



GLOBAL VALUE CHAIN DEVELOPMENT REPORT 2023

# RESILIENT AND SUSTAINABLE GVCs IN TURBULENT TIMES





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# RESILIENT AND SUSTAINABLE GVCS IN TURBULENT TIMES



IDE-JETRO





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# Contents

Tables, Figures, and Boxes .....	vi
Foreword .....	xiii
Publishing Partners .....	xv
Contributors .....	xvi
Acknowledgments .....	xviii
Abbreviations .....	xix
Editorial and Advisory Committee .....	xxv
Key Messages and Findings .....	xxvi
Executive Summary .....	xxviii
<b>Chapter 1: Examining Global Value Chains in Times of International Shocks .....</b>	<b>1</b>
<b>1.1 Introduction.....</b>	<b>1</b>
<b>1.2 Global Value Chains During Periods of Shocks .....</b>	<b>3</b>
<b>1.3 Dollar Prices and Global Value Chains .....</b>	<b>12</b>
<b>1.4 Potential Bottleneck Products in International Trade.....</b>	<b>17</b>
<b>1.5 Geographic Concentration in Value and Frequency of Trade .....</b>	<b>21</b>
Concentration in Foreign Value-Added Sources .....	21
Concentration in Frequency of Engagement .....	24
<b>1.6 Adjusting to Shocks.....</b>	<b>28</b>
Prospects for Global Value Chain Reconfiguration .....	30
Localization Policies in the People’s Republic of China .....	39
<b>Conclusion .....</b>	<b>43</b>
<b>References.....</b>	<b>45</b>
<b>Chapter 2: Impacts of Trade Tensions and COVID-19 on Global Value Chains.....</b>	<b>49</b>
<b>2.1 Introduction .....</b>	<b>49</b>
<b>2.2 Sources of shocks and their propagation in Global Value Chains .....</b>	<b>50</b>
Sources of Shocks and Mechanisms of Propagation .....	51
Propagation of Shocks through Tariff Measures in GVCs .....	52
Propagation of Shocks through Non-Tariff Measures in GVCs .....	54
<b>2.3 Patterns of Restructuring and Regionalization of Global Trade... </b>	<b>56</b>
Global Trade Picture .....	56
Trade Diversion .....	57
Reshoring and Regionalization.....	59
<b>2.4 Trade Tensions and Global Value Chains.....</b>	<b>62</b>
Trade Among the Major Economies .....	62

Triangular Trade between the PRC, the US and Third Countries.....	64
<b>2.5. COVID-19, GVCs and Digitalization .....</b>	<b>67</b>
The Impact of COVID-19 on Reshaping Global Value Chains.....	67
Counterfactual Analysis of the Impact of the COVID-19 Pandemic on GVCs .....	67
Digitalization, Resilience and Recovery .....	72
<b>Conclusion .....</b>	<b>76</b>
<b>Appendix .....</b>	<b>78</b>
1: Changes in the Average Global Value Chain Production Length as a Result of the US–PRC Trade Tension.....	78
2: Top Five Trading Partners of the World’s Main Economies .....	79
3: Gross Trade between the US and ASEAN Countries .....	80
4: CGE Model Construction and Scenario Setting .....	81
5: The Impact of Digital Policy on Global Value Chains .....	84
<b>References.....</b>	<b>85</b>

### **Chapter 3: Toward a Secure and Resilient Energy Supply Chain ..... 90**

<b>3.1 The Impact of Rising Geopolitical Tensions on the Rules Underpinning the Multilateral Trading System.....</b>	<b>91</b>
Why are GVCs, Including Energy Value Chains, Vulnerable to an Erosion of WTO Norms through Goeconomics? .....	91
How Geopolitical Crises are Eroding the Legal Fabric of the MTS and of Global Value Chains: The Effects of the Russian War in Ukraine on Energy Supply Chains .....	93
“Trade Weaponization” and Trade Sanctions are Escalating .....	94
Possible Legal Responses to Protect the MTS and Global Value Chains Against Goeconomics.....	95
<b>3.2 New Dynamics of Global Energy Supply Chains .....</b>	<b>99</b>
The COVID-19 Shock to Energy Supply Chains .....	99
The US-PRC Trade Tensions and Its Impact on Energy Supply Chains .....	100
Geopolitical Tensions and Their Impact on Energy Supply Chains: Energy Geopolitics .....	101
The Energy Crisis and Energy Security .....	102
<b>3.3 Geopolitical Changes and New Evolution of Energy Supply Chains .....</b>	<b>104</b>
Historical Evolution of Energy Domination and Energy Geopolitics.....	104
The Dynamic Evolution Global Energy Supply Chains.....	106

