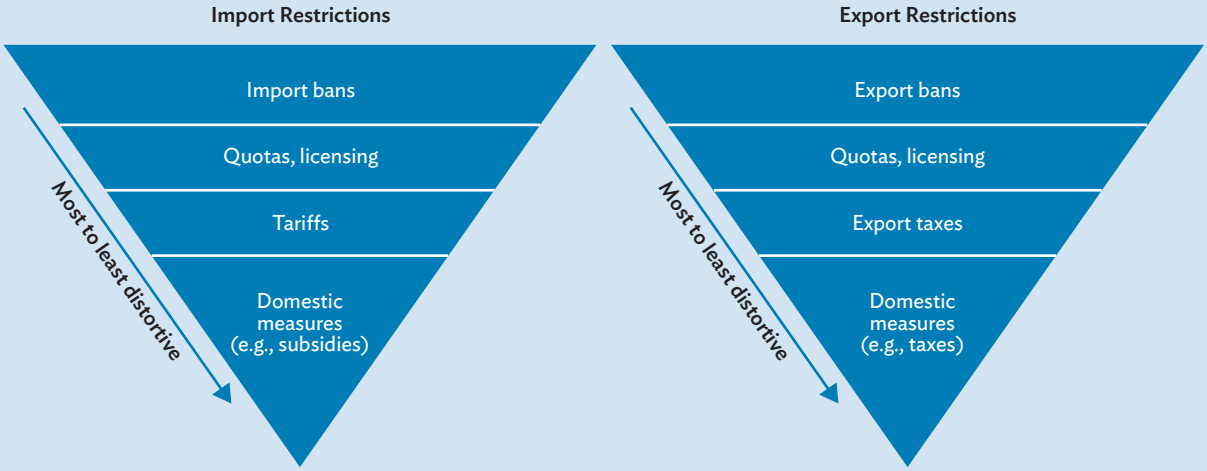
Box 5.1: continued

imports and exports are also more frequently used by EMDEs, possibly reflecting their more limited fiscal or administrative capacity. Over the past decades, the use of subsidies has been more prevalent in EMDEs, contributing to the sizable stock of "legacy" measures that are still in place. Discriminatory policies feed trade tensions and sometimes run counter to trade rules.

By steering resource reallocation to certain sectors, industrial policy can have significant domestic and cross-border economic impacts (spillovers); but empirical evidence of net economic benefits is mixed. Overall, economic gains from IP are moderate and uneven, and they are more effective when addressing highly distorted upstream sectors with suitable tools (Baquie et al., 2025). Case studies point to certain broad enabling factors behind IP successes, including targeting sophisticated sectors with export orientation and ex ante competitive products (Huang et al., 2025) or sectors with high network linkages to other sectors (Liu, 2019), as well as resource-intensive activities (Lebdioui, Lee, and Pietrobelli, 2020), while enforcing competition and accountability (Cherif and Hasanov, 2019).

The bar to get industrial policy right is high even when market forces fail to provide a socially efficient outcome. Government intervention under "real-world" conditions of market imperfections are rarely if ever non-distortionary, leading at best to what is termed a "second best" allocation in terms of welfare. In general, the most efficient policy instruments to correct for domestic price distortions due to market failure are domestic taxes and subsidies rather than trade policy and protection (Bhagwati and Ramaswami, 1963; Lashkaripour and Lugovskyy, 2023). Addressing non-economic objectives such as defence (production targets), self-sufficiency (import targets), sectoral employment (factor use targets) or climate change (carbon emissions targets), implies efficiency is no longer a primary consideration and requires different combinations of instruments (Bhagwati, 1969; Corden, 1957). Nevertheless, there are significant practical hurdles such as fiscal constraints, administrative capacity, rent seeking and corruption to attain net positive welfare outcomes and desired non-economic objectives.

Figure B 5.1.2: A General Hierarchy of Trade Restrictive Policies



Note: These are intended as general guidance; the size of the distortion of an individual measure will vary depending on scope and implementation.

The IMF covers industrial policy in its surveillance and policy advice when it is macro-critical or can generate significant cross-border spillovers. Key considerations in staff's advice are whether (i) a well-established case for IP exists, i.e., addressing a well-identified market failure that cannot be addressed through horizontal policies, (ii) effective design which considers economy-wide complementary policies and governance capability, (iii) benefits outweigh costs and (iv) implementation compatible with fiscal sustainability, external and domestic stability, and a country's WTO commitments. The IMF's advice on trade-related aspects of industrial policy is grounded in Article I of its Articles of Agreement, "to facilitate the expansion and balanced growth of international trade.." This entails favouring less distortionary implementation of IP, with due consideration to trade and investment spillovers, and advising against discriminatory features, which are almost always unnecessarily costly and encourage retaliation (Figure B 5.1.2).

As more countries resort to industrial policy to manage structural transformation and the green transition, there is a need for deeper collaboration among international organizations on IP issues. Data gaps remain a key challenge to improve tracking of IP measures, benchmarking countries, assessing IP effectiveness and facilitating fact-based policy coordination to mitigate harmful IP interventions. Some work is ongoing to improve the availability of cross-country data, such as the Joint Subsidy Platform jointly developed by the IMF, the OECD, the World Bank and the WTO, and further joint work is under way (IMF, OECD, WBG, and WTO, 2022). Staff at the IMF have also initiated a collaboration with the Global Trade Alert on a New Industrial Policy Observatory (NIPO) to monitor developments in 75 jurisdictions (Evenett et al., 2024; Evenett et al., 2025). Drawing on their respective expertise, international organizations can coordinate data collection efforts on critical IP issues (e.g., green subsidies) and identify further actions to increase transparency and availability of information on IP measures adopted by countries.

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Box 5.1: continued

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Note: The author of this box is Adam Jakubik. This box draws from material in Evenett et al. (2024) and IMF (2024). The views expressed herein are those of the author and should not be attributed to the IMF, its Executive Board, or its management.

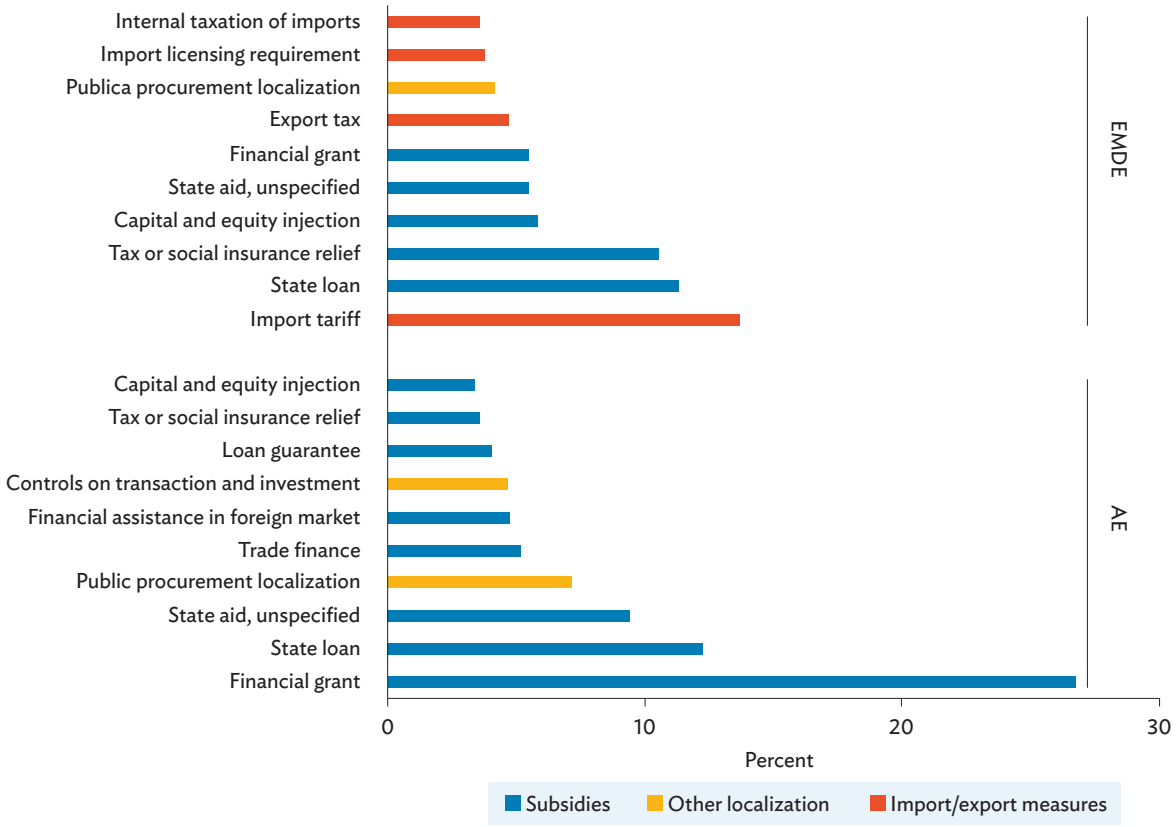
5. 3 Evolving Practices in Industrial Policy: Recent Developments and Key Insights

The last several years have witnessed a resurgence in the use of industrial policy instruments (Irwin, 2023; Evenett et al., 2024), with governments across income levels implementing measures that range from direct fiscal support to regulatory incentives and trade-related restrictions. While some of these interventions respond to immediate shocks such as the COVID-19 pandemic, others reflect longer-term shifts in economic strategy driven by techno-nationalist ambitions, especially as countries seek to strengthen domestic capabilities in technologies foundational to their resilience, competitiveness, sustainability or security. The scope and pace of these interventions are documented in a growing set of databases and policy surveys (Millot and Rawdanowicz, 2023; EBRD, 2024; Evenett et al,. 2024; Juhász et al., 2025).

Of the various efforts to track and document the resurgence of industrial policy measures, the most comprehensive one is that by Evenett and colleagues (2024), who assembled a database (the New Industrial Policy Observatory dataset, NIPO) of industrial policy announcements across 75 jurisdictions between January 2023 and early 2024. Their analysis focuses on measures targeting clean energy, semiconductors, digital infrastructure and upstream sectors such as critical minerals. The database reveals substantial variation in both the instruments deployed and the sectors targeted.

Advanced economies tend to rely more on direct grants, equity stakes and public procurement, while EDMEs often use tax-based incentives, trade-related restrictions and subsidized lending (see Figure 5.3). As discussed in Section 1, China's expanding subsidy programmes have become central to its industrial strategy (see Figures 5.4 and 5.5). Firm-level evidence (Zhang et al., 2024) shows how these measures, especially upstream subsidies, shape export behaviour and sectoral upgrading.

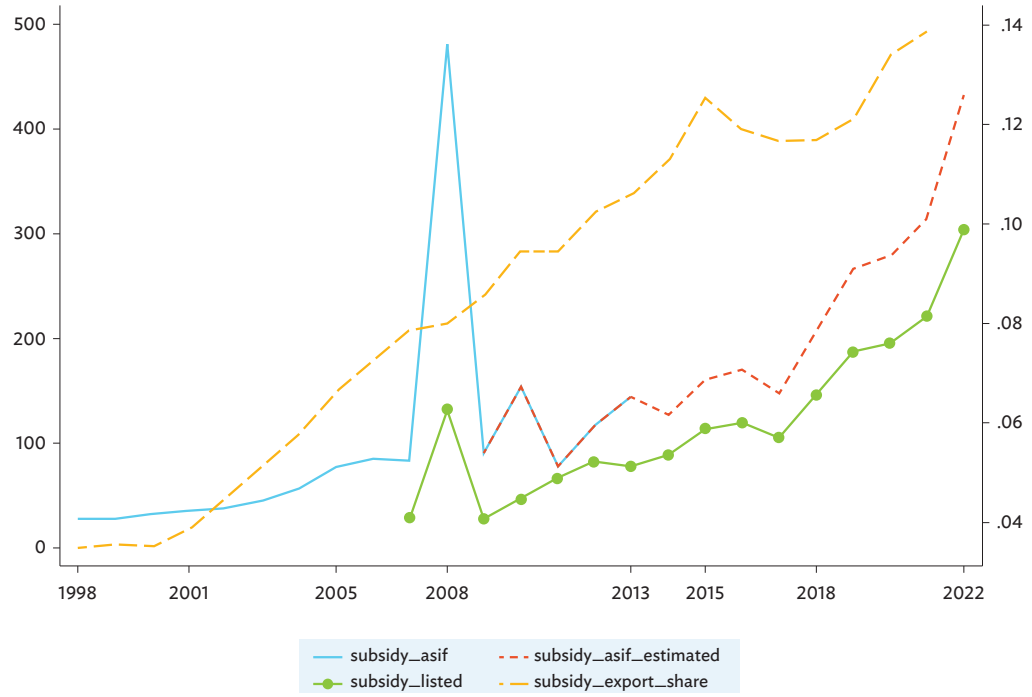
Figure 5.3: Trade Distortive Industrial Policy in 2023 by Income Group



Note: AE = Advanced economies; EMDE = Emerging markets and developing economies.
Source: Figure 3 ("Trade distortive industrial policy tools in 2023 by income group") in Evenett et al. (2024).

The research by Zhang et al. (2024) also examines how the impacts of industrial subsidies in China reverberate through domestic supply chains, reshaping trade and firm behaviour. Using firm-level and industry-level data, they estimate how subsidies provided to one segment of a value chain alter input costs and demand conditions for firms in related sectors. Their findings show that direct subsidies boost export activity at both extensive (participation) and intensive (volume) margins. More strikingly, indirect subsidies, especially those channelled through first-tier upstream sectors, have even stronger impacts on the export outcomes than direct subsidies. Overall, upstream subsidies, channelled through supply chains, emerge as powerful levers of export growth. The study also reveals heterogeneous effects by firm ownership: while both domestic and foreign-invested firms benefit from direct subsidies, upstream indirect

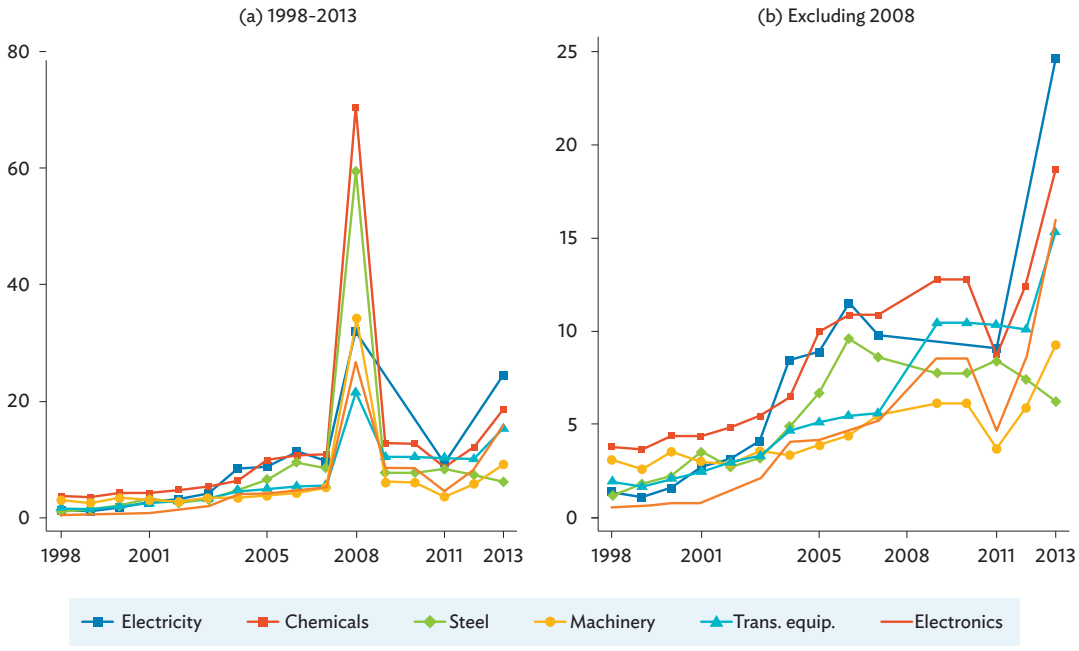
Figure 5.4: The Rise of Industrial Subsidies in China



Note: Subsidies are defined as direct government payments (billion RMB) to manufacturing, mining and utilities sectors. *subsidy_asif* captures subsidies directly reported by above-scale industrial firms in China's *Annual Survey of Industrial Firms (ASIF)*; *subsidy_asif_estimated* denotes econometrically estimated total subsidies based on ASIF data, accounting for unreported or missing subsidies; *subsidy_listed* draws on WIND data for listed firms, capturing government support disclosed in annual financial reports, such as R&D grants, tax rebates and special funds; *China_export_share* shows China's share in global exports, indicating export orientation and competitiveness. The figure reveals that China's subsidy disbursements rose sharply after 2008, serving first as counter-cyclical stimulus and later as instruments for upgrading, green transition, and resilience, reaching about RMB430 billion ($60 billion) by 2022.

Source: Compiled by Zhang et al. (2024) based on ASIF, WIND, and WITS databases, as in Figure 1 ("The rise of industrial subsidies in China") in Zhang et al. (2024).

Figure 5.5: Industrial Subsidies in Major Chinese industries



Note: Classification of industry is based on 2002 China Input-Output Tables.

Source: Compiled by Zhang et al.(2024) based on the ASIF, as in Figure 2 ("Industrial subsidies in major industries") in Zhang et al.(2024)

subsidies disproportionately favour domestic firms, which benefit from both first and second-tier subsidies, whereas foreign firms benefit primarily from second-tier only.

Indeed, international variations in industrial policy practices reflect more than just fiscal capacity. They also reveal divergent philosophies on how best to address structural constraints and enhance long-term competitiveness. In many cases, the design and delivery of industrial policy are shaped by the institutional features of the state (Juhász et al., 2025; OECD, 2025), including the administrative quality of public agencies, the availability of sector-specific information and the existence of mechanisms to evaluate and adjust interventions over time. The economic consequence of these policies has become an important area of inquiry, particularly with respect to their effects on trade and investment flows. Some of the strongest insights to date come from model-based analysis, including recent work by Bekkers and Jhunjhunwala (2024), who use a global computable general equilibrium (CGE) model to simulate the effects of unilateral and multilateral production subsidies in sectors with high input-output linkages.

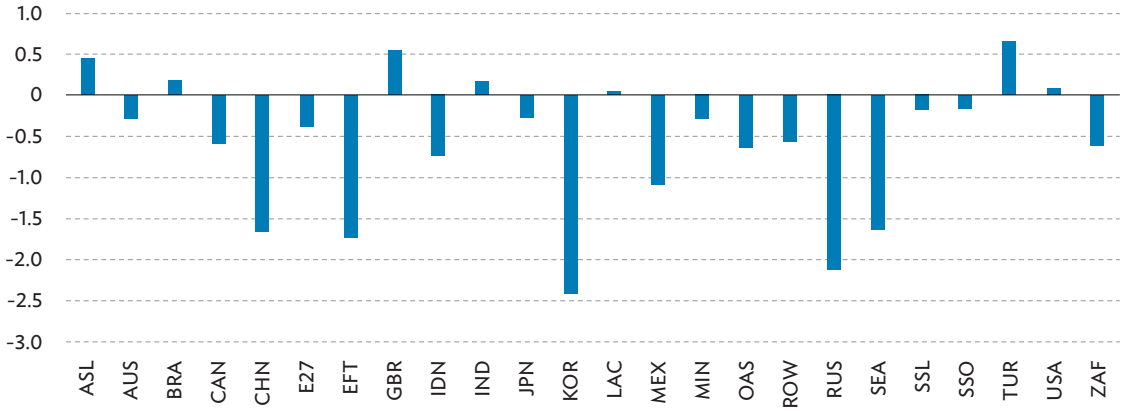
Their simulations show that unilateral subsidies can not only boost domestic output and exports in the targeted sector but also generate substantial positive spillovers for third countries, particularly when those countries are embedded in the same production networks. Moreover, the results suggest that coordinated subsidy schemes may achieve larger global welfare gains while mitigating distortions. These findings help clarify the conditions under which subsidies generate not just substitution effects but also productive complementarities, potentially supporting Dadush's view that subsidy concerns may be overstated in some contexts. However, this finding applies primarily to large-scale interventions in sectors with distinct structural characteristics, not to the modest development finance or small and medium-sized enterprise (SME) support programmes that comprise much of the Global Trade Alert (GTA) database.

A key contribution of the work lies in quantifying the magnitude and direction of cross-border spillovers, as well as identifying sectors that are most susceptible to international feedback effects. Sectors such as semiconductors and electric vehicle components – characterized by intensive network linkages, dense international sourcing patterns and capital-intensive production – appear particularly sensitive to changes in cost structures induced by subsidies. Their simulations illustrate the estimated output and welfare effects across regions under different subsidy scenarios (see Figure 5.6).

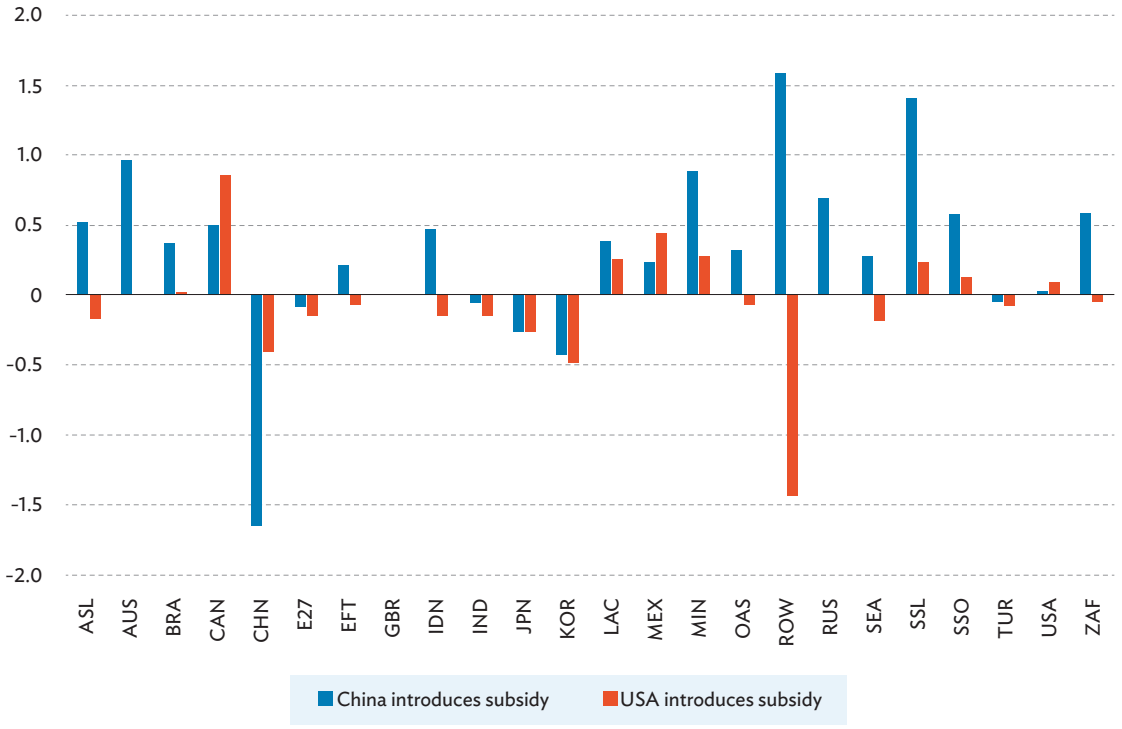
While CGE models provide a structured way to simulate subsidy effects under a range of assumptions, complementary empirical work, such as that by Zhang et al. (2024), which directly measures how subsidies affect input costs, demand conditions and export outcomes, is needed to assess how policies operate in practice. Their findings show that both upstream and downstream subsidies contribute significantly to sectoral export outcomes, with the strength of these effects contingent upon the sector's technological structure and market concentration.

Figure 5.6: Simulated Welfare and Output Effects of Subsidies

A. Simulated real income effects from unilateral introduction of a 10% output subsidy in the manufacturing sector (% change)



B. Projected changes in real income when China and the US would introduce a 10% manufacturing subsidy (% change)



Note: Using the WTO Global Trade Model, Bekkers and Jhunjhunwala (2024) simulate how industrial-subsidy shocks spread across economies with intermediate linkages. Panel A shows the real-income effects of a unilateral 10% output subsidy in manufacturing. Most subsidizing regions experience small welfare losses due to fiscal costs and terms-of-trade deterioration, while third-country effects are generally positive because of lower import prices and stronger upstream demand. Panel B shows the case where both China and the US introduce a 10% manufacturing subsidy: coordinated action moderates own-country losses and yields broader, more balanced global gains. Together, the simulations indicate that subsidy spillovers are often positive in general equilibrium and that coordinated industrial policies can raise global welfare more than isolated national programmes.
asl = Asia, Low Income; aus = Australia; bra = Brazil; can = Canada; chn = China; e27 = European Union (27); eft = EFTA (Norway, Switzerland, Iceland, Liechtenstein); gbr = United Kingdom; idn = Indonesia; ind = India; jpn = Japan; kor = Korea; lac = Latin America; mex = Mexico; min = Middle East and North Africa; oas = Other Asia (e.g., Malaysia, Philippines, Thailand); row = Rest of the World; rus = Russia; sea = Southeast Asia; ssl = Sub-Saharan Africa, Low Income; sso = Sub-Saharan Africa, Other; tur = Türkiye; usa = United States; zaf = South Africa.

Source: Figure 3 ("Simulated Real Income Effects from Unilateral Introduction of a 10% Output Subsidy in the Manufacturing Sector, % Change") and Figure 5 ("Projected Changes in Real Income when China and the USA would Introduce a 10% Manufacturing Subsidy, % Change") in Bekker and Jhunjhunwala (2024).

Indeed, this type of analysis complements macro-modelling work by offering granular, firm-level evidence of how subsidy measures operate through real production linkages. It also reinforces the view that the impact of a subsidy is not limited to the targeted firm or sector but depends on how that firm connects to others within and across borders. As Zhang and colleagues argue, the observed effects may also be amplified in policy environments where multiple instruments – subsidies, public procurement and trade regulation – are used in tandem and layered together.

Both the Bekkers and Zhang papers suggest that identifying the type of industrial policy instrument in use is only a starting point. Equally important is understanding how that instrument interacts with supply networks, competitive dynamics and the institutional architecture in which it is embedded. For instance, a production subsidy to an upstream input supplier may have minimal effects in a fragmented, low-margin sector. But in sectors featuring strong economies of scale and tight linkages to export markets, such upstream subsidies can trigger substantial downstream spillovers. These empirical and model-based contributions point to the need for a typology-driven approach to industrial policy monitoring. The variety and diversity of policy interventions reported in databases like the Global Trade Alert or the Joint Subsidy Platform suggest that simple classification by instrument or sector may be insufficient. Instead, several recent contributions have proposed more structured typologies based on risk profile, scale and network centrality. Reed (2024), for example, offers a three-tiered framework to classify industrial policy by ex-ante success probability, linking policy ambition to sectoral capabilities and market growth trajectories. This type of framework, though not without limitations, offers a way to differentiate between benign policy experimentation and excessive strategic overreach.

Some have also proposed governance mechanisms that reflect the diversity of industrial policy measures. One academic proposal, outlined in Koopman (2025), suggests that sector-specific observatories and typology dashboards could serve as a soft-governance complement to legal enforcement. Although this framework will be discussed in more detail later, it is worth noting here that the empirical material in this section provides much of the rationale for why differentiated approaches to monitoring and dialogue may be preferable to one-size-fits-all disciplines.

Much of the literature reviewed above takes a cross-sector perspective, several more focused contributions provide sector-specific assessments that complement these broad surveys. Goldberg et al. (2024) present one of the most systematic analyses of the semiconductor industry – arguably the most strategically significant of today's targeted sectors. Their study employs a three-pronged methodology: (i) a historical review of state support, (ii) the use of natural language processing (NLP) to identify and quantify industrial policies in the GTA database (2010–2022) and (iii) a structural model drawing on proprietary data from the Global Semiconductor Alliance (2004–2015) to infer unobserved production subsidies.

They show that subsidies – in the form of grants, tax incentives, loans and equity injections – are pervasive across all major producers, and have significantly ramped up since 2020, with China, the US, Japan, South Korea and India substantially increasing financial support. The measures typically target production upgrading and capacity expansion, alongside R&D and innovation. Policymakers are motivated by goals of economic growth, international competitiveness and, increasingly, resilience and national security. Although China stands out in absolute monetary terms, the estimates indicate that the country is not an outlier once market size is considered, as South Korea's intensity can be higher, though cross-country comparability is imperfect. The conclusions are supported by both the NLP-based and model-based approaches. Moreover, they note that the sharp scaling up of subsidies across all major semiconductor-producing countries, together with the expanded use of tools driven by geopolitical concerns – including export controls, foreign investment screening and merger reviews – has intensified the risk of a global "subsidy race".

Bown and Wang (2024) echo this point, complementing the empirical evidence with a policy-oriented perspective on semiconductors as the emblematic case of modern industrial policy. They trace the sector's evolution – from early US dominance and the US-Japan disputes of the 1980s to the rise of TSMC and South Korean memory producers – and stress that contemporary interventions, increasingly shaped by geopolitical concerns, now extend well beyond subsidies. Their analysis situates the US CHIPS and Science Act, the European Chips Act and Japan's support for TSMC and Rapidus within this broader global contest, warning of overcapacity and renewed trade conflict reminiscent of the 1980s and 1990s. Importantly, they argue that the interaction of subsidies, trade restrictions and a highly integrated GVC raises fundamental questions about multilateral compatibility, underscoring the governance challenges examined later in this chapter.

Finally, it is important to recognize that many industrial policies are deployed to serve overlapping goals, including innovation, employment and resilience. Their evaluation, therefore, cannot be confined to trade metrics or short-term output effects alone. As the next section will explore, a full accounting of impacts also requires attention to firm-level upgrading, convergence dynamics and changes in investment behaviour – especially in sectors with global strategic significance.

5.4 Economic Impacts: Firm Behaviour, Productivity and Supply Chain Reconfiguration

The economic impacts of industrial policy are not limited to direct effects on output or trade volumes. In many cases, interventions are intended to alter firm behaviour, shift production strategies and induce broader structural changes in how firms interact within and across value chains. While the aggregate effects of these interventions can be difficult to isolate, firm-level and sectoral data increasingly allow for more targeted

assessment of whether, and how, industrial policy supports upgrading, convergence and reconfiguration in global production. The study by Bai et al. (2025) investigates the effectiveness of the quid pro quo (market for technology) policy – an important and controversial component of China's industrial policy. This policy which mandated foreign automakers to partner with domestic firms to gain market access, aims in part to facilitate technology/knowledge transfer. The paper explores whether, to what extent and through what channels the quid pro quo policy contributes to knowledge spillovers and enhanced product quality in the domestic automotive sector compared to the unrestricted foreign direct investment (FDI) policy.

Using rich, firm-level data the authors test whether the domestic automaker affiliated with foreign joint ventures (JVs) learn more from their foreign partners than non-affiliated peers. They show that domestic affiliates converge in the specific quality strengths of their foreign partners – evidence of directed learning rather than a generic rise in averages. Quantitatively, affiliation-based spillovers add roughly 8.3% to affiliates' quality gains over 2001-2014, over and above industry-wide spillovers from foreign presence. Bai et al. (2025) further trace the transmission mechanism to worker mobility and shared supplier networks. Knowledge flows from JVs to affiliated domestic automakers strengthened with the share of high-skilled workers (engineers and designers) involved, with worker mobility explaining up to 54% of total spillover effects. While "shared supplier spillovers" (Kee, 2015) – where the high-quality standards imposed by JVs raise the performance of shared domestic parts suppliers – explain up to 65% of affiliation-based knowledge spillover.

To quantify how quality upgrading affects sales and profits, the authors then estimate a structural model to recover consumers' willingness to pay for quality. They find that the 3.8-12.7% quality improvement from 2007 to 2014, driven by quid pro quo-induced knowledge spillovers, increased sales by 0.9-3.9% and profits by 1.0-3.5% for affiliated domestic models.

Overall, they find that while quid pro quo industrial policy facilitates knowledge spillovers and quality upgrading relative to unrestricted FDI, its overall impacts on domestic quality, sales and profits are modest. In the context of current US-China trade tensions, these findings suggest that China's recent policy change to remove the joint ownership requirement may not significantly hinder the quality upgrades and sales performance of Chinese domestic automakers.

This study also highlights the importance of industrial policy in shaping GVC governance: state-shaped participation rules do not just raise averages; they shape how knowledge spreads within global value chains, influencing who learns and through what linkages. Together, the findings illustrate how well-designed industrial policies can support learning and integration within global production networks, offering insights for developing economies seeking to strengthen domestic industries.

In another study, Barwick and colleagues examine China's large, ambitious and multi-instrument industrial policy programme to build a world-class shipbuilding industry (Barwick et al., 2024, 2025). Among the instruments are production subsidies, investment subsidies, entry subsidies and post-crisis consolidation measures like "whitelists" of targeted firms. Using firm-level data (1998–2014) and a dynamic industry equilibrium structural model with entry/exit, investment and production, they estimated hidden subsidies and simulated long-run outcomes under alternative policy designs. Their study addresses two sets of questions: how China's industrial policy shaped the industry's domestic and global evolution, and how effectively different subsidy instruments performed.

According to their estimates, China provided about RMB 624 billion ($91 billion) in shipbuilding policy support/subsidies between 2006 and 2013, roughly half of the industry's revenues. Of this, 6% went to investment subsidies, 25% to production subsidies and 69% to entry subsidies. Unlike Japan and South Korea, which focused on a few large firms, China's programme was broad-based, resulting in the establishment of a large number of new shipyards between 2006 and 2008 (more than 30 shipyards per year).

Their estimates suggest that subsidies between 2006 and 2013 boosted China's domestic shipbuilding investment and entry by 140% and 120%, respectively, and expanded its global market share by 42%. However, only 30% of the output gain reflected real global growth; the rest came from crowding out rivals in Japan and South Korea. Meanwhile, they also suggest that the programme caused fragmentation, excess capacity and depressed global ship prices. In the long run, the gross return rate on the entire policy mix – measured by the lifetime net profit gains of domestic firms divided by total subsidies (Δ net profit / subsidy, details below) – was just 18%. Put differently, every dollar of subsidies generated only 18 cents in additional profits for domestic producers, implying a net return of -82% once fiscal costs are considered. The poor performance stemmed largely from entry subsidies, which encouraged inefficient producers.

Based on these estimates, the authors conduct counterfactual simulations to assess the relative effectiveness of different policy instruments. They employ two main metrics. The first, "Δ revenue / subsidy", measures the increase in industry revenue generated per unit of subsidy; it captures how effectively a given instrument stimulates sectoral output and sales. The second, "Δ net profit / subsidy", gauges the net profit gained per unit of subsidy. This latter reflects the gross rate of return: a value below 100% indicates that the subsidy's costs outweigh its benefits to the domestic industry.

The authors find (see Table 5.3) that production and investment subsidies can be justified if the goal is revenue maximization, as each raises lifetime industry revenue by RMB 1.53 per RMB of subsidy (Δ revenue / subsidy ≈ 153%). Moreover, investment subsidies yield higher profits (Δ net profit / subsidy ≈ 74%) than production subsidies (Δ net profit / subsidy ≈ 50%), because they expand capacity in ways that reduce future costs. Entry subsidies are the least effective (Δ net profit / subsidy ≈ 32%) and

wasteful even by revenue metric (Δ revenue / subsidy ≈ 66%), generating fragmentation and idleness. They also note that using all instruments in conjunction lowers returns compared to using each in isolation because distortions are convex.

Beyond the choice of policy instrument, the authors demonstrate, through a series of other counterfactuals, that other aspects of industrial policy design – timing, targeting and duration – are equally critical. They show that counter-cyclical subsidies during the 2009-2013 downturn yielded a 70% return – nearly double the 38% from pro-cyclical support. Targeting profitable firms ("whitelist") raised returns to 71% versus 37% for universal subsidies. Short-term, targeted programmes also outperformed permanent ones by limiting inefficient entry and strengthening scale economies.

They also conclude that there is insufficient evidence to support the standard rationales for industrial policy in the context of the shipbuilding industry. They find no evidence of meaningful strategic trade rents, given the industry's fragmented global structure and slim markups; no sign of industry-wide learning-by-doing, since the main ship types relied on mature technologies; and only limited evidence for domestic spillovers to labour markets, steel or related sectors.

From a GVC perspective, China's shipbuilding subsidies illustrate how a domestic intervention in an upstream capital goods sector can reverberate internationally. By reallocating production from more efficient yards in South Korea and Japan to a fragmented set of Chinese entrants, the industrial policy programme reshaped the geography of shipbuilding and pushed down global ship prices by 9-17% for bulk carriers and tankers. These price declines translated into lower freight rates – around 6% for bulk carriers and 2% for containerships – which in turn boosted China's trade volume by roughly 5% (about $144 billion annually between 2006 and 2013). Manufactured exports carried in containerships rose by about 5.5%, while raw-material imports transported in bulk carriers grew by 4.3%. In GVC terms, the subsidies redistributed surplus away from rival producers towards global buyers and traders, showing how a sector-specific policy can propagate through downstream trade networks and alter cross-border competitiveness, underscoring the need to evaluate industrial policy through an explicitly international lens.

A growing body of evidence shows that industrial policy can influence productivity dynamics by shaping firms' participation in GVCs. Using matched Chinese customs and industrial firm data from 2000-2013, Ma et al. (2024) conduct one of the most systematic analyses of this relationship, focusing on firm productivity dispersion in Chinese manufacturing. They first estimate a baseline regression linking firm-level backward GVC participation to intra-industry productivity convergence. The results show a statistically significant negative relationship between GVC participation and the productivity gap between firms and the sectoral frontier, suggesting that firms with greater access to imported intermediates tend to converge towards the industry frontier more rapidly. The table below (Table 5.4) reports their main estimates.

Table 5.3: Welfare Effects of Industrial Policy		
	Δ Net profit / Subsidy	Δ Revenue / subsidy
Panel A. Comparison of different policy instruments		
Investment subsidy	74 %	153 %
Production subsidy	50 %	153 %
Entry subsidy	32 %	66 %
All subsidies (aggregate)	18 %	72 %
Panel B. Industrial policy and the business cycle		
Procyclical subsidies	38 %	189 %
Counter-cyclical subsidies	70 %	168 %
Panel C. Targeted industrial policy		
Subsidize All firms	37 %	85 %
Subsidize "Whitelist" firms	71 %	105 %

Source: Table 1 ("Welfare Effects of Industrial Policy") in Barwick et al. (2024).

Table 5.4: Impact of GVC Participation on Firm Productivity Gap (Baseline Estimates)			
Specification	Coefficient for GVC participation	Standard error	Significance
(1)	−0.0331	(0.0034)	***
(2)	−0.0332	(0.0034)	***
(3)	−0.0332	(0.0034)	***
(4)	−0.0333	(0.0034)	***
(5)	−0.0330	(0.0033)	***
(6)	−0.0328	(0.0033)	***

Note: Controls incrementally added across specifications (age, financing constraints, subsidies, profits, leverage); Significance levels: * 0.10;** 0.05; *** 0.01.
Source: Adapted from Table 2 ("Baseline Regression") in Ma et al. (2024).

Ma et al. (2024) further demonstrate the robustness of these results using instrumental variable estimation strategies, establishing a causal link between GVC participation and productivity convergence. They show that this convergence is not driven by uniform improvements across firms but by asymmetric effects: lagging firms gain disproportionately (more substantial and statistically very significant) from GVC integration, while frontier firms experience smaller (and not statistically significant) changes. This tends to suggest a selection and diffusion mechanism – where lower-productivity firms benefit from technology transfer, while top firms become more specialized and face weaker innovation incentives. The table below (Table 5.5) summarizes these heterogeneous effects by productivity quartile.

Table 5.5: Heterogeneous Impacts of GVC Participation Across Productivity Quartiles			
TFP quartile	Coefficient for GVC participation partiparticipation	Standard error error	Significance
TFP < Q1	0.052	(0.007)	***
Q1 ≤ TFP < Q2	0.001	(0.001)	
Q2 ≤ TFP < Q3	0.002	(0.001)	
Q3 ≤ TFP	0.004	(0.006)	

Note: Significance levels: *** 0.01.
Source: Adapted from Table 6 ("Differential Impacts on TFP Quartiles (TFP)") in Ma et al. (2024).

Further contributing to this understanding, Zhang et al. (2024) provide evidence that industrial subsidies play a role in fostering innovation and quality upgrading (see Table 5.6). Their analysis shows that both direct and indirect subsidies are associated with higher export prices and improved product quality. Crucially, despite higher prices, these interventions lead to a lower quality-adjusted price for exports, suggesting a net welfare-enhancing effect for foreign consumers. This quality upgrading is driven by direct subsidies through increased firm-level investment and R&D expenditure, while indirect subsidies stimulate export activity through intermediate inputs from upstream industries. This implies that subsidized firms can invest in R&D and quality control to produce higher-quality exports, which is crucial for maintaining competitiveness in global markets.

Table 5.6: The Effect of Subsidies on Quality						
	(1)	(2)	(3)	(4)	(5)	(6)
	Entry	Entry	Value	Value	Quantity	Quantity
Subsidy	0.0120***	0.0120***	0.0124***	0.0124***	0.0116***	0.0116***
	(0.000127)	(0.000127)	(0.000644)	(0.000644)	(0.000659)	(0.000659)
Subsidy_up1		-0.289***		0.117		-0.158
		(0.0208)		(0.0269)		(0.107)
Subsidy_up2		0.0221***		-0.0229		-0.00407
		(0.00606)		(0.0269)		(0.0284)
Productivity	0.0327***	0.0326***	0.103***	0.103***	0.0796***	0.0796***
	(0.000400)	(0.000400)	(0.00212)	(0.00212)	(0.00217)	(0.00217)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Destination-product-year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	10313270	10313270	4931475	4931475	4931475	4931475
adj. R-sq	0.211	0.211	0.644	0.644	0.758	0.758

Note: Dependent variables: log unit value, log product quality, and log quality-adjusted unit value; Independent variables are defined as follows: subsidy denotes direct government support received by each firm; subsidy_up1 and subsidy_up2 capture the indirect effects of first-tier and second-tier upstream subsidies transmitted through input–output linkages; productivity is firm-level labour productivity, included as a control for efficiency differences; *Firm FE* is firm fixed effects; *Destination-product-year FE is Destination-product-year* fixed effects; ASIF-Customs matched sample 2000–2012. Standard errors are clustered at the firm level. Significance levels: * 0.10;** 0.05; *** 0.01.
Source: Adapted from Table 8 ("Subsidy and product quality: Firm-product-destination-level") in Zhang et al. (2024).

While Ma et al. (2024) focus on convergence among firms already embedded in GVCs, other studies have looked more directly at how industrial policies affect sourcing, investment and production strategies. Wong et al. (2024) analyse firm responses to recent semiconductor-related industrial policies in East Asia, particularly in South Korea, Chinese Taipei and mainland China. Their research draws on firm-level data, policy documents and investment records to track how leading chip producers have adjusted to US export controls, domestic subsidy programmes and anticipated shifts in demand (see Table 5.7). In Chinese Taipei and South Korea, firms have increasingly pursued "dual-GVC" strategies – maintaining high-end fabrication capacity domestically or in allied countries, while continuing limited-volume or lower-tier production in China. This approach reflects not only regulatory pressure but also strategic hedging, with firms seeking to preserve access to both Western and Chinese markets.

Table 5.7: Comparative Semiconductor Firm GVC Strategies in Response to US Semiconductor-Related Policies, Based on Wong Et Al. (2024)

Firm	Geographic Strategy	Technology Allocation	Policy Linkage
TSMC	High-end fabs in Chinese Taipei; low-end in China & Japan; selective expansion to US	3nm–2nm in Chinese Taipei; ≥16nm in Nanjing; 5nm in Arizona	CHIPS Act subsidies; licensing for China fabs
Samsung	DRAM fully domestic; foundry in US; NAND in China	DRAM in Korea; logic 4nm in Texas; NAND in Xi'an	Waivers for Chinese fabs; US subsidies
SMIC	Fully domestic; minor legacy integration with global firms	Focus on 14–7nm (DUV-based); heavy investment in domestic tooling	Self-reliance plan; export control constraints
YMTC	Domestic-only; rising layer count in NAND	232-layer NAND; mature lithography	National funding; limited foreign access

Source: Authors' compilation based on Wong et al. (2024).

Chinese firms, meanwhile, have responded by increasing their reliance on domestic supply networks and by ramping up investment in local equipment manufacturing and chip design. However, Wong et al. (2024) note that the absence of key inputs and equipment, many of which remain subject to foreign export restrictions – continues to constrain China's ability to move up the value chain. Their analysis emphasizes that the effectiveness of industrial policy in enabling upgrading depends not only on financial support, but also on access to complementary technologies and international market integration. In this sense, policy effectiveness is conditional not only on domestic institutional capacity, but on the international policy environment in which firms operate.

This asymmetry in response also reflects differences in industrial policy instruments and institutional capacity. Chinese Taipei and South Korea have pursued collaborative investment agreements and public-private coordination mechanisms, whereas China's approach has emphasized state-led direction and extensive fiscal support. The outcomes to date underscore the importance of external constraints, such as export restrictions and supplier diversification, shaping the feasibility of policy goals.

This theme also emerges in Zhang et al. (2024), whose analysis of Chinese subsidy spillovers, discussed in the previous section, includes estimates of how sectoral input-output position affects firms' responsiveness to industrial policy. They find that firms more deeply embedded in domestic supply chain – either as critical input providers or as downstream assemblers – exhibit greater responsiveness to sectoral subsidies in terms of export growth and technology adoption. These results are consistent with the idea that the "transmission elasticity" of industrial policy depends on a firm's position within the value chain and its exposure to policy-relevant nodes.

Complementing these studies, Goldberg et al. (2024) provide a model-based assessment of learning by doing (LBD) in the semiconductor sector. Their estimates show that plant- and product-specific LBD is far smaller than often assumed, while economies of scope across technologies within firms are more substantial (around 4.7%). Most strikingly, incorporating cross-border effects nearly doubles the learning rate (around 8%), revealing significant international spillovers embedded in the fabless-foundry model. Yet these benefits are neither automatic nor inevitable: firms may restrict access to frontier technologies, and historical evidence shows that no domestic semiconductor industry has advanced without international technology transfer via FDI, licensing or collaborative R&D. From a GVC perspective, these findings highlight that subsidies in one jurisdiction can reduce costs and spur innovation abroad, complicating attribution of policy impacts solely at the national level.

Taken together, these studies reinforce the idea that industrial policy effects are highly heterogeneous and mediated by structural features of production networks. They also suggest that focusing exclusively on direct beneficiaries may underestimate the full scope of policy impacts. In sectors with dense input-output linkages or strong agglomeration effects, second- and third-order impacts may be at least as important as direct responses. The presence of large multinational firms, which coordinate production across jurisdictions, further complicates attribution, as firm-level decisions are often shaped by policy packages across multiple countries.

Beyond firm-level behaviour, there is also evidence that industrial policy is contributing to broader supply chain reconfiguration. This is especially visible in sectors with both high strategic salience and heavy capital intensity. Semiconductors, battery storage and green technologies have seen significant new investment announcements, often involving site selection decisions that respond not only to cost and infrastructure, but also to policy incentives and geopolitical risk assessments. Several studies, including those reviewed in Section 5, provide evidence that FDI flows are being redirected towards "connector" countries positioned to serve multiple export markets. While the long-term effects of these shifts remain uncertain, they are likely to affect regional trade patterns, supplier development and the geography of technological diffusion.

The studies reviewed thus far employ diverse methodological approaches – from firm-level reduced-form regressions to structural dynamic models to computable general

equilibrium simulations. Each approach has distinct strengths and limitations that shape what can be inferred from the results.

Several findings have emerged with cross-study support, including productivity convergence effects from GVC participation and the presence of upstream and downstream subsidy spillovers through input-output networks. However, many results – such as the specific magnitudes of learning-by-doing effects in semiconductors (Goldberg et al., 2024), the precise welfare impacts of China's shipbuilding subsidies (Barwick et al., 2024), and the quantitative estimates of quid pro quo policy effects (Bai et al., 2025) – reflect specific sectoral and institutional contexts that may not generalize.

The relationship between subsidy magnitude and trade distortion also remains contested. Bekkers and Jhunjhunwala's CGE work (2024) suggests that subsidies in highly networked sectors can generate positive international spillovers, potentially supporting the view that concerns about distortion may be overstated in some contexts. However, these findings apply primarily to large-scale interventions in network-intensive sectors like semiconductors, not to the modest development finance or SME support programmes that comprise much of the interventions tracked in global databases, as Dadush (2022) emphasizes.

In sum, the economic effects of industrial policy are increasingly being mediated through firm decisions about sourcing, investment and upgrading within GVCs. Evaluating these effects requires empirical strategies that account for network position, firm heterogeneity and strategic interdependence. While the full set of dynamic consequences is difficult to observe in real time, recent research has begun to clarify the conditions under which industrial policy supports convergence and structural transformation, and where it may instead reinforce fragmentation or stasis. These questions become even more salient in the context of international rivalry and strategic competition, the subject of the next section.

5.5 Strategic Rivalry and the Geography of Adjustment

Building on the firm-level patterns discussed earlier, this section shifts from microeconomic behaviour to the broader geopolitical forces shaping GVC geography and industrial strategy. The recent resurgence in industrial policy cannot be separated from shifts in the global political economy. In many cases, state interventions have been prompted by concerns about geopolitical rivalry, technological leadership and the perceived vulnerabilities associated with concentrated production or input dependencies. While such concerns are not new, their prominence in industrial strategy – especially among large economies – marks a significant break from earlier policy frameworks built around liberalization, specialization and market-based adjustment.

Strategic dynamics are also affecting broader patterns of production and investment. A growing number of firms are reconfiguring supply chains to reduce exposure to geopolitical shocks, particularly those involving the US, China and their respective trade partners. The study by Zhang et al. (2026/forthcoming) examines supply chain vulnerability in the Guangdong-Hong Kong-Macao Greater Bay Area and across the Strait. Their analysis links cross-border production relationships to risk sensitivity in key sectors such as electronics, information technology and machinery. Using sector-level and firm-level data, they identify where cross-Strait production is highly integrated and is most exposed to external disruption (see Figure 5.7), and how firms have responded through sourcing diversification and asset relocation.

The Goldberg et al. (2024) analysis further highlights how the semiconductor sector exemplifies the strategic dilemmas of industrial policy. Their model-based simulations suggest that when multiple countries expand subsidies simultaneously, outcomes may range from destructive zero-sum reallocation of market share to more benign scenarios where international spillovers turn the contest into a "race to the top". In this latter case, subsidies provided in one jurisdiction reduce costs and accelerate innovation abroad, such that competition among states enhances overall technological progress and global welfare rather than eroding it. These findings reinforce the view that strategic rivalry in semiconductors cannot be assessed solely in national terms: the sector's cross-border spillovers mean that subsidy races, while often wasteful, may also produce (sometimes unintended) global complementarities.

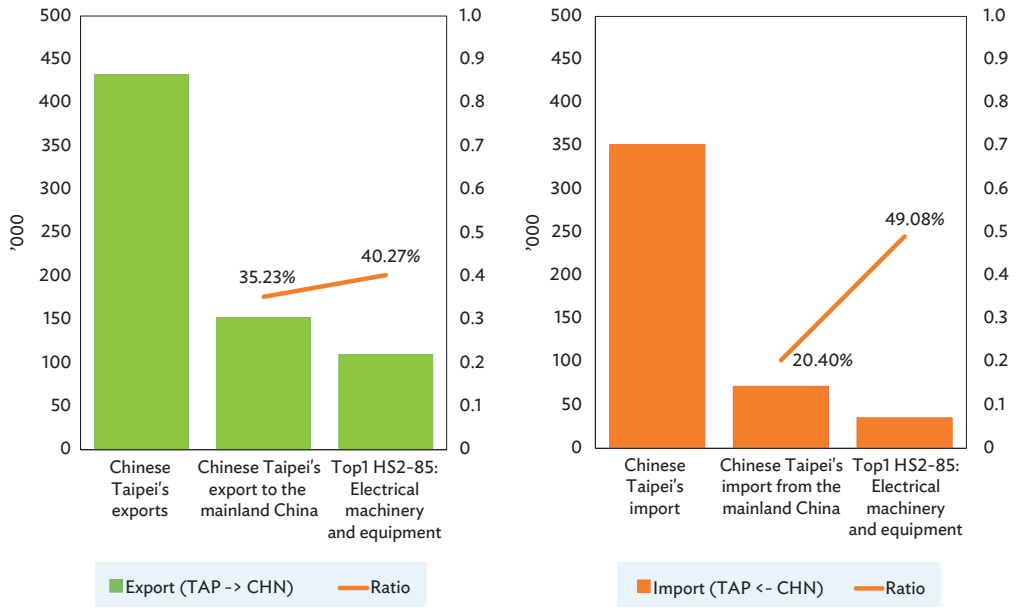
These findings are consistent with recent work on "connector countries", which has highlighted the role of third-party economies in absorbing trade and investment displaced by strategic rivalry. Jakubik et al. (2024) synthesise evidence from multiple studies showing that countries such as Viet Nam, Mexico, Türkiye and members of ASEAN have gained export market share and FDI as firms seek to reduce concentration in sensitive markets. These gains have been most pronounced in electronics, textiles, automotive parts and select energy technologies. While in many cases the shifts reflect re-routing rather than deep restructuring, the long-term effects on industrial upgrading and regional economic integration remain significant.

Recent IMF analysis also examines how trade fragmentation and supply-chain rerouting affect non-aligned economies, or so-called connector countries (see Box 5.2).