CGE Simulation Analysis for the Impact of the Energy Supply Chains Re-Shaping .....	113
<b>3.4 Renewable Energy and the Future Directions of Energy Supply Chains and Energy Trade.....</b>	<b>118</b>
Carbon Neutrality, Energy Transition, and Renewable Energy Development .....	118
Renewable energy supply chains and the new world energy market and trade .....	119
Challenges facing to renewable energy supply chains .....	120
<b>3.5 Potential Impact of the Energy Dynamics on the Emission Goals .....</b>	<b>122</b>
<b>Conclusions.....</b>	<b>125</b>
<b>References.....</b>	<b>127</b>

#### **Chapter 4: From Fabless to Fabs Everywhere? Semiconductor Global Value Chains in Transition..... 132**

<b>4.1 Introduction.....</b>	<b>132</b>
<b>4.2 Semiconductor Global Value Chains: Segments and Value Added Structure .....</b>	<b>136</b>
<b>4.3 Semiconductor Global Value Chains: Major Economy Participants .....</b>	<b>141</b>
<b>4.4 Changing Fortunes in the Global Semiconductor Industry: From Integrated Fabs to the “Fabless Revolution” .....</b>	<b>145</b>
The Rise of the Fabless Firms.....	148
The Rise of the Dedicated Foundry.....	151
Overall Specialization in the Semiconductor Market.....	153
<b>4.5 The Role of the Government in the Development of the Semiconductor Industry .....</b>	<b>155</b>
Support in Advanced Economies for Semiconductor Production .....	155
Rise of the East Asian Tigers .....	156
<b>4.6 The Rise of East Asia in Semiconductor Global Value Chains.....</b>	<b>164</b>
<b>4.7 Techno-Nationalism: Must Real States Have Fabs? .....</b>	<b>170</b>
<b>Conclusions.....</b>	<b>178</b>
<b>References.....</b>	<b>183</b>

#### **Chapter 5: Tracing Carbon Dioxide Emissions along Global Value Chains..... 188**

<b>5.1 Historical CO<sub>2</sub> Emissions and Climate Change Challenges .....</b>	<b>189</b>
<b>5.2 Visible Impacts of Climate Change .....</b>	<b>190</b>
<b>5.3 Historical CO<sub>2</sub> Emissions and Challenges Towards the Achievement of Carbon Neutrality .....</b>	<b>190</b>

5.4	CO <sub>2</sub> Emissions and Their Responsibilities along Global Value Chains .....	194
5.5	Tracing CO <sub>2</sub> Emissions in Global Value Chains.....	194
5.6	Production- vs Consumption-Based Emissions and Emissions Transfers along GVCs .....	196
5.7	Sharing CO <sub>2</sub> Emissions Responsibilities Across Economies along Global Value Chains .....	198
5.8	Tracing CO <sub>2</sub> Emissions of Multinational Enterprises in Global Value Chains.....	201
5.9	Measuring the CO <sub>2</sub> Emissions of MNEs in GVCs .....	201
5.10	Changing Trends in MNEs' CO <sub>2</sub> Emissions.....	203
5.11	Decomposing MNEs' CO <sub>2</sub> Emissions by Trade Patterns .....	205
5.12	Measuring the Carbon Footprints of MNEs in GVCs .....	208
5.13	Component Structure of MNEs' Carbon Footprints, A Producer Perspective.....	210
5.14	Component Structure of MNEs' Carbon Footprints, A Consumer Perspective.....	210
5.15	Re-evaluating the Carbon Mitigation Responsibilities of MNEs in Global Value Chains: From a Factor Income Perspective .....	212
5.16	Environmental Costs and Economic Benefits of MNEs .....	213
5.17	Possible Incentive Fund Led by MNEs.....	219
	Conclusion and discussion .....	220
	References.....	224