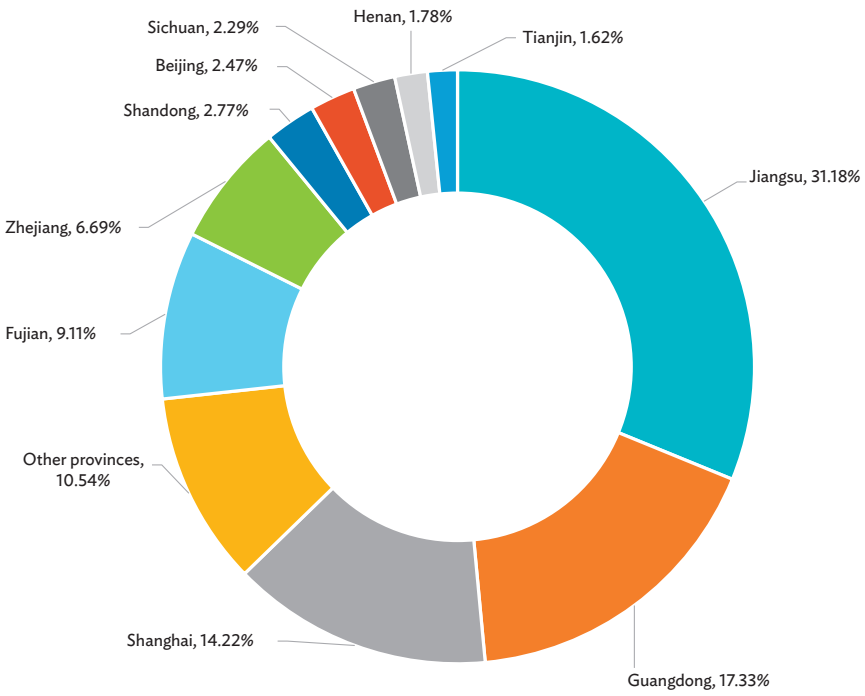
Freund et al. (2024) and Gopinath et al. (2025) offer complementary evidence based on global investment flows and trade patterns. Their analyses show that while the overall structure of GVCs has not collapsed, there are clear signs of decoupling in strategic sectors and of a move towards multi-regional sourcing strategies. In practice, this has meant shorter supply chains, new logistical hubs and growing attention to the political geography of trade. These patterns may accelerate if industrial policy continues to be used as a tool of strategic alignment rather than simply economic development.

Figure 5.7: Cross-Strait Production Integration and Vulnerability to External Shocks

A. Trade between Chinese Taipei and mainland China



B. Regions where Chinese Taipei's firms have invested in mainland China



TAP = Chinese Taipei.

Note: Panel A shows that bilateral trade between Chinese Taipei and the mainland has expanded rapidly since the early 2000s, peaking before the US-China trade conflict and remaining highly asymmetric: Chinese Taipei's exports to the mainland – dominated by intermediate goods in electronics and machinery – far exceed its imports. The pattern illustrates deep cross-Strait production linkages in high-technology sectors. Panel B. shows that Chinese Taipei's firms' investments are concentrated in coastal provinces – particularly Guangdong, Jiangsu, Fujian, and Shanghai – with recent diversification towards central and western regions such as Sichuan and Chongqing. The geographic spread mirrors both the evolution of China's industrial upgrading and firms' efforts to manage costs and supply-chain risks.

Source: Figure 3 ("Trade between Chinese Taipei and Mainland China") and Figure 4 ("Regions where Chinese Taipei's firms have invested in Mainland China") in Zhang et al. (2026/forthcoming).

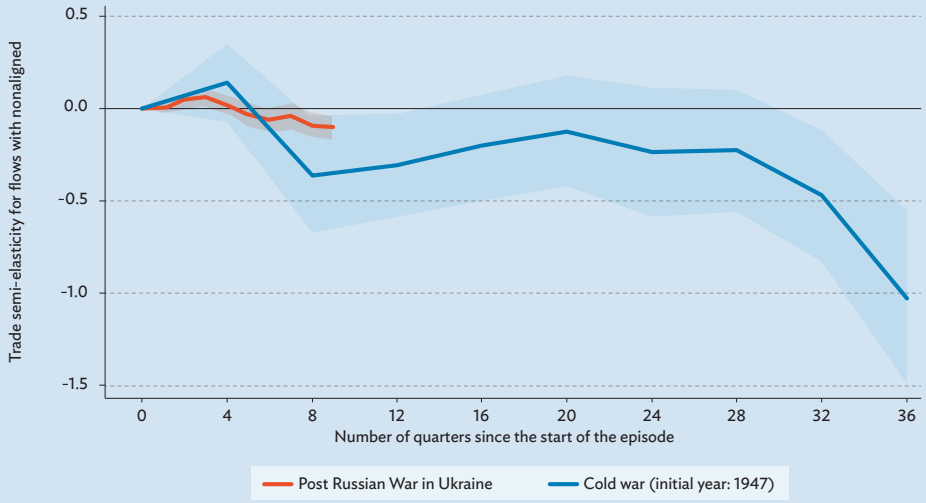
Box 5.2: What Do We Know About the Impact of Geoeconomic Fragmentation on Third Countries?

As geopolitical tensions mount and countries adopt new policy measures, trade and investment flows are shifting across countries. Some third countries – if not directly affected by the measures adopted by countries in geopolitical confrontation – may, under certain conditions, replace links between previous partners. This note summarizes key findings from the economic literature on the effects of US-China tariff policies and Western trade sanctions on Russia on trade and FDI of such third countries.

Against this backdrop, global trade and investment flows are reallocated across countries. Major economies are adopting trade, investment and other policy measures to reduce reliance on certain countries for geopolitical reasons. This involves the use of tariffs – as in the case of 2018-2019 US-China tariff hikes that covered $450 billion in trade flows – and other measures. As directly affected partners may reduce their respective market shares, this can create opportunities for third countries to fill in the void.

Certain third countries with suitable economic and policy conditions may reap some short-term benefits from such shifts in economic activity but also face risks associated with higher geoeconomic fragmentation. Certain non-aligned countries may be able to substitute for declining Chinese imports by the US (Gopinath et al, 2025). The economic mechanism is simple: as firms internalize the effect of new policies on their supply and buy decisions, they substitute their business partners and shift their economic activity towards alternative locations, which may result in more opportunities for these countries. The role played by such countries has been highlighted as a critical differentiating factor between the current period and the Cold War when trading blocks were more isolated (Gopinath et al, 2025 and Figure B 5.2.1). Yet, the degree of such shifts depends on many factors, including the size and distribution of tariffs and other measures imposed on different countries – including those third countries – and the degree of product substitutability. The reallocation of GVCs to such countries may also reflect broader long-term shifts related to those countries' attractiveness as a business location and is sensitive to whether those countries will themselves be subject to policy actions.

Figure B 5.2.1: Trade Fragmentation: the Cold War and Now



Source: Gopinath, Gourinchas, Presbitero, and Topalova (2025)

Such supply chain reconfigurations can take multiple forms. They may mean trade reallocation involving changes in real economic activity – for example, when a firm opens a new factory in another country, either to produce there, or to export products from that location. This decision may be driven by a particular policy or broader economic factors. They may also involve sheer rerouting, whereby the same product is transshipped through third countries to circumvent trade restrictions. Changes in FDI flows can be associated with either, or none, of these phenomena as multinational firms amplify trade reallocation or rerouting patterns.

Which countries can facilitate reallocation depends on the type of flow and policy in question. Geographic proximity, structural similarity to the partner affected by the measure, supply capacity, pre-policy patterns of comparative advantage and supply chain linkages can influence which country experiences potential changes in trade and investment patterns. For example, in the case of US-China tariff policies of 2018-2019, countries similar in terms of their economic structure to those countries affected by bilateral tariffs have been found to increase their exports to the relevant markets according Fajgelbaum et al. (2024). In the case of the Western sanctions on Russia, several Central Asian countries have experienced a rise in trade opportunities (Corsetti et al., 2024).

Overall, there is strong evidence of supply chain reallocation through changes in trade and investment flows (e.g., Fajgelbaum et al., 2024; Freund et al., 2024; Gopinath et al., 2025, Graziano et al, 2024). Direct trade between the affected partners is found to drop while third

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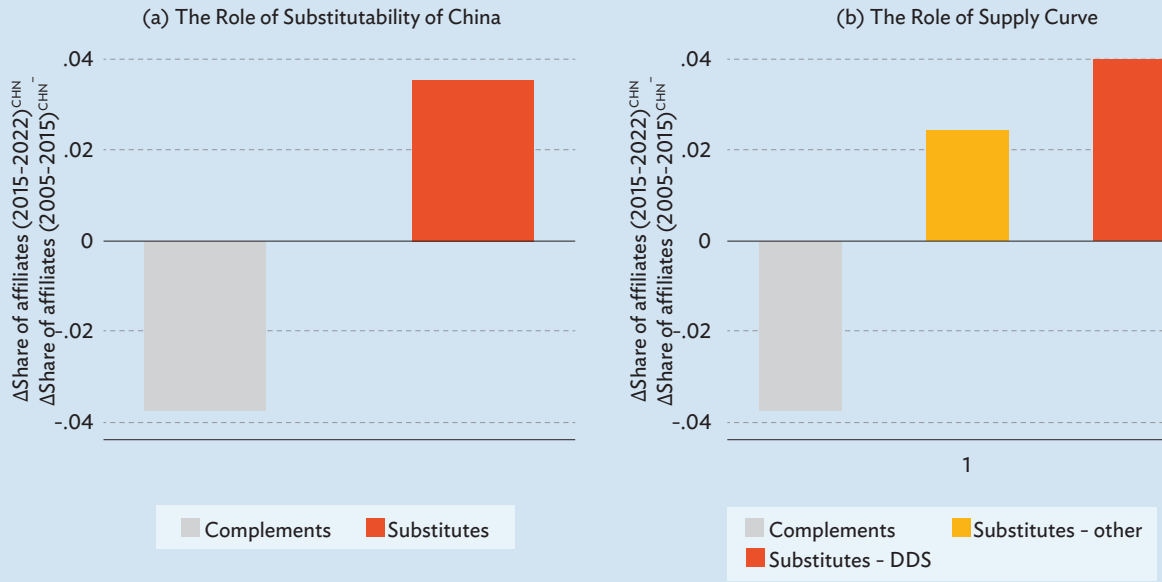
Box 5.2: continued

countries not directly affected by the policies increased their market shares. The literature also provides further evidence on the nature of such reallocation of trade, FDI and other economic activity, some of which are highlighted below:

- Trade patterns: Several studies show that following the US-China tariff policies of 2018-2019, some third countries increased imports from China and exports to the US, particularly in sectors most affected by trade restrictions (Gopinath et al., 2025; Fajgelbaum et al., 2024). Policies other than tariffs can also unleash adjustment. For example, stand-by countries in the region not targeted by the Western trade sanctions on Russia since 2022 also experienced surges in exports to Russia and imports from EU, especially in sanctioned products (Borin et al., 2023, Corsetti et al., 2024).
- Foreign direct investment: Evidence further shows that countries whose exports increased the most as a consequences of trade diversion are also the ones that received the strongest boost in FDI inflows (Ahn et al., 2023, Aiyar et al., 2023, Aiyar et al., 2024, Xue, 2024); and that there is a correlation between countries' gain in US imports market share and their gain in Chinese outward FDI (Gopinath et al., 2025). Studies also find that multinational firms increased the number of affiliates in countries that are China's substitutes and have economies of scale (Figure B 5.2.2), especially in sectors most exposed to the tariffs (Graziano et al. 2024). Country-specific studies also find a confirmation of adjustment in FDI flows (e.g., Arizala et al., 2025) and that the changes in trade were driven by exports and imports by foreign-owned firms (e.g., Utar et al., 2023; Wu, 2023).
- Nature of adjustment: There is weak evidence that third countries that increased trade in response to US-China tariffs serve as mere platforms to circumvent trade barriers through transshipment while they connect different blocs through value added trade and FDI flows (Utar et al., 2023; Iyoha et al., 2024; Schulze and Xin, forthcoming). This is consistent with the findings that changes in trade have been associated with increases in employment, trade diversification and activities of multinational firms operating in such countries (Utar et al., 2023; Rotunno et al., 2024, Fajgelbaum et al., 2024; Graziano et al. 2024). Meanwhile, some partial rerouting of trade to Russia through some Eurasian Customs Union countries might have emerged as a response to EU sanctions in 2022 (Chupilkin et al., 2023, Borin et al., 2023).
- Country characteristics: Pre-shock country characteristics can influence how bystander countries are affected. This includes the extent of their prior supply chain linkages and specialization patterns (Freund et al., 2024), the level of substitutability of the affected trading partner and supply capacity of the third country (Fajgelbaum et al., 2024), and the coverage by preferential trade agreements (Barattieri et al., 2024, Utar et al., 2023, Graziano et al., 2024). The specific set of countries that benefit most depend on the policy measure and type of activity. For example, Vietnam, Thailand, South Korea and Mexico, experienced largest export increases following the tariff hikes.[1] Meanwhile, Türkiye saw increased exports to Russia after the imposition of trade sanctions and Armenia, Kazakhstan and the Kyrgyz Republic emerged as a route for EU exports to Russia following sanctions.

Figure B 5.2.2: Reallocation of Multinational Activity Across Countries



Note: The figure shows the mean difference between the change in the share of foreign affiliates of MNEs from China (in a given country relative to all Chinese MNEs globally) in 2015-2022 and in 2005-2015 across countries within the following groups: Complements, Substitutes, Substitutes with downward-sloping supply curve (DSS) and Substitutes - Other, following the classifications from Fajgelbaum et al. (2024).
Source: Graziano, Sztajerowska and Volpe Martincus (2024)

[1] The average export growth in taxed products across countries is 6.4% with a standard deviation across countries of 6.2% (compared to a standard deviation of just 1.4 percent implied by a specification with homogeneous tariff elasticities).

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Box 5.2: continued

To conclude, geoeconomic fragmentation has already led to significant reallocation of trade and investment flows towards third countries, and there may be further adjustments going forward. Studies find increases in trade and investment activity within products and sectors affected by US-China tariff measures and to a lesser extent sanctions on Russia. At least in the case of adjustments to the imposition of tariff, changes involved reallocation of supply chains rather than mere transshipment. As more recently countries adopted new FDI policies – notably investment screening mechanisms – going forward, trade and investment patterns are likely to reflect not only changes to trade but also those policies and their possible interactions. For example, reallocation of investment may also take place in reaction to FDI measures as multinational firms can reroute their investment through intermediary countries (Damgaard et al., 2019, Tan, 2024).

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Note: The authors of this box are Lorenzo Rotunno and Monika Sztajerowska. The views expressed herein are those of the author and should not be attributed to the IMF, its Executive Board, or its management.

The evolving geography of adjustment has implications for developing and middle-income countries as well. Some countries stand to benefit from diversification efforts, while others may find themselves marginalized if they lack the capacity to meet sourcing, standards or compliance expectations in increasingly regulated sectors. These distributional consequences are difficult to model, but are becoming more visible in trade data, investment flows and policy dialogue. They also raise questions about

whether industrial policy coordination – or at least transparency – can help avoid fragmented competition that produces inefficient duplication or capacity gluts.

To date, institutional responses have been limited. The WTO's subsidy rules, while still in force, provide little direct guidance on how to evaluate spillovers or coordination failures that arise from simultaneous strategic interventions. Efforts such as the Joint Subsidy Platform have focused more on improving data availability than on resolving tensions. The IMF, in its most recent analytical guidance, has acknowledged the role of geopolitical fragmentation in shaping both macroeconomic and structural risks. Still, formal governance of industrial policy in a strategic rivalry context remains underdeveloped.

In this environment, the work by Zhang et al. provide valuable insights into how rivalry manifests in production and investment decisions. These findings reinforce the idea that industrial policy today operates not only through its direct economic channels, but also through its role in structuring global expectations and shaping firm-level responses to risk.

The next section considers how institutions are responding – or struggling to respond – to these developments, and how proposals for more transparent and differentiated governance might address some of the resulting challenges.

5.6 Governance Gaps and Institutional Responses

The resurgence of industrial policy has raised questions about how these policies are to be monitored, assessed and, where appropriate, coordinated. While domestic industrial strategies are shaped by national priorities and fiscal capacities, the effects of these interventions often extend beyond national borders. Given the cross-border nature of global production and the growing overlap in strategic sectors targeted by multiple governments, the challenge of governance is not simply one of discipline, but of information, interpretation and response.

The current multilateral rules on industrial subsidies are structured under the WTO's Agreement on Subsidies and Countervailing Measures (SCM). The SCM distinguishes between prohibited subsidies – such as export-contingent payments or local content requirements – and actionable subsidies that may cause adverse effects to other members. In theory, this framework provides both notification requirements and legal remedies. In practice, however, its operation has been constrained by institutional and political limitations. Notification rates remain low, dispute settlement is in partial paralysis and the analytical tools required to assess sectoral spillovers are not well developed within the legal context.

Parallel to these trade rule challenges, recent IMF and World Bank analyses highlight that industrial policy has become embedded in national fiscal frameworks and sovereign investment strategies, underscoring the need for greater macro-financial transparency and coordination (IMF, 2024b; Benitez and Bisbey, 2021; Baquie et al., 2025). Moreover, the SCM was designed at a time when industrial policy was primarily associated with classical trade distortions, rather than with climate, security or resilience goals. As such, it offers limited guidance on how to evaluate subsidies introduced as part of broader structural transformation agendas. It also provides no exemptions for measures adopted in response to supply chain disruptions or technological decoupling pressures. These omissions have led many observers to conclude that while the SCM remains a relevant legal foundation, it is insufficient on its own for governing the new generation of industrial policies.

In response, several multilateral institutions have sought to improve the informational and analytical environment surrounding industrial policy. The Joint Subsidy Platform, launched in 2023 by the IMF, the OECD, the World Bank and the WTO, aims to consolidate data, promote transparency and support peer dialogue. Its initial focus has been on assembling a common taxonomy of subsidy types, standardizing reporting templates and encouraging voluntary disclosure. While participation remains uneven and the platform is still developing its evaluative capacity, it represents a constructive attempt to re-establish shared baselines on policy trends.

Recent empirical work has begun to address these gaps. The OECD's new MAGIC (MAnufacturing Groups and Industrial Corporation) database provides standardized, firm-level estimates of subsidies – including grants, tax relief and below-market finance – for nearly 500 of the world's largest manufacturing firms over the period 2005-2022. By triangulating disclosures and applying benchmark estimation methods, the database reveals significant unreported and persistent subsidy flows, especially in strategic sectors such as semiconductors, steel and aluminium.

The IMF has also taken steps to clarify its role in the evolving industrial policy landscape. In a 2024 policy note, it emphasized that industrial policy can be relevant to surveillance when it has implications for fiscal sustainability, cross-border spillovers or macro-critical externalities. It proposed a set of criteria to assess the economic rationale for such policies, including the presence of identifiable market failures, the proportionality and targeting of interventions and the coherence with overall policy frameworks. Importantly, the IMF recognizes that some objectives, such as addressing climate risks or mitigating geopolitical vulnerabilities, may justify the use of selective industrial support, even in the absence of traditional efficiency justifications.

These efforts are complemented by academic proposals that seek to address transparency and coordination through more differentiated governance tools. One such proposal, outlined in Koopman (2025), suggests the establishment of a Global Industrial Policy Transparency Platform (GIPTP). Rather than functioning as a legal adjudication

body, this platform would organize policy observatories along sectoral lines, with each observatory responsible for tracking, analysing and reporting on industrial policy interventions in its respective domain. The intent is not to enforce disciplines, but to create a shared analytical space where policies can be evaluated based on their stated objectives, spillover effects and relevance to supply chain interdependence.

The proposed GIPTP also includes mechanisms for peer learning and structured dialogue. Observatories would generate typology dashboards to group policies by function, magnitude and exposure to international production. These dashboards could support multilateral forums in identifying areas of potential friction or coordination, without requiring formal consensus or legal rulings. While the proposal remains conceptual, it reflects a broader trend towards developing non-binding but structured approaches to industrial policy transparency.

Dadush (2022) offers a cautionary perspective on the design of governance responses. Rather than dismissing oversight efforts, he urges that they remain proportionate and grounded in data. Many subsidy programmes involve modest outlays or target SMEs, and should not be conflated with large-scale, distortionary interventions. He supports improved data tools but warns that miscalibrated governance could stifle legitimate development objectives. Recent OECD analysis based on the MAGIC database partially addresses this gap. While the database identifies certain firms as recipients of sustained and substantial support, the median annual subsidy across firms and years is relatively modest, typically below 1% of revenue. This reinforces the point that industrial policy, although visible and sometimes controversial, remains limited in scale for most global firms.

Taken together, these initiatives and perspectives suggest that the governance of industrial policy is entering a period of experimentation. There is no clear institutional consensus, and few binding mechanisms are likely to emerge in the near term. Still, the combination of soft-law platforms, enhanced data collection and sector-specific dialogue offers a practical way forward. These efforts may help reduce the risk of subsidy escalation, support more informed national policy design and improve the multilateral community's capacity to track and interpret the distributional effects of industrial policy.

The next and final section summarizes the main empirical and institutional observations of the chapter, highlighting where recent developments raise new questions for researchers and policymakers alike.

Before turning to that section, it is worth noting that the growing complexity of industrial policy is also reshaping how firms themselves compete, invest and organize production. Box 5.3 presents a business perspective on these dynamics, illustrating how companies are adapting their global strategies to navigate the new era of strategic subsidies and policy-driven competition.

Box 5.3: The View from Business: Competing in the Era of Strategic Subsidies

Introduction: A Shifting Policy Landscape

Several governments have recently adopted a more activist approach to industrial policy, reviving it as an instrument of national competitiveness and geopolitical statecraft. For firms in affected industries, this new policy environment has become a defining feature of today's competitive landscape.

The proliferation of subsidies, incentive schemes, public procurement mandates, local-content requirements, strategic public investments and technology partnerships has transformed how firms plan investments, structure supply chains and manage risk. From a corporate standpoint, industrial policy is no longer something governments impose on business; it is a systemic dynamic that firms must actively navigate and integrate into strategic planning. The sections that follow explore how businesses are adapting to, rather than resisting, the realities of this new policy environment.

1. Firms as Strategic Respondents, Not Passive Beneficiaries

While governments view subsidies as instruments to advance national priorities, firms increasingly interpret them as strategic signals guiding capital allocation and long-term planning. Semiconductor producers such as TSMC and Intel now calibrate global investments based on the interaction between financial incentives, policy stability and access to technological ecosystems. For instance, TSMC's decision to expand in Arizona under the US CHIPS Act and Intel's establishment of its Magdeburg facility with substantial German support illustrate how firms internalize public incentives into their investment calculus (Reuters, 2023; TSMC, 2024). In clean-energy industries, Northvolt's cell manufacturing projects in North America and Europe, backed by production-linked tax credits and green-industrial funding, and BYD's localization of electric vehicle production in Hungary demonstrate how industrial policy has become a roadmap for global expansion (Government of Canada, 2023; Northvolt AB, 2023; AP, 2023).

These developments underscore that businesses are no longer passive recipients of industrial policy. Rather, they are strategic participants shaping and responding to the evolving rules of the game. As one senior executive at Intel noted, "The support of European government partners is critical for success," emphasizing that private investment decisions now depend as much on the credibility and design of public frameworks as market fundamentals (Intel, 2022).

2. Policy Credibility and Institutional Capacity

The experience of Hyundai Motor Group and SK On illustrates how firms design investment and partnership strategies to manage compliance risk. Their memorandum of understanding on battery supply for North America explicitly aims to help both firms meet the Inflation Reduction Act's (IRS) domestic content provisions, requiring critical minerals and components to originate from the US or its free trade agreement (FTA) partners (HSAGP, 2024; Reuters, 2022). The evolving guidance issued by the US Treasury and IRS on the Act's "domestic content bonus" reinforces a broader lesson: administrative clarity is essential for corporate decision-making (US Treasury, 2024).

Even in Europe – long considered a place of strong state administrative capacity – Siemens Energy has voiced concern about the slow pace of state-aid approval. CEO Christian Bruch has gone on record saying "the most important issue is not how big the programme is .. but how to implement it faster" (Reuters, 2023). For many multinationals, policy credibility has become a first-order determinant of competitiveness.

Battery manufacturers share similar concerns. LG Energy Solution CFO Lee Chang-sil warned that "US tariffs and an early end to EV subsidies will put a burden on automakers, potentially leading to vehicle price increases and a slowdown in EV growth in North America" (Reuters, 2025). In Asia, CATL Chief Manufacturing Officer Ni Jun cautioned that uneven regulatory oversight could destabilize market competition: "One big player cannot always lower prices .. if it continues, all of its rivals will not survive (SCMP, 2025)."

3. Fragmentation and Compliance Complexity

The rapid expansion of subsidy regimes and their qualifying regulatory requirements has created not only a complex compliance environment but also a new form of industrial coordination. Governments are embedding industrial-policy objectives directly into regulatory design – using standards, reporting obligations and traceability mechanisms to steer investment, encourage domestic production and shape value chain geography.

For example, the EU's Battery Regulation (EU) 2023/1542 aligns environmental due diligence, carbon footprint and digital passport requirements with the bloc's broader strategic-autonomy agenda, effectively incentivizing localization and responsible sourcing within Europe (European Commission, 2023; CEPS, 2024). Likewise, the US Inflation Reduction Act ties eligibility for clean-energy tax credits to domestic-content and supply chain resilience goals, making compliance a determinant of investment location (CRS, 2024; IEA, 2024).

For multinational firms, this intertwining of regulation and industrial strategy has strategic implications: reporting and traceability obligations now influence where and how companies invest. As the European Automobile Manufacturers' Association notes, "technical implementation timelines have become a core determinant of competitiveness" (ACEA, 2021; ACEA et al., 2022).

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Box 5.3: continued

4. Coordination, Competition and Policy Uncertainty

Industry leaders increasingly draw analogies to past aerospace subsidies, warning that a patchwork of incentives could reignite trade disputes in sectors like electric vehicles and clean energy.

The IMF (2024) has likewise cautioned that "aggressive use of state subsidies risks .. triggering a tit-for-tat subsidy war". For multinational firms operating across these sectors, the challenge is not only to capture available incentives but to anticipate how policy races may reshape demand, margins and global production footprints. Meanwhile, a recent WTO case illustrates the risk: China has formally challenged India's electric vehicle and battery incentive programmes at the WTO, acting in part on complaints from Chinese firms such as BYD and others who say India's localization and production-linked incentives unfairly advantaged their domestic competitors and disadvantage Chinese exporters (Reuters, 2025; Economic Times, 2025).

Against this backdrop, leading business associations have explicitly urged stronger subsidy transparency and notification disciplines at the WTO level. BusinessEurope has called for "increasing transparency in such matters as subsidies notification" as a top priority for WTO reform, alongside a more structured monitoring function (BusinessEurope, 2025). In Japan, business association Keidanren likewise advocates meaningful reforms on industrial subsidies as part of WTO modernization (Keidanren, 2024). These positions align with efforts to develop transparent subsidy registries and enforceable reporting standards that firms say are needed to reduce uncertainty. Recent WTO committee minutes underscore why: compliance with subsidy-notification obligations remains concerningly low, undermining predictability for cross-border investors (WTO, 2024).

5. Implications for Global Value Chains

Subsidy-driven competition is reshaping global production geographies. Firms are no longer simply chasing cost savings – they are hedging geopolitical, policy and supply chain risk. As Apple's CEO Tim Cook explained: "We learned some time ago that having everything in one location had too much risk with it and so we have opened up new sources of supply over time." (Cook, 2025) It is precisely this logic that helps explain why countries such as Viet Nam, Mexico, Türkiye and India are emerging as new nodes in global value chains, offering access to multiple national incentives while reducing exposure to a single dominant market.

Foxconn's Chairman Young Liu described the same shift: "We want to move up on the value chain as much as we can in India. That's what we will be doing .. For sectors other than ICT, we think EVs and energy and also the digital-health industry" (Liu, 2024). Such strategies illustrate how industrial policy has become a determinant of comparative advantage, influencing where and how firms invest across regions.

Conclusion: Navigating the Policy-Driven Economy

The resurgence of industrial policy marks a structural shift in the global economy. Firms now compete not only on technology or cost but on their ability to read and align with policy architectures governments are adopting. What began as subsidies has evolved into a policy-driven environment where administrative credibility and cross-border coordination define competitiveness.

From semiconductors to clean energy and advanced manufacturing, corporate strategy is converging with public policy. Businesses are learning that policy intelligence – understanding how rules, incentives and industrial objectives interact across jurisdictions – has become as valuable as engineering excellence or financial discipline. The most successful firms will be those that treat industrial policy not as constraint or compliance exercise, but as a strategic domain in which advantage can be actively built and assertively exploited.

Global business is thus not merely adapting to the return of the state – it is actively co-authoring the next phase of globalization, one in which industrial coordination, corporate agility and public-private alignment will determine who leads in the age of strategic industrial policy. This box complements Chapter 5's empirical analysis of firm behaviour and supply-chain reconfiguration.

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Box 5.3: continued

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Note: This box was authored by Simon Lacey (formerly with the World Economic Forum, currently with Belt Road Capital Management). The views expressed are those of the author and do not necessarily reflect those of the affiliated institutions.

5.7 Summary Observations and Research Frontiers

The preceding sections have outlined how industrial policy is reemerging as a central feature of economic strategy across both advanced and developing economies. Motivated by a range of objectives – climate transition, technological competitiveness, economic security and resilience – these policies are increasingly implemented in a global context defined by production interdependence, strategic rivalry and institutional fragmentation.

While industrial policy is not a new phenomenon, its contemporary forms differ in several important respects. First, the targeted sectors now span a broader array of activities, notably those with dual-use applications or deep network externalities. Second, interventions increasingly operate within complex supply chains, meaning that direct and indirect effects can propagate through domestic and international production structures. Third, many of the stated goals – particularly those tied to security or decarbonization – do not fit neatly into existing welfare-based evaluation frameworks. As a result, both the measurement and governance of industrial policy have become more analytically and institutionally demanding.

5.7.1 Where the Evidence Converges

Despite the diversity of contexts and methodologies reviewed in this chapter, several findings appear consistently across studies:

Network effects and spillovers are substantial. The evidence strongly supports the view that industrial policy effects propagate through production networks. Multiple studies using different approaches – Liu's input-output analysis (2019), Zhang et al.'s firm-level regressions (2024), Bekkers' CGE simulations (2024), and Barwick et al.'s structural evaluation of China's shipbuilding programme (2024; 2025) – demonstrate that subsidies to upstream sectors generate downstream impacts, and vice versa. The magnitude of these spillovers often exceeds direct effects, particularly in sectors with dense supplier linkages.

GVC participation facilitates productivity convergence. Firm-level studies (Ma et al. 2024) across different countries and time periods consistently show that importing intermediate inputs is associated with faster convergence towards industry productivity frontiers. This effect is particularly strong for lagging firms and in technologically sophisticated sectors, suggesting a role for knowledge diffusion and competitive pressure.

Policy design matters as much as policy presence. The evidence from structural models (Barwick et al. 2024, 2025) and case studies (Juhász and Lane, 2024; Bai et al., 2025) indicates that how industrial policy is implemented – its timing, targeting, duration and coordination with other instruments – determines effectiveness at least as much as the choice to intervene. Counter-cyclical timing, selective targeting and institutional quality emerge as critical factors across contexts.

Firm and sectoral heterogeneity is pronounced. Industrial policy effects vary systematically by firm ownership, productivity level, sector characteristics and position in value chains. Blanket generalizations about whether industrial policy "works" miss this fundamental heterogeneity. The same intervention can accelerate upgrading for some firms while creating inefficiencies for others.

Cross-border effects are inevitable in integrated production systems. Whether through input cost changes, demand shifts or capacity reallocation, industrial policies in one jurisdiction affect firms and workers elsewhere. These effects can be positive (through learning spillovers or lower input prices) or negative (through market share displacement), but they cannot be avoided in sectors characterized by GVC integration.

Taken together, these findings imply that industrial policy is best viewed – and evaluated – as a system-level intervention: its outcomes and welfare effects depend less on the intent than on how interventions are designed and how they interact with production networks, firm heterogeneity and cross-border linkages.

5.7.2 Outstanding Questions and Research Gaps

Despite the recent advances, important questions remain unresolved or inadequately addressed in the current literature:

Long-run dynamic effects are poorly understood. Most empirical work examines short- to medium-term outcomes (typically 5-10 years), leaving the potential for path dependence, lock-in and hysteresis (David, 1985; Arthur, 1989; Krugman, 1991; Neffke et al., 2011; Lee, 2013) largely underexplored empirically. Yet we still know little about whether productivity gains persist, whether subsidized capacity eventually transitions to self-sustaining competitiveness, or how quickly displaced firms and workers adjust.

Optimal policy design remains largely unspecified. While recent studies, notably Barwick et al. (2024, 2025), demonstrate that design choices matter, we still lack systematic frameworks for determining optimal subsidy levels, targeting criteria or phase-out schedules across different contexts. Meanwhile, the conditions under which particular instruments outperform others are not well established beyond specific cases.

Measurement challenges persist. Existing subsidy databases capture different phenomena with varying completeness. Many forms of support – including implicit guarantees, preferential regulation and below-market provision of inputs – remain difficult to quantify. The economic significance of what we measure versus what we miss is unknown. As Dadush (2022) emphasizes, crude counts of interventions may substantially overstate their systemic importance, underscoring the need for more consistent metrics and valuation frameworks.

General equilibrium and welfare assessments are incomplete. Few studies sufficiently account for opportunity costs, revenue-raising distortions or broader economic adjustments triggered by industrial intervention. Existing welfare analyses – primarily based on CGE or structural models – rest on strong assumptions about market structure, consumer preferences and government efficiency. As a result, whether industrial policies generate net welfare gains for implementing countries – let alone globally – cannot be confidently assessed in most cases.

The political economy of policy persistence is underexplored. Once established, industrial support programmes are notoriously difficult to remove. Yet the literature focuses heavily on adoption and short-term impacts, with limited attention to what sustains interventions beyond their economically optimal duration, how they are eventually phased out (if at all), and what happens when they become entrenched rents rather than temporary supports. As Juhász and Lane (2024) emphasize, the durability of industrial policy often reflects institutional and coalition dynamics rather than economic fundamentals, underscoring the need for greater attention to governance and exit design.

Cross-country coordination and subsidy races remain inadequately examined. While Goldberg et al. (2024) and others raise concerns about competitive subsidy escalation, we lack rigorous empirical evidence on whether current patterns constitute destructive races or potentially beneficial competition. The conditions that might support successful coordination versus those that make it infeasible or counterproductive remain largely theoretical, requiring further empirical investigation.

The distributional consequences of industrial policy – both within and across countries – are not yet well understood. Who gains and loses from industrial policy – across skill groups, regions, sectors and countries – receives insufficient systematic attention. The political sustainability and social legitimacy of these interventions likely depend on these distributional outcomes, yet they remain poorly mapped.

5.7.3 What We Can and Cannot Conclude

Based on the evidence reviewed, several conclusions can be stated with reasonable confidence:

- Industrial policy interventions have measurable effects on firm behaviour, investment patterns and trade flows, particularly in targeted sectors.
- These effects extend beyond direct recipients through supply chain networks and competitive dynamics, implying second- and third order impacts that partial equilibrium metrics miss. Policy effectiveness varies substantially with institutional capacity, design choices and sectoral characteristics.
- The scale of contemporary industrial policy has increased significantly in strategic sectors such as semiconductors and green technologies, though the aggregate economic significance relative to GDP remains debated.
- Cross-border spillovers – both positive and negative – are an inherent feature of industrial policy in GVC-integrated sectors, so assessment must account for incidence on third countries and feedback effects through production networks.

We cannot yet conclude:

- Whether most industrial policies generate net welfare gains for implementing countries or globally, given heterogeneity in market structure, firm and sectoral characteristics, learning externalities and cross-border spillover effects.
- What the optimal instruments, targeting criteria or phase-out strategies are across different contexts.
- How persistent the observed effects are – i.e., whether they represent temporary distortions (e.g., capacity cycles) or lasting capability-building (productivity, innovation, and quality upgrading).
- Whether current patterns constitute a problematic "subsidy race" or reflect reasonable responses to market failures and strategic imperatives.
- How severely informal and hard-to-measure forms of support distort the apparent picture based on tracked interventions, given notification gaps and limited observability of many instruments.

The evidence is insufficient to support:

- Strong prescriptive recommendations about when countries should or should not adopt industrial policies, as context-dependence, network exposure and administrative capacity, among so many other factors, materially shape outcomes.
- Confident predictions about long-run effects on global production geography or technological leadership, as complex and dynamic factors – such as relocation, innovation, learning and policy interactions – evolve over multi-year horizons with continuous policy feedback.
- Clear judgments about whether specific interventions are "legitimate" responses to market failures versus protectionist rent seeking without standardized disclosure on aims, magnitudes, network incidence and so on.

5.7.4 Implications for Future Research

The renewed prominence of industrial policy reflects deeper changes in the global economy – technological, environmental and geopolitical. Several research priorities emerge from this review:

Methodologically, there is a need for longer panel datasets, better measurement of hard-to-observe support mechanisms, and research designs that can credibly identify causal effects in the presence of multiple simultaneous policy changes and strategic behaviour by firms and governments.

Substantively, priority areas include understanding long-run dynamic effects, mapping distributional consequences more systematically, developing frameworks for assessing optimal policy design across contexts and examining the political economy of policy persistence and termination.

Institutionally, continued efforts to improve transparency through platforms like the Joint Subsidy Platform, sector-specific observatories and standardized reporting are essential for building the shared factual basis necessary for both research and dialogue. As Koopman (2025) proposes, differentiated governance approaches that reflect sectoral variation and capacity differences may prove more practical than uniform disciplines.

The institutions tasked with global economic governance are beginning to adapt, but the frameworks in place remain incomplete. While no consensus has emerged on how industrial policy should be governed in an era of strategic interdependence, the evidence reviewed here provides a stronger empirical foundation for ongoing efforts. What remains clear is that industrial policy will continue to be a central tool of economic management, particularly in strategic sectors. Understanding its effects, supporting transparency and developing appropriate governance mechanisms will require sustained engagement from researchers, policymakers and international institutions alike.

Industrial policy has re-emerged as a defining feature of global economic strategy. Its reach now extends beyond traditional development objectives to encompass resilience, security, and technological leadership. The evidence assembled in this chapter underscores both the potential and the pitfalls of state intervention in an interdependent world economy. Effective governance will hinge on transparency, coordination and the capacity to balance national objectives with global stability.

As the discussion turns from industrial policy to the financial foundations of globalization, Chapter 6 examines how capital – both long-term and short-term – sustains participation in GVCs. It explores how FDI and trade finance operate as complementary pillars of global production, shaping not only where industries locate, but also how deeply firms integrate and upgrade within cross-border networks.

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6

Foreign Direct Investment, Trade Finance and Global Value Chain Integration

Zhengrui Cheng,[1] Xiang Ding[2] and Marc Auboin[3]

6.1 Overview

Foreign direct investment (FDI) and trade and supply chain finance (TF/SCF) constitute the structural architecture and operational lifeblood of global value chains (GVCs). They are the twin financial pillars upon which modern cross-border production and exchange rest. FDI enables firms to establish production networks across borders by financing the fixed capital and embedded know-how necessary for fragmentation of tasks and specialization across countries. In parallel, TF/SCF lubricates the continuous flow of inputs and outputs through working capital, guarantees and risk mitigation tools, ensuring that the GVC system functions smoothly. Without either form of capital, the contemporary map of global production would neither have taken shape nor be able to function.

This chapter explores the distinctive, yet deeply interrelated roles, of FDI and TF/SCF in enabling participation and upgrading in GVCs. Using newly harmonized datasets, we

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Note: The work on this chapter was led by Zhengrui Cheng, Prof. Xiang Ding, and Dr. Marc Auboin

provide two central empirical contributions. First, we demonstrate how FDI reshapes production structures in host economies by altering the composition and sourcing of capital goods. Our analysis reveals that the presence of bilateral FDI correlates with greater convergence in capital input structures – particularly in sectors where imported capital plays a large role, highlighting the importance of capital-embodied technology transfers. However, this convergence is not observed for intermediate inputs, suggesting that the mechanisms of assimilation are rooted more in fixed investment than in recurring input substitution.

Second, we examine the extent to which TF/SCF mitigates operational frictions in cross-border trade, particularly for small- and medium-sized enterprises (SMEs) and lower-tier suppliers. By mapping TF/SCF coverage and cost disparities across countries, we document the sharp inequalities in access and affordability, particularly in emerging and frontier markets. Trade and FDI exhibit distinct financial geographies: trade is more sensitive to bilateral stock market development, while FDI flows respond more to private credit depth. Yet both remain highly distance-sensitive, and the centrality of countries in trade and investment networks is increasingly decoupled. This divergence underscores the importance of addressing not only the flow of goods and capital, but also the platforms and institutions that connect them.

Importantly, we show that the absence of adequate trade finance can prevent even FDI-rich countries from fully leveraging their export potential. When trade finance only covers transactions between multinationals and their affiliates, domestic suppliers are often excluded from meaningful participation. This creates a shallow form of integration, where local firms remain constrained by delayed receivables and working-capital bottlenecks. Conversely, trade finance in the absence of fixed investment may lock firms into low-value added roles, unable to climb the technological ladder.

Policy responses should therefore adopt a layered financial framework. Strategies must be tailored to firms' positions in the value chain and to the nature of their capital constraints, whether structural (investment-related) or operational (liquidity and risk-related). Examples such as Mexico's development bank and export credit agency Banco National de Comercio Exterior (Bancomext) offer useful models, where trade finance instruments are bundled with investment support to build domestic supplier ecosystems. These integrated approaches are increasingly being digitized, linking commercial banks, development institutions, investors and firms on unified platforms to co-mobilize both fixed and working capital.

Ultimately, the complementarity of FDI and TF/SCF calls for integrated strategies. Liberalizing trade and attracting investment without deepening TF/SCF markets risks underutilization and exclusion; promoting TF/SCF without anchoring long-term investment undermines upgrading. Financial infrastructure that co-deploys long- and short-term capital, sequenced and synchronized, offers the most promising path to inclusive and resilient GVC integration.

The analysis that follows substantiates this dual-capital framework with new empirical evidence, tracing how the interaction between structural investment and operational liquidity shapes the depth and inclusiveness of global value chain participation. The chapter unfolds in two interconnected parts that together explain how finance underpins global value chain integration. Section 6.2 analyses the short-term liquidity mechanisms of TF/SCF that sustain day-to-day operations. Section 6.3 turns to the long-term investment dimension, FDI, that anchors production and transmits technology across borders. Read together, these two perspectives reveal a single financial continuum: FDI builds the productive base and TF/SCF keeps it in motion. Understanding this continuum is essential to designing policies for a more resilient and inclusive phase of re-globalization.

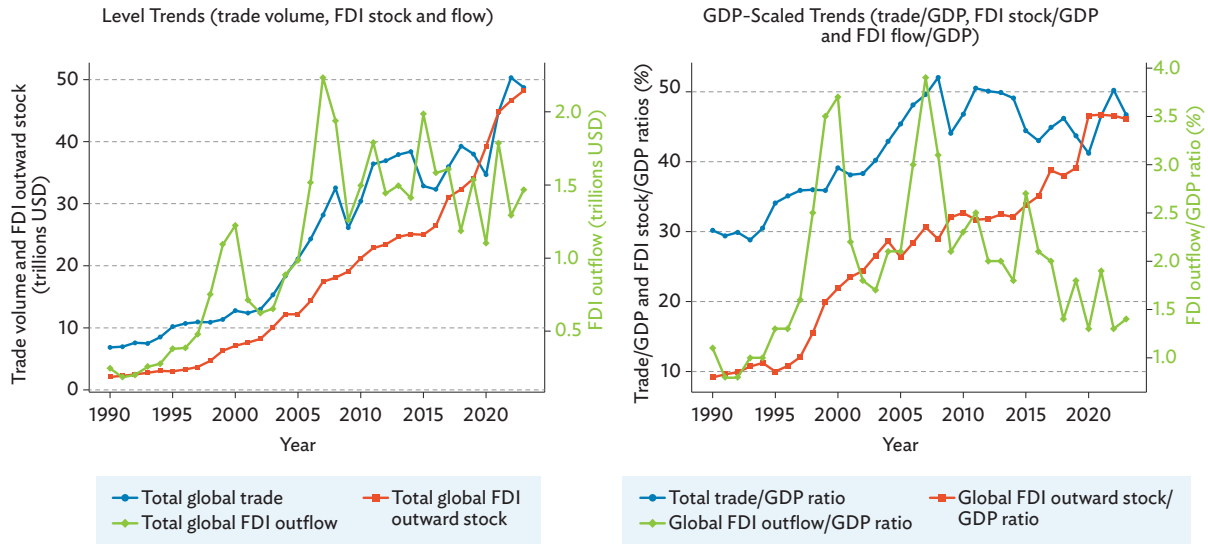
6.2 The Layered Financial Architecture of Global Value Chains

6.2.1 Globalization at a Crossroads

The historical arc of globalization has long been told as a story of accelerating integration – of trade volumes rising faster than gross domestic product (GDP), of capital moving fluidly across borders and of firms unbundling production across geographies. For much of the post-war period, and especially from the 1990s through the mid-2000s, this narrative was borne out in the data. As illustrated in Figure 6.1, both global trade and FDI surged in absolute terms, with trade volumes climbing above $50 trillion and global outward FDI stocks exceeding $45 trillion by 2023. During this same period, the globalization of economic activity outpaced overall growth, with trade-to-GDP and FDI-outflow-to-GDP ratios rising sharply through the early 2000s.

Yet since the Global Financial Crisis, momentum has slowed. Trade volumes and FDI stocks have continued to rise in absolute terms, but the intensity of cross-border integration – measured relative to global output – has plateaued. The right-hand panel of Figure 6.1 captures this inflection point with clarity. The global trade-to-GDP ratio, once the most emblematic indicator of globalization's progress, has remained relatively flat since 2008. FDI outflows as a share of GDP, after peaking in the early 2000s, have declined and stabilized at lower levels. The post-2008 era is thus not one of deglobalization per se, but rather of deceleration and structural maturation.

Figure 6.1: Global Trade and FDI Indicators (1990–2023)



Source: UNCTAD.

This duality continued growth in stock variables, but stagnation in flow raises important analytical and policy questions. The divergence is not merely statistical noise; it reflects a deeper transition in the organization of global production. Inflows of new FDI, especially greenfield investments, have slowed, while the existing multinational enterprise (MNE) networks built during earlier decades have continued to expand in value. The global FDI stock has grown smoothly and consistently, suggesting that retained earnings, reinvested profits and valuation gains on existing assets now dominate the evolution of global capital. This is especially evident in capital-intensive sectors where assets appreciate embedded know-how, scale economies and rising returns to technology.

Moreover, the slowdown in globalization is not limited to advanced economies. Emerging and developing economies, long viewed as the major beneficiaries of trade openness and cross-border investment, have also seen a moderation in their trade and FDI growth relative to GDP. The symmetry of the trend across income groups suggests that the observed deceleration is not driven solely by changes in the structure of demand in the Global North or by ageing populations in industrialized economies. Instead, it points to structural forces operating globally, ranging from rising geopolitical tensions and a reassessment of supply chain risks to the digitalization of services and a reconfiguration of economic geography in the post-COVID era.

At the same time, this evolution reveals an important shift in the binding constraints that determine who participates in globalization and how. If the early phase of GVC expansion was shaped by barriers to investment, such as fixed costs, institutional risk and knowledge diffusion then the present phase is increasingly defined by operational frictions: the liquidity gaps, counterparty risks and capital-access asymmetries that

prevent firms from remaining integrated in GVCs once the infrastructure is already in place.

On the financial side, one of the most significant and often underappreciated impediments to trade is the availability of trade and supply chain finance. In theory, once production structures have been established through FDI, firms should be well-positioned to leverage global demand. In practice, however, many firms – especially smaller suppliers in developing countries – face critical constraints in financing the working capital needed to participate in cross-border production. Payment cycles in GVCs can stretch over months, and firms that lack access to affordable short-term finance often find themselves excluded from higher-value linkages, even when demand exists and capacity is in place.

Against this backdrop of decelerating globalization, understanding the financial foundations of cross-border production becomes essential. This chapter therefore analyses globalization through a dual capital lens, showing how long-term investment (FDI) and short-term finance (TF/SCF) jointly sustain participation in global production networks. The first part examines how FDI establishes the structural foundations of production across borders, embedding technology, know-how and fixed capital. The second part turns to the liquidity architecture that keeps these networks operational, enabling firms to meet orders, manage risk and finance trade. Seen together, these mechanisms form a layered financial architecture of globalization, where investment and liquidity are complementary forces rather than separate domains. Understanding this interplay is essential to designing policies that promote a more resilient, inclusive and re-globalized world economy. The following section turns to the evidence on trade and supply chain finance, showing how liquidity constraints shape firm participation and, ultimately, the effectiveness of FDI-led integration.

6.2.2 Global Trade and Trade Finance

Having established how FDI provides the long-term foundation for global production, we now turn to the short-term financial mechanisms that keep those networks functioning. Even the most well-capitalized investment systems depend on day-to-day liquidity to move goods, process payments and manage risk. TF/SCF supply this liquidity layer, translating the structural capital of FDI into continuous cross-border production.

TF/SCF form the operational backbone of global value chains. They bridge the gap between production, shipment and payment, ensuring that firms of all sizes can exchange goods and services across borders. These instruments – including letters of credit, guarantees, credit insurance, and short-term working-capital loans – reduce counterparty risk and sustain liquidity along the supply chain. Without them, cross-border commerce would slow sharply, especially for small and medium-sized enterprises (SMEs) that depend on external finance to participate in trade.

The core functions of TF/SCF are risk mitigation and liquidity provision. Exporters seek payment assurance once goods leave their control, while importers require time to verify quality or resell before paying. Intermediate contracts reconcile these interests through structured payment mechanisms. Modern TF/SCF increasingly combines bank intermediation with insurance and fintech solutions that extend credit on the strength of invoices, purchase orders or buyer reputation rather than traditional collateral.

1. What is Trade and Supply Chain Finance, and What Does It Do for Traders?

Trade and supply chain finance comprise the short-term, operational layer of GVC liquidity. They include payment mechanisms, open accounts, documentary collections and letters of credit, alongside guarantees, credit insurance and working capital loans explicitly linked to trade flows. Provided by commercial banks, insurers, export credit agencies, factoring firms and digital platforms, these instruments collectively bridge the time and risk gaps that characterize most cross-border transactions. Their common function is to ensure that exporters are paid, importers receive goods on time and production networks continue operating even when trust, timing or liquidity are uncertain.

Box 6.1: Trade Finance Instruments at a Glance

Trade finance instruments mitigate payment and delivery risks in cross-border trade. They differ in who carries the risk exporter, importer or intermediary and in how much liquidity they unlock for production and shipment.

- Instruments enabling cross-border payments
- Instruments guaranteeing payments
- Loans enabling imports, production and pre-export finance
- Mixed instruments with more than one of the above objectives

Payment methods

Payment methods include:

Least secure ↓ Most secure	1. Cash-in-advance payments, often practiced in developing countries, requires the importer to pay for goods well in advance of receiving them – sometimes by as much as a year. This provides the exporter with payment certainty but leaves the importer (the buyer) with the full risk of default and of non-delivery. In effect, a cash-in-advance payment is a free credit granted by the buyer to the seller. It is non-performance based in the sense that, other than the contract, the buyer does not have the guarantee, upon payment, that the goods will be delivered in the required quantity and quality. 2. Letters of credit are the most widely used instrument within the category of documentary trade finance. In its simplest form, a letter of credit is a written commitment to pay and is typically issued by a bank on behalf of the buyer (importer) to the seller (exporter) or its bank. Letters of credit carry several obligations for the seller (delivery conditions, submission of documentation) and the buyer (notably the guarantee that if the buyer is unable to pay, the bank will cover the outstanding amount). 3. Documentary collections refer to the handling of documents by banks according to instructions received, typically by an exporter or their bank, to obtain either direct payment or acceptance of deferred payment. This differs to a letter of credit in that the bank faces no liability in the case of payment default or non-conformity of final goods.

continued on next page

Box 6.1: continued

	4. Open account payments usually indicate payments that occur following shipment or receipt of goods. While cash-in-advance payments provide full certainty to the exporter, open account payments provide certainty to the importer against any risk. In effect, an open account payment is a credit by the seller to the buyer. Similar to cash in advance, these payment arrangements are not bank intermediated but can be insured, where credit insurance is available. Otherwise, they leave the full risk of being borne by the exporter/seller. In academic literature, cash-in-advance and open account payments are sometimes referred to as "trade credit".

Payment Guarantees

In addition to payments, trade finance instruments guarantee future payments to the seller/exporter or the delivery of goods or services. Payment guarantees and stand-by letters of credit are where banks guarantee payment to the exporter on delivery of the goods. Letters of credit (depending on the type) can have dual roles of payment instruments and payment guarantees at the same time. Bid bonds and performance bonds fall into this category and help the recipient to mitigate counterparty risk in the delivery of goods or services.

Loans Related to the Production and Movement of Goods

Trade finance also includes working capital loans that are financing import, production, and/or export of cross-border goods, including: (i) pre-export finance, which finances expenditures before export deliveries take place; (ii) post-shipment/import finance to enable the importer to pay the exporter at a subsequent stage once the goods have been sold; and (iii) working capital loans related to a cross-border purchase order, which are lump sums borrowed to finance a firm's short-term needs and are more flexible ways to pre-finance imports and exports.

Supply Chain Finance

Supply chain finance (SCF) refers to financial techniques and structures mitigating the risk of operating in an open account payment environment. This includes risk mitigation practices to optimize the management of working capital locked in supply chain processes, explained in Box 6.3. Factoring, reverse factoring and anchor-based lending are part of these practices.

Trade finance is generally short term, covering transactions of less than one year – while longer-term financing for capital goods or infrastructure exports is classified by financial markets as export finance. Many trade finance instruments operate under internationally recognized legal standards, notably those set by the International Chamber of Commerce (ICC) for letters of credit and documentary collections.

Beyond traditional banking channels, trade credit may also be extended directly between trusted counterparties. In such cases, credit and political risk can be mitigated through insurance provided by export credit agencies and private insurers. Credit insurance has also expanded into the supply chain finance space, offering protection against payment default or insolvency and enabling firms to leverage receivables, purchase orders or invoices as collateral. These receivables-based instruments have become a key source of liquidity, especially for small suppliers.

Trade and supply chain finance systems together rely on a broad network of intermediaries – banks, insurers, export credit agencies and factoring firms – to manage the timing and risk asymmetries that define cross-border trade. Fundamentally, these mechanisms bridge the gap between when exporters seek payment for production and shipment and when importers can pay after receipt and verification of goods.

When trade finance facilities are limited or unaffordable, exporters must rely on their own working capital and face higher risks of non-payment, while importers may need to prepay and assume delivery risk. In extended value chains, these exposures can accumulate firms often act simultaneously as buyers and sellers, creating large volumes of payables and receivables. Open-account terms – common in modern supply chains with payment lags of 60-120 days – shift financing burdens to suppliers. Supply chain finance solutions such as reverse factoring and buyer-anchored liquidity programmes help mitigate these imbalances by converting receivables into cash and reinforcing liquidity throughout the production network.

2. Data Issues and Estimated Market Size

All institutions and individuals acknowledge the absence of reliable, globally consistent statistics covering trade finance instruments. As the International Monetary Fund, or IMF (2003) observed, "data on trade credit is not readily available", and the Bank for International Settlements, or BIS (2014) later confirmed that comprehensive global reporting still does not exist. Relying on the relatively basic distinction between bank-intermediated versus non-bank intermediate trade finance (including inter-company lending/credit). The BIS (2014) noted that while national banking statistics capture some of these flows, no systematic coverage exists at the global level. Some legally standardized instruments, such as letters of credit and documentary collections, are tracked through ICC and SWIFT systems. However, while most of these trade-related financial facilities and guarantees are identified and defined by national and international statistical manuals, such as the IMF's sixth edition of the Balance of Payments Manual, or the BIS Guide on International Locational Banking Statistics, they are rarely consolidated into a single framework, leaving researchers dependent on fragmented institutional or private data.

By combining the limited data sources available, the BIS (2014) estimates annual bank-intermediated trade finance flows at $6.5-8 trillion, roughly 35-40% of world merchandise trade at the time. Data on non-bank trade finance, including inter-company credit, factoring and reverse factoring remain far less transparent, though such channels are known to be significant. According to Berne Union statistics, cross-border short-term credit insurance coverage totalled about $2-3 trillion, with roughly two-thirds linked to non-bank inter-company credit.

While these figures overlap – for instance, insured letters of credit appear in both sources – they jointly suggest that total trade finance activity already exceeded $8 trillion a decade ago. Given subsequent growth in supply chain finance techniques and digital platforms and the relative decline of traditional letters of credit global trade finance flows are now likely above $10 trillion annually, though precise measurement remains elusive due to fragmented reporting and evolving market structures.

Box 6.2: Sources of Trade Finance Data

Insured trade credit (Berne Union): Data reports on transactions supported by Berne Union members. Annual flows were estimated at $3 trillion in 2023, most of which were short-term finance. Private insurers dominate the short-term segment, while export credit agencies have a larger share in the medium-to-long segment. Flows may overlap with other sources of data such as trade credit or letters of credit when they are insured or re-insured. This is also true for inter-company credit (supply chain finance) that is insured by a private or public insurer. See https://www.berneunion.org/DataReports.

Letters of credit (SWIFT): Reporting of letters of credit and documentary collections based on payment messages, including Category 4: flows for documentary collections, except the three least used cash letter messages, and Category 7: flows for commercial and standby letters of credit and guarantees. Annual flows are currently estimated at $2.5 trillion. While information on SWIFT messaging is restricted, occasional reporting can be found in the ICC Global Surveys on Trade Finance, and the Financial Stability Board Correspondent Banking Data Report. See https://iccwbo.org/news-publications/policies-reports/global-survey/ and https://www.fsb.org/uploads/P040717-4.pdf

Trade receivables (Eurostat): Available for only a few countries. See https://data.ecb.europa.eu/

Factoring and reverse factoring (Factoring Chains International, or FCI): Total factoring flows recorded by the FCI based on aggregate information collected from its members. Total factoring flows were estimated at $3.8 trillion in 2023 while international factoring flows were estimated at $754 billion. See https://fci.nl/en/industry-statistics

3. Literature on Trade Finance and International Trade

Productivity levels, the intensity of financial constraints and/or a firm's financial vulnerability might impact trade on the internal or external margins, or both (Chaney 2016; Manova 2013). The literature considered heterogeneity at many levels, across firms and sectors (Manova 2013); and lately across firms in countries at various levels of development, generally showing on the one hand a negative association between the higher cost, higher perception of risk and lower availability of trade finance, and on the other, exports especially to poorer and smaller economies (Demir, Michalski and Ors, 2017; Oefele, Schmidt-Eisenlohr and Yu, 2016; Niepmann and Schmidt-Eisenlohr, 2017; Paravisini et al., 2015).

Schmidt-Eisenlohr (2013) in investigating the underlying mechanisms between trade and financial conditions, studied firm contract payment choices. He found that both source and destination countries' legal and financial conditions affected trade flows through the type of trade finance obtained in these respective financial markets. In particular, the study found that the financing costs were proportional to the distance between the source and destination countries, which in turn significantly dampen trade: a percentage point increase in financing costs in a country was associated with 2% lower exports and 2.3% lower imports in that country.

Recent World Trade Organization (WTO)-International Finance Corporation (IFC) studies in West Africa and the transnational region of the Mekong showed that only 25% of goods trade was supported by trade finance. The share of bank-intermediated trade finance for the WTO-IFC target countries in West Africa is below the continental average of 40%, which is lower than the global average (AfDB 2020). In selective, fragmented trade finance markets, bank rejection rates for trade finance applications are high and tend to fall disproportionally on new clients and smaller firms. When selected, these firms face higher prices and collateral requirements.

Earlier literature showed that, while access to trade finance increased the probability of becoming an exporter, high cost of finance affected countries with a lower level of financial development and sectors with a higher level of financial vulnerability (Berman and Héricourt, 2010); hence a country's level of financial development affected firms' probability of becoming exporters. Firms with higher levels of financial vulnerability tended to depend on "lower" quality banks (Amiti and Weinstein, 2011).

Firm-level data from the World Bank Enterprise Surveys (WBES) show that 71% of the working capital needs of exporters in low- and middle-income countries (LMICs) are financed from internal funds and retained earnings while 18% (9%) are financed by bank and non-bank financial institutions (supplier credits). WBES data also shows that 40% of the total annual sales of exporters were paid post-delivery. In the absence of affordable trade finance, the lag between export financing and export earnings imposes severe liquidity constraints on firms (Contessi and De Nicola, 2013; Dornel et al., 2021).

Studies based on customs data show that for middle-income countries such as Türkiye, Chile and Colombia, trade takes place to an increasing degree on open account, as trust develops between local suppliers and foreign buyers (Ahn et al., 2011; Demir and Javorcik, 2018). While this offers opportunities for supply chain finance arrangements, supply chain finance markets are non-existent or in their infancy in many low-income countries, thereby leaving significant gaps between local firms and FDI-firms benefiting from foreign buyers' support. Recently conducted bank surveys helped identify key supply and demand constraints to expanding trade and supply chain finance markets, from high collateral requirements used as offsets for weak contract enforcement, to limited financial literacy, lack of capacity and scale of local banks, absence of non-bank solutions, insufficient access to foreign currency and shortages of low-cost funding (Beck et al., 2023; IFC and WTO, 2022, 2023).

The unequal distribution of TF/SCF access across firms mirrors the broader asymmetries observed in FDI flows. Just as investment tends to cluster in established hubs, liquidity also concentrates among large, well-connected firms, leaving smaller suppliers financially marginalized. Understanding these asymmetries is essential to designing policies that connect both long-term and short-term layers of finance in a more inclusive way.

6.2.3 Trade Finance and Heterogeneity

1. Trade Finance Across Countries and Levels of Development

Building on the preceding discussion, this section examines how liquidity frictions translate into firm-level disparities. The distribution of trade finance access reflects the same concentration patterns seen in FDI, capital clusters around incumbents, while liquidity gaps persist for smaller and newer firms. Indeed, availability and cost vary greatly across countries and levels of development. The literature established

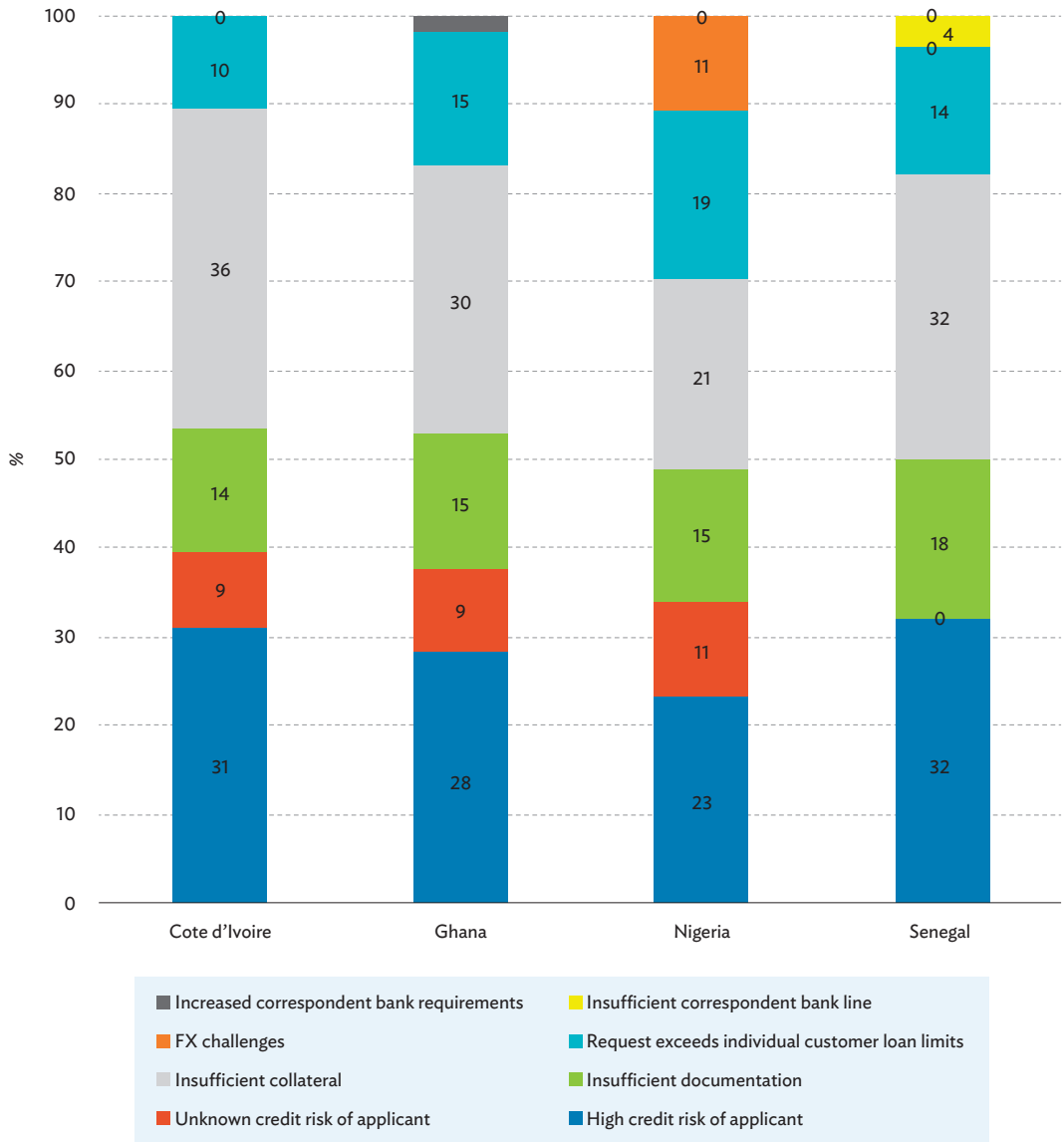
that, while access to trade finance increased the probability of becoming an exporter, high cost of finance affected countries with a lower level of financial development and for sectors with a high level of financial vulnerability (Berman and Héricourt, 2010); hence a country's level of financial development affected firms' probability of becoming exporters. Firms with higher levels of financial vulnerability tended to depend on "lower" quality banks (Amiti and Weinstein, 2011). Financially vulnerable industries were more sensitive to the cost of external capital than exports of less vulnerable industries, with such sensitivity growing during periods of financial crises (Chor and Manova, 2012). In general, the level of financial development in the host country is a key institutional characteristic that dampens the horizontal motive for FDI and favours vertical and export platform forms of multinational activity (Bilir et al., 2019).

According to the Asian Development Bank (ADB), global trade finance gaps in developing countries, a measure of rejections by banks of trade finance requests from exporters and importers, reached $2.5 trillion in 2022, against $1.4 trillion in 2018. Part of such rejections is justified on the grounds of lack of creditworthiness of firms, a motive that can also be found in developed countries; but part of rejections is also attributed to supply and demand factors which are more specific to developing countries, such as lack of collateral or lack of compliant (poorly documented) applications, lack or insufficient correspondent banking relations and lines of credit, insufficient access to foreign currency and lack of scale for local banks (which prevents them from financing higher value trade transactions), and shortages of low cost funding (Beck et al., 2023; IFC and WTO, 2022, 2023).

While statistics on rejection rates are not available for all countries, existing surveys indicate that rejections rates by banks for trade finance applications can be high in low-income regions, such as in West Africa (25% of the value of requests), against 12% for the continent as a whole (AfDB, 2020; IFC and WTO, 2023). There can be legitimate reasons for rejections, particularly if presented applications are risky or non-compliant. Besides, not all rejections translate into foregone trade – only 20-40%, according to existing literature and other surveys (Nyantakyi et al., 2022). However, blocked trade finance applications lead firms to look for less optimal solutions such as drawing on their own funds, borrowing through informal (and more expensive) channels, from their suppliers and micro-credit institutions (IFC and WTO, 2022).

As shown in Figure 6.2, lack of collateral and high perception of the applicant risk are at the top of the list of banks' motives for rejections in Africa. In international trade, though, the merchandise itself is used as collateral for trade finance. International business law makes it possible to seize and resell such merchandise in case of default. In low-income countries, further collateral is often sought by banks in doubt that legal enforcement mechanisms would not allow them to take ownership of the merchandise in case of default.

Figure 6.2: Trade Finance Rejections in West Africa



Source: IFC and WTO (2022).

High Prices and Self-Exclusion

Previous rejections of applications and high levels of selectivity prompt firms to simply refrain from applying to banks altogether. Self-exclusion may also be induced by higher prices than benchmarks in other emerging markets where financial markets are more developed or competitive.

As a result of high selectivity, self-exclusion and high prices, the share of trade supported by trade finance stood only at 8% in Mexico, 15% in Senegal, 20% in Nigeria and 20% in Viet Nam, and even significantly less so in Cambodia and in Lao People's

Democratic Republic (PDR) (3%). These low shares can be compared to the average of the African continent (40%), which incorporates emerging markets such as Egypt, Morocco and South Africa, hosting some of the continent's largest banks. According to the BIS (2014) and WTO (2016), the share of trade supported by trade finance in developed countries would appear to be equal or superior to 60%.

Indeed, developed countries and advanced emerging markets can rely upon financial centres mobilizing sophisticated banks and instruments, such as supply chain finance, on a large scale. Considering that trade finance is typically a short-term and low risk type of financing, in advanced economies 90-day letters of credit and pre-shipment facilities are available at low prices, close to the inter-bank rate.

By contrast, trade finance prices can significantly exceed global emerging market benchmarks in low-income countries, even though the ICC's data on trade finance default does not single out Africa or any other emerging region as recording significantly higher financial delinquency on trade. However, several cumulative factors such as foreign exchange scarcity, lack of competition, high processing fees due to limited digitalization, and a high perception of risk towards new customers may explain the high price margins recorded in the IFC-WTO surveys.

The average charge for confirmed letters of credit was reported to be around 3.5% of the transaction value in Nigeria, 4% in Côte d'Ivoire and Senegal, and 3.5% in Cambodia and Viet Nam for the limited number of companies to which such facilities were available, compared with a 2% global average for emerging markets and 0.25-0.5% typically observed in advanced economies. Short-term working capital pre-shipment facilities were priced at 9% above the bank's refinancing rates in Côte d'Ivoire and Senegal, 12% in Nigeria. In Cambodia, average charges above the refinancing rate would not exceed 5% but could easily reach 7-8% for firms with lower credit rating.

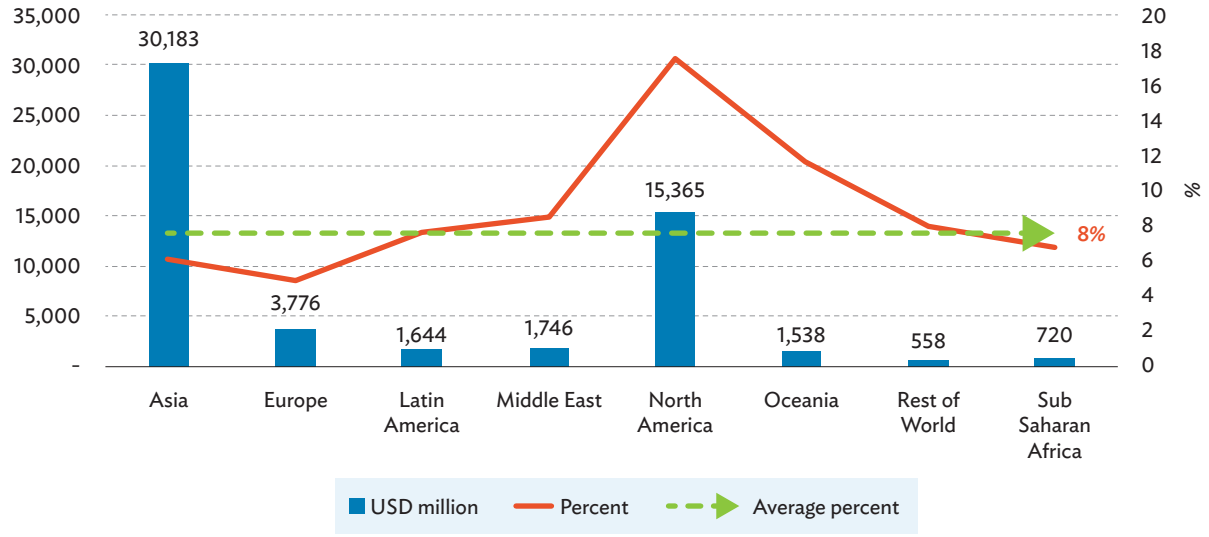
In such rationed markets, where the risk perception of lenders towards potential borrowers is high, limited available trade finance goes to well-established companies first, if not exclusively (IFC & WTO, 2022, 2023). In the regions (Economic Community of West African States, or Ecowas, and Mekong in particular), trade finance is concentrated, with too few banks directing too little finance towards a small group of well-established traders, contributing to "freezing" the existing product profile of traded goods. The reports concluded that more trade finance, at lower cost, could help achieve a more diversified trade mix for low-income countries and expand regional trade.

Market selection and segmentation also affected countries well integrated into global value chains, such as Cambodia and Viet Nam. For example, in Viet Nam, international firms producing within the country could get supply chain finance support from global

banks abroad. Large, "first tier" local companies could obtain trade finance from local institutions, albeit at rather expensive rates. However, producers downstream in supply chain production rarely qualify for trade finance. Considering the high rejection rates for trade finance applications, the high costs for trade finance, and the low coverage of trade in recent WTO-IFC studies, counterfactual scenarios were carried out using the WTO global trade model.

It was calculated that raising trade coverage from 25% to only 40% in both the West African and Mekong regions, and reducing the cost of trade finance to advanced emerging economies' benchmarks, would increase annual trade flows by 8% on average, as shown in the Figure 6.3. Roughly three-quarters of the gains would accrue from the potential increase in the share of trade, and about 20% from the reduction in the cost of trade loans. In both regions, intra-regional trade would be boosted significantly, supporting locally owned economic sectors or supply chains.

Figure 6.3: Increase of Exports and Imports By Trading Partner, USD Value and Percentage Growth



Source: IFC and WTO (2023).

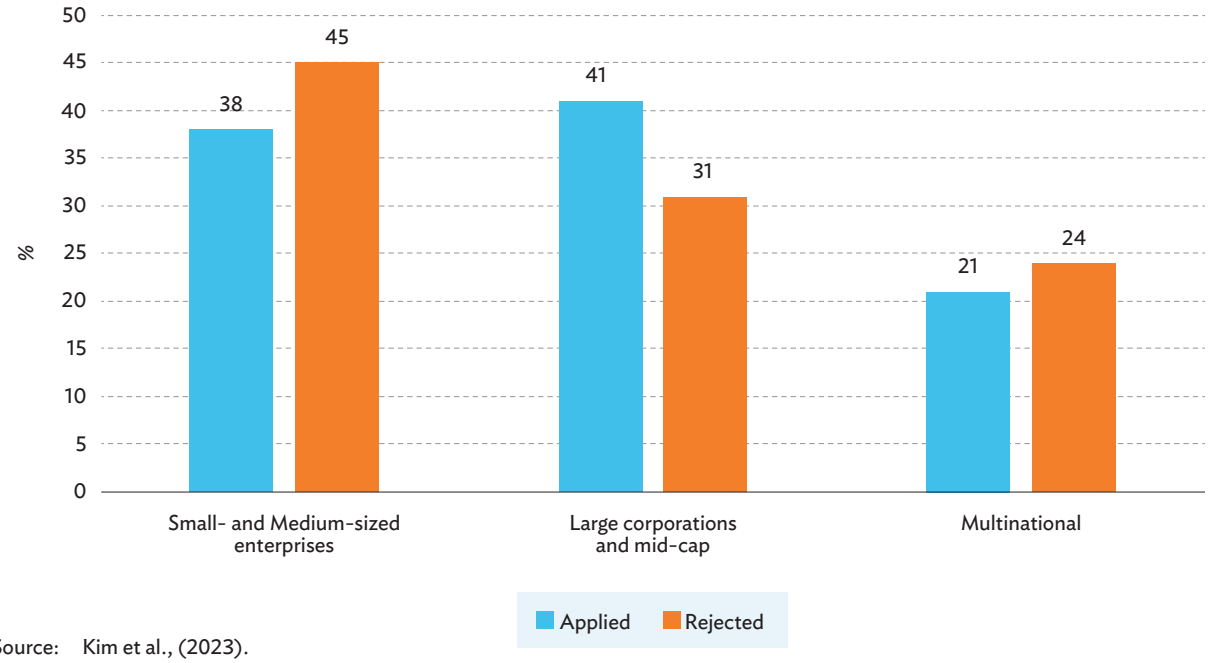
2. *Firm Heterogeneity: SMEs Versus Large Companies*

Access to trade and supply chain finance remains highly uneven across firms. As detailed in Chapter 2 (see Section 2.3), micro, small and medium-sized enterprises (MSMEs) face persistent structural barriers that limit their ability to obtain affordable financing. These include high collateral requirements, insufficient credit histories and

weak relationships with financial intermediaries. Even where aggregate trade finance volumes expand, access remains concentrated among a few large and well-connected firms, leaving smaller producers and new entrants underserved.

These asymmetries are evident across developing regions. In Africa and Southeast Asia alike, liquidity and risk-mitigation instruments are typically available only to top-tier firms or multinational suppliers, while domestic SMEs rely heavily on internal funds or informal credit. The concentration of intermediation within a narrow set of banks and anchor buyers constrains the diffusion of liquidity along supply chains, reinforcing segmentation within global and regional production networks.

Figure 6.4: Applications and Rejections by Firm Type



Source: Kim et al., (2023).

Differences in firms' risk profiles are often evidenced by the collateral requirements and approval time for trade finance applications. Banks in the survey said they frequently ask for additional collateral because shortcomings in local legal enforcement make them uncertain that they would be able to seize and resell merchandise. Foreign firms are likely to obtain better lending conditions in terms of collateral requirements while at the same time having their trade finance applications approved significantly faster.

In the IFC-WTO study on trade finance in West Africa, it was established that SMEs customarily pay higher interest rates than large corporates. In both West Africa and the Mekong region, large companies may be charged no more than 4-5% above the refinancing rates, while the corresponding premium for SMEs stands at 7-9%. The same goes for import financing.

Local companies, mostly SMEs, with their smaller balance sheets, are more likely to face onerous collateral requirements and often lack the financial sophistication to negotiate effectively with their financiers. As an illustration, over two-thirds of Ecowas respondents stated that SMEs and micro-enterprises face higher rejection rates than other categories of applicants, pointing to the fact that SMEs, including women-owned SMEs, are disproportionately affected by trade finance gaps, and more likely to be excluded from formal financing channels.

These patterns underscore a central insight of this chapter: structural capital without liquidity yields shallow integration, while liquidity without investment traps firms in low-value added roles. The following section explores how new financial instruments, such as supply chain finance platforms, can bridge this divide.

6.2.4 Supply Chain Finance

1. From Trade Finance to Supply Chain Finance

Having traced how liquidity asymmetries fragment participation, we now examine how supply chain finance innovations attempt to reconnect those missing links, turning financial architecture into an instrument of inclusion.

Supply chain finance represents an increasingly important evolution within the broader universe of trade finance, reflecting the structural transformation of global production from bilateral trade relationships to complex, multi-tiered value chains. While traditional trade finance instruments – such as letters of credit or documentary collections – focus on the risks and liquidity needs associated with cross-border transactions between exporters and importers, supply chain finance is concerned with the financial frictions that emerge within the production process itself (See Box 6.3). It operates further upstream, offering financing solutions that help firms manage their cash flows not only at the point of export, but throughout the entire chain of production, assembly and delivery.

At its core, supply chain finance seeks to improve working capital by unlocking liquidity tied up in receivables and payables. It enables suppliers – often smaller and less creditworthy firms – to receive early payment on their invoices at a discount, based on the stronger credit profile of the buyer, sometimes referred to as the “anchor firm”. This dynamic is especially important in open account transactions, where goods are delivered well before payment is due, a common practice in today’s global supply chains. Instruments such as factoring, reverse factoring (also known as confirmed payables finance), dynamic discounting and payables-backed loans all fall under the SCF umbrella. These tools help mitigate the risks associated with long payment cycles, which, if left unaddressed, can create liquidity bottlenecks that ripple through an entire value chain.

The relationship between TF and SCF is best understood as complementary rather than substitutive. Traditional trade finance ensures that goods can cross borders safely and efficiently, providing the necessary liquidity and risk of mitigation for export transactions. Supply chain finance, by contrast, ensures that the flow of intermediate goods, components and services feeding into those exports is not disrupted by financial constraints. In effect, TF supports the "front-end" of cross-border exchange, while SCF undergirds the "back-end" of production and delivery, particularly where input sourcing and assembly are fragmented across jurisdictions. Together, they form a financial infrastructure that mirrors the architecture of global production itself – layered, interdependent and highly sensitive to disruptions at any point in the chain.

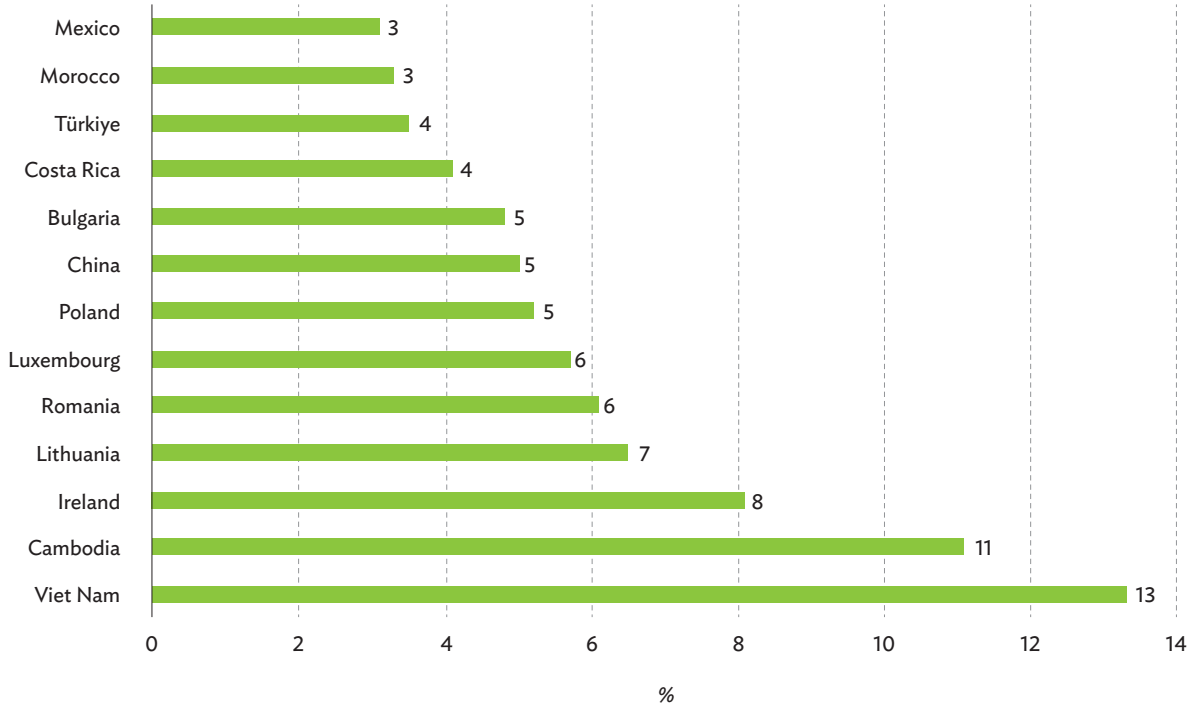
From a policy perspective, supply chain finance offers both a diagnostic lens and a lever for action. Its uptake, or absence, can serve as an indicator of how well financial systems are supporting deeper integration into GVCs, particularly at the lower tiers where suppliers are most vulnerable. Governments and development finance institutions have begun to take notice. Programmes such as Mexico's Nacional Financiera (Nafin) platform, which offers reverse factoring solutions backed by public guarantees, demonstrate how public policy can catalyse SCF uptake and improve SME inclusion. In regions like West Africa and Southeast Asia, efforts by the WTO and IFC to map the landscape of supply chain finance, assess constraints and support new platforms are laying out the groundwork for more inclusive financial ecosystems. As global supply chains continue to evolve, SCF will remain a critical element of the financial toolkit – one that must be nurtured alongside traditional trade finance to ensure that the gains from globalization are more evenly shared.

2. The Rise of Supply Chain Finance

About half of global trade is supply chain trade (UIBE, 2023), a share that is on the rise (49% in 2022, up from 46 in 2011). Supply chain trade is prevalent in large manufacturing sectors such as electronics and electric generation, motor vehicles, aeronautics, textiles and clothing, and food processing. Many developing countries and emerging markets have increased their participation in supply chain production in recent years.

SCF covers a relatively wide variety of financial instruments, techniques and arrangements, ranging from receivable financing to buyer-backed financing, under which banks supply liquidity to suppliers on the back of the buyers' credit rating (Box 6.3). The cross-border part of supply chain finance is the "tip of the iceberg" in a market where exported goods or components qualify as international SCF, and payment flows between domestic suppliers qualify as domestic supply chain finance. Notwithstanding this distinction, where domestic supply chain finance exists, the cross-border component would tend to expand as well. In Europe and North America, domestic SCF techniques such as factoring and reverse factoring have existed for decades in domestic trade (distribution, supermarket chains). Technology, improved

Figure 6.5: Selected Economies' Average Annual Growth in GVC Participation, 2010-2020



Source: WTO (2023).

risk management and adequate legal frameworks convinced banks to internationalize their programmes, mainly for their clients operating overseas, mostly multinational companies.

Yet only few countries operate full indigenous supply chain finance platforms. With the gradual adoption of e-invoicing in Latin America, the factoring market developed since the turn of the millennium in Mexico, Brazil, Chile and Colombia. Rising supply chain production provided good grounds for the Mexican market to expand, with domestic segment SCF being now roughly four times as large as the international one (WTO-IFC, 2025). However, even in Mexico, international banks dominate the supply of such finance on local and international platforms, despite the existence of at least two local factoring platform (e-Factor Diez and Nafin's).

Data from joint trade finance surveys conducted by the IFC and the WTO illustrate the limited (albeit growing) intake of international chain finance in emerging markets. In countries like Viet Nam and Cambodia, where many small firms have managed to tap into supply chains in sectors like textiles and consumer electronics despite operating primarily on a cash basis, shortages of supply chain finance are significant. Although more than 50% of these countries' trade is supply chain related, only 0.5% of their trade is supported by SCF from local financial institutions. Local and international financial institutions in the most advanced emerging market in these surveys, Mexico, provided

$12 billion in supply chain finance for cross-border operations in 2023, all programmes considered: anchor-based liquidity supplied through main buyers, factoring and reverse factoring generated either from local or international platforms. Yet, this relatively advanced market accounting for 18% of total trade and supply chain finance supplied in Mexico, supported only 1% of total Mexico's trade in that year. Some 90% of all SCF was provided by only three banks, with multinational corporations being the main clients (WTO-IFC, 2025). As the main buyers, their participation in these programmes may support tier-one or tier-two suppliers. However, "deep-tier" financing remains elusive.

It has been observed that a significant share of trade finance granted locally, when available, was provided in the form of expensive working capital lines or overdrafts, mostly as a substitute for lack of supply chain finance. Yet, this was far from being generalized. In Viet Nam, 70% of exporting SMEs in Viet Nam experienced difficulties accessing such working capital. In Mexico, 75% of MSMEs did not qualify for bank loans. In sectors such as textiles and clothing and electronics, the implication of local banks in securing buyer-seller financing arrangements was particularly low (WTO-IFC, 2023, 2025), with many small actors operating on suboptimal cash or informal arrangements.

By contrast, in developing countries supply chain finance is relatively common for local suppliers in the electronics, aeronautics, automotive and agri-food industries.

Access of firms to trade and supply chain finance is, to a large extent, a factor in the overall level of financial inclusion. In Mexico, the WTO and IFC found that, on average, only 25% of importers and exporters had access to bank loans, with significant firm heterogeneity (41% for large firms, 8% for micro-enterprises). Despite the progress in digital banking, many traders remained without any access to financing, let alone trade and supply chain finance, which appeared in this context as a "premium product" mostly available to large firms (WTO-IFC, 2025).

For the majority of MSMEs – securing SCF from local banks is a significant challenge even when local platform exists. Companies must be identifiable as right holders; high costs may apply to them in the form of higher discount rates on invoices and higher interest rates for buyer's backed liquidity. Without fintech assistance, the assessment of credit risk proves to be difficult.

Yet, the benefit of increasing supply chain finance in developing economies is substantial. WTO research (Auboin et al., 2016) showed that a 10% increase in the use of international factoring can boost countries' trade by 1%. Recent firm-level data from China shows strong positive association between firm's export related notes receivables and export earnings (Liu et al., 2024). In this way, SCF innovations extend the logic of FDI: they embed finance directly into production networks, creating a continuum between structural investment and operational liquidity.

Box 6.3: Definition of Supply Chain Finance from the Global Supply Chain Finance Forum

In 2016, a group of senior trade bankers and lawyers worked at establishing a standard but broad definition of supply chain finance, under the aegis of several professional organizations such as the Bankers Association for Finance and Trade, the Euro Banking Association, Factors Chain International, the International Chamber of Commerce and the International Trade and Forfaiting Association.

The Global Supply Chain Finance Forum (GSCFF) defined SCF as the "use of financing and risk mitigation practices and techniques to optimize the management of the working capital and liquidity invested in supply chain processes and transactions" (GSCFF, 2016, p. 24). The forum further highlighted that "SCF is typically applied to open account trade and is triggered by supply chain events", further noting that the "visibility of underlying trade flows by the finance provider(s) is a necessary component of such financing arrangements which can be enabled by a technology platform".

The Forum argued that SCF is an evolving set of practices using or combining a variety of techniques. Buyers and sellers in these transactions work with finance providers to raise finance using SCF techniques that are at varying levels of novelty – at one extreme using cutting edge techniques and at the other using variants of traditional trade finance. The techniques are often hybrid, additionally employing other financial and physical supply chain services. Finance providers offer their services in the context of the financial requirements triggered by purchase orders, invoices, receivables, other claims and related pre-shipment and post-shipment processes along the supply chain. Such techniques include, inter alia, receivable and invoice finance (factoring and reverse factoring), financing against purchase orders, pre- and post-shipment lending, insured inter-company credit and generally working capital arrangements obtained by participants in the supply chain on the back of the good credit rating of large buyers.

In this sense, SCF can be seen as a general portfolio of financing and risk mitigation techniques and practices supporting the trade and financial flows along the supply and distribution chains, domestically as well as internationally. It is important to note that supply chain finance does not only involve the international part of the transaction, but most often domestic value addition and distribution.

Source: GSCFF (2016).

6.2.5 Access to Finance and Trade Opportunities: A Quantitative View

Building on the preceding discussion of how financial mechanisms – such as trade credit, factoring and supply chain finance – embed liquidity into production networks, it is important to assess the scale and structure of these effects systematically. While qualitative evidence highlights the growing integration of finance and trade, the magnitude of this relationship remains an empirical question. How much do well-developed financial systems enhance trade and investment flows? Do countries with more compatible financial architectures participate more deeply in global value chains? To address these questions, the following analysis turns to a quantitative framework that links macro-financial indicators with trade and FDI outcomes across economies.

Building on the earlier discussion of trade finance as a layered system of constraints, this section draws on a bilateral gravity framework to estimate how financial compatibility between countries affects the intensity of their trade and FDI relationships. The empirical approach is grounded in a well-established tradition in international economics: controlling for economic size and geographic distance, we examine how bilateral trade and investment flows respond to differences in financial system development and depth.

The analysis uses cross-sectional data in 2019 covering 114 countries, resulting in a stable panel of 982 country pairs. Trade data is sourced from the Centre d'Études Prospectives et d'Informations Internationales (CEPII)'s Base pour l'Analyse du

Commerce International (BACI) database, which provides harmonized information on bilateral merchandise flows. FDI stock data comes from the World Bank's Bilateral FDI dataset (WBG-HBFDI), which captures the cumulative value of cross-border investment positions. To measure financial development, we draw on the World Bank's Global Financial Development Database (GFDD), focusing on standardized indicators of private credit and stock market capitalization. These variables serve as proxies for the depth of the banking sector and the sophistication of capital markets, respectively. All financial indicators are constructed as bilateral interactions – multiplying origin and destination values – to capture the idea that financial compatibility is a joint property of both economies. A more detailed breakdown of the data construction and modelling approach is provided in Part II of this report, which focuses on FDI's role in GVC development.

Table 6.1: Gravity Estimation of Trade and FDI in 2019

Gravity Model Results 2019: Standardized Bilateral Financial Variables

	Trade Models			FDI Stock Models			FDI Flow Models		
	(1) Basic	(2) +Bilat PC	(3) +Bilat SM	(4) Basic	(5) +Bilat PC	(6) +Bilat SM	(7) Basic	(8) +Bilat PC	(9) +Bilat SM
Log Distance	-0.979***	-0.979***	-1.014***	-1.089***	-1.153***	-1.100***	-1.006***	-0.979***	-1.135***
	(0.034)	(0.037)	(0.048)	(0.056)	(0.064)	(0.079)	(0.077)	(0.087)	(0.107)
Bilateral Private Credit (O×D)(std.)		0.104			0.277*			0.521**	
		(0.093)			(0.158)			(0.224)	
Bilateral Stock Market (O×D)(std.)			0.302***			0.047			-0.242**
			(0.050)			(0.131)			(0.123)
Observations	944	793	392	944	793	392	704	592	313
R-squared	0.920	0.915	0.930	0.786	0.794	0.777	0.702	0.717	0.719
Fixed Effects	Origin+Destination								

Note: 2019 cross-section. Robust standard errors in parentheses,*** p<0.01,** p<0.05, * p<0.1. Coefficients for bilateral private credit (OxD) and bilateral stock market (OxD) are standardized. They represent the effect of a one standard deviation increase in each bilateral financial variable. For example, a coefficient of 0.302 implies that a one standard deviation increase in bilateral stock-market development raises trade by 30.2%.

Source: CEPII BACI, World Bank Bilateral FDI (WBG-HBFDI), World Bank GFDD.

Table 6.1 presents the gravity estimation results. As expected, distance remains a powerful barrier to cross-border economic activities. Across all models, the distance elasticity for trade hovers around -1, consistent with the historical benchmark. FDI flows and stocks exhibit even greater sensitivity, underscoring the importance of spatial frictions and information asymmetries in investment decisions, even in a digitally connected global economy.

More revealing, however, are the results that emerge once bilateral financial development is introduced. On the trade side, the depth of capital markets emerges as a strong and statistically significant facilitator of international commerce. When both countries in a trading pair have well-developed stock markets, their bilateral

trade flows increase substantially. This relationship holds even after accounting for country fixed effects, suggesting that the effect is not merely a function of individual country size or geography, but a deeper complementarity in financial infrastructure. In short, when firms on both sides of the border can access equity markets, they are better equipped to manage liquidity, extend supplier credit and navigate payment risks, thereby reducing the frictions associated with cross-border transactions.

In contrast, banking sector depth plays a more muted role in explaining trade flows. Although private credit is positively associated with trade, the relationship lacks statistical significance once other controls are included. This suggests that capital markets, not banks, are the more decisive channel for enabling arms-length trade, particularly in environments where working capital and trade credit need to be mobilized quickly across borders.

The story shifts meaningfully when turning to foreign direct investment. Here, bilateral banking depth exerts a stronger influence, particularly in the case of FDI flows, where deeper joint credit markets are associated with significantly larger investment volumes. This is consistent with the idea that banks play a more active role in funding new cross-border ventures and facilitating the movement of capital through syndicated loans or acquisition financing. Stock market development, by contrast, shows no significant effect on FDI stocks and a negative relationship with FDI flows. One possible interpretation is that capital market development and FDI serve, to some extent, as substitutes: when equity financing is readily available, firms may be less reliant on multinational structures to achieve international scale.

Taken together, the results point to a clear distinction between the financing architectures that underpin trade and those that underpin investment. Capital markets facilitate trade by lowering transaction costs and enabling decentralized credit relationships, while bank-based systems are more directly linked to the flows of capital that support the expansion of multinational firms. This divergence helps explain why trade and FDI do not always move in tandem and why strengthening both market-based and bank-based financial systems may be necessary to fully unlock the benefits of global integration.

These findings reinforce a central theme of this report: access to finance – particularly well-matched finance across borders – is a foundational determinant of GVC participation. Capital-scarce economies cannot rely on investment alone to integrate into global production networks. Without the financial infrastructure to support trade, local suppliers – especially SMEs – remain excluded from the opportunities created by globalization. A resilient and inclusive financial system is thus not merely a macroeconomic asset, but a key enabler of sustained, broad-based trade-led growth.

6.3 Foreign Direct Investment as a Catalyst for Global Value Chain Assimilation

The second part of this chapter turns from liquidity to structure, from the short-term financing mechanisms that keep production moving to the long-term capital that anchors it. FDI represents the structural layer of the GVC financial system, embedding technology, managerial know-how and fixed assets that shape where and how production takes place. In contrast to the working capital finance examined in Part I, which determines which firms can stay operationally connected, FDI defines how deeply economies are integrated and how effectively they can upgrade within global production networks. Together, these two forms of capital – structural and operational – constitute the unified financial architecture of reglobalization: liquidity keeps the system in motion, and investment gives it direction and durability.

6.3.1 Foreign Direct Investment and Trade: Literature Review

FDI has long been recognized as one of the central mechanisms shaping globalization. It is not only a vehicle for moving capital across borders, but also a primary channel through which technology, management know-how and organizational practices spread. More than simply financing multinational expansion, FDI has become a structural force that organizes trade patterns, shapes the geography of GVCs, and increasingly determines which countries and firms capture the gains from international integration (Helpman, 1984; Antràs and Helpman, 2004).

The theoretical understanding of FDI has evolved considerably over time. Early work in the 1960s and 1970s emphasized that FDI could not be explained by frictionless models of capital flows. Instead, it reflected firm-specific advantages – such as proprietary technologies, brands and organizational capacity – that encouraged companies to internalize production across borders rather than rely solely on contracts or licensing (Hymer 1976; Vernon 1966; Kindleberger 1969). This thinking crystallized in John Dunning's "eclectic paradigm", which highlighted three necessary conditions for investment abroad: ownership advantages, location benefits and the efficiency gains from internalization (Dunning, 1977; Dunning, 1981). These insights remain relevant today, particularly in explaining why multinationals continue to expand in contexts where financial markets are incomplete or legal enforcement weak (Buckley and Casson, 1976; Williamson, 1985).

A long-standing debate in the literature centres on whether FDI and trade are substitutes or complements. Horizontal FDI (HFDI), where firms replicate operations abroad to serve local markets, was initially seen as a substitute for trade – especially in high-tariff environments (Markusen, 1984; Brainard, 1997). In contrast, vertical FDI (VFDI), where firms locate different stages of production across countries to reduce costs, typically complements trade by generating cross-border flows of intermediate goods (Helpman, 1984).

Subsequent theoretical advances have moved beyond this dichotomy. The knowledge-capital model developed by Markusen (1995, 2002) integrates both horizontal and vertical motives, while Helpman, Melitz and Yeaple (2004) introduce firm-level heterogeneity into the analysis, showing that only the most productive firms engage in FDI. Their framework also underscores the importance of market frictions and firm matching in determining internationalization strategies. Empirical studies largely support the view that FDI and trade are more often complements than substitutes. Lipsey and Weiss (1981, 1984) found that US affiliates abroad both import inputs from their parent firms and boost exports to third countries. More recently, Tintelnot (2017) and Antràs and Chor (2013) demonstrate that firms use FDI strategically to manage complex supply chains, often investing in a single country to export regionally or to optimize access to multiple markets. These patterns are amplified in the context of deep trade agreements, which reduce entry costs and harmonize regulations (Tintelnot, 2017).

From a development perspective, the literature highlights both opportunities and risks. On the one hand, FDI can generate productivity spillovers to local suppliers and labour markets, particularly when strong backward linkages are present (Javorcik, 2004; Alfaro et al., 2004). Meta-studies confirm that such spillovers are real but conditional on host country characteristics such as human capital, infrastructure and institutional quality (Havranek and Irsova, 2011). More recent work using transaction-level data reveals long-term benefits for domestic firms that become part of MNE supply chains, including sustained productivity gains and access to new buyers (Alfaro et al., 2022; Carballo et al., 2023).

At the same time, FDI flows are increasingly shaped by geopolitical realignments and strategic concerns. Since the war in Ukraine, investment patterns have become more clustered along political and security lines, with countries prioritizing resilience and "friend-shoring" over pure efficiency (Gopinath et al., 2025). Connector countries with ties to multiple blocs are emerging as key investment hubs (Gopinath et al., 2025), suggesting a reconfiguration of the global FDI network.

These empirical insights have been greatly enhanced by advances in data. The World Bank's Harmonized Bilateral FDI (WBG-HBFDI) database provides detailed bilateral FDI stock data across more than 250 economies, while firm-level sources like Orbis Cross-border Investment Database enable real-time tracking of multinational strategies (Steenbergen et al., 2022; Bureau van Dijk (Moody's Analytics), n.d.). These tools are critical for understanding the micro-dynamics of FDI and for designing policy frameworks that can unlock its developmental potential. We further build on these data resources in Part II of this chapter, where we analyse network-level features of global FDI and trace their implications for GVC participation.

6.3.2 Data Sources

Understanding the evolving role of FDI in global trade requires empirical tools that can meaningfully capture how capital flows map onto production and trade structures across countries and sectors. Our analysis builds on a set of harmonized and complementary data sources that, when combined, enable us to track FDI patterns, production linkages and trade relationships across time and geography with considerable granularity.

At the centre of our dataset is the WBG-HBFDI database, a comprehensive, cleaned and policy-relevant resource that consolidates bilateral FDI positions and flows for more than 250 reporting and partner economies. Developed by Steenbergen et al. (2022), the WBG-HBFDI addresses long-standing issues in global FDI data – such as inconsistency in definitions, directionality mismatches and mirror asymmetries – by applying a rigorous, multi-source harmonization process. The dataset integrates official data from four principal repositories: the IMF's Coordinated Direct Investment Survey (CDIS), the Organisation for Economic Co-operation and Development's (OECD) International Direct Investment Statistics, United Nations Conference on Trade and Development's (UNCTAD) bilateral FDI matrix, and China's Ministry of Commerce statistical bulletins. To reconcile discrepancies and maximize coverage, the World Bank team applies a multi-step algorithm that prioritizes host-reported OECD data, then leverages mirror statistics and secondary sources to fill gaps. For each country-pair-year observation, the dataset includes metadata on the underlying source, coverage quality, use of estimation or inference, and whether the value is directly reported or derived. Special flags also identify tax haven jurisdictions and transactions involving special purpose entities (SPEs), allowing researchers to explicitly test the sensitivity of results to the presence of so-called "phantom FDI".

We draw on two key files from the WBG-HBFDI suite. The first is the aggregate bilateral dataset, which reports inward and outward FDI flows and stocks between all available country pairs from 2001 to 2021. This dataset forms the empirical backbone of our gravity analyses in Part I and the network-based exploration of FDI-GVC linkages in Part II. The second is the sectoral disaggregated file, which breaks down FDI stocks across 24 sectors based on International Standard Industrial Classification of All Economic Activities (ISIC) Rev.4 classifications. Importantly, this sectoral coverage is constructed using a combination of direct reporting and mirror imputation. While only 42 countries report sector-specific FDI stocks – including major source countries such as the US, Japan, South Korea, Canada, Singapore and Brazil – the mirror methodology enables estimation of sectoral exposure in a broader set of developing countries. Together, these two datasets comprise more than 1.5 million observations and offer the richest publicly available mapping of bilateral capital relationships over the past two decades.

In addition to FDI data, we incorporate production and input-output linkages from the World Input-Output Tables (WIOT) 2016 (World Input-Output Database, or WIOD, 2016), which are part of the broader WIOD project. WIOT provides annual supply-use matrices for 43 economies (plus a rest-of-world aggregate), covering 56 sectors from 2001 to 2014. This data enables us to trace sector-specific flows of intermediate goods, final demand and gross output, and to construct measures of forward and backward linkages along value chains. We complement WIOT with the bilateral capital supply-use dataset developed by Ding (2023), which imputes bilateral capital service flows – including both tangible assets like machinery and intangible inputs like research and development (R&D) – based on a calibrated neoclassical growth framework. Importantly, we extend Ding's original cross-section to a panel format, thereby generating annual bilateral capital-use estimates at the country-sector level.

To match investment patterns with trade flows, we merge these datasets with disaggregated merchandise trade data from CEPII's BACI database (HS02 classification). BACI reconciles UN Comtrade records using mirror data and cross-declarations, producing consistent bilateral trade values and quantities for roughly 5,000 six-digit products and over 200 countries. We aggregate these flows to the country-pair-year level to align them with the structure of the FDI datasets, ensuring consistent partner definitions and temporal coverage.

All variables are retained in current US dollars, and we preserve negative FDI entries where they reflect disinvestment or position reversals. Data integration is performed using International Organization for Standardization's three-digit ISO3 country codes, and all sectoral mappings follow the ISIC Rev.4 concordance. Where discrepancies or missing values exist – for instance, in sectoral totals for countries such as South Korea – we use cumulative flows or interpolation subject to consistency checks.

The resulting panel allows us to trace the evolution of bilateral capital relationships, sectoral investment patterns, trade flows and GVC integration over the past two decades. It also supports multiple levels of analysis from cross-sectional regressions and panel estimations to network-based mapping of production and investment linkages. The depth, consistency and metadata richness of the WBG-HBFDI database enables us to explore not only headline investment trends but also the institutional and structural underpinnings of modern global production.

The abovementioned data serve as the foundation for the analysis in both Part I and Part II of this report. While Part I focuses on the joint role of trade finance and financial development in shaping trade outcomes, Part II turns to FDI as a structural force behind global production networks. Our analysis leverages the WBG-HBFDI data alongside WIOT and BACI to examine how multinational firms deploy capital across borders, how these patterns align with trade and value chain configurations, and how they evolve in response to policy and market shifts.

A more detailed discussion of our methodology, sample construction, and sensitivity checks, particularly with respect to tax havens and phantom flows, can be found in Appendix A. The next section turns to a more conceptual review of FDI's role in organizing global production and enabling GVC assimilation.

6.3.3 Network Analysis: The Trade-Investment Ghostbusting

The relationship between FDI and trade has long stood at the centre of globalization narratives. Yet as financial structures have become more complex, the links between productive capital and real economic flows have grown harder to trace. The question is no longer just how much FDI exists, but what kind of FDI and through what mechanisms it shapes GVC participation.

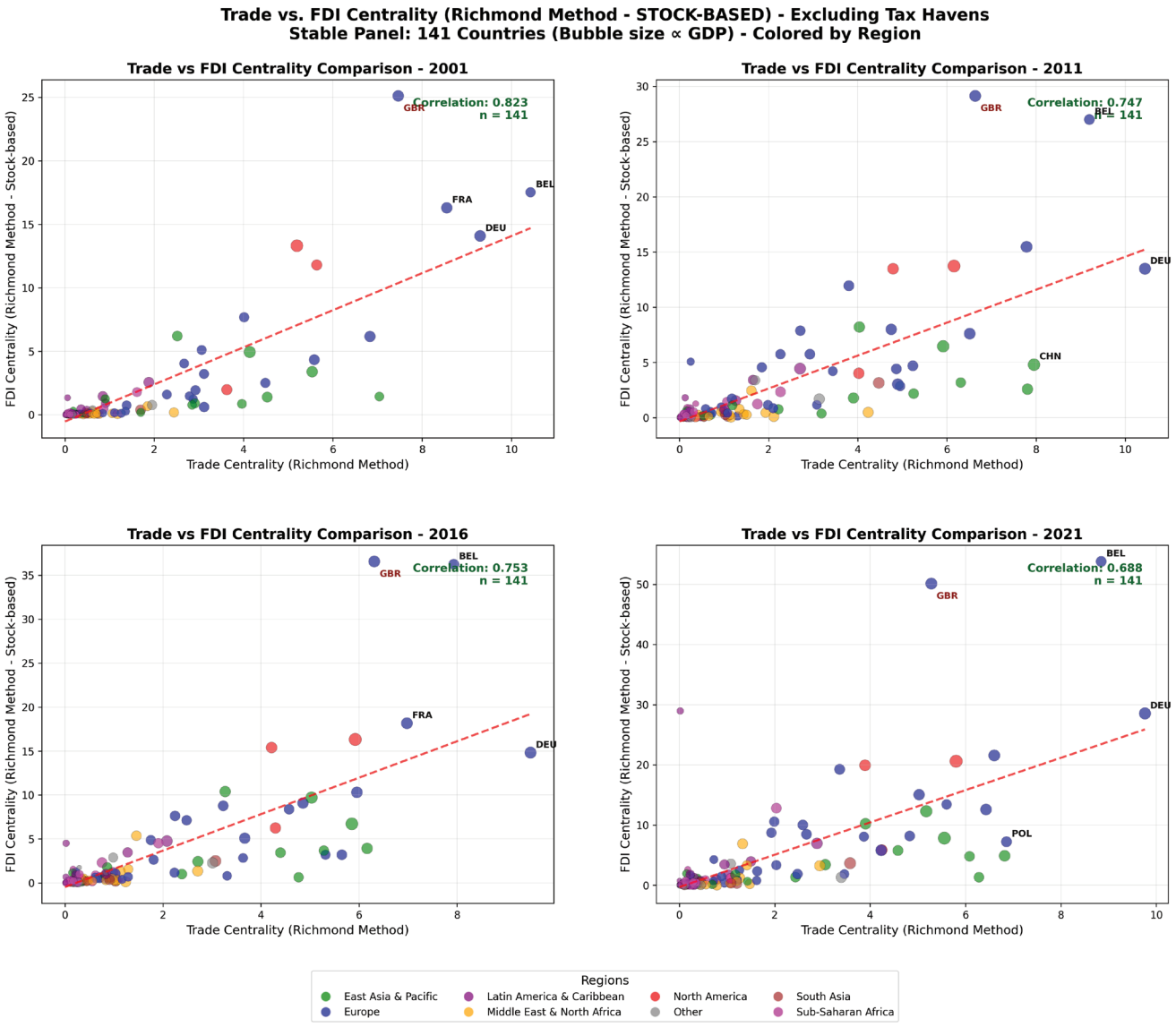
To explore this, we take a fresh look at the network architecture of global investment using an adaptation of the Richmond (2019) centrality measure originally developed for trade networks. Our version captures a country's FDI centrality by weighing both the scale of its bilateral FDI ties and the systemic importance of its partners, using data from the World Bank's WBG-HBFDI database (see Appendix for technical details). The goal is to see how central economies are in the global investment network, and whether this centrality still mirrors that of trade.