## Chapter 6: Greening Global Value Chains: A Conceptual Framework for Policy Action.....228

6.1	Introduction.....	228
6.2	The Driving Factors of Global Value Chain Greening .....	231
6.3	Types of Environmental Innovation .....	240
6.4	Actors Involved in Environmental Innovation.....	243
6.5	The Enabling Mechanisms of Environmental Innovation.....	245
6.6	The Outcomes of Global Value Chain Greening .....	247
6.7	A Three-Pronged Strategy for GVC Greening .....	249
	Conclusion .....	253
	References.....	256

## Chapter 7: Global Value Chains for Inclusive Development .....261

7.1	Introduction.....	261
7.2	GVCs can Improve the Performance of MSMEs in Developing Economies.....	263
	The Context: MSMEs' Role in Developing Economies and Trends in their GVC Participation .....	264



GVCs Facilitate Access to International Markets .....266

GVCs Facilitate the Transfer of Good Management Practices .....267

GVCs Facilitate Quality Upgrading.....269

GVCs Facilitate Technology Transfers and Innovation.....272

GVCs Facilitate Access to Trade Finance for MSMEs .....273

**7.3 GVCs Can Help Workers in Developing Economies.....275**

GVCs Can Support a Shift to Formal Employment .....276

GVCs Can Improve Job Quality .....278

GVCs Tend to Widen Wage Inequality.....280

GVCs Can Support Gender Equality .....283

GVCs Can Reduce the Incidence of Child Labour .....288

**7.4 The Future of Inclusive GVCs .....289**

Digital Platforms and GVCs .....290

Automation and Outsourcing.....291

AI and Services GVC .....292

**7.5 Main Messages and Lessons for Policymakers.....293**

**Conclusion .....297**

**References.....299**

**Appendix**

**Background Paper and Chapter Authors' Workshop for the Global Value Chain Development Report 2023 .....313**

## Tables, Figures, and Boxes

### TABLES

1.1	Criteria for Classifying Product Categories as Potential Bottlenecks .....	19
1.2	Top Exporters of Potential Bottleneck Products, 2000–2021.....	21
1.3	Domestic Value-Added in Processing Exports v Normal Exports, People’s Republic of China; 2007, 2012, 2017 (%).....	42
A1	Scenarios in the CGE Modeling.....	81
A2	Projected Impacts of Digital Input and Technological Improvements on GVC Activities in 2025.....	84
3.1	Change in Oil Trade Flows Under the Combined Scenario (% Changes Relative to the Baseline) .....	117
4.1	Domestic/Regional Value Added in the Semiconductor Value Chain by Activity, 2021 (in percent).....	143
4.2	Changing Fortunes in the Global Semiconductor Industry: Key Trends and Drivers, 1959–2022.....	147
4.3	World’s Top Semiconductor Lead Firms by Type, Revenue, and Share, 2000–2020 (in US\$ billions and Percent of Semiconductor Market) .....	150
4.4	Evolving Domestic and Institutional Contexts of Industry Development in Selected East Asian Economies, 1980–2022 .....	159
4.5	Geography of World Semiconductor Manufacturing by Fab Location, Product Applications, and Capacity, 2000–2018 (foreign owned in parentheses).....	168
4.6	World’s Top Semiconductor Manufacturers by Fab Capacity, Main Applications, Fab Locations, and Markets, 2010 and 2018 .....	169
5.1	Sharing Emission Responsibilities along GVCs.....	200
5.2	Net Carbon Transfer and Incentive Fund of Advanced Economies to Emerging Markets and Developing Economies in Selected Industries through MNEs (2016).....	220
6.2	Biophysical Outcomes of Global Value Chain greening.....	248
6.3	A Three-Pronged Strategy for GVC greening.....	250

### FIGURES

1.1	Decomposition of World Exports, 2007–2022 .....	4
1.2	Backward and Forward Global Value Chain Participation Rates, World, 1995–2022.....	5
1.3	Global Value Chain Participation of Economies, 2007–2010 and 2018–2022 .....	7
1.4	Global Value Chain Production Lengths by Sector, World, 2007–2010 and 2018–2022.....	8
1.5	Global Inflation Rates, 2000–2022 (%).....	12
1.6	Differences in Backward and Forward Global Value Chain Participation Rates, Nominal vs Real, 2007–2022 .....	14

1.7	Discrepancy, Variability, and Divergence of Real and Nominal Global Value Chain Participation .....	15
1.8	Export Value and Share of Potential Bottlenecks in the World, 2000–2021 .....	20
1.9	Backward Dependence on Value-Added, Top 20 Economies and Rest of the World (\$ million) .....	23
1.10	Trade in a Directed and Unweighted Network .....	25
1.11	Pass-Through Indices, Top 20 Economies and Rest of the World .....	29
1.12	Herfindahl-Hirschman Indexes of Economies, 2007–2010 and 2018–2022 .....	32
1.13	Agglomeration Classes of Economies, 2007–2010 and 2018–2022 .....	36
1.14	Backward and Forward Agglomeration of Selected Economies, 2019, 2020, 2021 .....	38
2.1	The Change of the Average Cumulative Input Tariffs .....	53
2.2	The Trend of Global Tariff and NTMs .....	55
2.3	Trade Facilitating and Restricting NTMs during COVID-19 .....	55
2.4	Global Export of Merchandise and Service .....	56
2.5	Global Trade of Intermediate and Final Products in 2021 .....	57
2.6	Change in Gross Exports in 2017–2019 and 2019–2022 .....	58
2.7	The Domestic Value-Added Share in the Total Export .....	60
2.8	Changes in Developing Asian Economies' Value-Added Trade in Intermediate Goods .....	60
2.9	Changes in Sectoral Production Length of the PRC and the USA .....	61
2.10	Top Three Trade Partners in Merchandise of the US .....	62
2.11	PRC-US Trade in High-Tech Products .....	63
2.12	US Export to PRC Subject to US's Government Export Control .....	64
2.13	Indirect Import of Intermediate Inputs from the PRC to the US through Third Regions .....	65
2.14	The Ratio of Indirect Intermediate Import of the US from the PRC through ASEAN and USMCA Countries .....	66
2.15	The Share of Total, Simple and Complex GVC Activities .....	68
2.16	Changes in Value-Added Activities in 2020 (%) .....	71
2.17	Growth rates of GVC items in the PRC, the US, Mexico, and India .....	72
2.18	Counterfactual Outputs of ICT and non-ICT Industries During the COVID-19 .....	74
2.19	Potential GDP Changes (%) and Digital Infrastructure .....	75
2.20	Changes in the Average Global Value Chain Production Length as a Result of the US–PRC Trade Tension (%) .....	78
2.21	ASEAN Exports to the US as a Share of Total Exports (2017–2021) .....	80
2.22	Intermediate Imports from the PRC as a Proportion of ASEAN Total Intermediate Imports by Country (2017–2021) .....	80
2.23	The GVCGE Framework .....	82
2.24	The Effects of Policy Shocks on Economic Variables .....	83
3.1	Changes of Global CPI Due to Energy Shock .....	103