The results, visualized in Figure 6.6, tell a remarkably coherent story. When we limit the analysis to a stable panel of 141 non-haven economies, the correlation between trade centrality and FDI centrality is both high and persistent over time. In 2001, the correlation stands at 0.823, and while it softens slightly by 2021, it remains solid at 0.688. Countries that are highly central in the global trade network – like Germany, France, the United Kingdom (UK) and Belgium – are also central in the global investment network. The relationship is intuitive: nations that serve as key hubs in goods trade are also where long-term capital relationships cluster, reflecting the tight complementarity between production and investment in real-economy GVCs.

But this coherence disappears when we reintroduce the full sample of 163 countries, including offshore financial centres and jurisdictions heavily involved in tax-optimized investment structures. As shown in Figure 6.7, the correlation between trade and FDI centrality weakens sharply: from 0.759 in 2001 to just 0.278 in 2021. Instead of a close alignment between production and capital, the network becomes increasingly distorted by a few jurisdictions whose FDI centrality far exceeds their role in trade. Notably, countries such as Luxembourg, Bermuda and Ireland appear as outsized nodes in the FDI network yet barely register in trade flows. These are not hubs of production, but rather platforms for financial intermediation, legal structuring and tax optimization.

This divergence is further highlighted in Figure 6.8, which traces how the topology of the FDI network changes over time. In 2001, the network is relatively balanced, with traditional industrial economies forming the backbone of investment relationships. But

Figure 6.6: Trade vs. FDI Centrality – Excluding Tax Havens

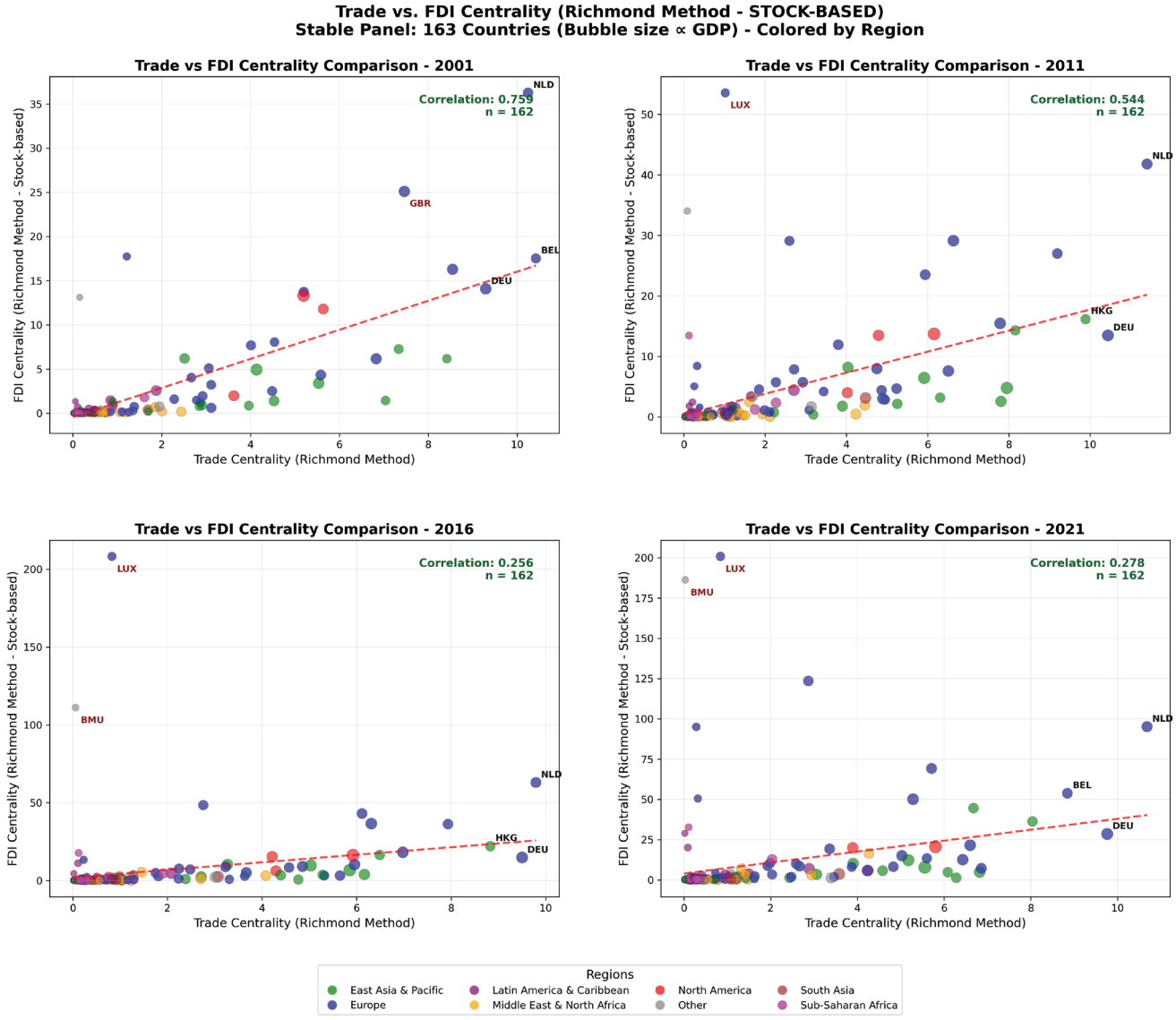


Source: World Bank's WBG-HBFDI database.

by 2011, and more so by 2021, offshore centres dominate the global map. Luxembourg (LUX), Bermuda (BMU) and Ireland (IRL) become central not because of their industrial base, but due to the rise of SPEs and pass-through investment vehicles, as documented in studies such as Damgaard, Elkjaer, and Johannesen (2019) and Garcia-Bernardo et al. (2017). These structures allow multinationals to reroute capital flows through low-tax jurisdictions, inflating the recorded stock of FDI without corresponding changes in physical assets, employment or trade.

What emerges, then, is a two-layered investment network. The first is a real economy layer, where trade and FDI move together, production follows investment and centrality reflects actual economic influence. The second is a financial structuring layer, where

Figure 6.7: Trade vs. FDI Centrality – Full Sample

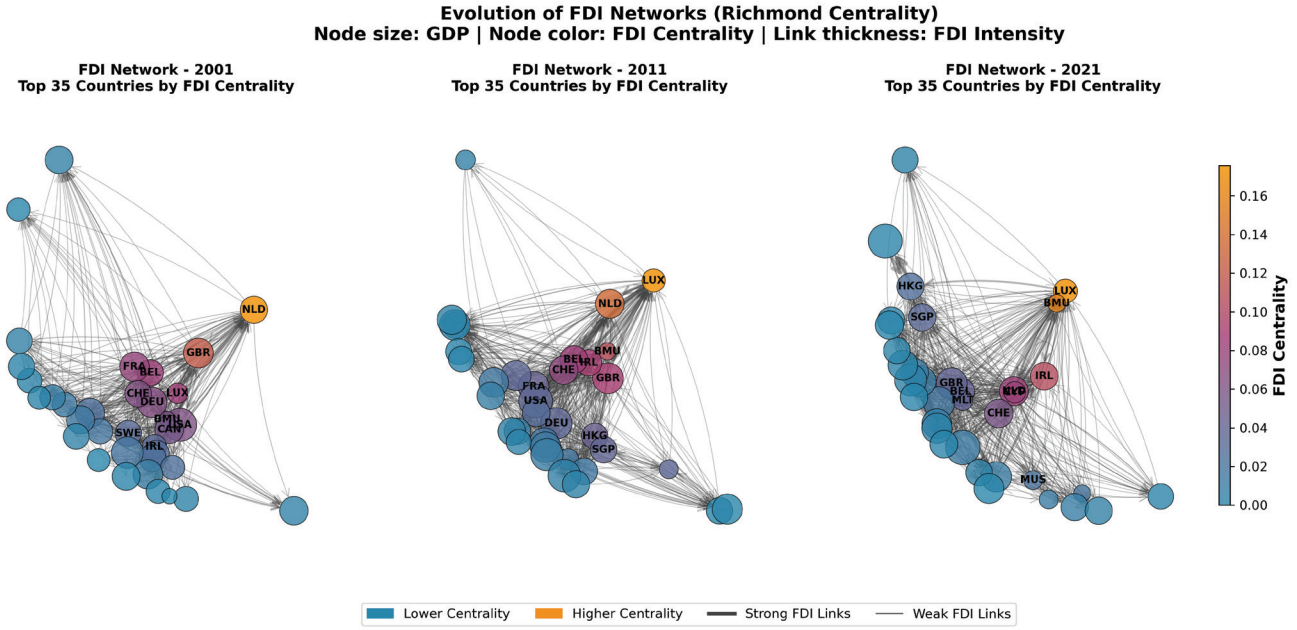


Source: World Bank's WBG-HBFDI database.

capital is mobile for tax, regulatory or legal reasons, often with limited connection to local economic activity.

Our methodological approach makes this distinction clear. By leveraging the haven/SPE flags in the WBG-HBFDI dataset, we construct a "de-havened" version of the FDI network that filters out these financial hubs. This enables us to identify the productive core of the global investment system – where FDI actually embeds production, builds supplier linkages and supports GVC integration. At the same time, we do not discard the full network. Rather, we view the two versions as complementary lenses: one focused on real capital formation, the other on the balance sheet dynamics that increasingly shape how investment is booked and reported.

Figure 6.8: Evolution of FDI Network Centrality – Top 35 Economies, 2001-2021



Source: World Bank's WBG-HBFDI database.

These results also help reconcile the earlier findings in the report. Recall from Part I that trade finance plays a crucial role in enabling firm participation in GVCs. That insight aligns closely with the observed relationship between trade and de-havened FDI centrality: countries with deeper financial ecosystems and more efficient access to working capital tend to be central in both. Conversely, in the full network, this relationship breaks down, because tax havens are central in capital but peripheral in goods.

From a policy perspective, the implications are twofold. First, analysts and international institutions should routinely report FDI statistics both with and without tax havens, and wherever possible, use "ultimate investing country" adjustments to reallocate pass-through flows to their source. Second, for countries aiming to deepen their participation in GVCs, attracting FDI should not be seen in isolation. The same institutional factors that support trade – such as reliable contract enforcement, export credit insurance and trade financing infrastructure – also enhance the productivity and embeddedness of FDI.

In short, once the noise of financial engineering is filtered out, the underlying story remains clear and intuitive: trade and FDI continue to move together, and countries that are central in one are often central in the other. It is this real economy layer of globalization that policymakers must engage with – and it is this layer that we continue to examine in the sections that follow. Box 6.4 offers a comprehensive overview of the different types of offshore financial centres.

Box 6.4: Understanding 'Conduit' and 'Sink' FDI: The Hidden Architecture of Global Capital Flows

Not all FDI is created equally. While conventional FDI reflects real economic activity – such as building factories, establishing subsidiaries or acquiring productive assets – a substantial and growing share of recorded cross-border investment is better understood as "phantom" capital, routed through a handful of financial centres for tax optimization and regulatory arbitrage. Understanding this distinction is essential for interpreting global FDI patterns and for designing policies that target genuine economic integration.

Work by Damgaard, Elkjaer, and Johannesen (2019) introduces a powerful framework for identifying the true structure of international capital flows by classifying countries into two roles within the FDI ecosystem: conduit and sink jurisdictions.

- Conduit economies act as intermediaries through which investment is routed, typically for legal or tax-related reasons. These countries – such as the Netherlands, Luxembourg and Ireland – host a disproportionate share of pass-through FDI that originates elsewhere but is funnelled through their financial and legal systems en route to its final destination. Conduit jurisdictions often offer favourable bilateral tax treaties, investor protections and advanced financial infrastructure that facilitate these routing strategies. The scale is enormous: in some cases, more than 90% of the FDI stock recorded in a conduit economy reflects financial flows with little to no local economic footprint.
- Sink economies, on the other hand, are where investment flows effectively come to rest. These jurisdictions absorb large volumes of capital, but much of it is ultimately disconnected from productive activity. Often characterized by low or zero corporate taxation, limited transparency and strong confidentiality laws, sink jurisdictions such as the British Virgin Islands, Bermuda and the Cayman Islands attract FDI for holding purposes, shielding the underlying assets from tax authorities and other forms of oversight. In sink economies, real investment activity is often minimal despite headline FDI figures being extremely large.

This dual structure of conduit and sink FDI has profound implications for global statistics. It helps explain why certain countries appear extraordinarily central in FDI networks despite playing only a marginal role in global trade. Moreover, it contributes to the observed divergence between trade and FDI centrality over time, especially in recent decades, as financial engineering has become more central to multinational tax strategies.

Recognizing these dynamics is not just a technical matter of data interpretation. It directly affects how we assess which countries are truly integrated into global value chains, where investment is supporting productive upgrading and where capital is simply being routed for accounting purposes. Policymakers and researchers increasingly emphasize the need to separate "real" FDI, associated with tangible assets and jobs, from "phantom" FDI that distorts global statistics and complicates efforts to design evidence-based trade and investment policies.

6.3.4 Foreign Direct Investment and Global Value Chain Integration: An Econometric Analysis

We conduct a deeper investigation into the trade-FDI nexus by correlating FDI with measures of GVC participation. If FDI were purely driven by financial arbitrage opportunities and entailed simply a transfer of asset ownership, we would expect neither the production process nor trade integration (e.g., the set of buyers and sellers) to change. On the other hand, if FDI involves financing real investments in new capital goods or transfers in technology and capital, much of the production process could change, including the types of inputs used and the sources of inputs, as well as the mix of buyers.

To measure such changes in the production process, we draw on the capital-augmented world input-output table in Ding (2023). This dataset includes information on country-sector-level spending on intermediate inputs as well as capital services, differentiated by country and sector of origin. Both intermediates and capital can be sourced from different upstream sectors and origin countries. The key contribution of this dataset is that it links up the country and sector that supplies the goods and services purchased as investment with the country and sector that uses the flow services of capital over time.

We use this dataset to construct shares of spending out of each downstream country-sector (n, j) on different types of inputs (k) from different countries (i) in each year between 2001 and 2014. Formally:

$$\beta^{M}_{njik,t} = \frac{\pi_{nik,t} M_{njk,t}}{X_{nj,t}},\ \beta^{K}_{njik,t} = \frac{\pi_{nik,t}\, r_{njk,t} K_{njk,t}}{X_{nj,t}}$$

Here, $M_{njk,t}$ is the value of purchased intermediate inputs from sector k used in country n, sector j; $\pi_{nik,t}$; is the import share of expenditures country n makes on sector k from country i; $X_{nj,t}$ is gross output; and $r_{njk,t} K_{njk,t}$ are imputed user costs of capital. The coefficients $\beta^{M}_{njik,t}$ and $\beta^{K}_{njik,t}$ represent cost-side exposure to inputs provided by sector k from country i, and satisfy:

$$\sum_{i,k} \beta^{M}_{njik,t} + \beta^{K}_{njik,t} = 1 - \beta^{L}_{nj,t},$$

where $\beta^{L}_{nj,t}$ is the labor share in country n, sector j.

We measure changes in the production process using the cosine similarity in expenditure shares between the same sector in two countries, n and m. We investigate whether changes in FDI increase, decrease or leave unchanged the similarity in production expenditure shares between host and source countries. Table 6.2 reports estimates from the following regression:

$$Sim_{nmjt}\left(\beta^{K}_{njik}, \beta^{K}_{mjik}\right) = \gamma_1 \log FDI_{nmt} + \gamma_Z \log FDI_{nmt} \times Z_{njt} + FE_{njt} + FE_{mjt} + FE_{nmj} + \epsilon_{nmjt},$$

where $Sim_{nmjt}(\cdot)$ is the cosine similarity of expenditure shares on capital over the supplier dimension (i, k) for a pair of producers in sector j from two different economies n and m. FDI_{nmt} measures the outward stock of FDI from m to n, and Z_{njt} is a set of time-varying host-country–sector characteristics, such as capital intensity, import intensity or imported capital intensity. $FE_{njt} + FE_{mjt} + FE_{nmj}$ describes a stringent trio of triadic fixed effects (leaving only the dimension unabsorbed).

We focus primarily on similarity in capital expenditure shares because capital is typically associated with know-how and suited to a particular production process. If there is technology transfer, a likely consequence is that foreign multinational production in a host country begins to resemble production at home in terms of both the types and proportions of capital inputs used and where these inputs are sourced.

Our focus on capital is also motivated by Ding (2023), who finds that there is more unexplained heterogeneity in capital service expenditure shares across countries as there is heterogeneity in intermediate input expenditure shares.

We use imported-capital intensity as our main interaction variable, defined as:

$$Z_{njt} = \sum_{i \neq n} \sum_{k} \beta^{K}_{njikt}$$

This serves as our main interaction variable to study whether more imported-capital intensive sectors are more prone to assimilation following FDI.

Table 6.2 provides evidence in support of our assimilation hypothesis. First, column (1) shows that FDI stocks on average do not meaningfully correlate with similarity in capital services use. The remaining columns analyse heterogeneity. Column (2) shows that, however, the correlation is positive whenever the destination country and sector is imported-capital intensive. This is our benchmark specification. For country sectors at the top decile of the imported capital intensity distribution, a one log-point increase in the bilateral FDI stock (roughly a doubling) is associated with a 1% (of standard deviation) increase in cosine similarity.

Table 6.2: FDI and GVC Assimilation in Capital Use

	(1)	(2)	(3)	(4)	(5)
log(FDI Stock)	0.002**	−0.000	0.000	0.000	0.001*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
log(FDI Stock) × Import Capital Intensity		0.094***	0.158***		0.169***
		(0.009)	(0.015)		(0.014)
log(FDI Stock) × Import Intermediate Intensity				0.016***	0.018***
				(0.002)	(0.003)
log(FDI Stock) × Import Intensity			0.005		
			(0.003)		
log(FDI Stock) × Capital Intensity			−0.025***		−0.013***
			(0.002)		(0.002)
log(FDI Stock) × Intermediate Intensity					−0.006***
					(0.001)
Observations	304,824	304,824	304,824	304,824	304,824
R^2	0.970	0.970	0.970	0.970	0.970

Note: The dependent variable is the cosine similarity between two economies in a given sector over expenditure shares on capital services disaggregated by supplying sector (k) and country (i). Cosine similarity is standardized to unit variance within the sample. All specifications include a saturated trio of triadic fixed effects: FE_{njt}, FE_{mjt}, *and* FE_{nmj}. The main explanatory variable, *log (FDI Stock)*, varies at the *nmt* level. Interaction variables (in subsequent rows) vary at the *njt* level. Standard errors in parentheses. *p< 0.05, **p< 0.01.***p< 0.001.

Column (3) controls for separate interactions between log FDI stock and import intensity and capital intensity to show that the findings in column (2) are driven specifically by imported-capital intensity. Column (4) finds a weaker (but still positive) effect for sectors that are imported -intermediates intensive. Column (5) puts all interactions together to show that the baseline effect of FDI stocks leading to GVC

assimilation in imported-capital intensive countries and sectors survives additional controls.

Table 6.3 provides evidence that assimilation is limited to the use of different types of capital and its imports from different countries of origin. We repeat the same specifications but use cosine similarity in intermediate input use on the left-hand-side. We find much lower and insignificant magnitudes. If anything, columns (3) and (5) find that similarity is lower whenever bilateral FDI stocks are high among imported capital-intensive sectors.

Table 6.3: FDI and GVC Assimilation in Intermediate Input Use

	(1)	(2)	(3)	(4)	(5)
log(FDI Stock)	0.001	0.001*	0.001	0.000	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
log(FDI Stock) × Import Capital Intensity		−0.009	−0.056**		−0.036*
		(0.008)	(0.020)		(0.015)
log(FDI Stock) × Import Intermediate Intensity				0.010*	0.024**
				(0.004)	(0.008)
log(FDI Stock) × Import Intensity			0.016**		
			(0.006)		
log(FDI Stock) × Capital Intensity			−0.001		0.007**
			(0.001)		(0.002)
log(FDI Stock) × Intermediate Intensity					−0.004***
					(0.001)
Observations	304,824	304,824	304,824	304,824	304,824
R^2	0.961	0.961	0.961	0.961	0.961

Note: Dependent variable is the cosine similarity between two economies in a given sector over expenditure shares on intermediate inputs, disaggregated by supplying sector (*k*) and country (*i*). Cosine similarity is standardized to unit variance within the sample. All specifications include a saturated trio of triadic fixed effects: FE_{njt}, FE_{mjt}, and FE_{nmj}. The main explanatory variable, log(FDI Stock), varies at the *nmt* level. interaction variables (in subsequent rows) vary at the *njt* level, Standard errors in parentheses. *p< 0.05, **p< 0.01.***p< 0.001.

Table 6.4 breaks apart similarity into its two separate dimensions: similarity over supplying countries, and similarity over supplying sectors. Columns (1) and (2) repeat the specification from column (2) of Table 6.2 but break out the combined similarity in capital services use into these two different margins. We find that similarity increases in both dimensions. Among more imported-capital intensive producers, higher bilateral FDI is associated with higher similarity in both the mix of capital assets deployed in production and the location of countries where these assets are sourced. In comparison, columns (3) and (4) break out the results from column (2) of Table 6.3 and find mildly negative coefficients along both margins.

Table 6.4: FDI and the Margins of GVC Assimilation

	(1)	(2)	(3)	(4)
	Capital Sim. over k	*Capital Sim. over i*	*Intermediate Sim.over k*	*Intermediate Sim.over i*
log(FDI Stock)	−0.002***	−0.002**	0.001	0.001
	(0.000)	(0.001)	(0.001)	(0.001)
log(FDI Stock) × Import Capital Intensity	0.023***	0.153***	−0.053***	−0.020*
	(0.006)	(0.011)	(0.008)	(0.008)
Observations	304,824	304,824	304,824	304,824
R^2	0.980	0.969	0.962	0.953

Note: Dependent variable is the cosine similarity between two economies in a given sector over expenditure shares on (1) capital service across supplying sectors (k), (2) across supplying countries (*i*), (3) intermediate inputs across supplying sectors (*k*), and (4) across supplying countries (*i*). Each cosine similarity is standardized to unit variance within the sample. All specifications include a saturated trio of triadic fixed effects: *FEnjt*, *FEmjt*, and *FEnmj*. The main explanatory variable, log (*FDI Stock*), varies at the *nmt* level. Interaction variables (in subsequent rows) vary at the *njt* level, Standard errors in parentheses. *p< 0.05, **p< 0.01.***p< 0.001.

One interpretation consistent with the findings in Tables 6.2, 6.3, and 6.4 is that FDI involves the transfer of know-how embedded in investment goods. This know-how incentivizes the use of similar types of capital goods in production in the FDI host country as the source country. On the other hand, one motive for FDI is to take advantage of input cost advantages. This involves sourcing the most cost-effective intermediate inputs depending on the location of production. It is therefore reasonable that host and source countries use different mixes of intermediates in production sourced from different locations.

The contrasting results between assimilation in sources of capital input use versus sources of intermediate input use suggest that capital plays a distinct role, likely embodying skill and technology transfer. These results suggest that an FDI is more than a pure financial flow; rather, it entails assimilation in the physical production process insofar as the proportions of capital assets used (R&D versus machinery) as well as the countries where these assets are imported.

6.3.5 Policy Implications

The analysis presented in this chapter reveals the layered financial architecture that underpins GVC integration, one in which FDI provides the long-term scaffolding for international production, and trade finance serves as the operational lubricant that enables day-to-day transactions. This dual-engine model suggests that policy interventions affecting either side of the financing equation, structural capital or working capital, can generate cascading effects on global trade and investment patterns. Importantly, our findings point to both opportunities and vulnerabilities. While coordinated financial development can amplify trade flows, the proliferation of "phantom" FDI through tax havens and financial hubs can distort headline statistics and complicate policy targeting. As governments recalibrate their international

economic strategies in a context of growing geopolitical uncertainty, the following four areas emerge as particularly salient for policy design.

1. Export Controls and FDI Screening Mechanisms

Our network analysis underscores the critical distinction between "real" and "phantom" FDI – a distinction with direct implications for national security and technology governance. The rise of offshore financial centres in the global FDI network, despite minimal participation in trade or production, mirrors broader concerns about the role of SPEs in obscuring the true origin and destination of capital. This opacity becomes especially problematic in sectors involving dual-use technologies, sensitive data or critical infrastructure.

Recent datasets, such as the Global Trade Alert export restriction tracker and the PRISM database on investment screening regimes (Danzman and Meunier, 2023), show that countries are increasingly deploying screening tools to manage FDI risks. Yet our findings suggest that blunt restrictions on FDI may miss the mark unless accompanied by efforts to trace beneficial ownership and disentangle financial intermediation from productive control. A more effective approach would focus on transparency-enhancing measures, such as beneficial ownership registries and stricter reporting standards on the use of special purpose entities. These efforts should also be coordinated across jurisdictions to prevent regulatory arbitrage, particularly in highly financialized sectors.

2. Industrial Policy and Targeted Subsidies

FDI is not just a channel for capital transfer, it is a vehicle for technology adoption, supply chain reconfiguration and upgrading within GVCs. Our empirical findings suggest that inward investment can catalyse export growth and deepen network participation, particularly when partner economies also exhibit robust financial development. However, the benefits of FDI are unevenly distributed and often depend on host country capacity to absorb spillovers.

Recent evidence from Ruta and Sztajerowska (2025) finds that targeted subsidies, especially in capital-intensive industries, can increase greenfield FDI by up to 7%, with the largest effects observed in capital-intensive sectors. These findings resonate with our framework, in which fixed investment costs act as a binding constraint on GVC participation. From a policy perspective, industrial subsidies that lower the cost of capital formation – such as equipment grants, tax credits or co-financing programmes – can enhance a country's attractiveness to strategic FDI. Importantly, these incentives should be coupled with programmes that build absorptive capacity, such as workforce training, digital infrastructure development and local supplier upgrading.

3. Investment Treaties and Technology Transfer Rules

As FDI becomes increasingly strategic, the governance of cross-border investment is evolving. Investment treaties that once focused narrowly on expropriation and non-discrimination are now being reshaped to reflect concerns over technology transfer, data localization and regulatory sovereignty. Our chapter highlights the complementary role that capital market development plays in enabling trade but also reveals asymmetries in the responsiveness of FDI to institutional depth.

Literature on "deep" investment provisions, such as those prohibiting forced technology transfer or requiring transparency in investment screening, shows that well-designed treaties can enhance the credibility of host environments and lower the fixed costs of entry (Hofmann et al., 2017; Sztajerowska, 2021). However, not all treaties are equal in scope or effectiveness. Our findings suggest that bilateral and regional investment agreements are most impactful when they align with domestic policies to improve legal predictability, protect intellectual property rights and facilitate dispute resolution. In an era of "weaponized interdependence", investment governance must strike a careful balance between openness and resilience.

4. Investment Promotion and Strategic Targeting

Finally, the heterogeneity of FDI effects across sectors and countries suggests a key role for targeted investment promotion. While FDI from multinationals can unlock productivity gains and export potential, the likelihood of such benefits depends on the structure of investment – greenfield vs. mergers and acquisition (M&A), platform-seeking vs. market-seeking – as well as the capabilities of domestic firms. Data from the WBG-HBFDI dataset, together with firm-level case studies (Alfaro-Ureña et al., 2022; Carballo et al., 2023), shows that productivity spillovers and GVC integration are highest when local firms are vertically linked into multinational production networks.

OECD and World Bank research (Sztajerowska and Volpe Martincus, 2021) further reveals that investment promotion agencies (IPAs) that use sectoral targeting and aftercare services can significantly increase the depth of local linkages. Our analysis supports this view: FDI complements trade most powerfully when it is embedded in a financially developed, institutionally supportive ecosystem. Policymakers should therefore view investment promotion not merely as a tool for attracting capital inflows, but as part of a broader strategy to shape comparative advantage, catalyse innovation and anchor high-quality jobs within domestic economies.

Across its two parts, this chapter has shown that participation in GVCs depends on both the liquidity that moves production and the investment that anchors it. Trade and supply chain finance expand firm-level inclusion and resilience; FDI embeds technology, capital and organizational know-how. Together they form a layered financial architecture in which short-term and long-term capital reinforce each

other. Effective policy therefore requires coordination between TF development and investment promotion, linking working capital access with productive capital formation to achieve resilient and inclusive reglobalization.

To complement the analytical and empirical perspectives presented in this chapter, it is useful to understand how firms themselves perceive the evolving relationship between FDI, trade finance and GVC integration. From the corporate side, investment decisions and liquidity management are increasingly shaped by what may be termed a "finance-driven geography", in which the depth, credibility and interoperability of financial systems determine not only where production is located but also how reliably it operates. Box 6.5 offers a business sector view of these developments. It illustrates how multinational firms and financial institutions are adapting to shifting patterns of capital availability, regulatory environments and digital financial infrastructure, and how these dynamics interact with the structural forces analysed in the chapter.

Box 6.5: The View from Business: Financing Connectivity in the New Frontier of FDI and Trade Finance

Introduction: The Finance-Driven Geography of FDI, Trade Finance and (re)Globalization

Chapter 6 frames FDI as structural capital – embedding long-term capacity in host economies – and TF/SCF as the liquidity layers keeping cross-border production running. Together, they form a unified capital ecosystem increasingly decisive for GVC participation and upgrading. From the business side, FDI determines where and how production is organized; TF/SCF determines how reliably materials, components and services circulate.

TF underwrites the front end of cross-border exchange, ensuring goods move and get paid for; SCF underwrites the back end, providing working capital across multi-tier supplier networks. This helps explain why cash reliance in many emerging economies – with Viet Nam and Cambodia highlighted in this Chapter (WTO and IFC, 2023) – results in very low SCF penetration even where trade intensity is high, constraining business growth.

Two additional propositions from Chapter 6 resonate with corporate behaviour. First, capital market depth on both sides of a trading relationship lowers frictions and boosts bilateral trade, whereas banking system depth more closely links to FDI flows: equity markets oil trade wheels with better risk and liquidity management tools; banks mobilize loans and acquisition financing needed to create or expand multinational footprints at scale.

Second, services now account for a rising share of GVC activity and have proven notably resilient; TF/SCF must therefore extend to digitally delivered services and intangibles, not only containers and warehouses. Sophisticated financial offerings for services providers are a natural corollary of more developed regulatory regimes.

These factors combine as "finance-driven geography", whereby firms re-route investment and liquidity along corridors that maximize policy predictability, financial depth and digital interoperability. The result is not deglobalization but reglobalization via finance, so much so that financial flows can distort FDI data: a re-wiring of production around finance availability. This chimes with DHL analysis finding that global connectedness "unequivocally dispels the notion of globalization reversing course" (Logistics Business, 2024).

This section focuses on key themes: (1) treating capital as a supply chain input; (2) tracking the new geography of investment; (3) prioritizing policy credibility in investment regimes; and (4) developing trends in TF/SCF.

1. Capital as a supply chain input

As this chapter outlines, FDI builds production structures whilst TF and SCF sustain production flow. An HSBC executive notes: "An intelligently designed supply chain finance programme can do a lot of heavy lifting in de-risking trading relationships and improving supplier resilience" (BusinessWire, 2024).

In modern business, operations teams track physical lead time while finance teams monitor credit velocity – time from shipment or service milestone to cash at each chain tier. For managing boards, value chains are organized as much by capital flows as by goods flows; they are symbiotically related but need equal consideration.

continued on next page

Box 6.5: continued

Yet this development is uneven: Chapter 6 highlights World Bank data showing that in many emerging markets, exporters still finance most working capital from internal funds and retained earnings (71% in LMICs), with substantial shares (40%) of sales paid post-delivery. Banks and supplier credits provide only 18% of finance for LMIC exporters.

This expands cash-conversion uncertainty and forces firms to ration orders precisely when market windows open; TF/SCF access becomes a limiting factor for business revenues. Chapter 6's firm-level literature reinforces this mechanism: access to external finance and bank health shape both the extensive margin (the decision to export) and the intensive margin (how much and to whom) (Berman, 2010; Amiti and Weinstein, 2011). Higher financing costs map into lower trade volumes – even small cost increases translate into meaningful export and import reductions.

The implications for business are tangible: capital provided by TF/SCF are supply chain inputs requiring careful management, and policymakers can help businesses significantly by improving access to and the price of this financing.

2. The New Geography of Investment

The bilateral gravity framework in this chapter demonstrates what corporate boards contend with when planning future development: capital market depth on both sides of a trade relationship associates with more trade, while banking system depth on both sides associates with more FDI. Because services and software account for rising value added shares, data governance, e-contracting and payments interoperability now sit alongside wage costs and logistics when boards map the next plant, platform or shared-services hub. Modern location strategy has become a finance map as much as a cost map – consistent with Chapter 6's analysis of WBG-HBFDI and BACI evidence.

Specifically, firms now seek friend-shored finance (IMF, 2024) when siting new facilities, sourcing finance in economies where banks can mobilize long-duration, asset-backed loans and legal enforcement is predictable. This means increasing reliance on regional financial centres offering sophisticated instruments, efficient payment clearing and scale hedging – hence growing finance flows through conduit economies. Capital flow geography is defined less by lowest cost and more by highest financial compatibility.

Another popular corporate move is increasing use of in-market, syndicated loans, which have emerged as a board-friendly, "risk-off" complement to equity FDI. Instead of funding projects entirely with parent equity, firms co-finance with local currency tranches from host market banks and international lenders, often alongside export credit agencies or development finance institutions. This does four things that executives value: (1) de-risks exposure by giving senior lenders security over assets and revenues; (2) anchors domestic stakeholders in the project; (3) hedges FX by matching local revenues with local currency debt; and (4) preserves strategic optionality. Coupled with host governments' desire to attract FDI, local banks benefit from implicit government support when funding flagship foreign investments. This demonstrates why Chapter 6 explains that deeper joint credit markets associate with larger FDI volumes – banks actively facilitate cross-border expansion through syndications and acquisition finance.

This sits within broader re-wiring across corridors and "connector countries". In business decisions – consistent with patterns highlighted elsewhere in the report – Mexico, Viet Nam and Türkiye feature repeatedly as connector countries linking production nodes across blocs (Gopinath et al., 2025). Market evidence cautions against over-generalizing: "while some rerouting and transshipment may have occurred via Viet Nam, there is little evidence of similar activity through Mexico this year" (IIF, 2025). The implication for firms is to treat connector roles as dynamic and sector specific, not static labels, and to confirm that finance rails (correspondent banking, FX access, documentation) in each connector are fit for purpose.

Overall, networked FDI is growing: single financing nodes support investment flows into many economies; connector economies link production across trading blocs; services-intensive corridors open up with tax-efficient regimes. The geography of investment is increasingly complex, dynamic and liable to further change with policy shifts and market factors.

3. Policy Credibility in Investment Regimes

This reorganization directly affects the global economy. JPMorgan Chase Chair and CEO Jamie Dimon notes that "the restructuring of global supply chains... may lead to stickier inflation and ultimately higher rates than markets currently expect" (JPMorgan Chase, 2025). This and resultant policy changes impact how companies price expansion project risks.

continued on next page

Box 6.5: continued

As Chapter 5 highlighted industrial policy credibility's importance for firms and GVC development, the same holds for investment policy. As this Chapter concludes, FDI is most developmentally effective when embedded in "financially developed, institutionally supportive" ecosystems. Sudden changes in screening rules, capital-control regimes, weak contract enforcement or vague prudential guidance cause firms to re-price risk and can strand projects even where incentives exist.

From a business perspective, key FDI project risks heavily link to the local policy environment and regime credibility. Firms therefore discount destinations with ambiguous investment reviews or unpredictable market access, and pay premiums for clear investment statutes, reliable courts and sound regulatory supervision.

The gravity model results demonstrate that distance is a "powerful barrier" to trade and investment, with FDI flows and stocks exhibiting even greater sensitivity than trade. Part of this stems from spatial frictions and information asymmetries in investment decisions, but greenfield FDI shows more sensitivity to geopolitical distance than goods trade, especially in the past decade (McKinsey, 2025). This reinforces that firms seek stability in all policy aspects, not just those directly pertaining to investment.

4. Developing Trends in Trade Finance and Supply Chain Finance

Whilst the trends above are becoming increasingly understood, trade finance scarcity remains the binding constraint for inclusive participation. Chapter 6 notes the TF gap in developing economies widened markedly, reaching $2.5 trillion in 2022 (ADB, 2023), and frictions – collateral, enforcement, FX access and correspondent-bank capacity – produce high rejection rates and self-exclusion. Bank rejection rates reach about 25% of request values in West Africa, versus around 12% for Africa overall, with SMEs and new clients disproportionately affected (AfDB, 2020; WTO and IFC, 2023). This is why such a small share of firms' finance needs comes from banks, and why TF/SCF determines whether firms can translate FDI linkages into export growth – investment alone cannot bring capital-scarce economies into global production networks.

Even in relatively advanced markets, TF/SCF penetration is far below potential: trade supported by bank-intermediated TF stands at 8% in Mexico, 15% in Senegal, 20% in Nigeria and Viet Nam, and 3% in Cambodia and Lao PDR, compared with >=60% in developed economies. Prices track these frictions: in advanced systems, 90-day letters of credit price near inter-bank rates; in thin markets, collateral and margins surge (BIS/CGFS, 2014).

On the SCF side, Chapter 6 emphasizes that TF and SCF are complementary. TF helps goods and services cross borders safely; SCF keeps inputs flowing inside multi-tier networks. Technology and legal upgrades have enabled banks to internationalize domestic factoring/reverse-factoring programmes for MNEs, but "deep-tier" financing remains the frontier: surveys show only 0.5% of trade in some Mekong economies is supported by SCF from local institutions (WTO and IFC, 2023). Even in Mexico, where SCF is relatively developed and the Nafin platform highlighted in this Chapter has helped bring SMEs into formal liquidity channels, $12 billion of SCF in 2023 supported barely 1% of total trade, highly concentrated among three banks and anchor MNEs.

Digital trade finance platforms are beginning to compress these frictions – e-invoicing, e-KYC, digitized documents and risk-scoring reduce processing times and expand eligibility. Despite advances, limited progress in producing interoperable international standards for trade, including electronic trade documentation, hinder such systems' efficacy. Furthermore, Chapter 6's identified constraints (lack of collateral, weak enforcement, foreign exchange scarcity and lack of bank scale) still limit uptake in many markets; digital rails cannot outrun analogue institutions and cash-dominated economies.

While artificial intelligence (AI) and automation hold exciting productivity potential, financial market development and liquidity optimization across borders will be equally important in ensuring these gains can be realized.

We have also seen growth in green and sustainability-linked loans (SLL) in recent years, accounting for roughly 10% of the global total in 2024 (Natixis CIB, 2025). For boards and CFOs, the share of green borrowing is becoming a key performance indicator in its own right – not only for investor signalling, but because it unlocks customer access and compresses financing costs across the chain, with potentially lower yields of green bonds seen as the attractive "greenium" from a borrower's perspective (Pohl et al., 2023).

However, SMEs and businesses in emerging markets still face verification and data hurdles that can elevate capital costs (BIS, 2021; EBA, 2023). Eligibility for buyer programmes, SCF limits and margin discounts increasingly hinge on verifiable environmental, social and governance (ESG) metrics. Credit and data-infrastructure gaps mean many otherwise competitive firms cannot produce the verifiable metrics that open doors to green credit lines. Without verifiable ESG data, suppliers face smaller SCF limits, tighter collateral requirements or higher margins – raising capital costs. This shows how the same institutional and developmental constraints that depress TF/SCF access also shape who can join higher-value GVC nodes.

Overall, the strategic outlook for FDI, TF and SCF's role in GVCs is significant and warrants further study insofar as it can assist economic development. The message from this Chapter is clear for businesses and the policymakers who wish to support them: participation and upgrading in GVCs depends on co-optimizing financial structures and liquidity flows, including readily adapting to the finance-driven geography of investment.

continued on next page

Box 6.5: continued

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Note: This box was authored by Daniel Cowen MBE, Trade & Investment Lead, Greater China, World Economic Forum. The views expressed are those of the author and do not necessarily reflect those of the affiliated institutions.

6.4 Concluding Remarks

This chapter has argued that the global economy operates through a dual-capital architecture in which FDI provides the structure and TF/SCF provides the motion of production. Foreign direct investment and trade finance have traditionally been studied as separate instruments in the global economic toolkit, one long-term and strategic, the other short-term and transactional. Yet the evidence presented in this chapter suggests a more unified perspective: these two forms of capital flow operate not in isolation but in concert, serving as complementary facilitators of globalization and GVC integration. One sets out the structural foundations for cross-border production; the other enables the continuous exchange of goods, services and intermediate inputs that sustain those very linkages.

Throughout our analysis, a consistent theme appears: FDI and TF reinforce one another in expanding firm-level participation in global markets. For SMEs, the availability of working capital through trade finance can be transformative, but its benefits are magnified in environments where FDI has already created upstream or downstream linkages. Whether acting as suppliers to multinational affiliates or distributors of foreign-invested goods, SMEs are better able to leverage financing when embedded in broader investment ecosystems. In this sense, FDI not only brings capital and know-how, but also anchors value chain participation that makes TF more productive.

Conversely, the developmental impact of FDI itself is shaped by the financial environment into which it arrives. Our empirical results show that FDI-driven technology upgrading is more likely to occur in countries that are already capital-import intensive, that is, economies with the trade infrastructure and liquidity systems capable of absorbing sophisticated inputs. Without adequate access to finance importing machinery, R&D or intermediate goods, the knowledge embodied in foreign investment may fail to diffuse across local firms. Trade finance, in other words, is a critical enabler of absorptive capacity, particularly in sectors where upgrading depends on timely access to frontier technologies.

These insights carry direct implications for policy. The successful integration into GVCs requires more than liberalized trade and investment regimes; it demands a dual strategy that targets both long-term productive investment and short-term liquidity provision. Efforts to attract FDI – through industrial policy, investment promotion or treaty reform – must be accompanied by interventions that improve access to trade finance, especially for especially firms lacking collateral, scale or financial literacy. Similarly, reforms that strengthen banking systems, deepen capital markets and promote digital TF platforms can expand the pool of firms ready to benefit from FDI linkages.

In a global economy marked by heightened geopolitical risk, reconfiguration of supply chains and tightening credit conditions, the complementarities between FDI and trade finance become even more important. They are not merely coexisting instruments, they are mutually reinforcing pillars of economic integration. A resilient globalization strategy, therefore, must treat them as part of a coordinated financial architecture: one that supports the entry, survival and upgrading of firms in the evolving landscape of global production multiplier.

The preceding analysis has shown how liquidity, credit and investment together form the layered financial architecture of GVCs. Trade and supply chain finance sustain operational continuity, while FDI establishes the structural capital base that anchors production networks. Yet financial depth alone does not ensure upgrading or resilience. The ability of economies to convert financial inflows into productive transformation depends on how firms absorb, adapt and apply new technologies. These technological capabilities, ranging from digitalization and automation to process innovation and intangible capital, determine how value is created and distributed along GVCs.

The next chapter shifts from finance to technology, examining how participation in GVCs enables diffusion of knowledge, productivity convergence and skill development, while also revealing persistent asymmetries across firms, sectors and regions. Building on the layered resilience framework developed here, Chapter 7 argues that while finance and investment are necessary enablers, long-term competitiveness and inclusiveness ultimately depend on innovation ecosystems and the capacity to transform knowledge into sustained productivity gains.

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Annex 6.1: Methodological Notes for Chapter 6

This annex provides the formulation and implementation details for the Richmond centrality measure applied to global FDI networks. Richmond centrality was originally introduced by Richmond (2019) for trade flows, and we adapt it here to capture the structural features of bilateral FDI stock relationships.

Original Richmond centrality (Trade)

In its original formulation, Richmond centrality measures the importance of a country in the global trade network, weighting bilateral trade flows by both the size and the connectivity of partner countries. The basic formulation is:

$$TradeCentrality_{it} = \sum_{j \neq i} \left(\frac{Trade_{ijt}}{GDP_{it} + GDP_{jt}} \times s_{jt}^{Trade} \right)$$

Here, $Trade_{ijt}$ denotes the bilateral trade flow between countries i and j, GDP_{it} and GDP_{jt} are their respective GDPs, and s_{jt}^{Trade} represents the share of country j in total world exports.

Modified Richmond centrality (FDI Stock)

To adapt this framework for FDI, we construct a stock-based centrality measure that reflects the persistence and long-term nature of investment positions. The modified formula is:

$$FDICentrality_{it} = \sum_{j \neq i} \left(\frac{FDIStock_{ijt}^{Total}}{GDP_{it} + GDP_{jt}} \times s_{jt}^{FDI} \right)$$

Here, $FDIStock_{ijt}^{Total}$ is the bilateral outward FDI stock between i and j, while s_{jt}^{FDI} is the share of country j in global outward FDI stock. This highlights how systemic importance depends not only on direct ties but also on connections to globally significant capital exporters.

Richmond centrality provides a way to think about influence in networks beyond direct link strength. For trade, it highlights how being connected to a globally important exporter confers additional systemic importance. Our adaptation for FDI preserves this idea but adjusts it to the unique characteristics of capital stocks: persistence, long-term relationships and the role of MNE structures. The result is a measure that captures the evolving architecture of global FDI, distinguishing between productive capital linkages and financial flows routed through offshore centres.

Box 6.A.1: Illustrating Trade vs. FDI Centrality with a Simple Example

To illustrate the mechanics of the Richmond centrality framework, consider a stylized global economy with three countries: A, B and C.

- Country A is a large economy with GDP of $10 trillion.
- Countries B and C are medium-sized, each with GDP of $5 trillion.
-

Trade Example
Suppose the bilateral trade flows are as follows:

- A exports $500 billion to B and $500 billion to C.
- B and C each export $100 billion to A, but trade little with each other.

In this case, A has high trade centrality not only because of the absolute size of its flows, but also because its partners B and C together account for a large share of global trade. B and C, by contrast, are less central, as their trade is concentrated with a single partner.

FDI Example
Now consider FDI stocks:

- A holds $1 trillion of outward FDI in B and $1 trillion in C.
- B and C each hold $50 billion in A, but both channel $500 billion through each other as financial conduits.
- Here, the centrality picture shifts. While A remains important due to the absolute size of its outward FDI, the intense bilateral FDI ties between B and C – despite their modest GDPs – push them to the centre of the FDI network. Their role as conduits amplifies their systemic importance, even if their real economic activity is smaller.

Implications
This example shows why the Richmond centrality measure, when applied to FDI stocks, highlights financial hubs and conduits (such as Luxembourg, Singapore or the Netherlands) that do not always appear central in trade. In practice, these hubs often owe their prominence not to large-scale domestic production, but to their role in facilitating and re-routing multinational investment flows.

7

Technology, Productivity and Inclusive Growth Through Global Value Chains

Neil Foster-McGregor and Wenbo Zhu

7.1 Introduction

For more than three decades, global value chains (GVCs) and rapid technological change have combined to reshape the global economy. These two closely intertwined forces have altered patterns of production, opened new pathways for economic catch-up and facilitated the transfer of technology and knowledge across borders. At the same time, they have coincided with rising concerns about inequality – especially within economies – as the distribution of the gains from globalization and innovation has varied widely both across and within economies.

One common view is that global income gaps between economies have narrowed, while income and opportunity gaps within economies have widened. Since the 1980s, rapid growth in economies such as the People's Republic of China (PRC) and India has contributed to a decline in between-economy inequality (Bourguignon, 2016; Milanovic, 2016). At the same time, within-economy inequality – driven in part by rising top incomes (Piketty, 2020) – has increased in many economies, particularly high-income ones. Commentators have pointed to the global fragmentation of production through GVCs and the uneven diffusion of digital and automation technologies as possible drivers of these patterns (Acemoglu and Restrepo, 2019; Duarte et al., 2022).

At their core, GVCs enable specialization, efficiency and learning, enabling economies to participate in global production without building the full industrial base. Technological advances – especially in information and communications technologies (ICTs), logistics and digital platforms – have been instrumental in supporting this fragmentation.

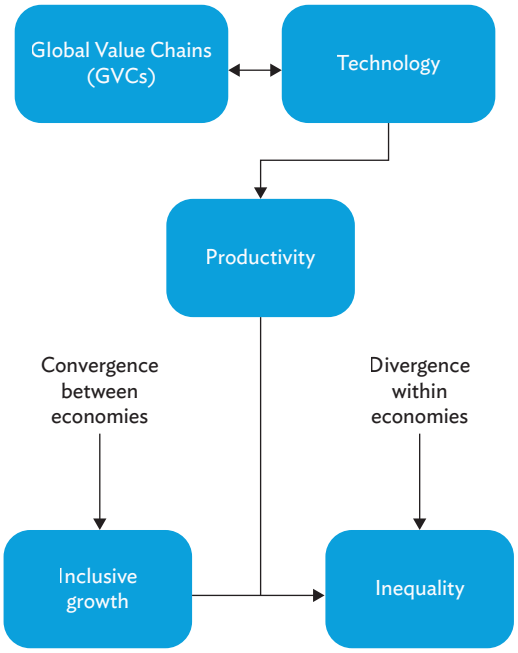
Note: The work on this chapter was led by the Asian Development Bank (ADB) and the University of International Business and Economics. The views expressed are those of the authors and do not necessarily reflect the views and policies of ADB or its Board of Governors or the governments they represent.

Technological change has enabled production processes to be broken down into discrete tasks, further lowering coordination and transport costs that enable these tasks to be located across economies according to cost and capability advantages (Baldwin, 2011).

GVCs, in turn, can serve as channels for technology diffusion, exposing firms to international standards, upgrading pressures and new forms of knowledge. Firms embedded in GVCs often face incentives to innovate, adopt new technologies and improve productivity (e.g., Agostino et al., 2025; Zeng et al., 2025). This interaction – GVCs enabling technology transfer and technology enabling deeper global value chain integration – has the potential to boost productivity growth and drive structural transformation.

Yet important questions remain. What factors influence the extent to which GVC participation speeds catch up? To what extent are these gains widely shared within participating economies? Are the benefits of GVC participation and technological change concentrated among certain firms, workers or regions? Could new technologies – especially automation and artificial intelligence (AI) – alter the distribution of income in ways that limit the inclusiveness of productivity gains?

Figure 7.1: Global Value Chains, Technology and the Productivity-Inequality Trade-Off



Source: Authors.

Understanding these questions requires examining how GVC participation and technological change interact to influence productivity – and how the resulting gains are distributed (Figure 7.1). This chapter investigates both productivity and distributional outcomes to identify the channels linking GVCs, technology and inclusiveness, and to

explore policy options for aligning these forces with broader development goals. It asks: How have GVCs and technology affected productivity across firms and economies? Through which mechanisms might they influence inequality within economies? What policies can help ensure that the benefits are more widely shared? By asking such questions, the chapter seeks to address the broader query of whether GVCs and technology primarily serve as engines of productivity and convergence between economies, or whether they can also shape inequality within them – and under what conditions.

The chapter proceeds as follows. Section 7.2 investigates the prevailing convergence-divergence narrative by examining trends in between- and within-economy inequality. Section 7.3 focuses on the productivity effects of GVCs and technology – at both macro and micro levels – and outlines key mechanisms of convergence and learning. Section 7.4 builds on this to examine inequality dynamics, highlighting how GVCs and new technologies shape labor markets, wage structures and firm dynamics. Section 7.5 discusses policy strategies for enabling inclusive productivity growth – ranging from skills and innovation policies to digital infrastructure and labor protections. Section 7.6 concludes by summarizing the key messages and outlining implications for policymakers in a world of rapid technological and economic transformation.

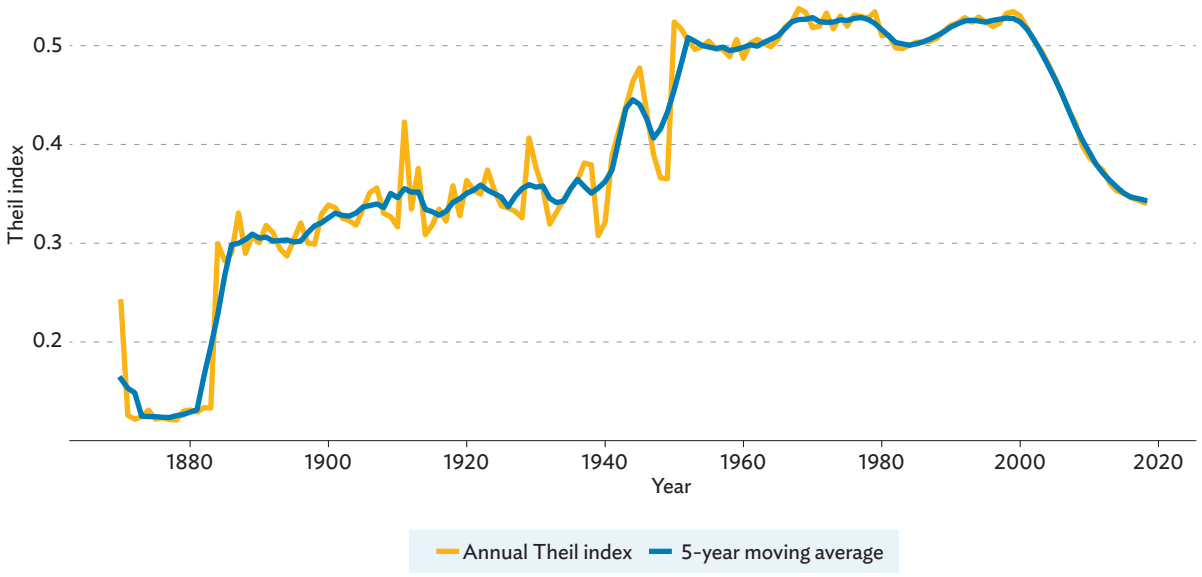
7.2 Recent Developments in Between- and Within-Economy Inequality

Debates around the impact of globalization and global value chain integration often start from a stylized fact: during the GVC era, inequality between economies has fallen sharply, while inequality within economies has risen. These dynamics are frequently linked to political backlash against globalization, particularly in high-income economies, and to renewed protectionist pressures (WTO, 2024). However, both the narrative of dramatic between-economy convergence and the idea of widespread within-economy divergence deserve closer scrutiny (Milanovic, 2012; Lakner and Milanovic, 2013).