3.2	Historical Evolution of Energy Domination and Energy Geopolitics .....	105
3.3	The Dynamic Evolution of Energy Supply Chains and Geopolitics .....	107
3.4	Change in US LNG Exports .....	108
3.5	Change in US Gas Exports .....	109
3.6	The Diamond Energy Supply Chain in Asia-Pacific .....	109
3.7	Change in Russian Oil Exports.....	110
3.8	The West and East Pipeline of Russia to Asia .....	111
3.9	Real GDP Impact of Energy Supply Chain Restructuring (% Changes Relative to the Baseline).....	115
3.10	Changes in Gas Trade Flows Under EU-US Energy Supply Chains Scenarios (% Changes Relative to the Baseline) .....	116
3.11	Changes in Gas Trade Flows Under Eurasian Energy Supply Chains Scenarios (% Changes Relative to the Baseline) .....	116
3.12	Change in Primary Energy in the Future.....	124
3.13	CO <sub>2</sub> Emissions from Combusted Fuels in the Future.....	125
4.1	The Basic Structure of Semiconductor Value Chains.....	137
4.2	Semiconductor Value Added by Activity, 2019 (in percent) .....	142
4.3	Semiconductor Global Value Chains and the Production Networks of ICT End Products .....	142
4.4	Breakdown of the Global Wafer Fabrication Capacity by Region, 2019 (in percent).....	144
4.5	Price to Book Ratios of Leading American Semiconductor Firms, 2013-2022 .....	149
5.1	Visualization of Climate Change Impacts .....	191
5.2	Major Economies' Historical CO <sub>2</sub> Emissions from 1830 to 2021 and their Targeting Years for Carbon Neutrality .....	191
5.3	Smile Curve of Value-Added vs Crying Curve of CO <sub>2</sub> Emissions along GVCs .....	193
5.4	GVC-Based Accounting Framework for Tracing Emissions.....	195
5.5	Developed and Developing Economies' CO <sub>2</sub> Emissions along GVCs.....	197
5.6	Changing Trends and Decompositions of MNEs' CO <sub>2</sub> Emissions (2005-2016) .....	203
5.7	Changing Trends and Decompositions of MNEs' CO <sub>2</sub> Emissions in Selected Countries.....	205
5.8	Decomposition of MNEs' Export-Embodied Emissions (2005-2016).....	206
5.9	CO <sub>2</sub> Emissions of MNEs in the Textile Sector of Top 10 Economies (2016) .	207
5.10	Decomposition of Third-Country-Induced Emissions of MNEs in the Textile Sector of Selected Economies (2016) .....	208
5.11	Component Structure of MNEs' Carbon Footprints, a Producer's Perspective (2016) .....	211
5.12	Component Structure of MNEs' Carbon Footprints in Selected Economies, A Consumer's Perspective (2016).....	211

5.13	CO <sub>2</sub> Emissions Measured by PBA and FIBA between 2005 and 2016 (Mt) ...	214
5.14	Value-Added Calculated by PBA and FIBA between 2005 and 2016 (Billion USD).....	215
5.15	PBA and FIBA MNEs' CO <sub>2</sub> Emissions and Value-Added of Selected Economies (2005 and 2016).....	216
5.16	PBA and FIBA MNEs' CO <sub>2</sub> Emissions and Value-Added of the Basic Metals Sector in Selected Economies (2016) .....	218
5.17	Cumulative Net Carbon Transfer and Incentive Fund of Advanced Economies to Emerging Markets and Developing Economies through MNEs (2005-2016) .....	219
6.1	Overview of Greenhouse Gas Emissions Across the Value Chain.....	230
6.2	Sri Lanka's Performance in Textile and Clothing Manufacturing, 1990–2021.....	234
6.3	The Plan A Model Eco-Factories.....	235
6.4	A Purse Seine Net .....	238
6.5	Leather Production in an Arzignano Tannery.....	241
7.1	Share of Employment by Firm Size in Developing Economies (%) .....	265
7.2	Growth in the Share of Firms Participating in GVC in the Recent Decades (2006–2022).....	266
7.3	Quality of Management Practices and GVC Participation .....	268
7.4	Management Quality and Language Similarities between Host and HQ Country.....	270
7.5	Trade Finance Rejections .....	273
7.6	GVC Participation and Formal Share of Employment.....	277
7.7	Gender Wage Gap and GVC Participation.....	286