Between-economy inequality increased rapidly after the first industrial revolution with the rise of Western dominance and colonial empires, subsequently stabilizing at a high level (World Inequality Report, 2022) (Figure 7.2). In contrast, the past three decades have seen convergence in per capita incomes, particularly when measured with population-weighted indicators.

Using World Bank data on gross domestic product (GDP) per capita (in constant purchasing power parities) for 1990-2023, Figure 7.3 shows a pronounced decline in population-weighted between-economy inequality. However, this pattern looks less dramatic when using unweighted measures, suggesting that much of the apparent convergence is driven by a small number of populous emerging economies – most notably the PRC and India. Excluding these two economies, the weighted Theil index of economic inequality shows little net change over the period, with fluctuations masking the absence of sustained convergence.

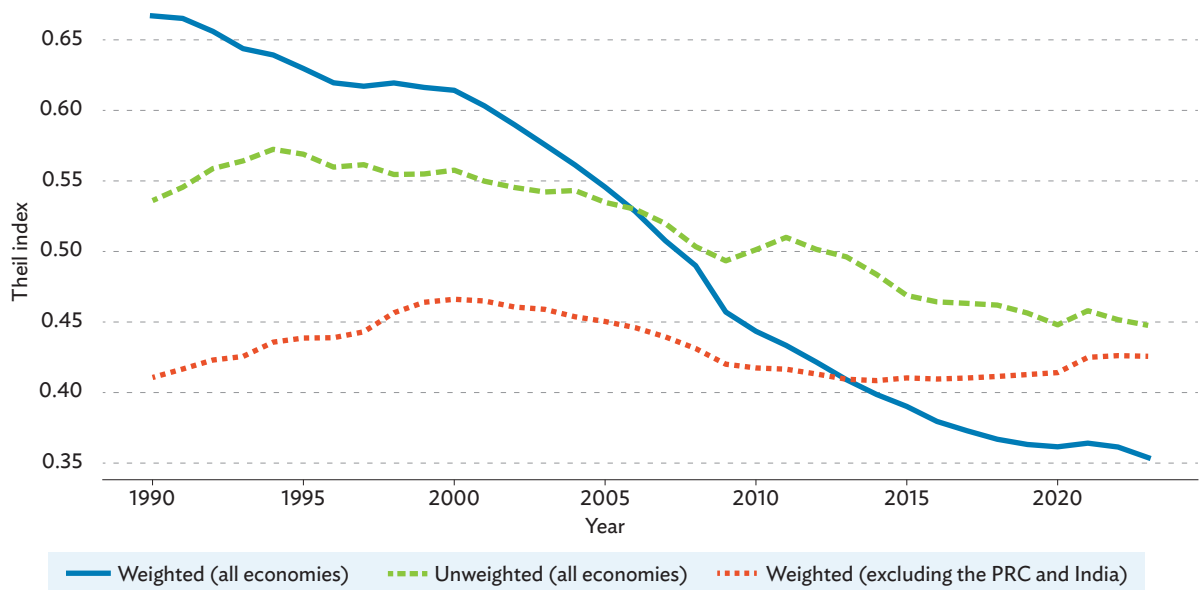
Figure 7.2: Developments in Between-Economy Inequality, 1870-2018



Notes: The indicator is based on data on per capita GDP in constant purchasing power parities (PPP). The weighted Theil index (for a particular year) is calculated as $T_W = \sum_{i=1}^{N} \frac{p_i}{P}\left(\frac{y_i}{\bar{y}} \ln\left(\frac{y_i}{\bar{y}}\right)\right)$, with y_i being per capita GDP of economy i, $\bar{y}$ being global per capita GDP, N being the number of economies, and $\frac{p_i}{P}$ being the share of economy i in the total population of all economies in the sample. The indicator is constructed using all economies available in the dataset in any given year, meaning that the indicator is not based on a common sample of economies.

Source: The Maddison Project Database 2020

Figure 7.3: Developments in Between-Economy Inequality Since 1990

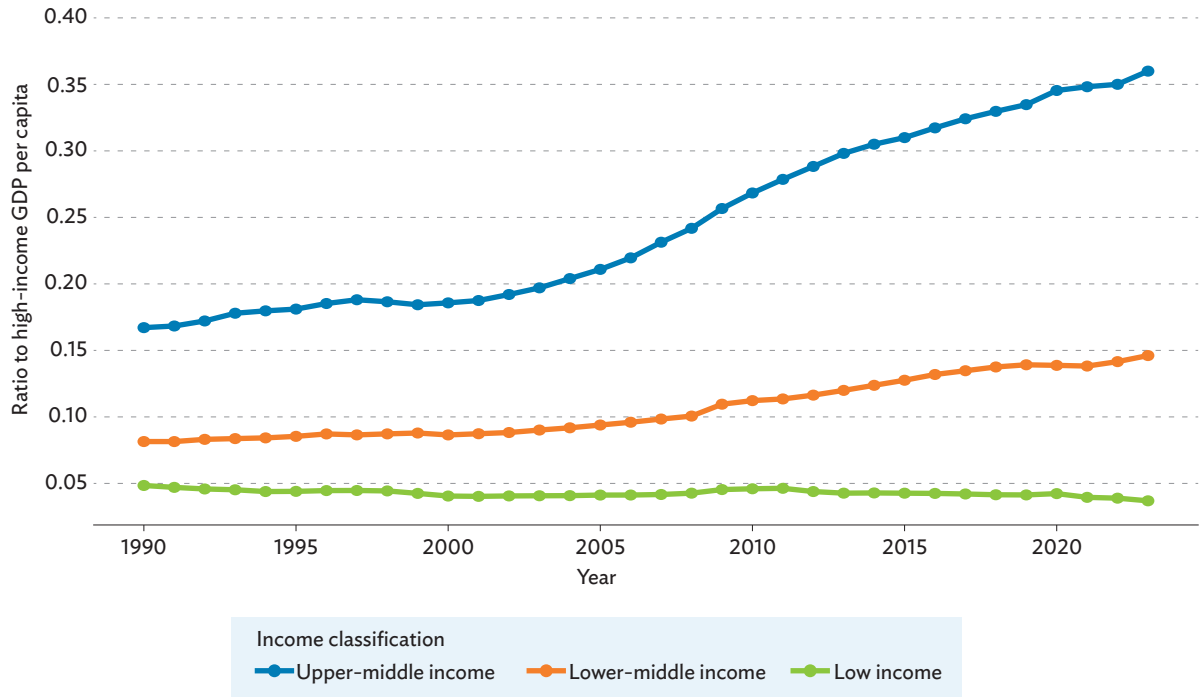


Note: The indicator is based on data on per capita GDP in constant PPP. The weighted Theil index (for a particular year) is calculated as $T_W = \sum_{i=1}^{N} \frac{p_i}{P}\left(\frac{y_i}{\bar{y}} \ln\left(\frac{y_i}{\bar{y}}\right)\right)$, with y_i being per capita GDP of economy i, $\bar{y}$ being global per capita GDP, N being the number of economies, and $\frac{p_i}{P}$ being the share of economy i in the total population of all economies in the sample. The unweighted Theil index drops the population weights in its construction.

Source: World Bank's World Development Indicators

The heterogeneity in outcomes can be further seen in Figure 7.4, which shows the ratio of (population-weighted) GDP per capita of low, lower-middle and upper-middle-income economies to that of high-income economies. The figure highlights how catch-up to high-income economies has occurred unevenly across income groups, with lower-middle and upper-middle income economies roughly able to double this ratio since 1990, but low-income economies seeing no catch-up to high-income economies. Such results are suggestive of the view that the potential benefits of GVC integration and recent technological developments have not been shared equally across economies.

Figure 7.4: Heterogeneous Catch-Up by Income Group



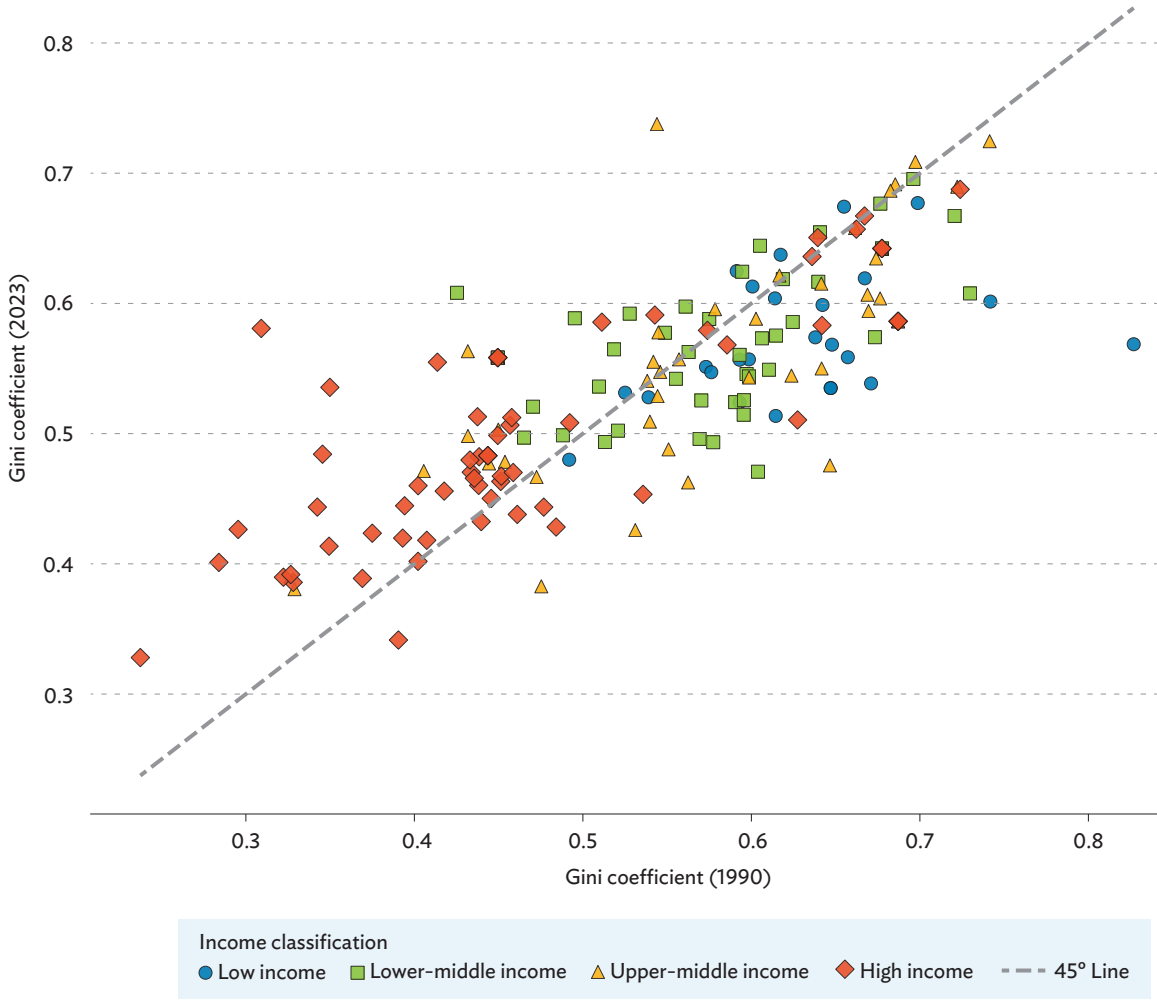
Note: The figure reports information on the ratio of the population-weighted average GDP per capita (in constant purchasing power parities) of low, lower-middle and upper-middle income economies to that of high-income economies. The definition of income groupings is based on an economy's status in 2023, according to the World Bank's classification.
Source: World Bank's World Development Indicators

Turning to within-economy inequality, Figure 7.5 uses data from the World Inequality Database to report information on the Gini coefficient of within-economy income inequality in 1990 and 2023. The figure reveals that most high-income economies lie above the 45-degree line indicating rising inequality, albeit from initially relatively low levels in most cases. In contrast, while the 1990 values of the Gini for non-high-income economies tend to be relatively high, most of these economies lie below the 45-degree line suggesting declining inequality.

Figure 7.5 suggests that rising within-economy inequality is far from universal and is concentrated in certain contexts. This can be further seen in Figure 7.6, which

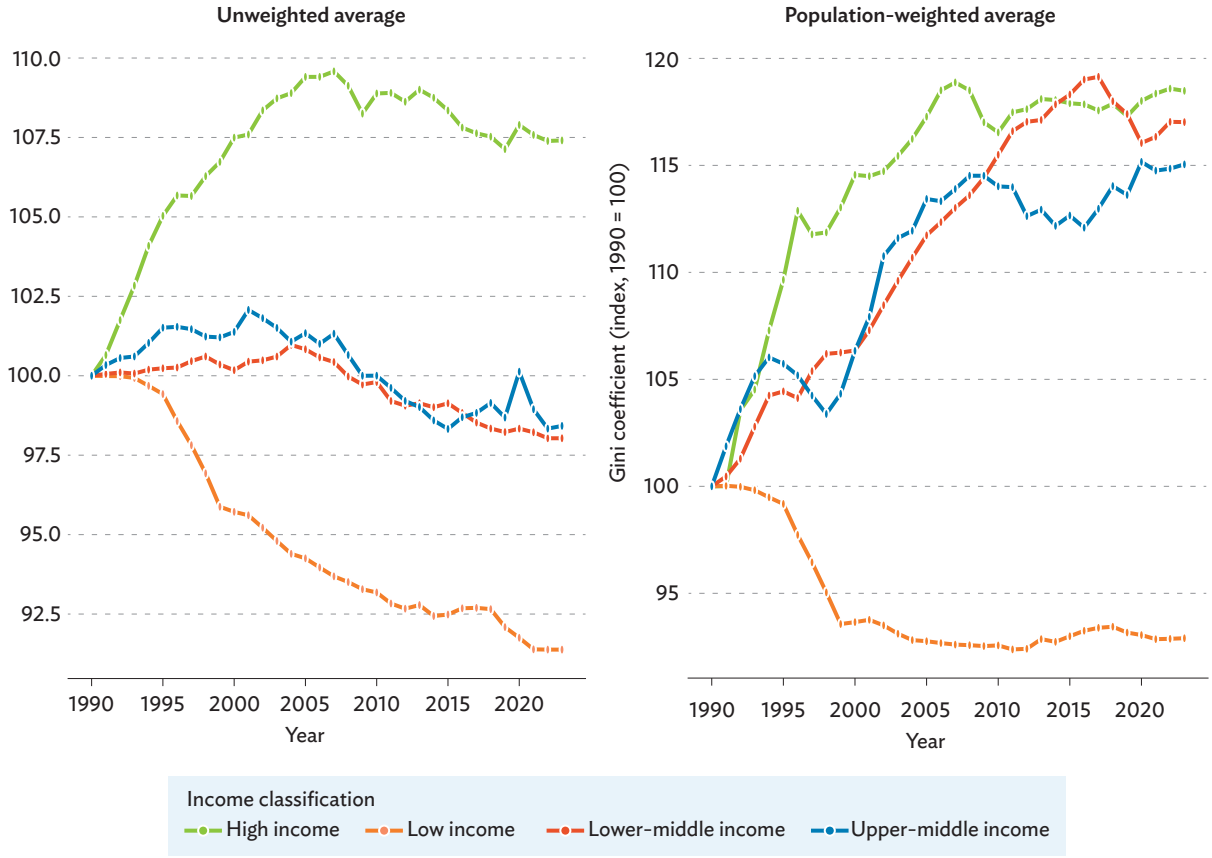
reports the evolution of the Gini coefficient by income level over the period 1990-2023, reporting both an unweighted and population weighted version of the index. The unweighted version of the index aligns well with the results in Figure 7.5, showing that rising inequality has been largely confined to high-income economies, with relatively large declines in the Gini coefficient for low-income economies. The figure also highlights that the rise of the Gini coefficient in high-income economies, as well as in lower-middle and upper-middle income economies, was largely confined to the period up to the global financial crisis, with the trend in inequality being downward in all income groups since then. Results when using a population-weighted average show rising inequality in high, upper-middle and lower-middle-income economies, highlighting that within the lower- and upper-middle-income groups, a subset of larger economies have seen increases in inequality.

Figure 7.5: Gini Coefficient in 1990 and 2023



Source: World Inequality Database

Figure 7.6: Evolution of the Gini Coefficient by Income Group, 1990-2023



Source: World Inequality Database

Taken together, these results add nuance to the conventional GVC-era inequality narrative. While between-economy inequality has fallen on a population-weighted basis, this appears to owe much to the performance of a few large economies, with the poorest showing little signs of convergence. Similarly, within-economy inequality has risen in many high-income economies but has remained stable or fallen in many lower income economies. Yet, this latter result hides variation in non-high-income economies, with a subset of often larger economies also seeing rising inequality.

These patterns raise questions about the extent to which the twin forces of GVC participation and technological change have been decisive drivers of inequality trends in recent decades, and whether their effects differ systematically across income levels, structural conditions and institutional contexts. The remainder of the chapter explores these possibilities by linking observed inequality patterns to productivity and distributional mechanisms associated with GVCs and technology.

7.3 Mechanisms: Global Value Chains, Productivity and Technology Diffusion

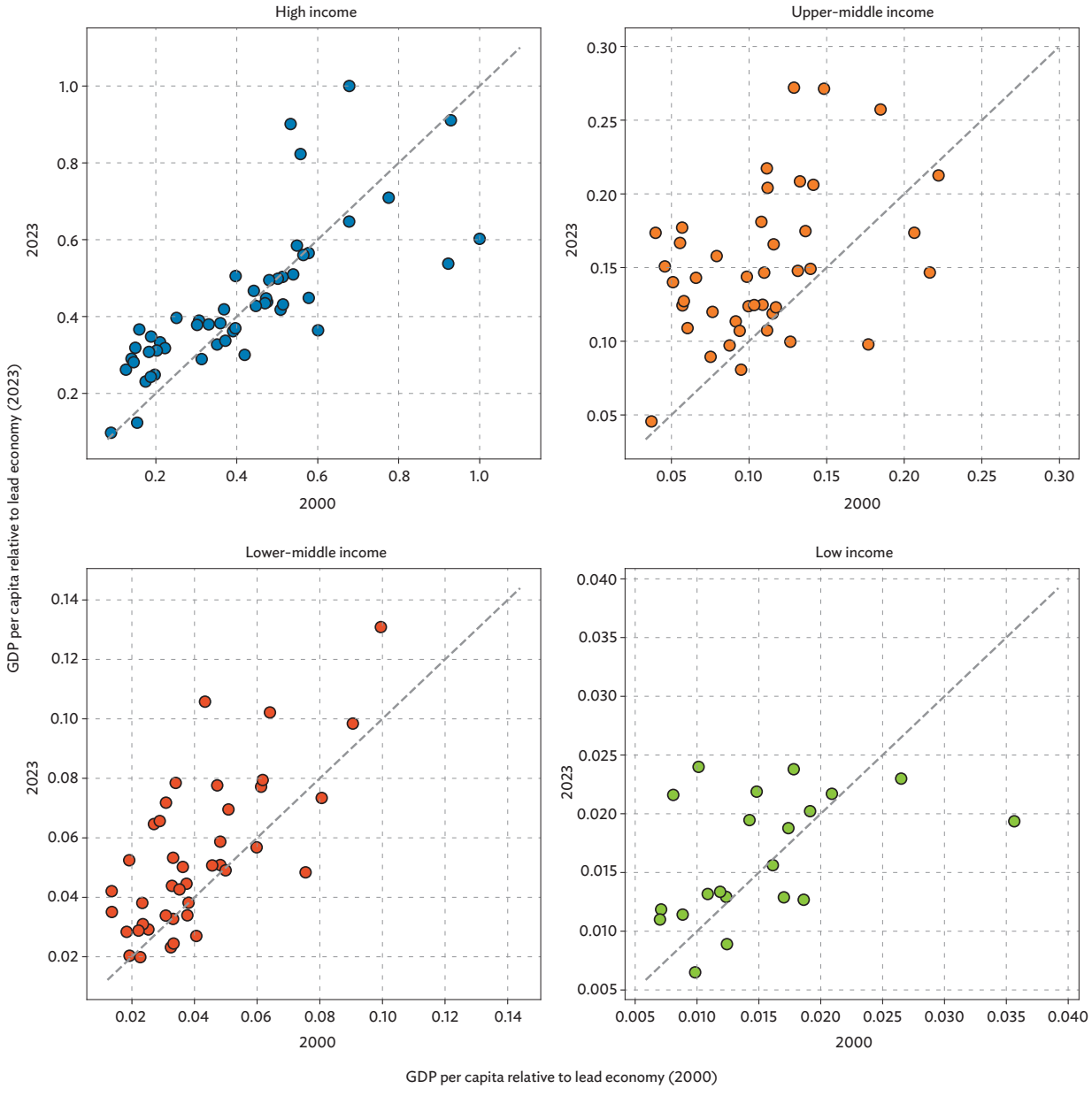
Since the turn of the century, there has been a general trend of between-economy convergence in per capita income. Figure 7.7 provides a visual representation of this phenomenon. The chart plots each economy's initial income level in 2000 (horizontal axis) against its subsequent average annual growth rate through 2023 (vertical axis). The downward-sloping trend line (in red dashes) demonstrates the core convergence dynamic: economies that started with lower income levels achieved higher growth rates, while those with initially higher incomes experienced more modest growth. The statistical relationship is significant ($p < 0.001$), confirming this general convergence pattern across the global economy.

Figure 7.7: Income Convergence Across Economies, 2000-2023

Source: World Bank's World Development Indicators

However, catch-up dynamics have been highly heterogeneous across economies at different income levels. Figure 7.8 illustrates this variation by showing catch-up dynamics across four income groups, with economies categorized by their 2023 income status. Each panel plots an economy's GDP per capita relative to that of the lead economy in 2000 (horizontal axis) against its relative GDP per capita in 2023 (vertical axis). The lead economy refers to the economy with the highest GDP per capita in the respective year (i.e., the richest economy in 2000 for the horizontal axis, and the richest economy in 2023 for the vertical axis). Points above the 45-degree line indicate that an economy has narrowed its income gap with the lead economy over the period.

Figure 7.8: Uneven Catch-Up Dynamics Across Income Groups, 2000-2023



Source: World Bank's World Development Indicators

The figure reveals two key dimensions of uneven catch-up dynamics across income groups. First, the dramatic scale differences among the four panels highlight the vast disparities in GDP per capita levels – low-income economies operate at income ratios of 0.01-0.05 relative to the lead economy, while high-income economies cluster at 0.4-1.0, illustrating the enormous development gaps that persist globally.

Second, catch-up effectiveness varies markedly by income level. While a substantial number of low-income economies appear above the 45-degree line, their actual convergence gains are minimal – most remain clustered near the bottom-left corner, suggesting persistent stagnation despite apparent catch-up potential. Lower-middle-income economies demonstrate modest but more meaningful progress, with several economies achieving noticeable convergence. Upper-middle-income economies exhibit the strongest catch-up performance, with multiple economies making substantial leaps toward the income frontier.

This heterogeneity reveals an important disconnect. While general convergence trends suggest catch-up opportunities exist globally, the actual convergence process is highly uneven across income groups. The evidence points to convergence mechanisms operating differently across development stages, with some economies facing particular barriers to translating growth opportunities into meaningful catch-up. The remainder of this section takes a closer look at the uneven catching-up process among lower-income economies, examining the underlying mechanisms by tracing the pathways through which GVC participation and technology affect productivity.

The analysis reveals that GVCs can serve as a powerful force for productivity convergence between economies, primarily through technology transfer mechanisms. However, simply participating in GVCs is insufficient to guarantee convergence benefits. The extent to which economies can harness these productivity gains depends critically on an economy's capacity to absorb and effectively utilize transferred technologies, including through an economy's positioning in GVCs. This differential capacity for technology absorption explains the structurally selective nature of GVC benefits and underlies the uneven convergence patterns observed across economies with varying levels of GVC integration.

This section is organized around three key questions. Firstly, how do GVCs enable productivity convergence, and how do these effects vary across sectors and development levels? Drawing on sector-level evidence, Section 7.3.1 shows that GVC integration accelerates productivity growth primarily through technology transfer, but the benefits depend critically on the type of linkages (forward vs backward), sectoral characteristics and network positions. This helps explain why GVC-driven convergence has been uneven, benefiting some participating economies while bypassing others.

Secondly, what are the micro-level mechanisms through which GVC participation transforms firm capabilities? Firm-level evidence discussed in Section 7.3.2 reveals

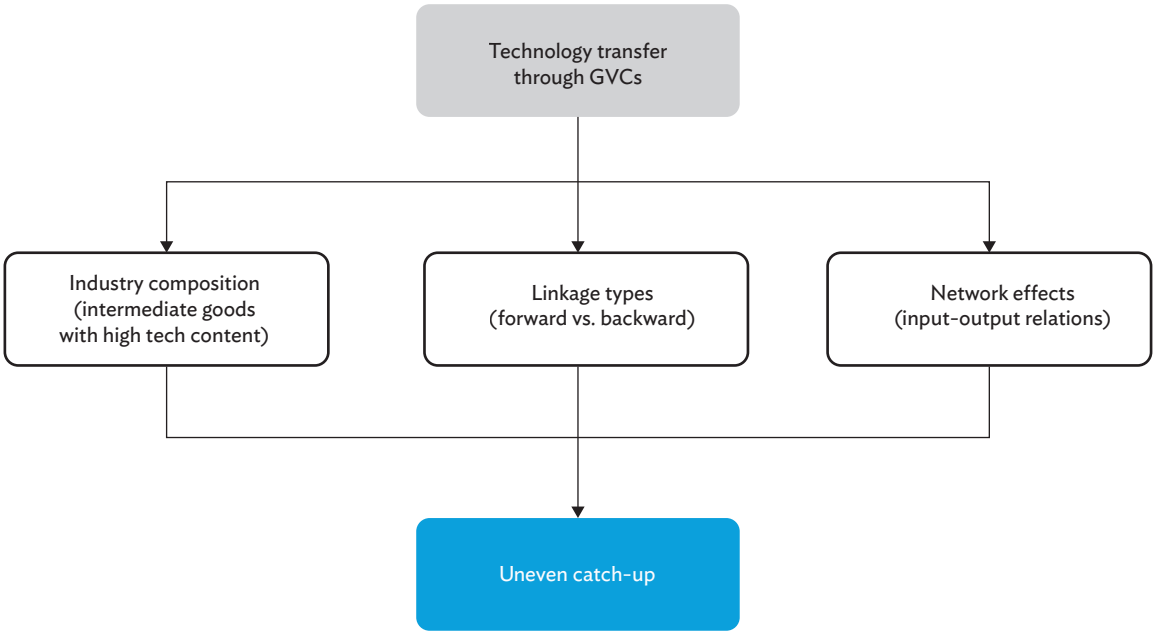
that benefits flow through specific relational channels – direct buyer support, network effects and knowledge spillovers – rather than broad market forces. Importantly, these gains are concentrated among initially less productive firms, suggesting GVCs work primarily through catch-up mechanisms rather than pushing frontier firms further ahead.

Thirdly, what structural features of GVCs make them such effective channels for knowledge transfer? Section 7.3.3 identifies how stable relationships and productivity interdependencies create powerful infrastructure and incentives for knowledge sharing. This impact also extends far beyond worker mobility and spin-off entrepreneurship.

7.3.1. Cross-Economy Evidence On Global Value Chain-Led Productivity Convergence

The aggregate-level evidence reviewed in this subsection helps explain why productivity convergence through GVCs has been uneven across economies and why benefits have concentrated among specific economies with particular structural characteristics. Rather than operating as a uniform force, GVC integration creates differentiated pathways for technology transfer and productivity growth that depend on how economies connect to global production networks and their underlying industrial composition (Figure 7.9).

Figure 7.9: Channels from Global Value Chains/Technology to Uneven Catch-Up Dynamics Across Economies



Source: Authors

Technology Transfer through Global Value Chains: Evidence for Productivity Convergence

In a background paper to this report, Foster-McGregor (2024a) shows that GVC integration accelerates productivity convergence across economies. Analysing Asian Development Bank (ADB) multi-region input-output data from 2007-2018, the study demonstrates that economies with higher GVC participation rates experience faster labor productivity growth, likely through technology adoption and process improvements that help participating economies catch up with global leaders.

Taking a longer historical perspective, Pahl and Timmer (2020) find that economies further behind the global productivity frontier benefit the most from global value chain participation. The study also finds that gains from GVC participation are particularly pronounced in industries that rely on sophisticated intermediate inputs such as electronics and transport equipment, where the technology content of traded goods is the highest. These results support the technology transfer mechanism: lagging economies gain access to superior technologies and organizational practices through GVC relationships.

The Critical Role of Linkage Types and the Threshold Effects

Foster-McGregor (2024a) reveals that the type of GVC linkage fundamentally determines both the speed and sustainability of these productivity gains. Forward linkages – where domestic production becomes inputs for other economies' exports – lead to more rapid productivity convergence even at relatively low levels of integration. These linkages facilitate continuous learning through exposure to international quality standards and buyer feedback, creating steady channels for capability upgrading that do not require massive initial investments.

Backward linkages – importing intermediate inputs for domestic production – show a more complex pattern. While backward linkages also enhance productivity convergence, they require higher participation levels to achieve more rapid convergence. Once past this threshold, however, the convergence bonus is relatively strong. As a result, the benefits in terms of convergence of GVC integration can be more easily obtained through forward GVC participation.

Global Total Factor Productivity and Compounding Network Effects

The uneven benefits of GVC participation on productivity growth depend not only on the type of linkages (forward vs. backward) but also on where economies are positioned within global production networks and their specific roles in these networks.

In a background paper to this report, Cheng, Fukao and Meng (2024) introduce a concept of "global total factor productivity", or global TFP, which measures the residual growth of final outputs of an economy sector that cannot be accounted for

by the growth of primary inputs – not only in the final production stage, but across all previous stages within the GVCs.

This concept highlights a fundamental shift in how productivity gains propagate in a GVC-integrated world: economic benefits from productivity improvements are no longer confined to the innovating economy alone. When one economy improves its productivity, the effect not only affects its direct trading partners but also ripples through GVCs via changes in the prices of goods and services, ultimately affecting the terms of trade and welfare of all other economies.

The magnitude and direction of these indirect effects are determined by the specific pattern of input-output relationships between all economies. Consequently, integration into production networks does not automatically translate into equitable welfare improvements across all economies. Rather, it can create winners and losers that depend on economies' positions and roles in international production networks. Remarkably, these indirect effects are found out to be quantitatively larger than their direct counterparts in general and appear to be more resilient to trade disruptions.

This network-dependent distribution of benefits can be further reinforced by innovation dynamics. Evidence from Ito et al. (2023) shows that network centrality – measured by access to customers directly and through value chains – correlates strongly with innovation outcomes, as firms with greater network access file significantly more patent applications. This evidence suggests a potential compounding effect, where economies that capture disproportionate productivity gains from their network positions may also develop superior innovation capabilities, making the uneven benefits of GVC participation self-reinforcing over time.

Summary: The Uneven Nature of Global Value Chain-Led Convergence

The evidence discussed in this subsection reveals the potential role of technology transfer in GVC-led productivity convergence, as well as why the catch-up process has been uneven in nature. A key insight emerges: GVC benefits are structurally selective, favouring economies with particular industrial compositions, GVC linkage types and network positions.

This selectivity highlights the central role of domestic absorptive capacity in determining whether GVC participation translates into meaningful productivity improvements. Indeed, these structural characteristics all reflect underlying differences in economies' ability to absorb and diffuse GVC-embedded technologies.

Having established these structural patterns, the section turns to firm-level evidence to understand the specific mechanisms: How exactly do individual firms absorb knowledge from their GVC partners, and which types of firms benefit the most?

7.3.2. Micro-Level Mechanisms: How Global Value Chain Participation Transforms Firm Capabilities

Firm-level evidence reveals two key mechanisms through which GVC participation drives productivity convergence: (1) direct knowledge transfer from lead firms and (2) network effects that expand market access. In a background paper to this report, Ma et al. (2024) also find that, perhaps most importantly for convergence, GVC participation for emerging economies primarily helps struggling firms catch up rather than pushing already-successful firms further ahead.

Direct Knowledge Transfer through Buyer-Supplier Relationships

When domestic firms begin supplying multinational corporations (MNCs), they do not just gain new customers – they gain access to global knowledge networks. Alfaro-Ureña, Manelici and Vasquez (2022) provide compelling evidence on how joining GVCs transforms domestic firms through direct knowledge sharing. Tracking nearly every firm in Costa Rica between 2008 and 2017, they find that after supplying to a MNC for the first time, domestic firms typically hire more workers and achieve higher productivity within four years. While there is often a short-term dip in sales to domestic customers, these sales rebound and grow by about 20% over four years. Crucially, this growth comes from sales to "better" buyers with stronger market positions and longer-term relationships.

The mechanisms behind this transformation are revealing. Nearly half of Costa Rican suppliers (44%) reported receiving direct support from MNC buyers, including shared blueprints, on-site audits and hands-on operational advice. One business owner described gaining access to a "global catalogue of best practices". Once firms successfully supply their first MNC, benefits compound: 78% found it easier to win contracts with other MNCs, creating a virtuous cycle of capability growth and market reputation.

Network Effects and Relationship Capabilities

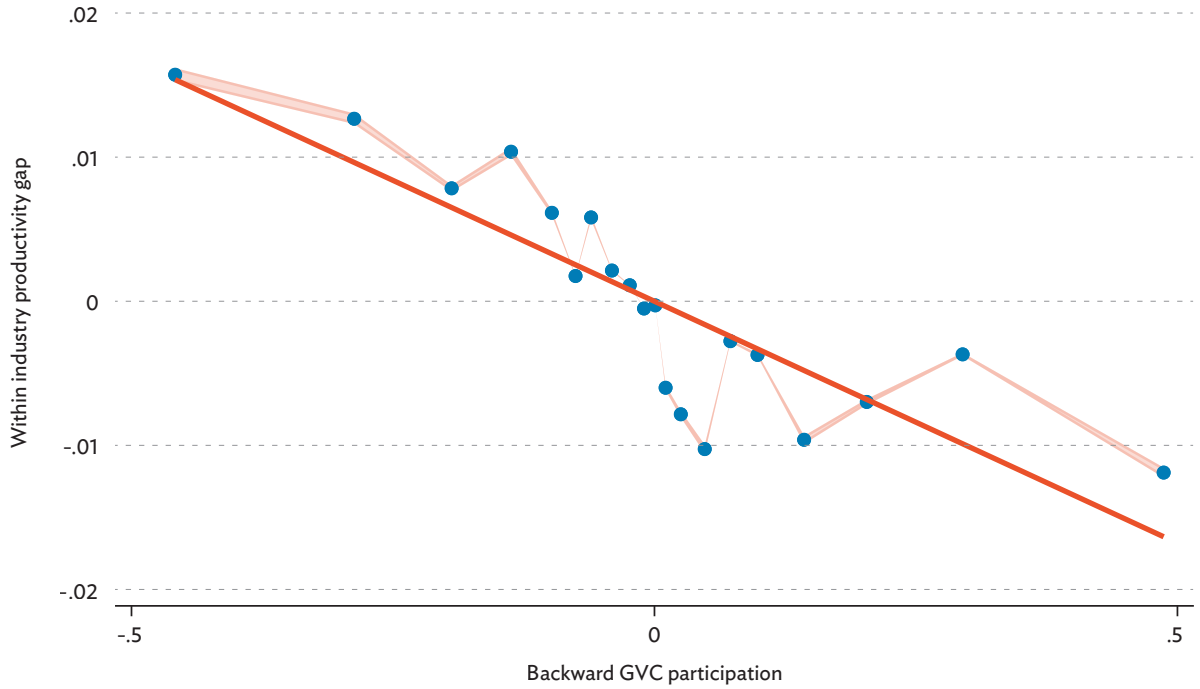
Amiti et al. (2024) examine whether these benefits depend specifically on multinational status by studying "superstar" firms in Belgium, where many leading firms are domestic rather than foreign. Their findings suggest that multinational status matters less than market position: domestic firms that begin supplying to any superstar firm – whether multinational or domestic – see productivity rise by about 8% within three years, along with growth in output, employment and international trade activity.

A key insight is what Bernard et al. (2022) term "relationship capability" – the ability to manage multiple customer relationships effectively. Superstar firms appear to transfer some of this capability to their suppliers, helping them reach new customers. Network effects amplify these benefits, as suppliers often gain access to buyers within the superstar's own customer base.

Industry-Wide Productivity Convergence

The paper of Ma et al. (2024) examines firms from the PRC from 2000-2013 and finds that doubling a firm's GVC participation reduces its productivity gap relative to industry leaders by 3.5 percentage points (Figure 7.10). Crucially, these gains are concentrated among the least productive firms – the bottom quarter sees marked improvements, while gains for already-productive firms are smaller (Figure 7.11).

Figure 7.10: Conditional Correlation Between Backward Global Value Chain Participation and Within-Industry Productivity Gap

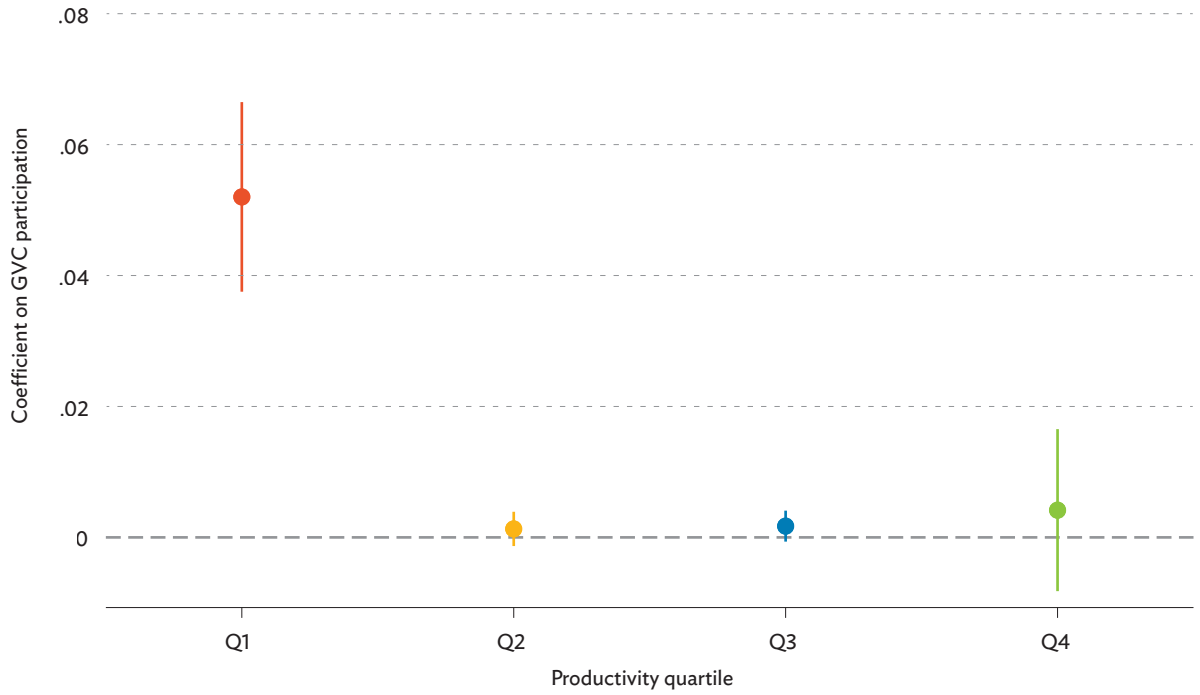


Note: The figure reports the conditional correlation between backward GVC participation at the firm level and the within-industry productivity gap (i.e., the productivity difference between the firm and the highest level in the industry). To control for firm-specific characteristics and time trends, both variables are first regressed on firm and year fixed effects, with the residuals from these two regressions then plotted. For better visualization, firm-level observations are grouped into 20 bins based on GVC participation levels, with each point representing the mean within bins.
Source: Authors

This pattern explains why GVC integration drives industry-wide productivity convergence for emerging economies. Rather than creating a few superstar firms pushing the productivity frontier, GVC participation appears to work by bringing lagging firms closer to best-practice standards through knowledge transfer and capability building.

These firm-level findings raise a natural question: what makes GVCs such effective channels for knowledge transfer and capability building? The answer lies in the fundamental structure of GVCs themselves – how they organize relationships between firms and create incentives for knowledge sharing that go far beyond traditional trade relationships.

Figure 7.11: Estimated Relationship Between Global Value Chain Participation and the Level of Productivity



Note: The figure reports estimated coefficients (and 95% confidence intervals) from regressions of productivity levels on backward GVC participation, firm age, age squared, capital-labor ratio, liability-asset ratio, government subsidy-sales ratio, and firm and year fixed effects. Separate regressions are estimated for each productivity quartile (Q1-Q4), where Q1 represents the lowest productivity quartile.
Source: Authors

7.3.3. The Architecture of Knowledge Transfer in Global Value Chains

GVCs function as sophisticated knowledge-sharing networks because of two structural features that distinguish them from traditional trade: stable, specialized relationships that enable tacit knowledge transfer, and productivity interdependencies that create strong incentives for active knowledge sharing. Combined with worker mobility and spin-off entrepreneurship, these two features transform GVCs into mechanisms for systematic technology transfer that extend far beyond direct participants.

Stable Relationships Enable Deep Knowledge Transfer

Unlike spot markets characterized by anonymous, transactional exchanges, GVCs are built on stable, long-term partnerships between firms engaged in highly specialized activities (Nunn, 2007; Kano, Tsang and Yeung, 2020). These enduring partnerships facilitate smoother knowledge flows across firms and, crucially, enable the transfer of tacit knowledge that typically requires repeated, trust-based interactions (World Bank, 2019; Piermartini and Rubínová, 2022).

The fragmentation of production into specialized tasks creates multiple touchpoints for learning. When firms simultaneously source inputs from and sell outputs to international supply chains, knowledge spillovers are particularly strong. Importantly, these benefits extend well beyond technological frontiers – middle-income economies gain significantly from foreign research efforts as GVCs have made knowledge diffusion less geographically constrained.

Productivity Interdependence Creates Sharing Incentives

The second key feature is that productivity complementarities along value chains create powerful incentives for knowledge sharing. When firms are interdependent within a production network, the productivity of each participant affects the performance of the entire chain. This gives lead firms – who coordinate and orchestrate these networks – strong incentives to actively support knowledge diffusion among their partners (Baldwin and Lopez-Gonzalez, 2015).

This represents a fundamental shift from traditional competitive dynamics. Rather than hoarding knowledge to maintain advantages, lead firms benefit from sharing expertise to eliminate bottlenecks and enhance overall network performance. The result is active technology transfer and capability building that goes far beyond what market forces alone would generate.

Knowledge Spillovers Beyond the Network

The impact of knowledge transfer extends well beyond direct participants through worker mobility and entrepreneurship. Bangladesh's garment industry transformation in the 1980s illustrates this multiplier effect (Rhee, 1990; Mostafa and Klepper, 2018; Verhoogen, 2023). In 1979, Bangladeshi company Desh Garment partnered with the conglomerate Daewoo from the Republic of Korea, sending 130 employees for six-month training in the Republic of Korea. Though the partnership ended in 1981, Desh's exports grew at over 90% annually, reaching $5 million by 1986/87.

Beyond Desh's own success, the real transformation came through spillovers. Trained workers who left Desh established new firms and trained additional workers, catalyzing industry-wide growth. Within a decade, Bangladesh expanded from a handful of garment manufacturers to 664 firms by 1988, demonstrating how GVC-initiated knowledge can multiply through labor mobility and spin-off entrepreneurship.

7.3.4. The Convergence-Divergence Paradox

While the discussion above suggests the potential for GVCs and technology diffusion to drive convergence between economies, these same mechanisms can simultaneously create inequality among them. GVC participation promotes knowledge diffusion and human capital accumulation that helps level the playing field internationally. However,

due to the structurally selective nature of GVCs, not all economies that participate in GVCs would benefit equally, potentially resulting in the uneven catching-up process observed among lower-income economies.

This structurally selective nature of GVCs generates inequalities not only between economies but also manifests within domestic economies. Pahl and Timmer (2020), for example, highlight a crucial tension between productivity convergence led by GVC participation and employment growth. They find that the presence of productivity gains from GVC participation do not generally translate to employment growth. The primary reason for this is that GVC production often involves adopting advanced, labor-saving technologies. To meet the high-quality standards of global markets, firms must rely on automation and capital-intensive processes, which reduce the demand for the abundant, low-skilled labor that emerging economies possess. Therefore, while a small number of highly skilled jobs may be created, the technology is ultimately better at substituting for workers than at creating mass employment opportunities.

This productivity-employment disconnect exemplifies how GVC integration can create distributional challenges within economies. The next section moves beyond convergence patterns between economies to inequality dynamics within them, examining how GVC-led technology transfer affects the functional distribution of income (i.e., labor vs. capital), within labor income distribution (i.e., skills, polarization, gender and vulnerable groups), firm heterogeneity (i.e., superstar vs. micro, small and medium-sized enterprises, or MSMEs) and ultimately regional inequality (i.e., urban/export hub vs. periphery).

7.4. Inequality, Labor Markets Global Value Chains and Technology

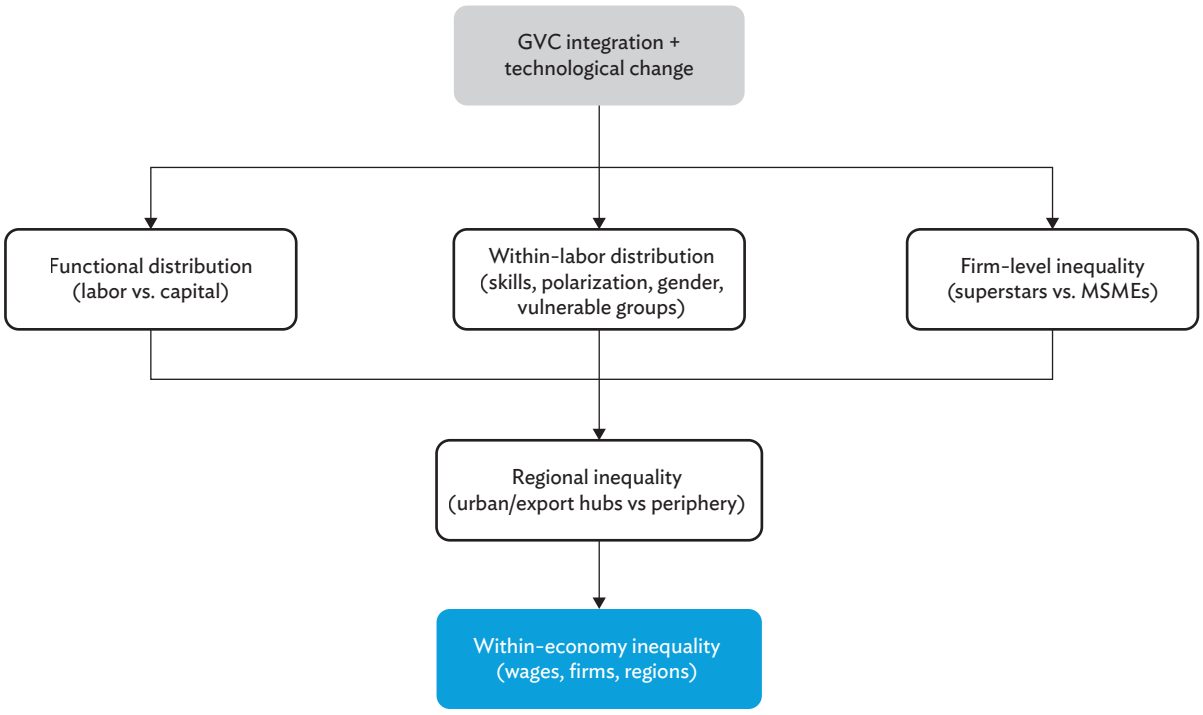
While GVCs and technological change, at least under certain conditions, have benefited productivity and fostered economic convergence across economies, their distributional consequences remain more contested. Productivity gains at the aggregate level may mask uneven effects across factors of production, worker type, firms and regions. In some cases, GVC integration and digital transformation may expand opportunities and raise incomes; in others, they may reinforce existing divides and shift value away from labor. This duality reflects the asymmetric ways in which the benefits of globalization and innovation are distributed across firms, workers and regions. The interaction between GVCs and technological change generates both opportunities and risks for inclusive growth. On the one hand, GVC participation can stimulate employment, skill development and wage growth – especially when domestic firms successfully upgrade and move into higher value-added segments. On the other hand, both GVCs and technology can exacerbate labor market inequalities by displacing workers in routine tasks, concentrating gains among skilled workers or large firms, and reinforcing geographical divides.

To unpack these dynamics, this section examines the main channels through which GVCs and technology shape inequality (Figure 7.12). Four dimensions stand out:

1. The functional distribution of income – shifts in the demand for and returns to capital and labor
2. Labor market effects – shifts in skill demand, job polarization and distributional patterns by gender, informality and worker vulnerability
3. Firm-level heterogeneity – the rise of superstar firms, pressures on MSMEs and uneven regional gains
4. Regional inequality – how effects due to the functional distribution, labor market effects and firm heterogeneity spatially manifest themselves

Together, these perspectives highlight both the risks of unequal outcomes and the conditions under which GVCs and technology can foster more inclusive growth. The section concludes by discussing how the new wave of automation may interact with GVCs to influence future inequality dynamics.

Figure 7.12: Channels From Global Value Chains/Technology To Within-Economy Inequality



Source: Authors

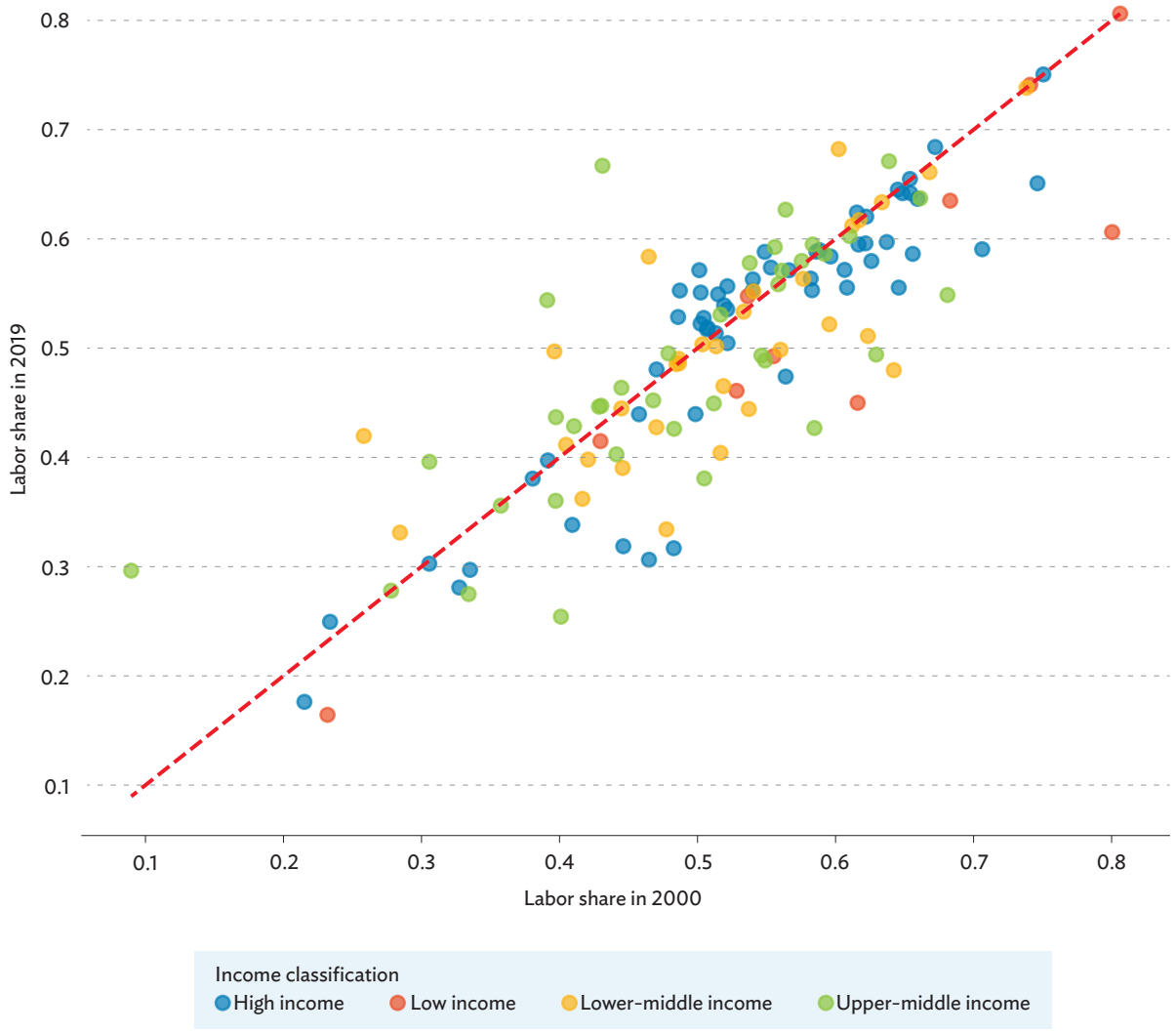
7.4.1. The Functional Distribution of Income

GVCs and technological change can combine to impact the functional distribution of income between capital and labor. Since the functional income distribution represents a major driver of personal income distribution (Daudey and Garcia-Penalosa, 2007;

Atkinson, 2009; Wolff and Zacharias, 2013; Coveri and Pianta, 2022), changes in the wage share due to the combined forces of GVCs and technological change can be an important driver of within-economy inequality.

Consistent with a longer run trend of declining labor shares, the GVC era has seen declines in labor shares across a range of developed and developing economies (Kheng, Mckinley and Pan, 2023; Harrison, 2024). Figure 7.13 reports data from the Penn World Tables on the change in the labor share between 2000 and the latest year in the dataset, 2019. The figure reveals that despite a great deal of heterogeneity, labor shares in 2000 were higher than those in 2019 in a majority of economies at all income levels.

Figure 7.13: Changes in Labor Shares Between 2000 and 2019



Source: Penn World Tables version 10.0 (Feenstra, Inklaar and Timmer, 2015).

The potential for GVCs to impact on the labor share is strong, with GVC integration increasing competitive pressures and incentivizing firms to contain labor costs by limiting wages or job losses. Offshoring labor-intensive tasks (e.g., assembly activities) from capital-abundant to labor-abundant economies also entails a higher capital-output ratio in the former, reducing the labor share in developed economies to the extent that capital acts as a gross substitute for labor (Harrison, 2005; Elsby, Hobijn, and Sahin, 2013; Helpman, 2016; Dao, Das and Koczan, 2020). This mechanism is central to the model of sequential production in GVCs of Sposi, Yi and Zhang (2021). They show how reductions in trade barriers lead to a reallocation of relatively upstream capital-intensive activities to relatively capital-abundant economies, highlighting that this technology effect of GVCs may be felt more strongly in developed economies.

In addition, by allowing for a greater substitutability of workers, GVCs can create the threat of tasks being offshored to other economies, with potentially negative consequences for worker bargaining power that can result in reduced wage shares and rising inequality in both developed and developing economies (Rodrik, 1997; Choi, 2001; Jeon, and Kwon, 2021; Coveri and Pianta, 2022; Guschanski and Onaran, 2023).

The interaction between GVCs and technology can be a further important driver of changes in the labor share. GVCs facilitate the diffusion and adoption of technologies, leading to capital-augmenting technological change that can have negative consequences for labor. Technological adoption and diffusion – particularly capital-augmenting forms such as robotics – can shift income toward capital, reducing labor's share (Karabarbounis and Neiman, 2014), especially when worker bargaining power is weak.

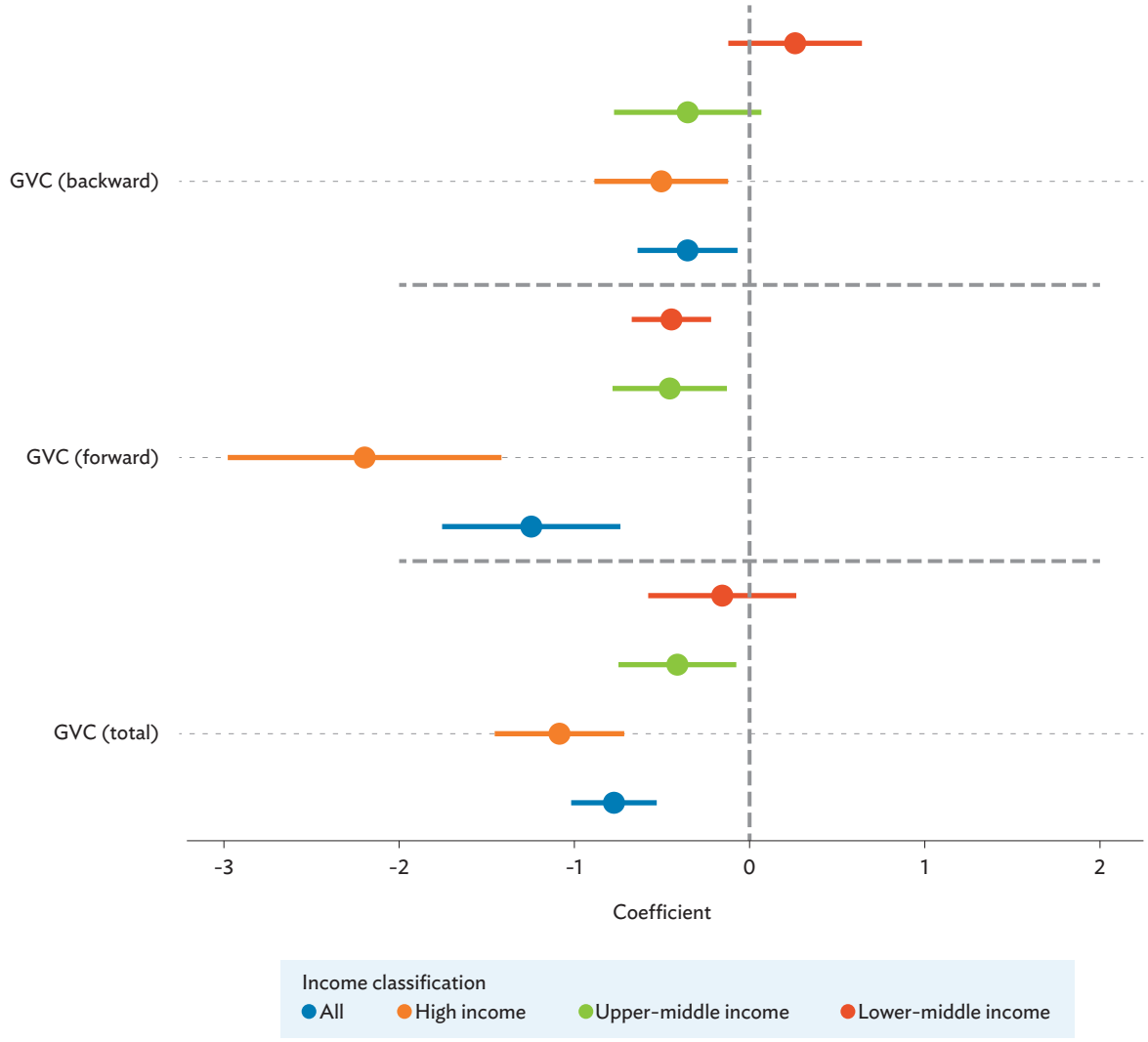
Recent evidence considering the relationship between GVC integration and the functional distribution of income shows that GVCs can negatively impact upon the labor share, but that the effects are heterogeneous and dependent upon the type of GVC integration. Riccio, Dosi and Virgillito (2023), for example, show that GVC integration can negatively impact upon the labor share, with this negative impact associated with increases in functional specialization in fabrication and marketing functions of suppliers along the value chain, particularly in lower-income economies. Reshef and Santoni (2023) combine information on GVC positioning and functional specialization, finding that forward GVC participation is associated with an accelerated decline in the labor share, with this effect being particularly strong for fabrication functions. In contrast, increases in backward GVC integration are positively associated with changes in the labor share of research and development (R&D) functions.

In a background paper for this report, Foster-McGregor (2024b) extends the analysis of Reshef and Santoni (2023) to consider high, upper-middle and lower-middle income economies. This increase in economy coverage across income levels comes at the expense of having no functional information and an exclusive focus on labor shares in manufacturing sectors. Estimating the relationship between indicators of forward and backward participation in GVCs and the manufacturing labor share, he finds evidence

of a negative impact of GVC participation on the labor share, with this effect being higher for forward than for backward GVC linkages (Figure 7.14).

Effects are further found to vary by development level, with the negative effects of GVC participation on the labor share tending to be larger in high-income economies and often insignificant in lower-middle-income economies (Figure 7.14). Such results are consistent with rising inequality trends being more prominent in developed economies, as well as with the arguments above indicating that the capital and technology bias of GVCs can have more negative impacts on labor in high-income economies.

Figure 7.14: Estimated Relationship Between Global Value Chain Participation and the Change in the Labor Share



Notes: The figure reports estimated coefficients (and 95% confidence intervals) from a regression of the annual change in the labor share on the change in GVC participation (forward, backward and total GVC participation), the ratio of robots to employment, economy, sector and time fixed effects.
Source: Authors' calculations

The paper of Foster-McGregor (2024b) further examines the interaction between GVCs and technology and its influence on the labor share. The paper shows that an increase in the share of robots per worker is associated with lower wage shares, suggesting a direct effect of automation on the wage share. Moreover, evidence presented in the paper suggests that GVC participation, notably forward GVC participation, is further associated with higher ratios of robots per worker. This latter result suggests that GVCs impact the labor share both directly and also by increasing the rates of automation, with these effects more common in, and often limited to, high-income economies.

In sum, the evidence suggests that GVCs and technological change have exerted downward pressure on labor's share of income, particularly in high-income economies and especially through forward linkages and capital-intensive technologies such as robotics. These aggregate shifts in the functional distribution matter because they shape the overall division between capital and labor. They also point to a broader challenge: the capacity of GVCs and new technologies to redistribute value unevenly across economies, sectors and worker groups.

7.4.2. Labor Market Effects

Impacts within labor markets remain the most immediate channel through which GVC participation and technological change are likely to affect inequality. Beyond changes in the functional distribution of income, the literature emphasizes skill-biased demand and job polarization as potential explanations for why productivity gains associated with GVCs and technology may not automatically translate into broad-based income growth. Wang and Yin (2015), for example, provide a useful theoretical lens, showing that international technology transfers – an intrinsic feature of GVCs – shift relative wages depending on whether the transferred technology benefits skilled- or unskilled-intensive sectors. If productivity rises in skill-intensive sectors, the skilled wage premium increases, whereas productivity gains in unskilled sectors can narrow inequality.

Indeed, the link between GVC participation and labor markets has been the theme of past *GVC Development Reports* (Bacchetta and Stolzenburg, 2019; Hollweg, 2019; Park, Lundquist and Stolzenburg 2023). Considering the impacts of GVCs on labor markets in advanced economies, Bacchetta and Stolzenburg (2019) note that while the overall contribution of GVC integration to declining manufacturing jobs in advanced economies is limited, it has led to job losses in certain sectors and regions. Demand for labor has also shifted towards higher-skilled workers, leaving low-skilled workers at a disadvantage and encouraging wider income disparities.

Hollweg (2019) emphasizes that GVCs have facilitated economic integration of lower-income economies, offering new avenues for growth and industrialization. She also highlights, however, that the benefits have not been distributed evenly. Integration of lower-income economies into GVCs has tended to be skill-biased, with demand for

skilled labor increasing often at the expense of low-skilled workers. This contrasts with theory, which would suggest an increase in demand for unskilled workers in labor-abundant lower-income economies (Baldwin and Evenett, 2015). This paradox of GVCs reallocating tasks to increase the demand for higher-skilled workers in both high- and lower- income economies can be explained if the activities received from global lead firms are more skill-intensive than domestic averages, resulting in a rising skill premium (Feenstra, 2007). Through their role in diffusing technology, GVCs have further led to the displacement of workers in traditional sectors through automation and digital technologies, effects that fall disproportionately on low-income and less-skilled workers.

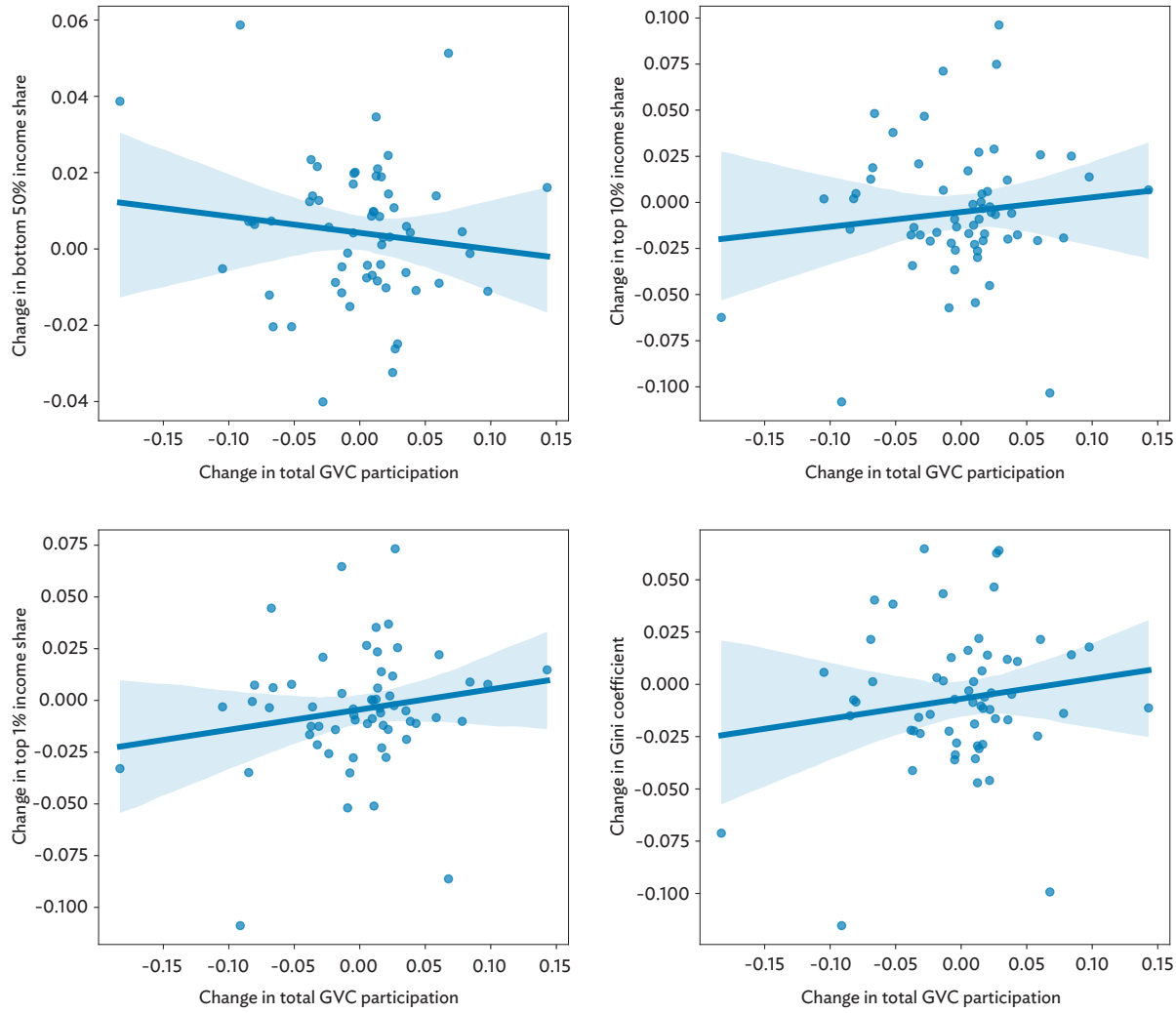
Beyond differences by skill, labor market outcomes are also mediated by structural characteristics such as gender, age and employment formality. Women remain concentrated in export-oriented industries that are labor-intensive but low paid, such as apparel, electronics assembly and agribusiness. While these sectors often provide entry into wage employment, they offer limited opportunities for upgrading and are highly exposed to global demand fluctuations (see, for example, Barrientos and Kabeer, 2004; Kalliny and Zaki, 2024). Young workers, meanwhile, are more likely to enter GVCs through routine or precarious occupations that provide limited career progression (ILO, 2017). Informality is another persistent feature, especially in developing economies where GVC integration often relies on informal subcontracting and home-based production (see, for example, Tartanoğlu, 2017). This weakens the transmission of productivity gains to workers and restricts access to social protection. These distributional patterns suggest that the inequality effects of GVCs operate not only through skill bias, but also through the segmentation of labor markets along gender, generational and formality lines.

In the *2023 GVC Development Report*, Park, Lundquist and Stolzenburg (2023) extend this perspective by showing that while GVC participation has improved employment opportunities, these are often concentrated in low- or medium-skilled, informal or precarious jobs, limiting the inclusiveness of gains. They further show that gender gaps persist in GVC trade, with women overrepresented in lower-paid, lower-skilled roles in export-oriented firms, while shocks such as COVID-19 or trade tensions tend to hit vulnerable groups hardest – low-skilled, informal and female workers, in particular – with uneven recovery trajectories.

The evidence presented in previous reports is thus mixed and suggests that any effects on labor market outcomes and on aggregate inequality trends are likely to be heterogeneous and depend on structural characteristics of the economy in question. Such arguments also suggest that aggregate level evidence of a relationship between inequality and GVC participation may be limited, something confirmed by casual evidence (see Figure 7.15) and recent literature. Carpa and Martinez-Zarzoso (2022), for example, find that backward participation increases inequality in developing economies in the short run, while the long-run effect is to reduce inequality. Results

for forward GVC participation tend to be insignificant. Gonzalez, Kowalski and Achard (2015) find limited evidence of a relationship between GVC participation and wage distributions, though some evidence of GVCs reducing wage inequality among the low-skilled segment of the labor force is found. Duarte et al. (2022) find evidence of a U-shaped relationship between an indicator of GVC positioning and inequality for a sample of 67 economies over the period 1995-2018. These results thus suggest that intermediate positions within GVCs can contribute to reduced inequality, while positioning in the tails is associated with higher inequality, perhaps related to the biased nature of labor demand in the tails.

Figure 7.15: Relationship Between Changes in Global Value Chain Participation and Indicators of Income Inequality



Notes: GVC participation is calculated using the methodology of Wang et al. (2017), with the GVC participation rate being the average of the forward and backward GVC participation rates. To control for the effects of economy size in influencing GVC participation rates, the change in GVC participation rate is the change between 2007 and 2023 in the residuals of a regression of the GVC participation rate on the log of GDP.

Source: World Inequality Database, ADB Multi-region input output tables

More recent evidence addresses this heterogeneity in several ways. Lewandowski, Madoń and Winkler (2024) find that GVC participation can impact within-economy wage inequality through two distinct channels. The direct effect operates through GVCs' influence on workers' wages – for example, by changing relative pay across occupations and sectors. The indirect effect works through GVCs' impact on the routine task intensity (RTI) of jobs, since more routine, offshorable work tends to pay less. Workers in offshorable occupations tend to work in more routine intensive work, especially in developing economies – a relationship that is strongest in tradable sectors. Since a higher RTI is associated with lower wages, GVC participation indirectly increases wage inequality. The direct effect of GVC participation, however, serves to reduce wage inequality in most economies. In emerging economies, the direct effect dominates the indirect effect, resulting in lower inequality, whereas in advanced economies the indirect effect dominates, with GVCs benefiting workers in non-offshorable occupations in tradable services.

The role of functions within global value chains in impacting inequality effects of GVCs is also considered by Coveri, Paglialunga and Zanfei (2024). They use data on foreign direct investment (FDI) by function to build indicators of involvement in different activities in GVCs, namely pre-production, production and post-production activities. They argue that inward FDI in knowledge-intensive functions can have varied effects on labor demand and wages. They may encourage structural changes in recipient economies towards better-paid jobs in new and high-growth sectors, which may be task- and skill-biased, raising skill premiums and increasing inequality (Hale and Xu, 2016; Bogliaccini and Egan, 2017). If upgrading in response to inward FDI is sufficiently widespread, however, then it may generate productivity gains that can benefit low-wage segments of the labor force, which in turn could reduce inequality. Their results suggest that larger shares of inward FDI in intangible-investment activities, particularly pre-production activities like R&D, are associated with lower inequality. As such, and in contrast to Duarte et al. (2022), engagement in activities at the ends of the value chain – i.e., upstream and downstream activities – is associated with lower income disparities.

Coveri, Paglialunga and Zanfei (2024) further consider indicators of GVC positioning and their relationship with inequality. They show that stronger forward linkages are negatively related to inequality in advanced economies but positively related in middle- and low-income economies. In other words, a more downstream position in GVCs is associated with higher income inequality in high-income economies. Conversely, a more upstream position in GVCs is associated with higher inequality in middle- and low-income economies, which it is argued may be due to the high levels of competition among intermediate input suppliers along with the concentration of profits in upstream industries providing commodity and energy materials.

7.4.3. Firm Level Heterogeneity

The distributional consequences of GVC participation are shaped not only by shifts between capital and labor, or across groups of workers, but also by heterogeneity among firms. GVC integration interacts with technological change to generate a sharp divergence in firm performance, with large, technologically sophisticated enterprises pulling away from smaller and less productive firms (Mattsson and Reshid, 2023).

A growing literature highlights the rise of "superstar" firms – large multinationals that combine scale, intangibles and global reach to capture an increasing share of value added and profits. These firms are best placed to exploit digital technologies, such as robotics and AI, which complement their organizational capabilities and intangible assets (e.g., Firooz, Liu, and Wang, 2025). The result is a concentration of productivity gains and rents among a narrow set of firms at the top of GVC hierarchies. This has direct implications for inequality: superstar dominance can reduce labor's bargaining power, suppress wage growth in supplier networks and limit the diffusion of technology and know-how to the broader economy (see, for example, Autor et al., 2020).

By contrast, MSMEs typically face higher barriers to upgrading and limited capacity to absorb new technologies. While digital platforms and e-commerce tools may lower entry costs by facilitating cross-border transactions or providing cloud-based services (Gopalan, Reddy and Sasidharan, 2022), evidence suggests that the benefits accrue unevenly (Marzi et al., 2023). MSMEs that are already relatively productive and digitally connected can expand their reach through platforms such as Alibaba or Mercado Libre (Pan et al., 2025). But many others remain locked into low-value segments of production networks, exposed to intense competition and vulnerable to shocks.

A further dimension is informality. In many developing economies, informal firms and workers are embedded in export-oriented value chains, often through subcontracting or casualized employment. While such linkages provide income opportunities, they rarely deliver productivity spillovers or access to upgrading, at least without building absorptive capacity (e.g., Djidonou, Foster-McGregor and Mathew, 2025). Informality thus becomes a mechanism by which the gains from GVC integration are diluted, with precarious work absorbing volatility while rents remain concentrated in formal lead firms. The coexistence of superstars, MSMEs and informal enterprises underscores how firm-level heterogeneity transmits the benefits and costs of GVC participation in highly unequal ways.

7.4.4. Regional Inequality

Regional inequality can be understood as the spatial manifestation of the dynamics already discussed at the level of production factors, workers and firms. GVC participation does not affect all places equally: it amplifies the advantages of regions

with concentrations of high-skilled labor, lead firms and complementary infrastructure, while leaving others behind (OECD, 2023a). Labor market polarization plays out geographically, as areas rich in routine-intensive manufacturing jobs are more exposed to automation and offshoring, while skill-intensive metropolitan regions capture new employment opportunities in high-value services.

Similarly, firm-level heterogeneity translates directly into uneven regional trajectories. Superstar firms cluster in global cities and specialized industrial hubs, where they benefit from agglomeration economies, innovation ecosystems and access to global networks (e.g., Crescenzi et al., 2018). By contrast, MSMEs and informal firms are often rooted in peripheral or rural areas, where limited infrastructure and weaker state capacity constrain their ability to upgrade. This divergence means that the distribution of economic activity across space is increasingly shaped by where "superstars" choose to anchor their operations versus where fragmented and vulnerable firms remain.

New technologies – AI, robotics, digital platforms – reinforce these divides. Regions with digital infrastructure, absorptive capacity and a skilled workforce can harness automation and platformization to integrate more deeply into GVCs. Others risk being bypassed by technological progress, with automation potentially eroding their traditional comparative advantage and digital divides preventing meaningful participation in new segments of trade. The resulting geography of globalization and technology is therefore highly unequal: some regions emerge as winners in the reorganization of global production, while others face marginalization or stagnation (Hartmann and Pinheiro, 2022; OECD, 2023a).

7.4.5. The Next Wave: Artificial Intelligence, Global Value Chains and Labor

Past waves of globalization and automation have reshaped labor markets largely through the offshoring of routine tasks, the rise of skill-biased demand and the concentration of value in globally integrated firms. The next wave of technological change – driven by AI, advanced robotics and digital platforms – carries the potential to both mirror and depart from these patterns in ways that could significantly alter the distributional consequences of GVC participation.[1]

Unlike earlier forms of automation that primarily targeted codifiable routine work, AI extends the technological frontier into non-routine cognitive tasks, reshaping not only the labor market but also the geography and organization of GVCs. Bekkers, Kalachyhin and Teh (2024), for example, show that AI may encourage GVCs through productivity growth and reduced trade costs, but also how the technology may exacerbate labor market polarization. High-productivity gains in capital- and skill-intensive services sectors such as finance, insurance and business services disproportionately benefit already-skilled

[1] This discussion is based on the background paper for the *GVC Development Report 2025* of Bastos (2024).

workers and capital owners. Meanwhile, sectors with low AI exposure or those in which labor replacement is feasible (e.g., routine manufacturing) may see job losses or wage suppression. Thus, while digitalization may reshape the geography of trade in ways that benefit some economies, it may also deepen within-economy inequality.

AI is advancing the scope of automation by complementing high-skilled, non-routine workers while increasingly displacing mid- and low-skilled cognitive roles that were previously insulated. Estimates by the OECD (2023b) suggest that 14-27% of jobs in member economies are highly automatable, with GVC-linked sectors such as logistics, electronics and business services among the most exposed. Task-based analyses show that while few occupations are entirely automatable, most contain tasks suitable for machine learning (Brynjolfsson and Mitchell, 2017), implying that AI is likely to restructure rather than fully eliminate jobs. The distributional risks of AI and automation are not uniform across worker groups. Evidence from developing economies shows that women and youth are disproportionately employed in routine-intensive occupations, leaving them more exposed to displacement and wage stagnation as AI and robotics diffuse (Pieters et al., 2025). Informal workers, who often lack access to training or digital tools, also face higher vulnerability to technological change. These patterns highlight that without targeted policies – skills development, inclusive training and social protection – automation and GVC-linked technological shifts may exacerbate existing inequalities within labor markets.

At the global level, AI and robotics may reconfigure the comparative advantages that have historically underpinned GVCs. Robot adoption has already been concentrated in automotive and electronics, but AI-enabled robotics are beginning to penetrate sectors such as textiles and pharmaceuticals that have traditionally relied on low-wage labor. This raises concerns about accelerating "premature deindustrialization" (Rodrik, 2016), as labor-intensive export models lose viability. Yet the productivity-enhancing effects of AI adoption in high-income economies may also expand demand and create new opportunities for emerging economies through trade and FDI (Artuc, Christiaensen and Winkler, 2019; Stapleton and Webb, 2020). Whether these forces crowd out or complement developing economies' participation in GVCs remains an open question.

AI also interacts with GVCs by lowering trade and coordination costs. Machine translation, predictive analytics and logistics optimization are reducing barriers to cross-border exchange and enabling more seamless integration of small firms into global production networks. For instance, eBay's introduction of AI-powered translation significantly boosted trade flows between the US and Latin America (Brynjolfsson, Hui and Liu, 2018). At the same time, the rise of platform-based GVCs introduces new asymmetries. Algorithmic visibility and reputation mechanisms often favour incumbent firms and performance outcomes can be driven more by algorithmic exposure than by underlying productivity (Chen and Xu, 2024). Without corrective policies, platformization may therefore deepen digital divides rather than democratize access to global markets.

The falling cost of intangible capital – data, software and AI capabilities – further tilts GVC participation toward firms and economies able to accumulate these assets. Zeng and Zhu (2024) argue that cheaper intangible capital can generate new jobs in knowledge-intensive segments of GVCs, but this upgrading potential is unevenly distributed. Lead firms and technologically advanced suppliers are best positioned to benefit, while smaller and less connected firms risk being locked into low-value tasks. Firm-level evidence already suggests that robot adoption is disproportionately concentrated among large, internationally connected enterprises (Artuc, Bastos and Rijkers, 2023), a pattern likely to intensify with the spread of AI.

These transformations will also carry uneven implications for workers across gender, age and informality. Women and youth are disproportionately concentrated in clerical, service and manufacturing roles that are highly automatable, while informal workers – lacking access to training and digital tools – face structural barriers to adaptation. By contrast, new opportunities in AI-enabled GVC segments such as design, R&D and digital services often require advanced skills and access to technology, creating risks of exclusion.

Taken together, these dynamics suggest that the distributional consequences of AI-GVC interactions will be highly uncertain and uneven. On the one hand, AI may deepen inequalities by displacing routine tasks, reinforcing firm-level concentration and eroding the labor-cost advantages of developing economies. On the other, it has the potential to expand trade, reduce coordination costs and create new upgrading opportunities for firms and workers able to adapt. The extent to which the next wave of technological change exacerbates or mitigates inequality will depend heavily on domestic conditions – education systems, training institutions, digital infrastructure and social protections – as well as on how global production networks themselves evolve in response to these frontier technologies.

7.5 Policy Responses – Harnessing Global Value Chains and Technology for Inclusive Growth

The chapter highlights a central paradox: GVCs and technological change can raise productivity and promote convergence between economies, but they can also deepen divides within them. Their effects on inequality are heterogeneous, often magnifying existing domestic strengths and weaknesses. This makes policy essential – not only for maximizing the productivity gains associated with GVC participation and technology adoption, but also for ensuring that those gains are distributed broadly. The central challenge is not whether economies integrate into GVCs or adopt new technologies, but how these processes are shaped so that they translate into inclusive growth.

On the productivity side, the evidence shows that GVC participation does not guarantee automatic benefits. Gains depend critically on economies' positions within global production networks and their domestic absorptive capacity. This suggests the need for a selective approach to integration. Rather than pursuing GVC participation indiscriminately, economies could focus on sectors and segments where they can build sophisticated capabilities. Smaller economies, which often lack the scale needed to reach threshold effects, may find regional value chains a useful stepping stone to global integration. At the same time, building the institutional and human capital foundations for absorptive capacity is vital. Without robust education, lifelong learning systems and vocational training, the knowledge and technology diffused through GVCs cannot be absorbed. Recent evidence shows that training programmes can reduce wage gaps in GVC-intensive sectors, underscoring the importance of skills development (OECD, 2023b). Strengthening R&D systems, digital infrastructure and innovation ecosystems also enables firms to adopt and adapt new technologies, while policies supporting small and medium-sized enterprises can help them meet international standards and link more effectively into GVCs. In this sense, sequencing can be crucial, with economies building capabilities before pursuing deeper integration once the conditions for sustained upgrading are in place.

Yet maximizing productivity is only half the story. Even where GVC-related gains materialize, they are often unevenly distributed – concentrated in capital-intensive sectors, specific regions or among higher-skilled workers. Ensuring that benefits spread more broadly requires a complementary set of inclusive policies. Because GVC participation is frequently associated with labor-saving technologies, governments could provide robust retraining, active labor market policies and portable social protection to help workers transition from declining sectors to emerging opportunities. Labor market regulations and practices, including minimum wages and collective bargaining and targeted support for vulnerable groups, including women and youth, can further cushion workers from volatility. Redistribution also plays a role: progressive taxation of GVC-participating firms, combined with investment of revenues into education, infrastructure and skills, can channel concentrated gains into broader national development. Spatial inequalities are another concern, as GVC benefits tend to cluster in core regions. Infrastructure investments, incentives for firms to locate in lagging regions and policies that facilitate worker mobility can help spread knowledge spillovers more evenly, while entrepreneurship programmes can extend GVC-related opportunities beyond immediate lead firms.

Finally, the governance of emerging technologies has become central to inclusive GVC participation. AI and digital platforms create powerful new opportunities but also risks of concentration and worker displacement. Policymakers may explicitly assess the labor market impacts of new technologies and adopt measures – through competition policy, fair taxation, open standards and technology transfer mechanisms – that prevent frontier innovations from being locked within a few lead firms. The strength of domestic institutions is critical here: economies with collective bargaining systems and

active labor market policies tend to experience more equitable outcomes from GVC and technology shocks, while weak institutional environments leave workers more exposed to polarization and declining labor shares.

In sum, successful GVC-led development requires moving beyond the assumption that participation alone delivers benefits. Productivity gains can be actively cultivated through strategic positioning and capability building, while inclusive outcomes depend on policies that diffuse and redistribute those gains across workers, regions and firms. Economies that manage this balance – harnessing GVCs and technological change for productivity while ensuring broad-based participation – will be best positioned to achieve convergence without falling into the trap of rising inequality.

7.6 Conclusion

Recent decades have seen the twin forces of GVC integration and technological change reshape the global economy. They have supported productivity growth and convergence between economies, but they have also introduced new fault lines within them. The evidence reviewed in this chapter shows that their effects are neither uniformly positive nor uniformly negative. Instead, they are deeply contingent on economy-specific institutions, firm structures, GVC positioning and policy environments.

Three broad conclusions stand out. First, GVCs and technology are not independent: they are mutually reinforcing. Technology has enabled the fragmentation of production, while GVCs serve as key channels of technology transfer. Second, the gains from this interaction are uneven. Aggregate productivity increases may mask widening divides across workers, firms and regions. Third, institutions matter. Where skills, infrastructure and social protections are strong, GVCs and technology can deliver broad-based gains; where they are weak, they may amplify inequalities.

For policymakers, the central challenge is not whether to participate in GVCs or adopt new technologies, but how to shape these processes so that they contribute to inclusive growth. This requires investments in human capital and absorptive capacity, support for MSMEs and vulnerable groups, and governance of emerging technologies such as AI to prevent concentration and exclusion.

Looking ahead, the policy debate must move beyond the binary of globalization and global value chains as opportunity or threat. The more relevant question is how economies can design strategies that harness GVCs and technology as engines of inclusive and sustainable development.

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8

Targeted Trade Deals As a New Form of Global Value Chain Governance[1]

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8.1 Introduction

The world economy has been exposed to major structural shifts that require a continuous adaptation of its institutional framework. As highlighted in the *GVC Development Report 2021* (Asian Development Bank et al., 2021) and the *GVC Development Report 2023* (University of International Business and Economics Beijing et al., 2023), climate change, digitalization and geopolitics are reshaping the trading system. For instance, climate change requires new goods and services to be traded and causes industrial reconfigurations with significant repercussions for the trading system. The rise of services and digitalization has weakened the role of tariffs for trade costs and shifted the focus towards non-tariff measures (NTMs) in sectors that are less regulated by multilateral or regional trade agreements. The COVID-19 pandemic and current geopolitical tensions have put a spotlight on patterns of concentration in trade flows as the focus of policymakers has shifted from efficiency gains to resilience and security.

However, further international integration and an adaptation of the rules-based system have become increasingly difficult. Political support for international trade has weakened amidst a backlash against globalization. Climate change, digitalization

[1] This chapter has been coordinated by staff of the World Trade Organization. It has been prepared under the responsibility of the authors, and the opinions expressed in it are those of the authors. The chapter does not necessarily reflect the positions or opinions of WTO members and is without prejudice to their rights and obligations under the WTO. The opinions expressed and arguments employed herein are not intended to provide any authoritative or legal interpretation of the provisions of the WTO agreements and shall in no way be read or understood to have any legal implications whatsoever. The terms and illustrations used in this publication do not constitute or imply an expression of opinion by the WTO Secretariat concerning the status or boundaries of any territory. Any errors are attributable to the authors.

and geopolitical tensions have not only resulted in the need to adapt the trading system, but they have also led some to question the benefits of an open rules-based multilateral system. In line with this, policy measures aimed at strengthening economic independence increasingly replace measures supporting interdependence (WTO, 2023). Moreover, a growing and more diverse membership in international institutions can make it more complex to find common ground in negotiations and more challenging to reach compromises. As a result, new multilateral agreements have become scarce and the speed at which new regional trade agreements (RTAs) are formed has slowed down.

Against this background, governments rely increasingly on different complementary forms of trade governance. For example, at the World Trade Organization (WTO), subsets of members negotiate within joint statement initiatives, or plurilaterals, on issues where current rules are limited. This includes agreements on the domestic services regulation, e-commerce or investment facilitation. At the unilateral level, some economies attempt to regulate carbon emissions embodied in trade flows through border adjustments. Relatedly, Chapter 5 of this report discusses the re-emergence of industrial policy to shape trade flows linked to the green transition, new technologies or critical raw material sectors.

In this chapter, we assess one such emerging form of trade governance: targeted trade deals (TTDs). We refer to TTDs as agreements that are typically sectoral or otherwise limited in scope and coverage, reflecting a targeted objective. In addition, they tend to focus on addressing regulatory barriers to trade through soft law provisions rather than formal binding agreements, which is why we consider the term deal appropriate. These instruments are also referred to in the literature as “mini deals”, “trade executive agreements” or “trade-related agreements”. Despite their often-limited formality, the trade-regulating nature of TTDs warrants closer examination to understand how governments are leveraging them to shape trade policy, and what their broader economic and strategic impacts might be. Exploring this novel dimension of trade policy can provide valuable insights into evolving global trade and value chain dynamics, as well as into the strategies WTO members employ to navigate contemporary economic and geopolitical challenges. This is particularly relevant for global value chains (GVCs), as they rely on more border crossings for their complex production networks than traditional trade.

Our analysis provides five key insights. First, TTDs are not a new phenomenon as such, but they have seen a sharp rise in the past five years. As they are subject to a relatively light implementation process, they can provide policymakers with a simple tool to address newly emerging challenges through a cooperative approach. In this regard, they can be an integral part of reglobalization, the theme of this report. For instance, TTDs can provide a regulatory structure in less regulated areas such as digital trade, or they can facilitate diversification of trade in concentrated sectors such as critical raw minerals. TTDs promote trade in a variety of sectors, or even horizontally, but we focus our analysis on digital trade and critical raw material (CRM) TTDs, as these areas

have been the primary target of the recent TTD expansion. We find that the number of country pairs, or dyads, connected through digital TTDs has increased by a factor of 35 since 2019.[2] Similarly, 80% of CRM TTDs have been signed between 2022 and 2024.

Second, our analysis shows that these agreements come in a variety of flavours, including formal agreements, exchanges of letters, joint statements, declarations, memoranda of understanding (MoUs), side letters and work plans. Unlike RTAs, these agreements tend to be narrowly tailored to address specific regulatory barriers or supply chain vulnerabilities. Their flexibility allows for targeted problem solving, rapid negotiation and implementation. However, they largely operate "under the radar" compared to RTAs, attracting less public scrutiny, oversight and academic analysis. For instance, TTDs are not notified to the WTO, and reporting often contains little information.

Third, TTD formation is driven by a limited set of factors clearly linked to their specific objective. Looking at both digital and critical mineral TTDs enables us to highlight the heterogeneity of TTD formation stemming from the underlying objectives of the different agreements. We find, for instance, that digital TTDs are primarily signed by governments with existing RTAs and a well-developed digital infrastructure and institutions. In contrast, CRM TTDs depend on the presence of resources in at least one party to the agreement, and institutional quality is not a determining factor. Importantly, and in contrast to many RTAs that are signed to advance regional integration, the physical proximity between two TTD signatories appears to be of less importance.

Fourth, we find support for TTDs increasing trade between the signatories in the regulated areas. The strongest evidence of TTDs having a systematic effect on trade is found for CRM TTDs, whereas for digital TTDs it is likely too early to be able to detect a similar impact. We also conduct a first analysis on the language of the legal texts of digital TTDs where we find suggestive evidence that those with binding language provisions are associated with a statistically significant increase in digitally deliverable services trade.

Fifth, we discuss how TTDs interact with the existing trade governance framework from both a multilateral and a national perspective. In light of their potentially trade-creating effects, we highlight how different provisions in existing WTO agreements relate to TTDs. We also examine their relationship to bilateral investment treaties given that CRM TTDs, in particular, are likely to stimulate not only trade, but also foreign direct investment. Finally, we point out that, while the less comprehensive negotiation and implementation process involved in TTDs offers certain advantages in addressing emerging challenges, it also raises questions as to the transparency and accountability with domestic stakeholders.

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2 A dyad refers to a pair of economies (e.g., France-Japan) used as the unit of analysis in studies of bilateral relations or agreements.

Our chapter builds upon and expands a small but growing literature on TTDs. The concept of TTDs was brought to the fore through Claussen's (2022) comprehensive analysis of the use of trade executive agreements (TEAs) in United States' (US) trade policy. She found that their use had substantially increased since the late 1990s and identified more than 1,200 TEAs with 130 trade partners, coinciding with the expansion of non-tariff measures (NTMs) in the trade policy toolkit. These TEAs have been predominantly used to address specific and narrowly defined trade issues, although more comprehensive TEAs have become more common since the mid-2010s. Notably, Claussen highlights that most TEAs are found to be negotiated solely by the executive branch and do not require congressional approval. While this makes them swift and targeted instruments for addressing urgent trade issues, it also raises constitutional concerns, particularly regarding the balance of power between the executive and legislative branches. Relatedly, the US Congressional Research Service published a report on congressional and executive authority over foreign trade agreements (Zirpoli, 2024) that mirrors many of the arguments made by Claussen (2022).

The signing of sectoral deals is not a development that is unique to the US. Cernat (2023) shows that the European Union (EU) has signed a large number of what he calls mini trade deals based on the EU's Official Journal database. Similar to Claussen (2022), Cernat finds that mini trade deals are often targeted at NTMs. Cernat also argues that using the term "mini" can be misleading as certain deals affect substantial trade flows, even compared to RTAs. A study by the National Board of Trade Sweden takes a global approach to conduct a mapping of TTDs (Larsson and Wennerberg, 2024). They provide a list of 114 TTDs across four domains with relevance for global value chains – resilience, digital, green and horizontal – signed between 2016 and July 2024. Another recent study, by the Africa Policy Research Institute identifies nearly 100 partnerships involving 12 external economies with various African economies concerning "critical" and "green" minerals (Beuter et al., 2025).[3] The study highlights how, despite their strategic importance, these agreements generally remain vague, non-binding and difficult to access, leading to a call for increased transparency and accessibility to understand their implications. This is a common thread across all prior studies on TTDs.

In this chapter, we build on and contribute to this literature through three main contributions. First, we extend the existing mapping of TTDs by the National Board of Trade Sweden in the digital and critical mineral space. Second, we conduct the first rigorous empirical assessment of the determinants leading to their signing and of their trade effects. Third, we expand the discussion of the relationship of TTDs both with respect to international trade law and domestic policy. The chapter is organized as follows. Section 2 introduces our definition of TTDs and their distinctive nature compared to other trade policy instruments. Section 3 provides a mapping of digital

[3] The study adopts a broad approach to TTDs, including any partnership related to mining and mineral resources. As a result, many of the agreements may not specifically pertain to critical raw minerals. This ambiguity makes it difficult to determine which of these agreements constitute TTDs specifically targeting critical raw minerals, which is why we conduct a more selective mapping approach in our own analysis.

TTDs and CRM TTDs and their provisions. Section 4 presents trends in TTDs and the results of the economic analysis, while Section 5 provides the analysis of the links to national and multilateral rules and regulations. Section 6 concludes.

8.2 Defining Targeted Trade Deals

The literature on TTDs uses various terms and definitions to describe alternative agreements that do not fit within the traditional framework of RTAs, partly reflecting their heterogeneous nature. Claussen (2022) was the first to extensively map these "mini" or "skinny" trade deals, coining the term "trade executive agreements" (TEAs) specific to the US legislative context. Examining EU legislation, Cernat (2023) referred to these agreements as "trade mini-deals". Both include a wide array of legal instruments in their national mappings, including mutual recognition agreements. Meanwhile, the National Board of Trade Sweden adopted the term "trade-related agreements", defining them as agreements between at least two governments with trade cooperation as one of the objectives, but lacking an explicit market access component or solely promoting investments (Larsson and Wennerberg, 2024).

In this chapter, we follow a similar approach to defining TTDs as in the literature, but in a more limited way, as our global perspective prevents a context-specific approach. In that regard, our definition is closest to that of the National Board of Trade Sweden. TTDs are defined as bilateral or plurilateral government-to-government agreements aimed at enhancing cooperation with a trade-related dimension, that are limited in scope, either by their sectoral focus or their market access commitments. We refer to these agreements as TTDs for three reasons. First, the term captures one key difference to RTAs, which is that TTDs tend to have more narrow objectives than broad-based economic integration. Second, it provides a neutral classification that avoids implications regarding specific legislative responsibilities, as seen with TEAs, but captures their often lighter negotiation and implementation process. Third, it moves away from labels such as "skinny" or "mini", which might suggest insignificance even though some agreements could have important trade impacts (Claussen, 2022; Cernat, 2023). By using the term TTD, we adopt a broad and inclusive framework that captures a part of the diverse and evolving nature of modern trade governance, ensuring its applicability across various policy environments and institutional settings.[4]

The heterogeneous nature of TTDs implies that it is difficult to develop a clean definition of TTDs and that every mapping will exhibit a degree of subjectivity. We also recognize that a broad term can create ambiguity concerning what type of agreements are included within the scope. However, if we introduced a more narrow or specific term (e.g., sectoral agreement), it would exclude a lot of the agreements we have identified due to their diverse structure and scope. A broader term, such as "trade

4 See section 3 for more details on our definition and selection criteria.

agreements" would blend them with RTAs that have been well studied in the literature and differ from TTDs across the key dimensions we highlight above. An additional difference to RTAs worth highlighting is that TTDs, through their focus on information sharing and regulatory co-operation, tend to improve market access by addressing NTMs rather than by removing or reducing tariffs. The TTD between Japan and the US regarding a framework on domestic electronic transactions is one example of this:

> *"Each Party shall endeavour to a) avoid unnecessary regulatory burden on electronic transactions; and b) facilitate input by interested persons in the development of its legal framework governing electronic transactions."*[5]

As previous studies have shown (e.g., Larsson and Wennerberg, 2024), TTDs can cover many sectors and areas due to their flexible nature. In this chapter we only focus on two of these – digital and CRM TTDs. There are three main reasons why we have chosen to specifically look at these areas. The first reason is the increased importance of digital trade and access to CRMs driven by technological change, climate change and geopolitical tensions. This also explains why TTDs in these two areas have surged. Second, digital and CRM TTDs differ along several dimensions, which makes them ideal to illustrate the heterogeneous nature of TTDs. Third, given our global coverage, we need to limit the scope of the analysis in light of resource constraints. However, digital and CRM TTDs are to be considered solely as illustrative examples of the broader importance of TTDs. Moreover, while the differences between TTDs in these two areas illustrate the diversity of TTDs, conclusions based on digital and CRMD TTDs might not adequately reflect TTDs in other areas. For instance, Claussen (2022) shows that TTDs for agricultural goods, often linked to standards and testing procedures, tend to be binding more frequently than the digital and CRM TTDs we have identified.

8.3 Mapping Targeted Trade Deals

8.3.1 Mapping Methodology

Using our definition of TTDs, we compiled a database that covers 185 TTDs, comprising 106 related to CRM, and 79 related to the digital economy and electronic commerce. When compiling this database, the concept of "trade-related" was interpreted flexibly, so that any agreement with a trade scope and pertaining, at least in part, to one of the sectors under study has been included in our database.[6] The TTD database captures international trade-related cooperation mechanisms within the selected sectors, while explicitly excluding RTAs and RTA chapters covering related topics. For practical purposes, the dataset is bound by a cut-off date of 31 December

5 Agreement between the United States of America and Japan concerning Digital Trade, Art. 9, Para. 2.

6 An overview of our operationalization of the TTD definition through inclusion criteria is available in Annex 1.

2024 and TTDs signed after this date are not included in the list. It is important to note that, even within the defined period, the dataset does not claim to be exhaustive. Given the opaque nature of these trade policy instruments, it is likely that a meaningful number of TTDs remains undocumented. Nonetheless, the resulting dataset offers a novel and valuable perspective on contemporary trade policy dynamics.

The database is constructed through extensive data collection efforts, primarily relying on public sources. The hierarchy of sources was as follows:

(1) Official documents
(2) Joint statements
(3) Government press releases (preferably from both sides)
(4) News media

Whenever possible, the official TTD texts were used for the analysis, as they provide the most comprehensive and authoritative sources of information. However, due to the frequent unavailability of these documents, reliance on joint statements and government press releases was often necessary, ideally from both participating parties. In limited instances, media reports were used when no official information could be found whatsoever. To facilitate the analysis, all non-English documents were translated into English using the ChatGPT-4o model.

Regarding the target area of TTD, in the case of CRM, an agreement is included only if CRM are explicitly mentioned, or if there is a strong case that critical raw minerals form an integral part of the agreement. General agreements covering mineral resources or mining are excluded, as they could predominantly concern oil, natural gas or other minerals outside the study's scope. Nevertheless, grey areas exist and were handled on a case-by-case basis. For example, a Turkish press release regarding the 2023 MoU between Türkiye and Saudi Arabia mentions that "the deal includes mineral investments and the cooperation required for cutting-edge technology, solar panels and electric cars". We interpret this as focusing on the critical raw minerals necessary for the green and digital transition, and hence include the MoU in our database. In the digital domain, the concept of "digital" is interpreted broadly to encompass cooperation in the digital economy and its related sub-sectors. Accordingly, digital TTDs may pertain to the digital economy, electronic commerce, key inputs like semiconductors, artificial intelligence (AI) or cross-border data flows.

The TTDs identified are then codified along multiple dimensions and, where the official text is available, its provisions are mapped. The TTD database captures the signatories, date of signing and entry into force,[7] type of agreement, binding nature, text availability,

[7] The date of entry into force is primarily relevant for formal agreements, which often require a period of ratification following the conclusion of negotiations.

accession status and duration of validity (see Annex 8.2).[8] The compiled list of TTDs facilitates the identification and analysis of broader trends and patterns. The in-depth provision mapping should enable a better understanding of how governments design TTDs and provide objective measures of heterogeneity that should allow for a more detailed examination of the effectiveness of specific TTD provisions. This is akin to the approach used by the literature on deep trade agreements (see, e.g., Mattoo, Rocha and Ruta, 2020). However, in the case of TTDs, this is constrained by the limited availability of TTD texts.

8.3.2 Provision Mapping Approach

We map the provisions of TTDs to investigate the scope and breadth of the cooperation areas they cover. Given the stark differences between the critical raw minerals sector and the digital economy, the mapping was done on a sectoral basis, allowing for additional thematic insights. Since this is a first-of-its-kind approach to these types of agreements and since TTDs are more heterogeneous than RTAs, our focus lies on identifying general themes and trends.

Our rationale behind the provision mapping is based in part on prior provision mapping efforts. The CRM provisions are based on the general thematic mapping conducted by the Africa Policy Research Institute (Beuter et al., 2025). Additionally, since most TTDs establish institutional mechanisms (e.g., working groups or coordination in multilateral fora), and some provisions specifically aim to improve infrastructure and logistics, we included those themes as provisions. Annex 8.3 presents a complete overview of the seven CRM TTD provisions that are mapped. For the digital provision mapping, we took inspiration from the Trade Agreement Provisions on Electronic-commerce and Data (TAPED) dataset (Burri, Vasquez Callo-Müller and Kugler (2025)). While the TAPED database provides more granularity in terms of the provisions mapped, given our focus on the macro trends and developments, we synthesized a range of frequent digital TTD provisions into broader categories. Ultimately, we ended up with nine digital TTD provisions to map, presented in Annex 8.4.

Overall, this provision mapping offers a structured yet flexible overview of key themes in CRM and digital TTDs, tailored to the study's focus rather than aiming for exhaustive detail. Drawing on existing datasets and informed by observed patterns in agreement texts, the selected provisions reflect both commonly recurring elements and sector-specific priorities. This approach supports a comparative analysis of how WTO members shape emerging trade policy areas.

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8 In some cases, multiple bilateral TTDs exist between the same country pair on the same topic under a shared framework. For example, the UK–Singapore Digital Economy Agreement is supplemented by seven MoUs covering related issues such as cybersecurity and digital trade facilitation. In such instances, only the overarching TTD is included in our TTD database to maintain an overview of standalone TTDs, insofar as this is possible. The number of digital TTDs would be even higher than 81 if each individual agreement were counted separately.

8.3.3 Non-Mappable TTDs

Given that the official signed TTD document is only available in less than half of the cases, we also attempt to obtain insights from the remainder of the TTDs. We run a large language model (LLM)-based general provision extraction on the source documents, such as government press releases or media reports. Using a structured prompt – unique to the sector – and employing the ChatGPT-4o model, we can distil information on the main areas of cooperation. However, we cannot make definitive statements about these contents, as ultimately we do not know the exact provisions or circumstances that were agreed upon. Moreover, governments may state the same priorities, but at times also emphasize different areas from the same MoU, depending, it may be assumed, on their respective policy contexts and priorities. Especially in the cases of press releases and news media reports, there is much diversity in the language used and the comprehensiveness of reporting. There are also instances where an MoU signing is merely acknowledged with no details about the contents apart from the main topic. We have thus decided to keep separate the analyses and interpretations from "mappable" and "non-mappable" TTDs as described in the previous and current section.

8.4 Descriptive Statistics and Empirical Analysis

Based on our database, we constructed a dyadic panel dataset where the unit of observation is a dyad-year or country-pair-year.[9] This structure enables us to explore both the determinants of TTD formation – why specific country pairs sign TTDs – and the impact of TTDs on trade flows where sufficient post-agreement data are available. Variables are harmonized for the two areas, digital and CRM, separately. Given the timing of the first sector-specific agreements, we use adjusted temporal windows. For CRM TTDs, we cover the period from 2006 to 2024 (with the first agreement in 2011), allowing for a sufficient pre-treatment span. For digital TTDs, coverage spans 2011-2024 (with the first agreement in 2016) to maintain comparability around TTD adoption periods.

8.4.1 Additional Data Sources

We merge our TTD dataset with multiple secondary sources. These encompass bilateral trade flows, geographic and historical linkages, governance and institutional quality, and measures of strategic resource capacity. The selected indicators reflect the core determinants of bilateral trade cooperation. Economic size, geographic proximity and historical ties capture standard gravity forces that shape trade potential, consistent with the foundations of the gravity model of trade (Anderson and Wincoop, 2003). Institutional quality, political alignment and regional integration proxies help

9 A dyad-year refers to one observation for a pair of countries in a given year. For example, the trade relationship between France and Japan in 2015 is one dyad-year, while the same pair in 2016 counts as another.

capture the legal and institutional scaffolding that facilitates cooperation – elements emphasized in both economic integration theory and research on trade agreement formation (e.g., Limão, 2007).

Our measures of CRM endowments and digital readiness capture how sector-specific conditions shape incentives for TTD formation. For CRMs, we focus on the maximum endowment within a dyad for a year. This enables us to test whether the presence of a large, resource-rich partner is what drives cooperation and whether TTDs are used to anchor access to major suppliers. For digital readiness, we look at both the dyadic mean for a year (average preparedness) and the intra-dyadic gap for a year (asymmetry). Taken together, these measures help us distinguish whether TTDs emerge in contexts of shared capacity or serve as instruments to manage uneven development. The table below summarizes additional data used for analysis, along with their primary sources.

Table 8.1: Overview of Additional Data and Source

Digital trade in services	We measure digital trade using exports and imports of digitally deliverable services (DDS), following international guidance from the Handbook on Measuring Digital Trade (International Monetary Fund (IMF), The Organization for Economic Co-operation and Development (OECD), UN Trade and Development (UNCTAD), WTO, 2023).[10] The underlying data come from the WTO-OECD Balanced Trade in Services (BaTiS) database, spanning the period 2005-2023.[11]
Critical raw minerals trade	Bilateral merchandise trade in selected Harmonized System (HS)-6 codes classified as "critical raw minerals or immediate downstream products" following the ADB-WTO Trade in Critical Raw Minerals Database. Data come from the WTO Analytical Database.[12]
Gravity controls: time-invariant controls	Standard dyadic controls – geographic distance, contiguity, common language, landlocked status, and colonial ties – are taken from the USITC Dynamic Gravity Dataset (DGD) (Gurevich and Herman, 2018). As these variables are time-invariant, we carry forward their 2019 values for the 2020-2024 period.
Gravity controls: economic size	We include GDP per capita (PPP, current international US dollars) as a measure of income level in the analysis of TTD formation, while total GDP –measured in constant US dollars – is used as a control variable in the trade impact regressions. All indicators are sourced from the World Bank World Development Indicators (WDI) API.
Gravity controls: institutional quality	To capture variation in institutional stability and regulatory quality, we include exporter-level values from the World Governance Indicators (WGI) API. Specifically, we use three components: rule of law, regulatory quality and governance effectiveness.
WTO membership	A binary indicator equal to 1 if both partners are WTO members in a given year.
Regional trade agreements	RTA dummy status is captured through a dyadic indicator equal to 1 from the year an agreement enters into force, as notified to the WTO. Source: WTO RTA Database and Mario Larch's Regional Trade Agreements Database from Egger and Larch (Egger and Larch, 2008).
Critical raw minerals endowment	For each dyad, we take the maximum production value of critical raw minerals (in constant 1998 USD) between exporter and importer. For regression analysis, we normalize by annual world totals and take the log of the maximum global production share, ensuring comparability across years. Source: United States Geological Survey (USGS) Mineral Commodity Summaries (2024, 2025); USGS Historical Statistics for Mineral and Material Commodities (2023); BGS World Mineral Statistics (2023); Our World in Data.

continued on next page

10 https://www.wto.org/english/res_e/booksp_e/digital_trade_2023_e.pdf

11 https://www.wto.org/english/res_e/statis_e/gstdh_batis_e.htm

12 https://ttd.wto.org/en/download

Table 8.1: continued

Digital infrastructure capability index (DCI)	Composite index (0-centered) based on standardized values of internet users, mobile subscriptions and secure servers per capita. Constructed from WDI indicators using annual z-scores.[13]
Shared regional bloc	Identifies whether both countries in a dyad belong to the same regional integration arrangement. Membership is time-invariant and manually coded based on bloc participation. Included blocs: USMCA, Mercosur, AfCFTA, ASEAN, EU, EFTA, SAARC and GCC.
Political alignment ("like-mindedness")	We proxy geopolitical proximity using ideal point distances in UN General Assembly roll-call votes, sourced from version 3 of the Bailey-Strezhnev-Voeten dataset (updated through 2023) (Bailey et al., 2017).
Geopolitical sanctions	To account for bilateral geopolitical tensions, we include dyadic sanction indicator (dummy) for a year from the Global Sanctions Database (GSDB, v3) (Felbermayr et al., 2020).

Despite our efforts to collect TTD data that was as comprehensive as possible, several limitations constrained our ability to estimate the trade effects of TTDs:

- Over 80% of CRM TTDs were signed between 2022 and 2024. With only one to two years of post-treatment trade data available for some of the agreements, there is potential for imprecise estimates when attempting to identify their effects on trade flows.
- The ideal measure for CRM endowments would be reserve data. However, such estimates are not available for the large sample of economies that we analysed. As a result, we needed to rely on production data which does not capture the impact of new mining investments.
- While digitally deliverable services represent the best available proxy for digital trade, they are a noisy measure of trade flows regulated by digital TTDs. On the one hand, they exclude digitally ordered goods, platform-enabled transactions, and software-embedded exports like mobile phones, which may lead to an underestimation of digital trade effects. On the other hand, DDS includes trade flows that are digitally deliverable but may not in fact have been digitally delivered, potentially leading to an overestimation. Nevertheless, this data remains the most comprehensive and internationally comparable source currently available, as it is constructed using established econometric and statistical estimation methods rather than raw administrative records, consistent with recent best-practice recommendations for gravity modelling (Larch, Shikher, and Yotov, 2025).
- Major initiatives, such as the Belt and Road Initiative (BRI) and the EU Global Gateway, may shape the strategic logic behind TTDs, but the documentation underlying them does not lend itself to the standardized coding necessary for inclusion. As such, they are discussed narratively but excluded from econometric modelling and quantitative analysis.

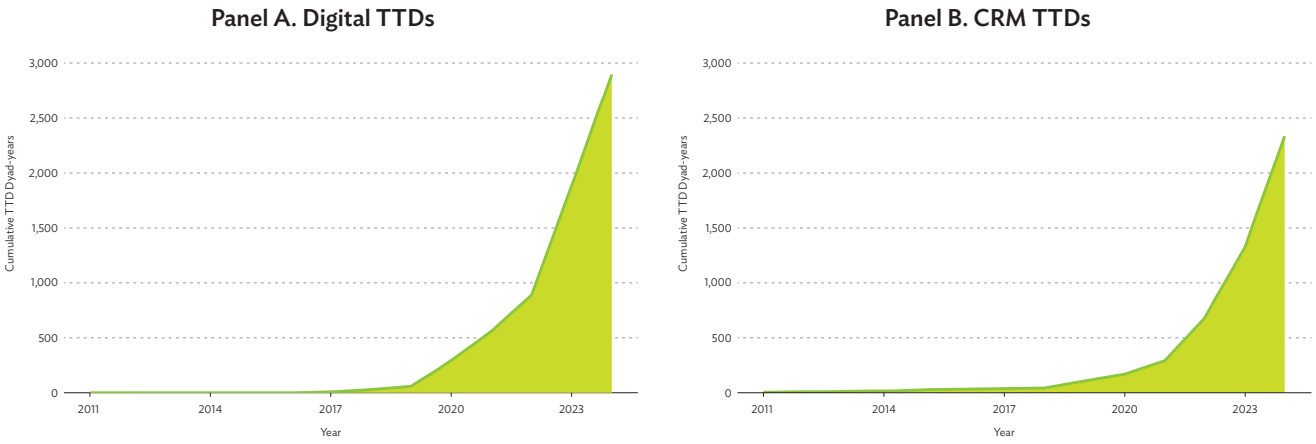
[13] DCI aggregates three WDI indicators – internet users per 100 people, mobile cellular subscriptions and secure internet servers per million people – into a standardized country-year index. Indicators are z-normalized by year to ensure comparability. A penalized version (weighted DCI) adjusts for missing components to reflect real-world infrastructure gaps.

We include three segments in our data analysis: (i) graphical illustration of TTD adoption patterns, (ii) exploratory analysis of agreement formation patterns and (iii) regression-based estimation of determinants of trade formation and trade effects. We combine descriptive evidence, event-style diagnostics and regression results to assess patterns in TTD formation and their potential effects on trade flows across digital and CRM sectors.

8.4.2 Patterns and Trends in TTD

Our database reveals a sharp rise in both digital and CRM TTDs since 2020. Of 185 targeted deals identified, around 80% (148) were signed after 2019. We also track dyad-years cumulatively, which enables us to capture both the signing of new TTDs and the persistence of existing ones over time. Our unit of analysis for Figures 8.1 and 8.2 is the dyad-year, representing a country-pair observed in a given year. Digital TTDs grew from fewer than 100 dyad-years in 2019 to almost 3,000 by 2024, marking a clear shift toward targeted deals as a trade policy instrument. CRM TTDs have also increased sharply in recent years, reflecting growing policy attention to mineral supply security (see Figure 8.1). Together, these shifts demonstrate how trade governance in both digital and mineral sectors has undergone rapid changes since 2020. Figure 8.2 illustrates this global expansion and the widening regional spread of TTD participation.

Figure 8.1: Cumulative Adoption of Targeted Trade Deals



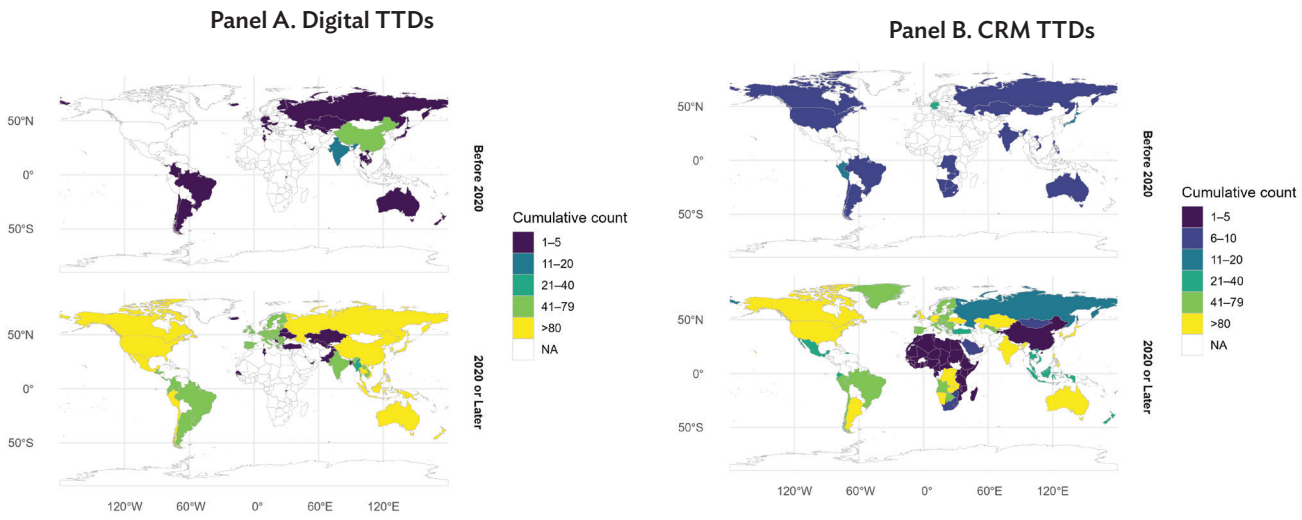
Source: Authors' calculations based on newly compiled TTD Database.

Digital TTD participation is concentrated among high- and upper middle-income economies, involving economies such as Chile, Japan and Singapore (see also Box 8.1). Regional coverage has expanded since 2020, mainly across North America, Europe and East Asia. Sub-Saharan Africa and much of the Global South are either excluded or remain marginal participants in global digital TTD activities. Cross-regional flows are concentrated in a few high-density corridors – particularly those between East

Asia and Europe and between Latin America and Europe – while South-South digital cooperation remains minimal. North-North and South-North pairings dominate, with more than 350 and 300 dyad-years, respectively, compared to fewer than 75 South-South pairings. This imbalance highlights a persistent digital divide and the risk of a fragmented global digital trade system shaped by advanced economies, with lower-income partners remaining on the margins.

CRM TTD participation is highly asymmetric across regions, actors and flows. As shown in the geographic distribution in Figure 8.2, most activity post-2020 has come from a small group of high-frequency signatories – led by the Republic of Korea, the US, Australia and the Democratic Republic of the Congo – which appear in over 50 unique dyad-years each. Regional flows remain concentrated, with the heaviest bilateral activity linking East Asia and Africa, as well as Europe and Latin America. North-South partnerships dominate the CRM TTDs landscape while South-South activity remains limited.

Figure 8.2: Global Spread of TTD Participation Pre- and Post-2020



Source: Authors' calculations based on newly compiled TTD Database.

Box 8.1: Government Perspectives on TTDs

Chile's Approach to Critical Raw Minerals and Global Value Chains

Division of Economic Analysis and Trade Policy (DAE), Undersecretariat for International Economic Relations (SUBREI), Ministry of Foreign Affairs of Chile

Chile, a global leader in copper and lithium production, plays a strategic role in shaping resilient and sustainable global value chains for critical raw minerals. These resources are essential for the green transition, including the deployment of renewable energy, electric vehicles and digital technologies. Chile is the world's leading exporter of copper concentrates (with a 29.4% share in 2024) and the second largest exporter of refined copper in the form of cathodes and cathode sections, representing 20% of total global exports; it is also the world's second largest exporter of lithium and leader in shipments of refined lithium, representing 42% of global exports of carbonates and hydroxides.

As one of the most open economies in the world, Chile has signed 35 trade agreements covering 65 markets, giving it preferential access to around 88% of global GDP. This extensive network of agreements, together with Chile's active participation in multilateral organizations, underpins its credibility as a reliable and responsible supplier in global markets.

Chile's commitment to critical raw minerals governance is reflected in several policy instruments at both the domestic and international levels. Its National Lithium Strategy sets the foundations for responsible and sustainable production, community participation, traceability and value creation through productive linkages, services and innovation. Internationally, Chile has strengthened cooperation via the 2023 Chile-EU Advanced Framework Agreement, which incorporates a chapter on energy and raw materials, and through a binational working group with Argentina under an MoU on lithium and salt flats, aiming to promote shared research, capacity building, sustainable extraction and value addition in regional value chains.

Additionally, Chile has signed an MoU with South Korea for cooperation in mining and mineral resources, including lithium (2022), and has engaged in exploratory talks and joint projects with other partners seeking secure supply chains and value added production. These initiatives exemplify how Chile links trade policy with broader global objectives, positioning itself as a key partner in sustainable and inclusive growth.

Through this approach, Chile positions itself not only as a leading exporter of copper and lithium, but also as an active shaper of international cooperation frameworks. By linking its trade policy with sustainability and reliability in supply, Chile strengthens its role as a strategic partner in global value chains critical for the green economy.

Singapore's approach to digital economy partnerships

Ministry of Trade and Industry, Singapore

Singapore's digital economy is expected to grow between US$40-65 billion by 2030, while Southeast Asia's digital economy is on track to reach $1 trillion in gross merchandise value, approximately four times the $263 billion gross merchandise value in 2024.[1]

Realizing this growth potential requires coordinated efforts by countries to create conducive environments for digital trade to flourish. Notably, countries have pursued different pathways to regulate the digital economy given its evolving and dynamic nature. Fragmented regulations could pose barriers for businesses to engage in cross-border digital trade. It is against this backdrop that Singapore pioneered digital economy agreements (DEAs) in 2020 to address new trade realities that were not addressed in traditional free trade agreements. Singapore's DEAs aim to put in place common rules, standards and frameworks to: (i) facilitate digital trade; (ii) ensure trusted and secure data flows; and (iii) build trusted digital systems. This would enable businesses, large and small, to improve their operational efficiency, reduce costs, have better cash flows from receiving faster payments, and enjoy greater trust in transacting in the digital economy. For instance, a case study from Lloyds Bank showed that the use of e-bills of lading helps to reduce the time taken to complete a transaction by 90%, from 15 days to just one day.[2]

Singapore has established a strong network of DEAs with ambitious digital trade rules thus far (Australia, the Digital Economy Partnership Agreement, the United Kingdom (UK), the Republic of Korea, the EU and the European Free Trade Association), and continues to expand this network to better connect and integrate with the global digital economy. Singapore is also a co-convenor of the WTO Joint Statement Initiative on E-Commerce, together with Australia and Japan.

1 Google, Temasek, Bain and Company (2023) e-Conomy SEA 2024
2 International Chambers of Commerce-Digital Standard Initiative (ICC-DSI) (2024) Key Trade Documents and Data Elements on the Frontlines.

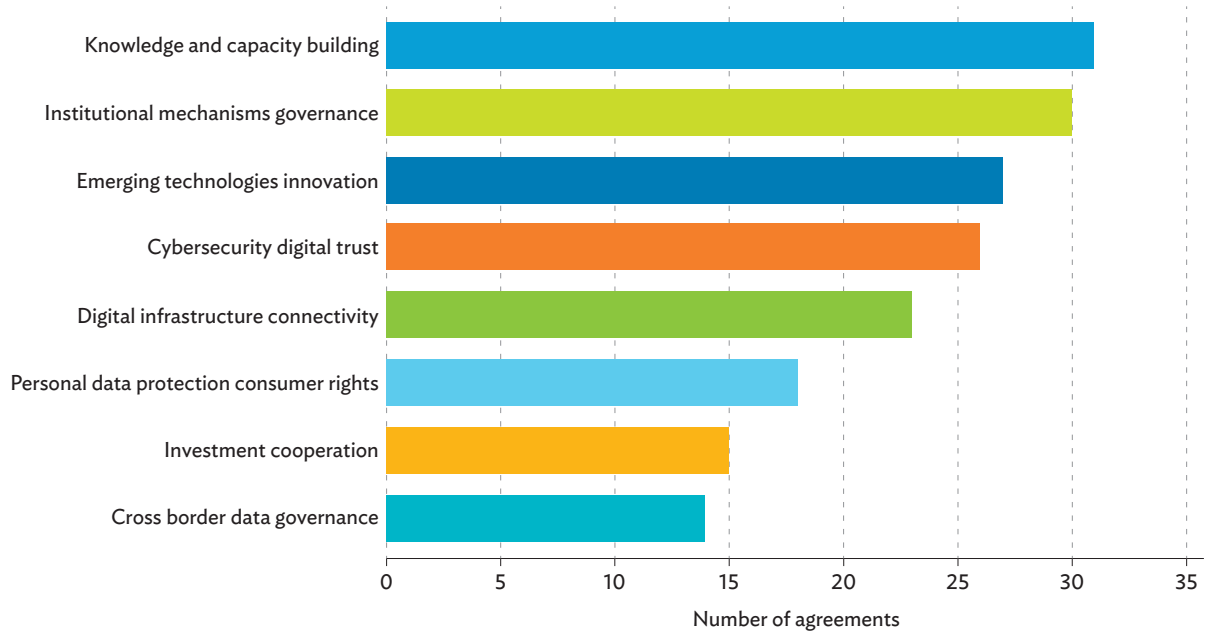
8.4.3 TTD Characteristics and Provision Analysis

Before presenting the findings of the provisions mapping, it is important to emphasize again that this analysis could only be conducted where the official texts of TTDs were publicly accessible. This is a much larger constraint than in the analysis of RTA provisions: the mapping could only be coded for about 42%, or 33, of digital TTDs and 52%, or 55, of CRM TTDs. Despite this limitation, the available texts provide valuable insights into the substance and structure of these increasingly prevalent trade policy instruments.

1. Digital TTD Provisions

Digital TTDs seek to address a broad range of policy areas under the digital economy umbrella. As depicted in Figure 8.3, core provisions shared by almost all analysed TTDs include commitments to knowledge sharing and capacity building, as well as to institutional mechanisms and governance. These features reflect an overarching emphasis on regulatory cooperation and strategic dialogue, rather than market access or trade liberalization in the traditional sense. Instead, the costs of non-tariff measures are intended to be reduced by addressing information frictions.

Figure 8.3: Presence of Various Digital TTD Provisions



Source: Authors' calculations based on newly compiled TTD Database. We mapped 33 digital TTDs; each entry shows how many of these targeted deals (out of 33) contain the respective provision.

In addition to these foundational elements, digital TTDs commonly set out areas for cooperation across different sector-specific themes. Commonly cited focus areas include emerging technologies (e.g., AI, semiconductors, quantum computing), cybersecurity and digital trust, and digital infrastructure and connectivity (e.g., data centres and submarine cables). The inclusion of these themes under TTDs reflects efforts to align trade policy with the evolving dynamics of the digital economy. In this sense, policy coordination and technological governance takes precedence over the mere facilitation of cross-border digital trade.

A distinguishing feature of digital TTDs is their relatively higher degree of formalization, particularly when compared to CRM TTDs analysed in the following subsection. In recent years, several comprehensive digital trade or digital economy agreements have been concluded. These agreements are signed as standalone legal instruments but may explicitly build upon and complement pre-existing RTAs. These comprehensive and formal digital TTDs establish new institutional frameworks and introduce detailed provisions on digital standards, cross-border data flows and fintech regulation, going well beyond the scope of traditional RTAs.

Investment provisions are less prevalent in digital TTDs. Only a minority of digital TTDs include investment-related language and, where investment is mentioned, it is typically broad and aspirational. Commitments often take the form of general encouragement or recognition of investment opportunities, rather than concrete initiatives or funding instruments. Only a handful of digital TTDs mention specific funding sources, and none contain commitments to specific investment projects. This relative absence of investment-specific provisions is perhaps unsurprising, given the intangibility and global reach of digital trade, which contrasts with the location-bound and capital-intensive nature of CRM extraction and processing. While investment may be relevant for digital infrastructure or data-related services, digital TTDs tend to focus more on standards alignment, regulatory cooperation and enabling frameworks than on financing or business linkages.

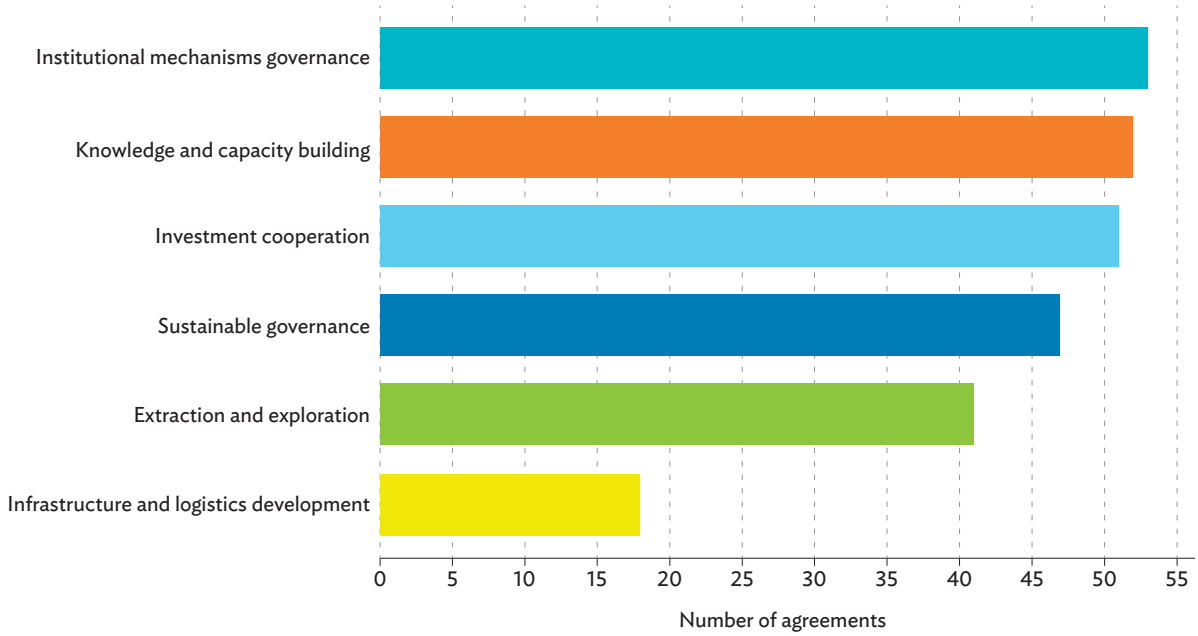
In sum, digital TTDs represent a strategic trade policy instrument aimed at shaping the future governance of the digital economy. They exhibit strong ambitious language and cover a diverse range of policy areas. However, their provisions are often phrased in broad and even vague and noncommittal terms. Few agreements provide operational detail or specify how the outlined goals are to be implemented. As a result, their practical impact remains difficult to verify based on publicly accessible information, limiting their transparency, accountability and verifiability as trade policy tools.

2. CRM TTD Provisions

Figure 8.4 illustrates the inclusion of selected provisions across CRM TTDs, revealing a notable degree of convergence in their substantive content. This uniformity is largely attributable to the widespread use of MoUs or memoranda of cooperation (MoCs),

which tend to adopt standardized, non-binding formats. These legal instruments often rely on templated structures and generalized language, contributing to a high level of similarity across TTDs, regardless of the economies involved.

Figure 8.4: Presence of Various CRM TTDs Provisions



Source: Authors' calculations based on newly compiled TTD Database. We mapped 55 CRM TTDs; each entry shows how many of these targeted deals (out of 55) contain the respective provision.

Despite diverse geopolitical and economic contexts, the scope of provisions in CRM TTDs are remarkably consistent. Nearly all CRM TTDs include references to institutional mechanisms, such as sectoral working groups or dialogues, and to technical cooperation, including knowledge sharing and capacity building. These priorities reflect a shared emphasis on upstream collaboration and strategic alignment in the context of securing CRM supply chains. Many targeted deals also invoke environmental, social or governance (ESG) goals, using language such as "sustainability", "responsible sourcing" or "environmental cooperation".

However, while these provisions imply a broad and coordinated agenda, the actual language used in CRM TTDs often remains generic and lacks operational detail, similar to digital TTDs. The texts rarely define how objectives, such as capacity building or environmental, social and governance (ESG) adherence, are to be achieved, by whom or within what timeframe. Institutional mechanisms are mentioned, but their structure, decision-making authority and follow-up procedures are usually left unspecified. Consequently, it is frequently unclear what practical steps are to be taken under a given agreement. Based on the published texts alone, monitoring progress or assessing implementation is virtually impossible.

A particularly illustrative example is the case of investment cooperation. As shown in Figure 8.4, the majority of CRM TTDs mentions investment. Yet, upon closer inspection, investment-related provisions are typically vague and declarative. Most TTDs refer to investment in general terms, using phrases such as "encourage" or "promote" without specifying concrete mechanisms, responsible actors or implementation pathways. Approximately one-quarter of TTDs mention potential sources of investment funding, but without making any direct commitments.[14] Only three TTDs refer explicitly to tangible investment projects, two of which are linked to the Minerals Security Partnership (MSP) – an alliance between 14 nations and the EU, represented by the European Commission. Thus, while investment frequently appears in the provision mapping, its presence may often signal rhetorical intent rather than constitute a structured or enforceable framework.

Nevertheless, the lack of detail in published CRM TTDs does not necessarily imply that no follow-up activity occurs. The EU MoUs, for instance those with Chile and Zambia, are accompanied by non-public implementation roadmaps that reportedly outline cooperation measures in areas such as supply chain integration, infrastructure development, research collaboration and capacity building (Carry, 2025; Schulze, 2025). These roadmaps suggest that operational planning exists behind the diplomatic signalling found in TTD texts, albeit generally not made public. However, the confidential nature of these implementation documents poses significant limitations. Since the roadmaps are not publicly available, it is practically impossible for external observers to assess whether the agreed-upon objectives are being pursued or achieved. This lack of transparency limits independent evaluation, public accountability and informed policymaking. It also complicates evaluating the commercial value of entering such targeted deals.

Conventional agreements include clear implementation mechanisms, institutional responsibilities and public information obligations. While they may also include imprecise, non-binding provisions, their aim is generally to include a majority of precise, binding provisions. In comparison, CRM TTDs seem to rely heavily on voluntary cooperation and non-committal language, often without formal monitoring structures or implementation frameworks. As a result, even when TTDs express high-level strategic ambitions, the absence of transparency and verifiable action plans could undermine their long-term effectiveness.

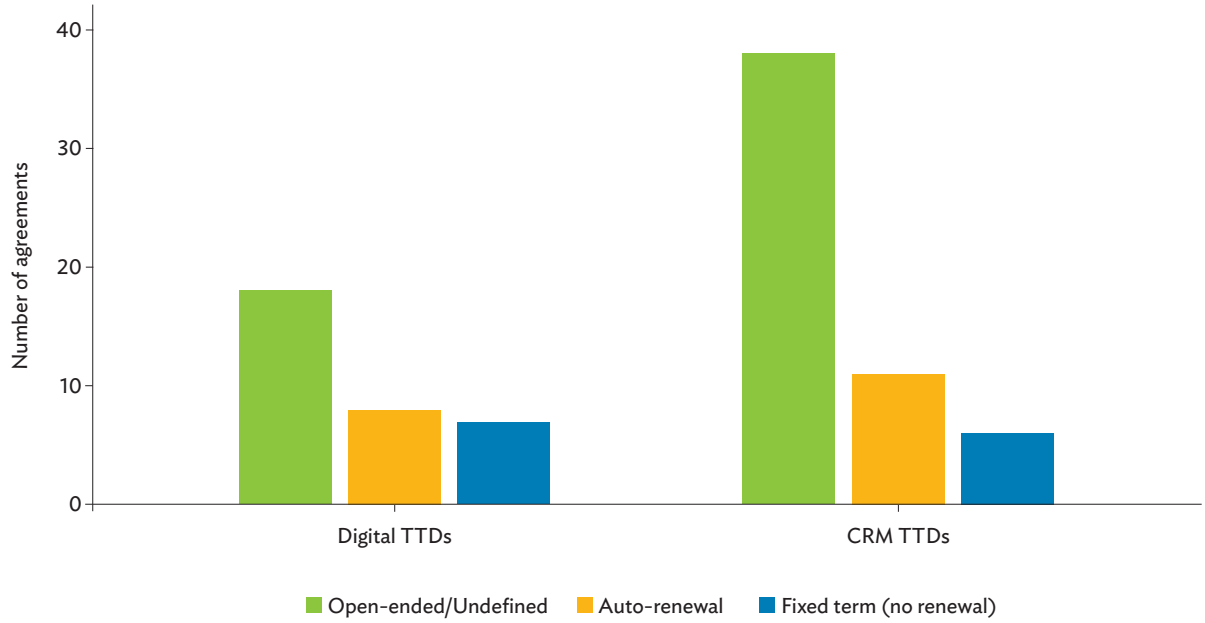
3. Duration and Entry into Force of TTDs

TTDs tend to be open-ended. Figure 8.5 presents the types of validity periods included in the texts of CRM and digital TTDs. A clear pattern emerges as most TTDs either specify automatic renewal or omit any reference to duration altogether, implying

[14] For example, EU MoUs often mention Global Gateway as a potential source of funding under CRM TTDs, but without stating further details.

an open-ended validity. This is particularly pronounced in CRM TTDs, and the vast majority of the TTDs fall into this category. Digital TTDs exhibit a somewhat more balanced profile, but auto-renewal or undefined terms are still very prevalent. In this regard, TTDs are similar to RTAs, which generally also do not contain a specific end date, precisely to ensure legal certainty. This suggests that TTDs are intended to achieve trade-generating outcomes within the areas they target.

Figure 8.5: Dates of Validity in TTD Texts



Source: Authors' calculations based on newly compiled TTD Database.

4. Enforceability and Dispute Settlement Mechanisms

The preceding provision mapping shows the wide range of cooperation themes addressed by TTDs but these themes do not reveal whether the provisions are legally binding or accompanied by mechanisms that ensure compliance. To move from descriptive coverage to an assessment of enforceability, we apply a structured, rule-based natural language processing (NLP) text analytics framework.[15] This approach is designed to identify provisions that contain mandatory legal language and effective dispute settlement mechanisms, distinguishing them from aspirational references or general statements of intent. In other words, the focus is on whether TTDs articulate obligations that can, in principle, be enforced, rather than merely signalling cooperation.

15 For "legally binding", provisions are coded as binding when a legal actor is paired with mandatory terms ("shall", "must", "is obligated to"). Any explicit disclaimer (e.g. "non-binding", "no legal obligation") is coded as non-binding; all others default to "not specified". For "dispute settlement", texts are coded as adjudicative when a dispute trigger is linked to third-party adjudication (e.g. "arbitration", "tribunal", "binding decision"). References limited to consultations or negotiations are consultative, and the absence of any provision is not specified.

In the CRM domain, binding commitments are extremely rare. Only three of 55 mappable TTDs (5%) employ mandatory legal language. Fourteen texts contain explicit non-binding clauses, while the vast majority (38 TTDs, nearly 70%) provide no specification. Dispute settlement provisions are even more limited, with 49 of 55 TTDs (close to 90%) omitting any mechanism, and the remainder containing only consultative references with no adjudicative recourse. Digital TTDs display a relatively higher degree of formalization. Among the 33 mappable deals coded, eight contain binding provisions, 13 have non-binding formulations and 12 are unspecified. On the dispute settlement dimension, 31 have no specified provision, while just two include consultative mechanisms. No digital TTD provides for adjudicative settlement.

Taken together, these findings underscore that the references to cooperation, dialogue or institutional consultation are frequent, yet they rarely translate into binding obligations or adjudicative dispute settlements. The result is a structure that privileges flexibility, signalling and expediency over legal precision and enforceability. Whether this has an impact on their trade effects, is ultimately an empirical issue that we examine below.

8.4.4 What Drives TTD Formation?

In this section, we examine patterns between TTD formation and key bilateral factors, including digital infrastructure, governance quality, political alignment and shared regional integration blocs. The descriptive analysis in section 4.4.1 highlights what could drive the formation of TTD and inform our choice of explanatory variables beyond the traditional predictors in the econometric analysis presented in section 4.4.2.

1. Exploring the Potential Drivers of TTD Formation

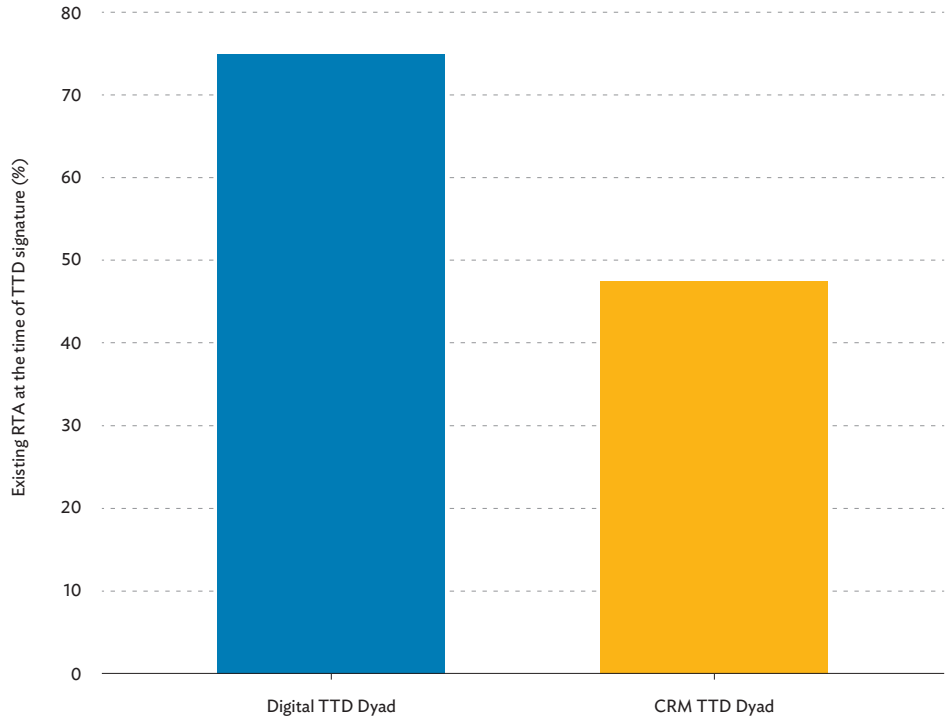
We begin by examining how institutional and governance linkages – such as existing RTAs, shared regional blocs and governance quality – are associated with the formation of TTDs. These factors may shape the enabling environment for agreement formation, particularly in areas with a high regulatory burden, such as digital trade. Additionally, the indicators explored here could help identify sector-specific drivers that extend beyond the gravity model. By comparing digital and CRM TTDs, we assess whether targeted trade deals tend to build on existing cooperation frameworks or arise from more strategic or resource-based considerations.

The Role of Institutional Scaffolding for TTD Formation

Pre-existing RTAs are very common for TTD signatories. This holds even more for digital TTD signatories than for CRM TTD signatories. Figure 8.6 shows that about 74% of digital TTD dyads, meaning country pairs that sign a digital TTD, already had an existing RTA in place at the time of TTD signing. If we consider the non-TTD dyads, only one out of five cases show an RTA. Digital TTDs, therefore, tend to build on and expand existing trade frameworks, often appearing as additional instruments

within broader economic partnerships. In contrast, Figure 8.6 also shows that 47% of CRM TTD dyads had an existing RTA in place at the time of signing a TTD. While RTAs can support CRM negotiations, digital TTDs are more likely to be tied to existing institutional structures. In contrast, CRM TTDs can emerge more opportunistically, often in response to resource or supply chain requirements.

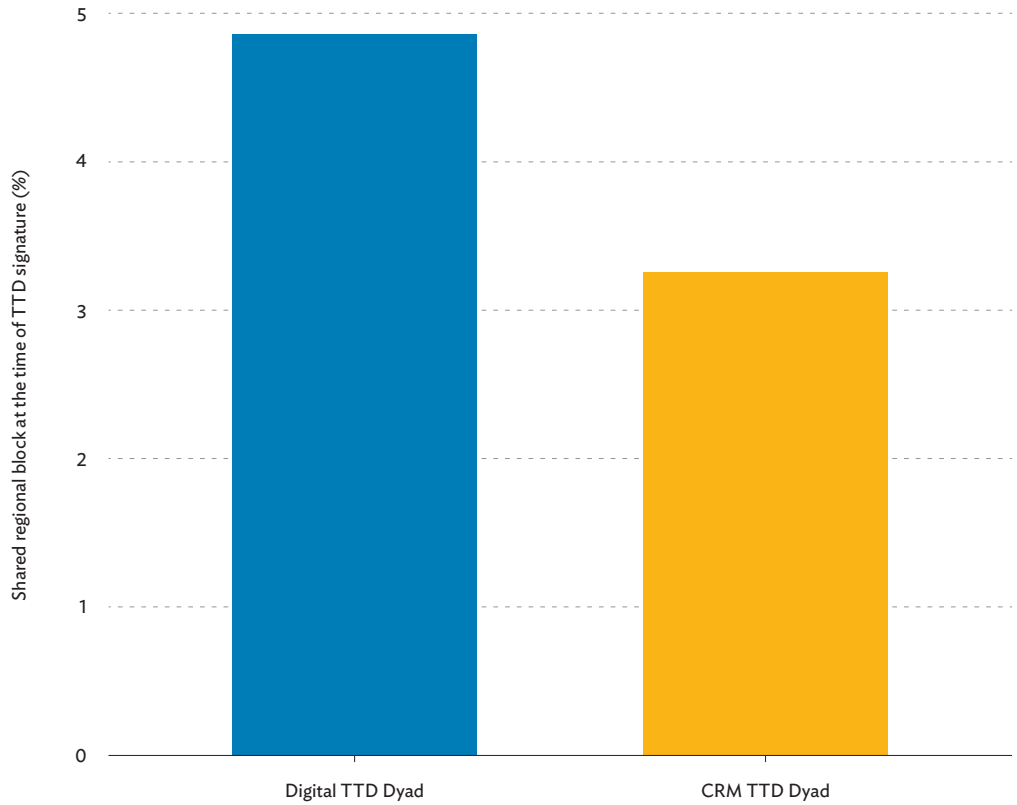
Figure 8.6: RTA Linkages and the Likelihood of TTD Formation



Source: Authors' calculations based on newly compiled TTD Database and RTA data from the WTO RTA database and Egger and Larch, 2008.

Regional bloc membership is another potential determinant of TTD formation, though to a much lesser extent than RTAs, and differing across TTD types. Figure 8.7 shows that digital TTDs are more often concluded between partners that belong to the same regional bloc, consistent with what is observed for RTAs. This underscores the role of existing institutional linkages in fostering digital cooperation. Among country pairs that sign a TTD, about 5% of digital TTD dyads and 3% of CRM TTD dyads share membership in a regional bloc at the time of signing. Together with RTA patterns, this suggests that digital TTDs are more likely to be embedded within established cooperation frameworks, whereas CRM TTDs tend to emerge in a more opportunity-driven manner, reflecting resource complementarities and strategic supply chain considerations that extend beyond formal regional architectures.

Figure 8.7: Shared Regional Bloc Status and Likelihood of TTD Formation



Source: Authors' calculations based on newly compiled TTD Database and Regional Blocs Database.

Governance Quality and TTD Formation

Governance quality on the exporter side potentially may play a notable role in TTD formation, particularly in the digital TTD domain. Digital TTDs are more likely to form when exporters have stronger governance institutions. Better rule of law, regulatory quality and government effectiveness reduce the perceived risk of digital exchange and support institutional trust between partners. In line with this, the data shows that exporters in digital TTD dyads score significantly higher across all three institutional dimensions: government effectiveness, regulatory quality and rule of law, compared to those in non-TTD dyads. This pattern suggests that importers are more likely to engage in digital trade deals with partners that offer stronger institutional environments for implementing and enforcing cross-border digital rules.

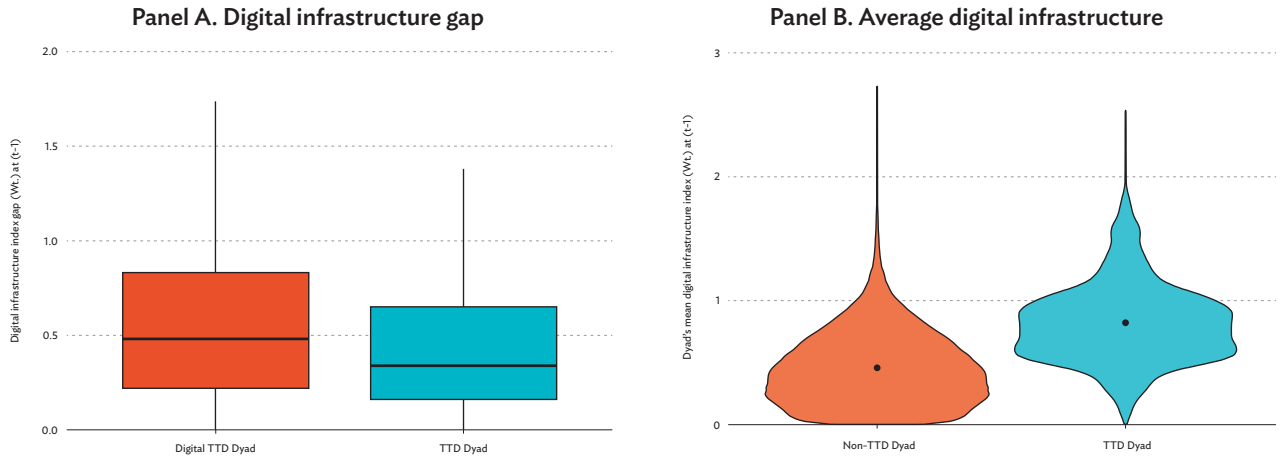
For CRM TTDs, the pattern is similar in direction but slightly less pronounced. Exporters in CRM TTD dyads have better scores than their non-TTD counterparts across all three governance indicators, though the differences are smaller than in digital trade. This observation suggests a trade-off in resource partnerships, where governance plays a role but could sometimes be outweighed by strategic factors such as supply chain security. Overall, these findings indicate that institutional reliability on the exporter side is positively associated with TTD formation.

Digital Infrastructure and Digital TTD Formation

Digital TTDs appear more likely to emerge between countries with similar levels of digital infrastructure. To evaluate whether technological capacity could influence the formation of digital TTDs, we utilize the customized weighted Digital Infrastructure Capability Index (DCI, see Table 8.1). As shown in Panel A of Figure 8.8, the infrastructure gap between TTD partners in a given year is significantly lower than that observed among non-TTD dyads. Such symmetry also increases the feasibility of similar regulations and reciprocal market access.

Beyond digital infrastructure symmetry, overall readiness is an important factor in agreement formation. Panel B of Figure 8.8 shows that the average digital infrastructure score for TTD dyads is significantly higher than that for non-TTD country-pairs or dyads. Hence, digital infrastructure appears to influence the formation of targeted deals consistent with Baldwin's "threshold model" (Baldwin, 2016; Baldwin and Jaimovich, 2012), which asserts that cooperation in areas such as digital trade becomes viable only after both partners reach a minimum level of capacity.

Figure 8.8: Digital Infrastructure and the Formation of Digital TTDs



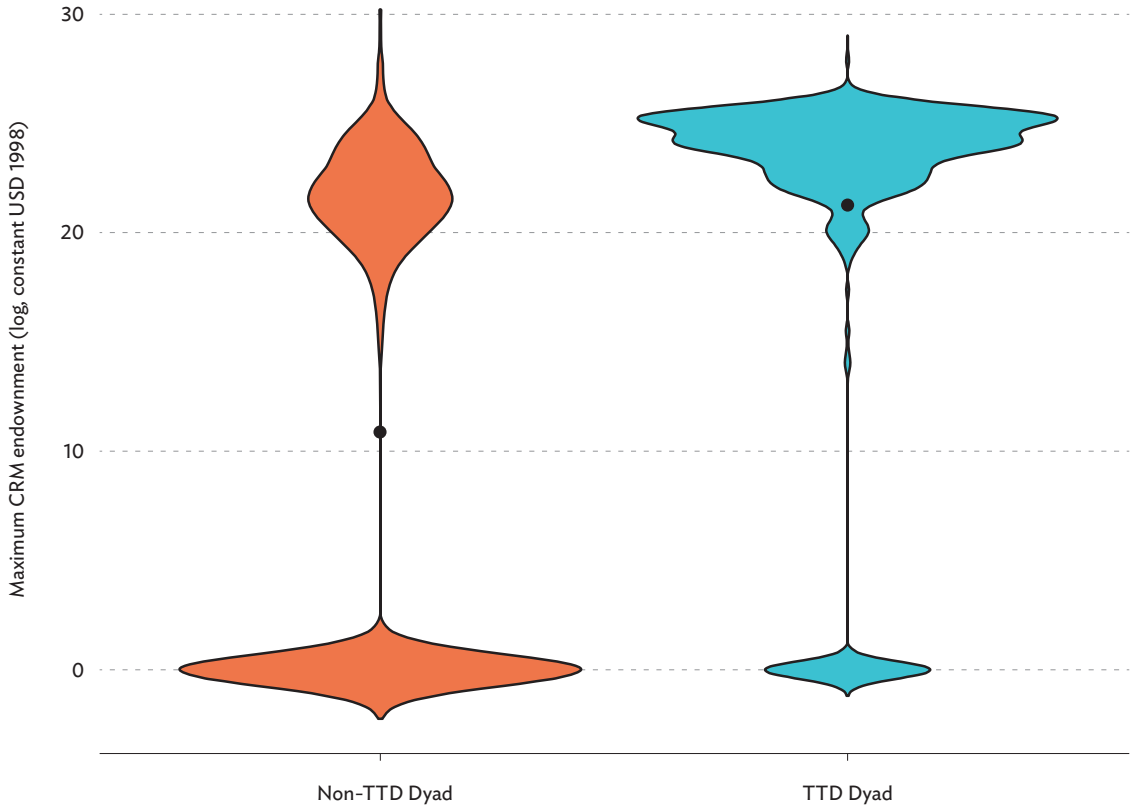
Source: Authors' calculations based on the newly compiled TTD database and the Digital Infrastructure Composite. Index constructed from the WDI and ITU data.

CRM Endowments and CRM TTD Formation

Like digital infrastructure for digital TTDs, CRM endowments in at least one CRM TTD partner increase the likelihood of CRM TTD formation. We create an anchor variable to capture the highest production value of critical raw minerals between exporter and importer for each year. The objective is to explore whether resource endowments influence the formation of CRM TTDs. This measure captures whether the presence of a large, resource-rich partner drives cooperation, operationalizing the idea that TTDs may be based on access to dominant suppliers. Figure 8.9 shows the distribution of maximum CRM endowments for TTD and non-TTD dyads. TTD dyads are disproportionately anchored by at least one partner with a large endowment, with

their distribution shifted well above that of non-TTD dyads. Thus, TTDs are more likely when a highly endowed partner is present in the trade deal, making the partnership strategically meaningful. The findings also suggest that resource-poor countries may be able to sign deals with major producers to increase supply chain resilience.

Figure 8.9: CRM Endowments and the Formation of CRM TTDs



Source: Authors' calculations based on the newly compiled TTD Database, CRM data from Our World in Data, and U.S. Geological Survey (USGS) Mineral Commodity Summaries.

2. Econometric Evidence on TTD Formation

A more robust examination of the determinants of TTD formation based on econometric analysis confirms many of the results arising from the descriptive statistics. To complement the exploratory analysis with more rigorous evidence, we estimate pooled logistic regression models (see Annex 8.5) to identify which factors are consistently linked to the likelihood of governments forming TTDs. As many of the determinants we have assessed above are correlated, such as digital infrastructure and governance quality, this approach enables us to more precisely identify the relevance of individual factors. The estimated coefficients are expressed as odds ratios that compare the impact of a variable on the likelihood of signing a TTD. For instance, the presence of an existing RTA increases the likelihood of digital TTD formation by a factor of about 8.22 relative to country pairs in a given year without an RTA.

Table 8.2: Drivers of TTD Formation (Odds Ratio)			
Variable	**Digital TTD**	**CRM TTD**	**Interpretation/Policy Insight**
Log distance	3.69***	1.11**	Greater bilateral distance is positively associated with the likelihood of TTD formation, strongly for digital and marginally for CRM.[16]
Contiguity	6.74***	1.17	Border sharing raises digital TTD odds, no effect for CRM.
Existing RTA	8.22***	1.91***	Prior RTAs are a huge predictor in digital, moderate in CRM.
Both WTO members	6.04***	4.80***	Multilateral membership strongly boosts odds in both.
Shared regional bloc	13.64***	2.19***	Regionalism drives digital TTDs, much weaker effect for CRM.
Mean dyad-year digital infrastructure	1.60***	—	High average readiness strongly boosts digital TTD odds.
Stronger partner CRM share	—	1.71***	CRM TTDs more likely when stronger partner holds non-trivial endowment.
UN General Assembly (UNGA) policy distance	1.38***	0.97	Digital TTDs may form despite political divergence; but no effect on CRM TTDs.
Governance effectiveness (exporter)	4.45***	0.78***	Good governance attracts digital partners; despite weaker governance of the exporter, CRM TTDs can form driven by necessity.
Sanctions	0.58**	0.71	Hostile ties strongly suppress TTD formation, especially digital.

Note: The binary dependent variable equals 1 if a digital or CRM TTD is in force between country pairs in a given year. All time-varying variables are lagged by one year, while time-invariant controls are taken contemporaneously. We estimate separate regressions for digital and CRM TTDs, with year fixed effects included to capture global shocks. Standard errors are clustered at the dyad level to allow for within-pair correlation. Additional non-reported controls include standard gravity variables such as contiguity, landlockedness and economic size.

The results highlight distinct drivers of digital versus CRM TTD formation. Digital TTDs are firmly rooted in institutional scaffolding, with existing RTAs, joint WTO membership and shared regional bloc membership all exerting significant effects (see Table 8.2). Digital readiness also has a significant influence on the formation of digital TTD. Targeted trade deals are likely when both partners have reached a basic level of capacity and maintain comparable infrastructure. Distance and contiguity both increase the probability of digital TTD formation, indicating two parallel patterns – regional integration among neighbours and cross-continental partnerships between advanced economies. The positive coefficient on distance suggests that digital cooperation can offset spatial constraints, consistent with mechanisms such as the modular structure of GVCs, the scalability of cloud-based collaboration and data-driven spillovers that facilitate partnerships across long distances. Exporter government effectiveness is strongly and positively associated with agreement formation, reflecting the centrality of capable institutions in sustaining digital cooperation.

For CRM TTDs, institutional factors such as WTO membership and regional ties remain relevant but play a more modest role than in digital trade. Additionally, CRM TTDs hinge on the presence of at least one partner with a significant critical raw minerals production value, consistent with an anchor logic. At the same time,

[16] Note: Distance is expressed in natural logarithms. A one-unit increase in ln(distance) corresponds to an e-fold (≈2.7-fold) increase in actual distance. The reported odds ratios therefore capture the effect of proportional rather than absolute changes in distance.

asymmetric deals could arise because smaller partners seek access to these anchors. Overall, TTD formation reflects a blend of institutional scaffolding and sector-specific dynamics. Digital TTDs are underpinned by existing integration, governance quality and digital readiness, while CRM TTDs are likely to cluster around resource anchors that create incentives for deals.

8.4.5 TTD Impact: Digital Trade and CRM

This section examines whether digital and CRM TTDs result in measurable increases in bilateral trade in digitally deliverable services (DDS) and critical raw minerals. To do so, we assemble a dyadic panel of bilateral trade flows, where our unit of analysis is dyad-year – a pair of countries observed in a given year. This structure allows us to track how trade patterns evolve before and after the signing of a TTD.

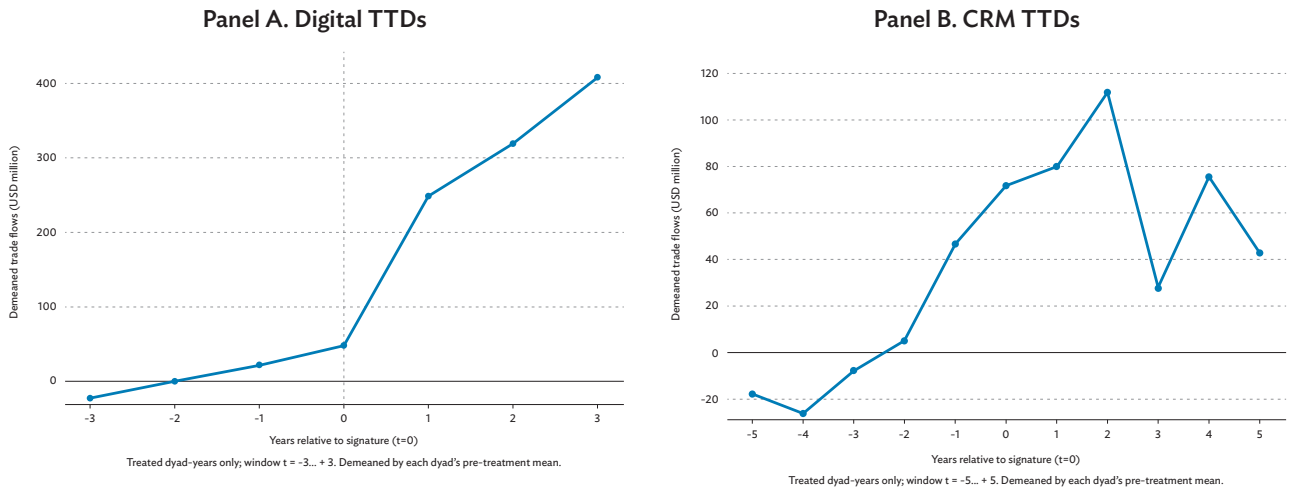
Panel A of Figure 8.10 shows that there is a jump in trade flows post-TTD signing. At the year of signature, the series depicts a discrete increase and continues to grow throughout the examined period. However, an upward trend is already visible in the years preceding the TTD signing. This continuous growth should therefore be interpreted with caution, as it may simply reflect global growth in digitally deliverable services trade rather than the direct effect of TTD implementation. The impact of the TTDs themselves can only be identified using the econometric tools in the following section. Similarly, Panel B of Figure 8.10 shows that bilateral trade in critical raw minerals increased sharply in the year prior to TTD signing, exhibiting anticipatory effects not uncommon for RTAs. While trade remains elevated throughout the post-treatment window, the increase pre-TTD-signing points to the importance of an econometric assessment.17

1. Do TTDs Boost Trade in Targeted Areas? Econometric Evidence

To estimate the impact of TTDs on bilateral trade flows, we run a state-of-the-art gravity regression to rigorously assess the effects while accounting through fixed effects for unobserved factors that may drive the changes in trade flows after the signing of a TTD, such as secular growth in the affected sectors. This is important since Figure 8.10 shows that there is an upward trend in bilateral DDS and CRM trade flows even before signing a TTD. To identify the presence of pre-trends and examine at trade patterns around TTD signings, we exploit dyadic panels of bilateral DDS and CRM flows and exploit the staggered timing of TTD signatures to trace outcomes around the time of implementation.

17 We also note that the COVID-19 pandemic likely increased volatility in bilateral CRM trade patterns. While digital trade activities largely continued during lockdowns, mining and other physical operations were disrupted by border closures and mobility restrictions. As several CRM TTDs were signed during this period, part of the observed volatility and subsequent rebound may reflect the broader post-COVID-19 recovery in global trade.

Figure 8.10: Bilateral Trade Around TTD Implementation[18]



Source: Authors' calculations based on the newly compiled TTD Database, the WTO-OECD BaTiS database and WTO Analytical Database.

An econometric assessment does not find a significant trade effect for the average digital TTD. To identify the effect of TTDs on trade flows, we estimate Poisson Pseudo-Maximum Likelihood (PPML) fixed-effects gravity regressions, which have become the standard in empirical trade research (Santos Silva and Tenreyro, 2006; Head and Mayer, 2014; Larch and Yotov, 2024).[19] The formal estimating equation and detailed results are reported in Annex 8.6. The gravity estimates indicate that digital TTDs do not yet yield a statistically significant effect on the bilateral trade of digitally deliverable services. This may be because our relatively short study period limits the ability to detect a measurable impact, and it may also be driven by the relatively noisy DDS measure. By collecting more data over time, we will be able to assess the effect of digital TTDs more reliably.

Different from digital TTDs, CRM TTDs do have a statistically significant impact on mineral trade flows. The empirical strategy for estimating CRM TTD trade effects closely follows the standard gravity literature (see Annex 8.6).[20] The results in Table

18 We conduct a treated-dyad only, demeaned event study: for each dyad-year that ever signs a TTD, we (i) compute event time, e = (t−TTD sign year); where e ∈ [−3,+3], (ii) demean levels by the dyad's own pre-TTD mean, and (iii) average across treated dyad-years at each e. We enforce absorbing treatment by excluding all dyads that ever show a reversal from TTD (1) back to no TTD (0) and require at least one pre-TTD observation. Since most digital TTDs were signed after 2020, we limit the comparison to a seven-year window, i.e. three pre- and three post-years, to have sufficient observations to make the comparison. As we have more CRM TTD signings prior to 2020, we can use a longer window of 11 years in the CRM case.

19 Given the short event window and limited dyad-years with digital TTD after year two of signing, our specification differs from the long-panel gravity setup. Rather than using exporter-year, importer-year fixed effects, and country-pair dyad fixed effects, which would absorb nearly all the limited variation, we instead include time-invariant exporter and importer effects to capture structural heterogeneity across countries, along with a common year effect to net out global shocks. To address country-specific fundamentals, we control directly for the GDP of exporters and importers (in logs), consistent with best practice in short panels.

20 As we have a longer post-treatment window, we can apply the standard gravity approach using exporter-year, importer-year, and dyad fixed effects. This specification ensures that identification comes from within-dyad variation over time – namely, the timing of CRM-TTD entry into force relative to existing RTAs.

8.3 indicate that CRM TTDs are associated with a statistically significant increase of about 12% in bilateral critical raw minerals trade. This effect is meaningful in policy terms: it suggests that such TTDs can facilitate greater cross-border flows of strategic resources, complementing existing RTAs, which raise CRM trade by roughly 30%. Together, these findings highlight that CRM TTDs have tangible effects on resource integration, potentially strengthening supply chain resilience and reducing vulnerability to concentration risks. The reason we describe the effect as meaningful is that a 12% rise (with a mean of $125.52 million per dyad-year) in bilateral trade flows is non-trivial in the context of critical raw minerals. By lowering barriers, CRM TTDs facilitate easier exchange of these strategic resources among partners.

Table 8.3: Effect of CRM TTDS on Bilateral CRM Trade Flows (PPML Estimates)[21]

Variable	Coefficient	% Effect
CRM-TTD (dummy)	0.117**	+12%
RTA (dummy)	0.303***	+35%

2. *Accounting for the Heterogeneity of TTDs*

The large heterogeneity of TTDs may imply that the averaged effects we have identified so far hide a large variance of effects across different TTDs. The TTD characteristics and provision mapping in Section 4.3 highlights that the TTDs in our dataset differ substantially concerning their provisions and nature, for instance regarding their legal status or enforceability. This is also reflected in the varying terminology used to describe the TTDs from agreements to simpler partnerships. These differences and the inclusion or absence of certain provisions or other TTD characteristics are likely to influence the impact of a TTD on trade flows. This is akin to the varying impact of RTAs according to their depth (Fontagné et al., 2023). Examining this heterogeneity is particularly relevant for digital TTDs, as our econometric results show no significant average effect of digital TTDs on trade in digitally deliverable services.

To provide an initial analysis of the impact of TTD heterogeneity, we rely on the variable that captures the use of a binding, or more compulsory, language in a given TTD as this may capture the extent of provisions and the ambition of a TTD more generally. As explained in section 4.3.4, this variable is constructed by applying a structured, rule-based NLP text analytics framework to the official TTD texts and identifies when a legal actor is paired with mandatory terms (“shall”, “must”, “is obligated to”). While for CRM TTDs, only three of the 55 mappable deals contain provisions with any binding language, digital TTDs provide a limited opportunity for exploration since among the 33 TTDs with mappable texts, a quarter include binding language.

21 Note: Effects are approximate percentage changes based on [exp(coefficient) - 1]*100.

When accounting for the heterogeneity of TTDs along this dimension in the gravity model, a clear pattern emerges. Digital TTDs overall do not significantly impact bilateral trade; however, those with binding language provisions are associated with a statistically significant increase in DDS trade. The coefficient for digital TTDs overall is statistically insignificant, indicating no average effect on the trade of digitally deliverable services. By contrast, the interaction term for digital TTD × binding language is positive and highly significant (see Annex 8.6 for the detailed results), suggesting that for those TTDs, bilateral trade increases by roughly one-third. RTAs remain strongly positive, in line with the broader gravity literature.

An important caveat of the analysis is that the number of TTDs with binding language is small, and the post-signing period is short. Hence, these preliminary results should be viewed as indicative and exploratory, and no causal interpretation should be inferred. The primary takeaway is that the heterogeneity of TTDs seems to be important for their trade effects. This illustrates the importance of having access to official TTD texts and suggests that further examining the role of heterogeneity is a central avenue for future research.

8.5 Legal and Policy Considerations for TTDs

TTDs can be integral building blocks towards reglobalization and increased trade but in a form that deviates from previous "blueprints". TTDs may serve as a stepping stone towards future, more formalized trade cooperation, providing a platform for building trust between trading partners. Or, as illustrated by the prevalence of pre-existing RTAs among digital TTD signatories, they may serve to deepen and expand existing relationships. This makes it relevant to examine links to the existing institutional framework. After all, TTDs are legal instruments that complement and interact with this framework. In what follows, we briefly explore some of the key legal and policy implications arising from this form of cooperation. This may enable policymakers to identify possible adjustments that help better exploit the potential of this relatively novel tool to increase predictability and lower barriers for international trade.

In particular, we look at three different areas. First, insofar as TTDs affect trade flows, we assess how they relate to the multilateral rules-based system. Second, the investment provisions contained in some TTDs create links to the existing network of investment treaties that we briefly illustrate. And third, like any public arrangement, TTDs can be examined regarding transparency, oversight and accountability. Unlike for instance RTAs, TTDs take different legal forms, concern a variety of sectors and have various objectives, and they differ from one another even for major parties. This introduces complexity when discussing these agreements and their impact. Moreover, it is important to re-emphasize that this chapter and the emerging literature on TTDs (see, e.g., Claussen 2022b) have identified a certain lack of transparency for some types of TTDs that makes any analysis difficult, not least as they have typically not undergone

domestic parliamentary review or formal ratification. Nevertheless, analysing some of the legal and policy issues of TTDs can contribute to better understand their nature and underlying processes and improve their functioning and outcomes.

8.5.1 TTDs and the WTO Framework

TTDs contain provisions aimed at addressing bilateral trade barriers, even if they do not grant market access. In line with this, the previous section has found some evidence in line with trade-creating effects among signatories. Moreover, as detailed above, TTDs concerning CRM and digital trade frequently focus on supply chain-related objectives. They are designed to enhance – or even guarantee – the fluidity and resilience of supply chains. In this context, they place strong emphasis on collaboration and cooperation to ensure continued access to strategically important goods and services. Paragraph 6 of the 2024 WTO Ministerial Declaration explicitly welcomes efforts to promote supply chain resilience within the WTO framework. Given these links, the question arises where TTDs may fit within the WTO framework.

To the extent that TTDs address matters already covered by WTO agreements, their scope may overlap with the rights and obligations of WTO Members. TTDs may reinforce these rights and obligations; they can also regulate the same issues in ways that diverge from WTO rules. In such cases, questions may arise as to how specific provisions fit within the WTO framework, particularly where they are found to restrict trade or confer benefits and advantages not extended to all WTO members. In these scenarios, the exceptions provided within the WTO legal framework, such as Articles XX and XXIV of the General Agreement on Tariffs and Trade, or their counterparts in the General Agreement on Trade in Services (GATS), may become relevant. Other relevant connections may exist, for instance concerning the regulation of mutual recognition agreements in Article 6 of the Agreement on Technical Barriers to Trade or Article VII of GATS, the Trade Facilitation Agreement, or, in some instances, the Enabling Clause.

The fact that situating TTDs within the WTO framework is complex may contribute to the fact that TTDs have not been notified to the WTO, or to any other plurilateral or multilateral body. Facilitating access to information about TTDs to outside parties, for instance through the various WTO notification windows or through WTO committees, could increase their potential to serve as building blocks for reglobalization. For example, it could facilitate other WTO members joining such agreements. Such positive spillover effects would maximize the potential of TTDs to address GVC issues such as limited inclusiveness and increase resilience. In addition, broader participation could increase trade opportunities by plurilateralizing trade-enabling regulations of frontier issues such as digital trade. As a result, improving TTD transparency is likely to be valuable independent of where TTDs fall within WTO agreements.

8.5.2 TTDs and Investment

Digital or CRM TTDs often overlap in different ways with existing investment treaty provisions embedded within bilateral investment treaties (BITs) or broader RTAs, underscoring the strategic nature of many such agreements. This overlap raises several potential legal issues. Beyond possible contradictions between trade and investment provisions, it is conceivable that an investor is in a position to allege discrimination or expropriation under a BIT or an RTA resulting from a policy change triggered by a TTD. The convergence of trade, investment and strategic security considerations within TTDs – particularly those concerning CRM and the digital economy – has introduced complex legal challenges, including regarding investor-state dispute settlement (ISDS). Policy shifts arising from TTD commitments that are perceived to disadvantage foreign products or services or investors may prompt affected parties to invoke protections under BITs or RTAs, alleging measures tantamount to indirect or de facto expropriation or discriminatory treatment. This dynamic can constrain economies' regulatory autonomy, potentially leading to "regulatory chill", wherein governments hesitate to adopt policies due to concerns over investment claims.

8.5.3 Domestic Issues of TTDs

The comparably light negotiation and implementation process of many TTDs can have implications from the perspective of public accountability, separation of powers, oversight, and enforceability within national jurisdictions. When TTDs are negotiated rapidly and informally, they bypass the comprehensive ratification processes typically required for multilateral or bilateral trade agreements. This does not prevent them from producing economic or legal effects, even if they are in many instances honorary pledges, mainly indicating the course of action that states intend to follow. Nevertheless, certain TTDs take the form of binding agreements, usually in simplified form (executive agreement), not involving the usual constitutional process for treaties, or requiring ratification. Some are more akin to mini treaties and must follow a formal constitutional procedure.

It is often unclear how TTDs should be approached or included in the economies' legal orders, and this will also of course vary between different legal systems. The legal ambiguity of TTDs is therefore evident. In some cases, TTDs by not being subject to parliamentary scrutiny, raise concerns about democratic legitimacy and the separation of powers (see, e.g., Claussen, 2022b). Moreover, TTDs that include regulatory commitments impacting citizens' rights, environmental standards or economic governance would benefit from public accountability. Finally, overlapping jurisdictions – such as those between federal and sub-federal governments in federations – may give rise to disputes regarding the competence to conclude or implement TTDs, complicating their domestic legal standing.

Ultimately, as for TTD's relationship with international economic law, transparency could help address many of the issues identified by the emerging literature on TTDs. Wider information sharing with domestic stakeholders would limit concerns regarding oversight and accountability and, yet again, could maximize the economic value of these agreements by increasing awareness among firms.

Before turning to the concluding section, it is useful to complement the empirical and legal analysis above with insights from the private sector. After all, TTDs ultimately shape the operating environment of firms, which act as both users and indirect co-producers of the emerging governance structures described in this chapter. The following box (Box 8.2) provides a business sector perspective on how companies interpret, respond to and navigate the growing landscape of targeted trade deals.

Box 8.2: The View From Business: Navigating Targeted Trade Deals in a Fragmented Global Economy

Chapter 8 of this report suggests that TTDs are becoming an increasingly prominent feature of the trade-policy landscape, particularly in the digital economy and critical minerals sectors. Although this certainly appears to be the case, from the perspective of global business, the emerging picture is less one of a radical break than of a familiar dynamic playing out through new instruments. Firms have long operated in a world where regulatory cooperation, soft-law commitments and plurilateral initiatives have shaped market access and other commercial outcomes in ways that are just as consequential as, say, tariff cuts or the reduction or elimination of quotas.

This expanding ecosystem of mini deals demands that companies adjust how they monitor negotiations, plan investments and engage policymakers. The chapter implicitly highlights several enduring lessons for business: that implementation determines real market access; that trade policy is now a core management function; that firms must track multiple cooperation forums; and that opacity continues to impose strategic uncertainty. This box examines how businesses navigate TTDs, complementing Chapter 8's analysis of these deals as a new form of global value chain governance.

Implementation Remains the Real Battlefield

From the perspective of the firms actually trading across borders or operating on foreign markets, trade agreements have never been self-executing. Even during the high-water mark of the WTO and the proliferation of comprehensive FTAs, firms were regularly forced to navigate the gap between legal commitments and commercial reality, which was indeed the whole reason dispute settlement procedures became an increasingly important and visible part of the global trade policy architecture. Market access concessions on paper often ran up against the reality of poor or haphazard implementation that took on various forms including licensing delays, opaque regulatory procedures, selective enforcement, divergent technical standards and sudden changes driven by domestic political developments.

Examples from earlier periods illustrate this pattern. Commitments in sectoral deals or FTAs on telecommunications and financial services sat alongside slow or uneven licensing in major emerging markets. Preferential tariff schemes under early regional agreements were undercut by complex rules of origin or inconsistent customs administration. In pharmaceuticals or electronics, divergent interpretations of technical standards meant firms could not rely on treaty text alone.

TTDs have not changed this structural reality so much as simply having multiplied the number of arenas in which it plays out. In critical minerals, for example, bilateral and plurilateral partnerships among producer and consumer countries set out objectives related to supply chain security, sustainability and local value addition. For firms, however, the operative constraints remain environmental permitting timelines, clarity of land use rules, the predictability of export licensing regimes and how investment-screening mechanisms are applied in practice. In the digital economy, purpose-built agreements on data flows, digital identities or source code protection may reduce uncertainty at the margins, but companies still navigate divergent privacy laws, cybersecurity requirements and sectoral regulations that can override or dilute the effect of agreements or frameworks negotiated and concluded at the international level.

As a result, firms approach TTDs the same way they have long approached multilateral and regional agreements: as signals rather than guarantees. The signing and ratification of these agreements is the beginning of a long implementation story that needs careful monitoring. The core business question remains: how – and how consistently – will commitments be applied by regulators, courts and administrative agencies over time?

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Box 8.2: continued

Trade Policy as a Strategic Management Function

Trade policy has always been of heightened strategic importance for internationally exposed companies. Large exporters, multinationals and globally integrated supply-chain actors have, for decades, monitored tariff changes, standards harmonization efforts, investment rules and the outcomes of international dispute settlement cases. What has shifted is the degree to which these considerations are now embedded in the day-to-day management of firms, rather than being confined to specialized government affairs or legal compliance units.

Several developments over the past decade have driven this shift. Data protection and cybersecurity rules have forced firms to redesign global data architectures. Export controls and investment-screening regimes in sensitive technologies have reshaped supplier relationships. Brexit, successive waves of tariffs and unilateral sanctions regimes have prompted wholesale reconfiguration of distribution networks. Large-scale industrial policy measures, such as the US Inflation Reduction Act, have made eligibility for fiscal incentives contingent on specific sourcing patterns and location decisions.

TTDs sit on top of this landscape and represent continuity in the trend of trade policy taking on strategic importance. Digital economy agreements may influence decisions about where to locate data centres. Semiconductor and critical minerals partnerships can affect assumptions about long-term supply security or future eligibility for tax credits. Green technology arrangements may shape expectations about procurement access or recognition of sustainability standards.

In response, many firms have moved from treating trade and industrial policy as external constraints to incorporating them as explicit variables in corporate planning. This is visible in at least three ways: Organizational structures: Companies are creating dedicated trade and regulatory intelligence functions reporting to senior management and board-level committees.

Decision processes: Capital expenditure and site selection processes increasingly assess policy exposure – not just in terms of current rules, but the direction of travel in key jurisdictions.

Skill profiles: Firms are recruiting policy specialists and trade lawyers into roles closer to core business functions, including supply chain management and product development. In this sense, TTDs do not change whether firms engage with trade policy but rather deepen how and where they do so inside the firm.

More Forums, Not New Logics: How Firms Read Targeted Trade Deals

From the standpoint of corporate strategists, TTDs are best understood as an additional layer of governance, not a distinct paradigm. The basic logic that firms apply when evaluating WTO commitments, FTAs or APEC initiatives continue to apply when they assess digital economy agreements, critical minerals MoUs or sector-specific cooperation frameworks.

At the macro level, firms ask largely familiar questions:

Does this initiative create legal certainty or merely represent policy signalling? Are its provisions binding, and if so, how much predictability do they afford in practice? Which domestic agencies will be responsible for implementation, and what is their track record? How does this framework interact with existing obligations under WTO law, FTAs and domestic regulation?

The answers to these questions often reveal that TTDs sit within a complex web of existing economic integration and regulatory cooperation frameworks rather than operating as standalone agreements. A digital trade corridor may reference principles already reflected in existing FTAs, while critical minerals partnerships may rest on pre-existing environmental and investment regimes. Firms must therefore treat TTDs as part of an overlapping regime complex rather than as a discrete layer.

The practical consequence is that TTDs rarely displace the work firms were already doing. Instead, they require existing monitoring machinery to extend to new sectoral clubs, implementation committees and standard-setting processes.

continued on next page

Box 8.2: continued

Firms as Quiet Co-Authors of Targeted Trade Governance

Although firms are not formal parties to TTDs, they are rarely passive observers. Over the past three decades, the private sector has acquired significant experience in shaping, clarifying and operationalizing trade rules. Sectoral business organizations and large firms supplied technical detail underpinning negotiations on telecommunications, financial services and customs facilitation. In regional settings, industry coalitions have played similar roles in e-commerce, investment and regulatory cooperation. Public-private dialogues around Asia Pacific Economic Cooperation (APEC) initiatives, Organisation for Economic Co-operation and Development (OECD) codes and G20 processes entrenched the idea that implementation is co-produced by regulators and firms.

The same pattern is visible in TTDs:

Digital economy agreements often draw on consultation with cloud providers, payments companies and logistics platforms, whose operational experience shapes notions of interoperability and workable data-transfer regimes.

Critical minerals partnerships rely on input from mining, processing, battery and automotive companies when specifying sustainability benchmarks and traceability requirements.

Green technology frameworks frequently build on technical standards first developed in corporate supply chain programmes and industry standards bodies.

This does not mean that firms control TTD design – governments still make final decisions and national security considerations increasingly loom large. But the detailed content of targeted deals is often heavily informed by private-sector practice, through formal consultations, industry submissions or informal expertise sharing.

Transparency, Fragmentation and the Black Box Problem

If there is one dimension where TTDs pose a sharper challenge than earlier instruments, it lies in transparency and process. Traditional trade agreements, especially in the WTO and FTA contexts, developed institutionalized channels for business input: public comment periods, advisory committees and stakeholder forums. While far from perfect, they provided recognized entry points for firms to make views known and anticipate how rules were evolving.

By contrast, many recent targeted arrangements – particularly in critical minerals and technology security space – are negotiated under heightened confidentiality. Governments cite national-security concerns, strategic competition or commercial sensitivity to justify limited disclosure. Detailed implementation roadmaps may be only partially public or not published at all. Even domestic industry stakeholders may have incomplete visibility into the precise scope of obligations or future decisions on project selection or eligibility criteria.

For business, this complicates matters in two ways. First, it makes forward-looking planning more difficult, since firms cannot easily map long-term capital decisions onto opaque frameworks. Second, it raises the stakes around informal channels of information, privileging actors with closer access to decision makers. Smaller firms and those in countries with weaker consultation traditions may find themselves at a relative disadvantage.

This black box problem is not entirely new – elements were present in earlier negotiations. But the concentration of TTDs in strategic sectors, combined with heightened geopolitical tensions, has made it more pronounced. As a result, firms are investing more heavily in regulatory intelligence capabilities and multilateral business coalitions that can monitor developments across multiple jurisdictions.

Strategic Implications for Firms and Policymakers

From the business perspective, the rise of targeted trade deals yields three broad implications.

First, TTDs do not eliminate the primacy of implementation; they entrench it. Firms will continue to judge the value of any initiative less by its rhetoric and more by how it is administered: the clarity of guidance, the consistency of enforcement, the efficiency of approval processes and the stability of underlying political commitments.

Second, trade and industrial policy have become fully internalized management concerns. The proliferation of TTDs reinforces the need for companies to mainstream policy analysis within their risk management, supply chain design, capital budgeting and technology strategies. Large firms are already building the institutional capacity to do this; smaller firms may require support from industry associations, chambers of commerce and public institutions that can help translate complex policy frameworks into operational guidance.

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Box 8.2: continued

Third, firms will remain active – if often understated – co-authors of the new trade architecture. Governments designing TTDs that are meant to be implementable and commercially meaningful will depend on granular industry input. Structures that institutionalize transparent, broad-based business engagement will serve both public and private interests by improving rule quality and reducing unintended consequences.

For policymakers, these insights from business suggest that the success of targeted trade deals will ultimately be judged less by the number of initiatives launched and more by their credibility, administrative quality and interoperability with existing frameworks. For firms, the task is to continue doing what many have already learned to do well: treat trade policy as a strategic variable, invest in understanding and shaping the evolving rule set, and focus relentlessly on the implementation realities that determine whether new agreements translate into genuine commercial opportunity.

Note: This box was authored by Simon Lacey (formerly with the World Economic Forum, currently with Belt Road Capital Management). The views expressed are those of the author and do not necessarily reflect those of the affiliated institutions.

8.6 Conclusions

In this chapter, we examine a rapidly proliferating instrument of trade cooperation – targeted trade deals or TTDs. We refer with this term to government-to-government trade-related cooperation that is limited to a particular objective. To study TTDs, we compile a global dataset of TTDs on the digital economy and critical raw minerals. Equipped with this dataset, we provide novel insights into the geographic distribution of these agreements, their content, and their economic and legal implications. In particular, we show that TTDs have expanded considerably within the past five years but that not all regions participate in TTD formation equally. These deals tend to focus on non-tariff barriers only, especially information frictions that can be reduced through consultative processes, and they tend to be explicitly non-binding. However, TTDs are also relatively heterogeneous. For instance, we do observe tariff liberalizing and/or binding provisions in some TTDs. Importantly, we are the first to establish empirically determinants of TTD formation and provide evidence indicating that TTDs can increase bilateral trade flows between signatories. Finally, we examine their status and relationship with the multilateral and domestic legal frameworks.

Overall, we find that TTDs fulfil pragmatically strategic objectives and contribute to international cooperation. The increasing prevalence of TTDs suggests that they might be able to serve as a valuable complement to RTAs and multilateral agreements, helping to bring trading partners closer to one another. Their flexibility enables trading partners to advance cooperation in specific sectors or policy areas without becoming entangled in the broader, and often more politically sensitive, negotiations. They fit, as a result, under the umbrella of reglobalization. This applies particularly to the growing use of TTDs by economies whose GVC integration has until now been limited. One example to that effect is the high number of agreements signed between European and Latin American economies, which may support a closer integration of Latin America in European GVCs and address barriers identified to Latin American GVC integration in Chapter 2 of this report.

We also find, alongside similar studies, that some TTDs are concluded with limited transparency and that some regions remain at the margins of TTD formation. Such TTDs could contribute to a fragmented global trading system or foster trade relationships that are perceived as unbalanced. Adopting a pragmatic approach to better incorporate them within existing frameworks and increase transparency, for instance regarding public access to official texts, could address many of these concerns. It could help maintain trust and coherence across the multilateral trade framework. It may also contribute to increased value of entering these cooperations.

To conclude, it is important to emphasize that this chapter is only a contribution to a small but growing literature on TTDs, and a key takeaway is that there remains much scope to better understand the content, functionality and effect of TTDs. Across all the dimensions of TTDs we study – economic and legal – there are numerous questions that we only touch upon and that deserve further analysis. By providing a dataset on TTDs, we hope that scholars can contribute to such questions, including the extension of the underlying data to other areas or newer agreements. The evidence clearly shows that TTDs have become an integral part of the institutional framework governing trade and GVCs. More analysis of these agreements could therefore help maximize their potential in facilitating trade.

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Annexes

Annex 8.1: TTD Inclusion Criteria

Critical raw minerals (theme-specific)	Does the agreement explicitly refer to cooperation on raw materials classified as critical or strategic? Or: Does the agreement implicitly pertain to such cooperation through clear references to activities, sectors, or infrastructure that directly support their production, processing, or trade? Or: Does the agreement not specifically mention "critical" raw materials but was it (a) established after the 2010 rare earths trade dispute, and (b) initiated by a country with a raw materials strategy in place?
Digital economy (theme-specific)	Does the agreement explicitly constitute cooperation in the digital economy or any related sub-sectors?
Trade-related	Does the text establish or support trade cooperation, directly or indirectly, between the countries?
Institutional scope	Does the arrangement fall outside the scope of a formal RTA, while potentially forming a separate instrument that supplements, amends or operates alongside a broader cooperative framework?
G2G	Is the agreement concluded between two or more governments or government entities?
Temporal	Was the agreement signed before or on the cut-off date of 31 December 2024?
Implementation status	Has the cooperation become active or otherwise entered into effect following its signing?

Annex 8.2: General TTD Provisions

Agreement name	How is the TTD commonly referred to in official or public sources?
Countries	What are the participating countries in the TTD?
Type	Under what classification does the TTD fall based on its title or official description?
Year	Which year marks the entry into force or activation of the TTD?
Composition	What is the structural composition of the TTD: bilateral, plurilateral or multilateral?
Binding nature	Does the TTD constitute a binding legal instrument or a non-binding political commitment?
Text available	Is the official text of the TTD available?
Source	From which source category was the TTD information extracted?
Accessions	Have there been any accessions to the TTD since its initial signing? If yes, country code and year are listed.
Timeline	What is the specified duration of the TTD, or how long is it intended to remain in force?
Renewal	Is the agreement subject to automatic renewal upon expiry?

Annex 8.3: Critical Raw Minerals TTD Provision Mapping Sheet

Theme	What is the main topic under the CRM umbrella?
Extraction and exploration	Does the text mention cooperation on exploration and/or extraction activities?
Knowledge and capacity building	Does the text include provisions for technical knowledge transfer, training or research cooperation?
Economic linkages and diversification	Does the text mention cooperation on business linkages, market access or industrial diversification?
Investment cooperation	Are there provisions for investment incentives, financing mechanisms, or joint investment projects? 0 = not mentioned at all 1 = mentioned as an aim but not specified 2 = mentioned and related to some potential funding source 3 = direct financial commitment
Sustainable governance	Does the text mention environmental, social or governance (ESG) principles or sustainability?
Infrastructure and logistics development	Does the text mention building or improving infrastructure necessary for production or exports?
Institutional mechanisms and governance	Does the text establish regulatory or institutional mechanisms for oversight, governance or alignment in multilateral fora?

Note: With the exception of the categorical nominal variable "Theme" and the ordinal variable "Investment cooperation", all responses are coded as binary values: 1 indicates the presence of the relevant provision in the agreement, and 0 indicates its absence.

Annex 8.4: Digital TTD Provision Mapping Sheet

Theme	What is the main topic under the digital economy umbrella?
Cross-border data flows	Is there a provision on the movement, localization or governance of data across borders?
Personal data protection and consumer rights	Is there a provision on personal data protection or consumer rights in digital environments?
Cybersecurity and digital trust	Is there a provision that supports cybersecurity, digital trust or the secure functioning of digital systems?
Trade facilitation	Is there a provision aimed at simplifying or enabling digital trade processes and transactions?
Digital infrastructure	Is there a provision on developing or enhancing digital infrastructure or connectivity?
Emerging technologies	Is there a provision promoting cooperation, development or governance of emerging digital technologies or innovation?
Investment cooperation	Are there provisions for investment incentives, financing mechanisms or joint investment projects? 0 = not mentioned at all 1 = mentioned as an aim but not specified 2 = mentioned and related to some potential funding source 3 = direct financial commitment
Knowledge and capacity building	Does the text include provisions for technical knowledge transfer, training or research cooperation?
Institutional mechanisms and governance	Does the text establish regulatory or institutional mechanisms for oversight, governance or alignment in multilateral fora?

Note: With the exception of the categorical nominal variable "Theme" and the ordinal variable "Investment cooperation", all responses are coded as binary values: 1 indicates the presence of the relevant provision in the agreement, and 0 indicates its absence.

Annex 8.5: Estimation Strategy and Regression Results

1. TTD formation - estimation equation

Pooled Logistic Model:

$$\Pr\left(TTD_{ijt=1}\right) = \log i\, t^{-1}\left(\beta_0 + \beta_1 X_{ij} + \beta_2 Z_{ij,(t-1)} + \delta_t\right)$$

Note: *i* is exporter and *j* is importer. Standard errors are clustered at the dyad level, accounting for arbitrary correlation across time within each bilateral country pair. Time-invariant dyadic variables (e.g., distance, language, contiguity) enter directly, while all time-varying predictors are lagged by one year (i.e., measured at *t-1*) to reflect pre-treatment conditions and reduce simultaneity concerns.

2. TTD formation – regression results

Table 8.A.1: Determinants of TTD Formation (Odds Ratio, Year FE)

Variable	Digital TTD OR (s.e.)	CRM TTD OR (s.e.)
Geographic and cultural factors		
Log distance	3.668*** (0.303)	1.111* (0.065)
Contiguity	6.736*** (2.642)	1.172 (0.347)
Common language	0.747*** (0.070)	1.172* (0.112)
Exporter landlocked	0.555*** (0.053)	1.136 (0.103)
Importer landlocked	0.518*** (0.048)	1.108 (0.100)
Institutional factors		
Existing RTA	8.218*** (0.830)	1.912*** (0.173)
Both WTO members	6.035*** (1.176)	4.796*** (0.725)
Shared regional bloc	13.638*** (3.180)	2.193*** (0.495)
Sector-specific capabilities		
Gap in digital infrastructure	0.942* (0.033)	—
Mean dyad-year digital Infrastructure	1.593*** (0.241)	—
Stronger partner CRM share	—	1.712*** (0.036)
Political and governance		
UNGA policy distance	1.384*** (0.081)	0.965 (0.056)
Governance effectiveness (exporter)	4.451*** (0.558)	0.779*** (0.069)
Rule of law (exporter)	0.245*** (0.028)	1,632*** (0.149)
Economic factors		
Log GDP per capita sum	3.036*** (0.318)	2.880*** (0.225)
GDP per capita gap (|ln|)	0.586*** (0.031)	0.872*** (0.041)
Sanctions	0.579** (0.149)	0.709** (0.096)
Model statistics		
Observations	300,506	469,421
Mean of dependent variable	0.018	0.009

Table 8.A.2: Determinants of TTD Formation (Average Marginal Effects, Year FE)		
Variable	Digital TTD AME	CRM TTD AME
Geographic and cultural factors		
Log distance	0.018*** (0.001)	0.001* (0.000)
Contiguity	0.026*** (0.005)	0.001 (0.002)
Common language	−0.004*** (0.001)	0.001* (0.001)
Exporter landlocked	−0.008*** (0.001)	0.001 (0.001)
Importer landlocked	−0.009*** (0.001)	0.001 (0.001)
Institutional factors		
Existing RTA	0.029*** (0.001)	0.005*** (0.001)
Both WTO members	0.024*** (0.003)	0.012*** (0.001)
Shared regional bloc	0.036*** (0.003)	0.006*** (0.002)
Sector-specific capabilities		
Gap in digital infrastructure	−0.001* (0.000)	—
Mean dyad-year digital infrastructure	0.006*** (0.002)	—
Stronger partner CRM share	—	0.004*** (0.000)
Political and governance		
UNGA policy distance	0.004*** (0.001)	−0.000 (0.000)
Governance effectiveness (exporter)	0.020*** (0.002)	−0.002*** (0.001)
Rule of law (exporter)	−0.019*** (0.002)	0.004*** (0.001)
Economic Factors		
Log GDP per capita sum	0.015*** (0.001)	0.008*** (0.001)
GDP per capita gap (|ln|)	-0.007***(0.001)	-0.001***(0.000)
Sanctions	−0.007** (0.003)	−0.003** (0.001)
Model statistics		
Observations	300,506	469,421
Mean of dependent variable	0.018	0.009

Note: Dyad-clustered robust standard errors (s.e.) in parentheses. All time-varying variables lagged one year except time-invariant geographic variables. Significance levels: * p < 0.10, ** p < 0.05, *** p < 0.01.

Annex 8.6: Impact of TTDs on Bilateral Trade Flows

1. PPML Gravity Model Estimation for Digital TTDs and Bilateral DDS Trade

We construct our estimation equation following the structural gravity framework. Given the short [−3, +3] horizon, we do not employ exporter-year or importer-year fixed effects; instead, we include time-invariant exporter and importer effects and a common year effect, while directly controlling for country-specific fundamentals (log GDPs). The estimating equation is specified as:

$$E\left[y_{ij,t}\middle|X_{ij,t}\right] = \exp\left(a \cdot DTTD_{ij,t} + b \cdot RTA_{ij,t} + c \cdot Z_{ij} + d \cdot GDP_{i,t} + e \cdot GDP_{j,t} + \varphi_i + \psi_j + \tau_t\right)$$

To aid interpretation of the estimation equation, this appendix provides a compact notation list. The list mentions the symbols used, their definitions, and the corresponding variables included in the empirical specification. This ensures clarity in linking the simplified equation to the gravity model discussed in the main text for causal analysis.

- $y_{ij,t}$ = Bilateral DDS trade between exporter i and importer j in year t
- $DTTD_{ij,t}$ = Digital TTD dummy
- $RTA_{ij,t}$ = Regional trade agreement dummy
- Z_{ij} = Vector of time-invariant controls between exporter and importer (contiguity, common language, colonial tie, log distance)
- $GDP_{i,t}$ & $GDP_{j,t}$ = Exporter and importer GDP (logs) in constant USD
- φ_i & ψ_j = Exporter and importer fixed effects
- τ_t = Year fixed effect
- a = Coefficient of interest (the impact Digital TTD on bilateral trade flows)

Turning to the PPML gravity framework, results indicate that digital TTD does not have statistically significant effect on bilateral DDS trade flows, while existing RTAs, geography, language and market size display strong expected effects (see Table 8.A.3). These results underline the need for more granular causal analysis of Digital-TTD provisions for a longer period of time.

Table 8.A.3: Impact of Digital TTDs on Bilateral Digital Trade Flows

Dep. var.: Bilateral DDS trade	Coef.	Std. Error
Digital TTD (dummy)	-0.013	(0.043)
RTA (dummy)	0.217	(0.088) **
Contiguity	-0.023	(0.121)
Common language	0.457	(0.090) ***
Colonial tie	-0.093	(0.119)
Log distance	-0.472	(0.043) ***
Exporter GDP (log)	1.029	(0.081) ***
Importer GDP (log)	0.723	(0.215) ***
N	429,410	
Mean of dep. var. (million USD)	63.29	
FE absorbed	exp, imp, year	
SEs	dyad-clustered	

Note: Dyad-clustered robust standard errors in parentheses. Significance levels: * p < 0.10, ** p < 0.05, *** p < 0.01.

2. PPML Gravity Model Estimation for CRM TTDs and Bilateral CRM Trade

The CRM specification follows standard gravity practice (Anderson and van Wincoop, 2003; Head and Mayer, 2014). Exporter-year and importer-year fixed effects absorb all country-specific shocks such as GDP or production, while dyad fixed effects capture time-invariant bilateral factors. Identification therefore comes from within-dyad changes in policy status. This design is consistent with the benchmark PPML approach in trade (Santos Silva and Tenreyro, 2006; Larch and Yotov, 2024), and the estimation equation is:

$$E\left[CRM_{ij,t}\middle|X_{ij,t}\right] = \exp\left(f \cdot CRMTTD_{ij,t} + g \cdot RTA_{ij,t} + \varphi_{i,t} + \psi_{j,t} + \delta_{ij}\right)$$

The notations are:

- $CRM_{ij,t}$ = Bilateral critical raw minerals trade between exporter i and importer j in year t
- $CRMTTD_{ijt}$ = CRM TTD dummy
- RTA_{ijt} = Regional trade agreement dummy
- $\varphi_{i,t}$ = Exporter-year fixed effects
- $\psi_{j,t}$ = Importer-year fixed effects
- δ_{ij} = Dyad (exporter-importer pair) fixed effects
- f = Coefficient of interest (the impact CRM TTD on bilateral trade flows)

Table 8.A.4: Impact of CRM TTDs on Bilateral Critical Raw Minerals Trade Flows

Dep. Var.: Bilateral CRM Trade	Coef.	Std. Error
CRM TTD (dummy)	0.117	(0.051)**
RTA (dummy)	0.303	(0.089) ***
N	250,252	
Mean of dep. var. (million USD)	125.52	
FE absorbed	exp-year, imp-year, dyad (exp-imp pair)	
SEs	dyad-clustered	

Note: Dyad-clustered robust standard errors in parentheses. Significance levels: * p < 0.10, ** p < 0.05, *** p < 0.01.

3. Digital TTDs, Binding Language and Impact on DDS Bilateral Trade

This annex extends the baseline gravity analysis of digital TTDs using a measure of enforceability as a proxy for the extent and ambition for the TTD to assess whether the heterogeneity of TTDs affects their trade effects. The model adds an interaction term for digital TTD × binding language, while the standalone binding language dummy is omitted due to multicollinearity. This setup separates the average effect of digital TTDs from the incremental effect of agreements that contain binding provisions. The

analysis is suggestive only: eight digital TTDs in our dataset include binding language, representing about 2% of digital TTD dyad-years and less than 0.1% of all dyad-year observations (including both TTD and non-TTD dyad years). Results should therefore be interpreted as preliminary and indicative only, and no causal interpretation should be inferred.

Table 8.A.5: Impact of Digital TTDs with Binding Language on Bilateral Digital Trade Flows

Dep. Var.: Bilateral DDS Trade	Coef.	Std. Error
Digital TTD (dummy)	−0.047	(0.048)
RTA (dummy)	0.224**	(0.088)
Digital TTD × binding language	0.284***	(0.110)
Contiguity	−0.025	(0.121)
Common language	0.461***	(0.091)
Colonial tie	−0.094	(0.119)
Log distance	−0.471***	(0.043)
Exporter GDP (log)	1.045***	(0.083)
Importer GDP (log)	0.742***	(0.215)
N	429,410	
Mean of Dep. Var. (million USD)	63.29	
FE absorbed	exp, imp, year	
SEs	dyad-clustered	

APPENDIX

Background Paper and Chapter Authors' Workshops for the Global Value Chain Development Report 2025

Program for
Background Paper Workshop Global Value Chain (GVC) Development Report 2025:
Re-globalization - Opportunities for More Inclusive and Greener GVCs
UIBE, Beijing, December 12 and 13, 2024
(Draft of Preliminary Program for discussion)
Organized by RIGVC_UIBE, with WTO, ADB, IDE-JETRO, and OECD.
Additional contributions from World Bank, IMF, WEF, and selected researchers.

December 12 all times Beijing	
8:00am – 8:15am	Opening Remarks; Chair: Siyan Shen
Speakers	Prof. Zhao Zhongxiu, President of UIBE Prof. Robert Koopman, Editor in Chief, GVC Development Report 2025/American University/RIGVC-UIBE Prof. Albert Park, Chief Economist, Asian Development Bank
20 minutes for each presenter, 5 minutes for discussants, and 5 minutes for Q&A	
8:15am – 10:30am	Session 1; Chair: Victor Stolzenburg (WTO)
8:15am – 8:45am	Reshaping the global automotive industry value chains. (UIBE)
Speaker	Ran Wang (UIBE) and Bo Meng (IDE-JETRO)
Discussant	Stela Rubinova (WTO)
8:45am – 9:15am	New opportunities for a more inclusive global EV supply chains: a study based on product space evolution.
Speaker	Yunfeng Yan (CUEB)
Discussant	Robert Koopman (RIGVC/AU)
9:15am – 9:30am	Tea break
Participant	All
9:30am – 10:00am	Geopolitical Risks and Global Value Chain Vulnerability: Nuancing the Role of Domestic-Controlled Enterprises versus Foreign-Controlled Multinational Enterprises
Speaker	Hao Xiao (Hunan University) and IDE-JETRO invited expert
Discussant	Ran Wang (UIBE)
10:00am – 10:30am	The Impact of Productivity on Welfare of Nations through Global Value Chains
Speaker	Wenyin Cheng (IDE- JETRO)
Discussant	Elisabetta Gentile (ADB)
10:30am – 1:00pm	Session 2; Chair: Robert Koopman (RIGVC/AU)
10:30am – 11:00am	Employment in GVCs, Productivity and Convergence
Speaker	Neil Foster McGregor (ADB)
Discussant	Wenbo Zhu (UIBE)
11:00am – 11:30am	Technological Convergence and Divergence by GVC Participation: A New Fact in a Countries Growth Pattern
Speaker	Wenbo Zhu (UIBE)
Discussant	Jong Woo Kang (ADB)
11:30am – 12:00pm	Firm Linkages and Domestic Value Added in Exports: Moving up the Global Value Chains with High-Speed Railways
Speaker	Enze Xie (School of Economics, Zhejiang University, and the World Bank)
Discussant	UIBE TBD

12:00pm – 12:30pm	Domestic Value Added in Exports: Evidence based on Customs Transaction Data
Speaker	Enze Xie (School of Economics, Zhejiang University, and the World Bank)
Discussant	Victor Stolzenburg (WTO)
12:30pm – 1:00pm	Intangible Capital and Job Flows in the Digital Age.
Speaker	Wenbo Zhu (UIBE)
Discussant	Enze Xie (School of Economics, Zhejiang University)
1:00pm – 2:00pm	Lunch
Participant	All
2:00pm – 4:15pm	Session 3; Chair: Bo Meng (IDE-JETRO)
2:00 pm – 2:30pm	Pass-Through Frequency (PTF) in GVCs
Speaker	Satoshi Inomata (IDE- JETRO)
Discussant	Robert Stehrer (WIIW)
2:30pm – 3:00pm	Does trade opening in the services sector improve the environmental performance of manufacturing sectors that intensively use services in their production process?
Speaker	Enxhi Tresa (OECD)
Discussant	Neil Foster-McGregor (ADB)
3:00pm – 3:15pm	Tea break
Participant	All
3:15pm – 3:45pm	Industrial Subsidies along Domestic Value Chains and their Impacts on China's Export Competitiveness
Speaker	Hongyong Zhang (RIETI and IDE-JETRO invited expert)
Discussant	Sebastien Miroudot (OECD)
3:45pm – 4:15pm	Access to trade finance: its importance for trade and value chain integration
Speaker	Marc Auboin (WTO)
Discussant	Larry Li (RMIT and IDE-JETRO invited expert)
4:15pm – 6:45pm	Session 4; Chair: Neil Foster-McGregor (ADB)
4:15pm – 4:45pm	WTO What's behind digital transformation in Africa
Speaker	Hildegunn Nordas (CEP)
Discussant	Matteo Fiorini (OECD)
4:45pm – 5:15pm	OECD Critical raw materials supply chains: mapping, concentrations, policy interventions
Speaker	Przemyslaw Kowalski
Discussant	Rainer Lanz (WTO)
5:15pm – 5:45pm	The Welfare and Cross-Border Spillover Effects of Industrial Subsidies
Speaker	Eddy Bekkers (WTO)
Discussant	Hongyong Zhang (RIETI and IDE-JETRO invited expert)
5:45pm – 6:15pm	Impacts of Geopolitical Risks on the Network Topology of GVCs: Multinationals vs Domestically owned Firm with a CGE model
Speaker	Yuning Gao (Tsinghua Univ and IDE-JETRO invited expert)
Discussant	Eddy Bekkers (WTO)

6:15pm – 6:45pm	Identifying Bottlenecks and Chokepoints in GVCs
Speaker	Robert Stehrer (WIIW)
Discussant	Michael Blanga-Gubbay (WTO)
6:15 pm – 8:00pm	Dinner
Speaker Participants	All

December 13	
9:00am – 11:00am	Session 5; Chair: Ran Wang (UIBE)
9:00am – 9:30am	Economic Opportunities and Risks of AI
Speaker	Paulo Bastos (WB)
Discussant	Neil Foster-McGregor (ADB)
9:30am – 10:00am	LAC and Africa GVC readiness for integration
Speaker	Anthony Cano Moncada (AU)
Discussant	Mattia Cai (OECD)
10:00am – 10:30am	Recent trends in GVC integration using the ADB's MRIOTs
Speaker	Nomundari Baatar (ADB)
Discussant	Mattia Cai (OECD)
10:30am – 11:00am	Global Value Chains, Automation, and the Labor Share'
Speaker	Neil Foster-McGregor (ADB)
Discussant	Enzie Xie (WB)
11:00am – 11:15am	Tea break
Participant	All
11:15am – 13:15am	Session 6; Chair: Stela Rubínová (WTO)
11:15am – 11:45am	Economic consequences of some hypothetical events
Speaker	Meichen Zhang (UIBE and IDE-JETRO invited expert)
Discussant	Satoshi Inomata (IDE-JETRO)
11:45am – 12:15am	Trade Induces Exposure to Extreme Heat at Workplaces in Low-Income Countries
Speaker	Meng Li (Shanghai Jiaotong Univ and IDE-JETRO invited expert)
Discussant	Neil Foster-McGregor ADB
12:15am – 12:45am	Making MNEs' Gains of Factor-Income in Global Value Chains Visible
Speaker	Gabriele Suder (Federation Univ of Australia and IDE-JETRO invited expert)
Discussant	Victor Stolzenburg (WTO)
12:45am – 13:15pm	Industrial policy and the reconfiguration of global value chains
Speaker	Shaopeng Huang (UIBE)
Discussant	Enxhi Tresa (OECD)
13:15pm – 2:00pm	Lunch
Participant	All
2:00pm – 4:15pm	Session 7; Chair: Satoshi Inomata (IDE-JETRO)
2:00 pm – 2:30pm	How Banks Go Abroad: The Impact of Fast Internet on Financial Services Export
Speaker	Stela Rubinova (WTO)
Discussant	UIBE TBD

2:30pm – 3:00pm	Productivity and competitiveness in an era of reconfiguration of Global Value Chains
Speaker	Ariel Luis Wirkierman (University of London and IDE-JETRO invited expert)
Discussant	Roberta Piermartini (WTO)
3:00pm – 3:15pm	Tea break
Participant	All
3:15 pm – 3:45pm	Preference utilization and GVC integration
Speaker	Thomas Verbeet (WTO)
Discussant	Sebastien Miroudot (OECD)
3:45pm – 4:15pm	Trade Effects of Carbon Pricing Policies
Speaker	Antonia Kurz (DIW)
Discussant	Meng Li (Shanghai Jiaotong University and IDE-JETRO invited expert)
4:15pm – 6:15pm	Session 6; Chair: Enxhi Tresa (OECD)
4:15pm – 4:45pm	Mapping re-globalization and shifts in GVCs
Speaker	Victor Stolzenburg (WTO)
Discussant	UIBE (TBD)
4:45pm – 5:15pm	Mini and alternative trade deals and GVCs
Speaker	Maria Donner (WTO) and David Wollenberg (WTO)
Discussant	Robert Koopman (RIGVC and AU)
5:15pm – 5:45pm	Recent developments in GVCs based on OECD ICIOs in previous year's prices and the Analytical AMNE database
Speaker	Mattia Cai (OECD)
Discussant	Angelo Jose Lumba (ADB)
5:45pm – 6:15pm	Visualizing Global Value Chains: Smile Curve, Network, Skyline and Revealed Comparative Advantage
Speaker	Bo Meng (IDE-JETRO)
Discussant	Joseph Mahinthan Mariasingham (ADB)
6:15pm – 6:30pm Closing Remarks (Chair: Robert Koopman, AU/RIGVC)	
	Xiaopeng Yin, Dean, RIGVC, UIBE Satoshi Inomata, Chief Senior Researcher, IDE-JETRO Ralph Ossa, Chief Economist, WTO

Program for
Chapter Authors Workshop
Global Value Chain Development Report 2025

June 19, 2025 | 9:00 AM – 5:00 PM
American University, School of International Service
3801 Nebraska Avenue NW, Washington, D.C. 20016
Room SIS 113

8:30 AM – 9:00 AM | Arrival and Registration
Coffee and light breakfast available in SIS lobby outside of SIS 113

9:00 – 9:15 AM | Welcome and Objectives for the Day
Robert Koopman, American University and Siyan Shen, RIGVC, UIBE

9:15 – 10:00 AM | Chapter 1 – Recent Developments in GVCs
Presenting Authors: Mahinthan J. Mariasingham, ADB (20 min)
Discussant: Hiau Looi Kee, World Bank (remote), and Zhi Wang (7.5 min each)
Open Discussion – 10 minutes

10:00 – 10:45 AM | Chapter 2 – Re-globalization: Opportunities and Risks for Inclusive Value Chains
Presenting Authors: Bob Koopman and Anthony Cano Moncada, American University and Michael Blanga Gubbay, WTO (20 min)
Discussant: Sebastien Mirodout, (remote) OECD (15 min)
Open Discussion – 10 minutes

10:45 – 11:00 AM | Morning Coffee Break

11:00 – 11:45 AM | Chapter 3 – Global Electric Vehicle Value Chains
Presenting Authors: Ran Wang, UIBE, and Bo Meng, IDE-JETRO (20 min)
Discussant: Mark P. Dallas, BEA and Union College, and Shanjun Li, Cornell University (7.5 min each)
Open Discussion – 10 minutes

11:45 – 12:30 PM | Chapter 4 – GVCs and Environmental Policy
Presenting Authors: Bo Meng, IDE-JETRO
Discussant: Alan Fox, USITC, and Simon Black, IMF (7.5 min each)
Open Discussion – 10 minutes

12:30 – 1:30 PM | Lunch (on premises)

1:30 – 2:15 PM | Chapter 5 – Industrial Policy and GVCs
Presenting Authors: Bob Koopman, American University and Shaopeng Huang, UIBE (20 min)
Discussant: Adam Jakubik, IMF, and Daria Taglioni, WB (7.5 min each)
Open Discussion – 10 minutes

2:15 – 3:00 PM | Chapter 6 – Capital Markets and Access to Finance in GVCs
Presenting Authors: Xiang Ding, Georgetown University
Discussant: Monika Sztajerowska, IMF (15 min)
Open Discussion – 10 minutes

3:00 – 3:15 PM | Afternoon Coffee Break

3:15 – 4:00 PM | Chapter 7 – GVCs, Technology, and Productivity
Presenting Authors: Neil Foster-McGregor, ADB, and Wenbo Zhu, UIBE
Discussant: Paolo Bastos, WB,
Open Discussion – 10 minutes

4:00 – 4:45 PM | Chapter 8 – New Policy Tools for GVCs
Presenting Authors: Victor Stolzenburg
Discussant: Kathleen Clausen (remote), Georgetown University, and Oliver Exton, IMF (7.5 min each)
Open Discussion – 10 minutes

4:45 – 5:00 PM | Wrap-up and Next Steps
Closing comments- Bob Koopman, AU and Neil Foster-McGregor, ADB

GLOBAL VALUE CHAIN DEVELOPMENT REPORT 2025

REWIRING GVCs IN A CHANGING GLOBAL ECONOMY

The Global Value Chain Development Report 2025, the fifth in this biennial series, is released at a time when global value chains (GVCs) are being rewired by technological change, the green transition and shifting geopolitical conditions. With the focus of policy-makers and business moving from efficiency gains to resilience, the report examines how production, trade and investment are reconfiguring across regions and what this implies for productivity and inclusive development. It provides an overview of recent trends in GVCs and documents the emergence of new regional hubs and firm networks. Special attention is given to changing patterns of GVC participation in Latin America, the Caribbean and Africa to explore how these regions may grasp the opportunities the ongoing shifts provide. The report also analyzes how digitalization and services are reshaping value creation, and pays particular attention to the reorganization of automobile and electric vehicle supply chains. It concludes by illustrating how these transformations lead to novel governance approaches, including industrial policies and targeted trade deals that address frontier issues such as carbon mitigation, critical minerals supply, and digital trade.

UIBE 1951 ADB IDE-JETRO World Economic Forum WORLD TRADE ORGANIZATION