## BOXES

1.1	Characterizing Economies Based on Differences in Current and Constant Price Estimates.....	16
1.2	Deriving the Number of Times a Supply Chain Passes Through a Sector .....	27
1.3	Calculating the Value-Added Agglomeration Index .....	35
1.4	Standard and Extended Input-Output Models .....	41
2.1	Changes in Global Trade Patterns – The Rise of Electric Vehicles and the Auto Industry .....	67
2.2	GVC activities with FDI heterogeneity.....	69
4.1	ASML and the Dominant Supplier of Semiconductor Lithography Equipment .....	140
4.2	Intel and the American Dominance in Integrated Device Manufacturing .....	146
4.3	Qualcomm and the “Double Revolution” of Fabless and Smartphones in the US.....	154
4.4	Singapore's Chartered Semiconductor Manufacturing and Failed State-Led Catching Up .....	160

4.5	Republic of Korea's Samsung as a Successful Product of the Developmental State? .....	162
4.6	HSMC and the Problems of Industrial Policy Implementation.....	164
4.7	TSMC and Technological Innovation in Chinese Taipei.....	166
4.8	The Impacts of US Sanctions on Huawei .....	177
5.1	Accounting for CO <sub>2</sub> Emissions of MNEs in Global Value Chains .....	202
5.2	Sectoral Level Analysis: Textile Industry .....	207
5.3	Accounting for Carbon Footprints of MNEs in Global Value Chains.....	209
5.4	The Concept of Trade in Factor Income and its Relationship with Gross Trade Volume and Trade in Value-Added (using US exports to PRC as an example).....	213
6.1	The (Un)Willingness to Pay for Green: Textile Suppliers in Sri Lanka.....	234
6.2	The "Tuna-Dolphin Problem" and the Drivers of Global Value Chain Greening .....	238
6.3	Environmental Innovation in Industrial Clusters—The Arzignano Tannery District .....	241
6.4	Valcucine A Mentoring-Driven Approach to Product Innovation.....	242
6.5	When private actors and government come together: The Hawassa Industrial Park.....	244
7.1	The Importance of Language Skills for Knowledge Diffusion.....	270
7.2	GVCs and Returns to Education .....	287

## Foreword

The *Global Value Chain Development Report 2023: Resilient and Sustainable GVCs in Turbulent Times*, the fourth in this biennial series, is released at a critical juncture in the evolution of Global Value Chains (GVCs). It first provides an update on trends in GVCs highlighting that international production networks remain a central part of globalization despite mounting pressures. The report then turns to its main theme which is informed by the fact that the intricate networks of international flows of goods, services, capital, and technology are currently facing exceptional challenges arising from geopolitical complexities and the impacts of climate change in the Post-COVID era.

Recent pandemic-related disruptions have revealed long-standing vulnerabilities in GVCs, especially those associated with over-concentration and over-dependence on a single economy or region for the supply of critical products — a circumstance exacerbated by recent geopolitical tensions. However, the current structure of GVCs is complex and has led to significant benefits for firms and consumers globally. It minimizes costs and maximizes scale economies since it allows economies to specialize in finely defined tasks, hyper-exploiting the concept of comparative advantage.

This makes reconfigurations costly and challenging. Importantly, it also leads to significant interdependencies that limit the scope for the weaponization of trade. For example, the global semiconductor value chain is a highly efficient and innovative network resulting from the delicate division of labor and specialization, where no single economy can competitively maintain a complete semiconductor supply chain on its own. Hence, self-sufficiency, de-coupling and de-globalization are far from being viable options for enhancing the resilience of semiconductor GVCs in the long term.

In parallel, the urgency of making GVCs greener has increased sharply with accelerating climate change. At present, more than 130 economies and regions have announced their carbon neutrality targets. A global consensus has emerged on the need to address climate change and promote green development. This trend has a great impact on the direction and pattern of GVCs through both institutional and technological innovation and collaboration. The report provides a comprehensive carbon emission accounting framework that allows tracing emissions through GVCs before proposing a conceptual framework that can help business and policymakers in their efforts to green GVCs.

Resilience and sustainability cannot be achieved without inclusiveness. Since the impacts of shocks tend to be unevenly distributed within economies, it is important that all parts of society are able to recover quickly for the economy as

a whole to be resilient. Integrating into GVCs leads to substantial benefits for workers and firms in developing economies, but the gains from integration are not always fairly distributed. To ensure that GVCs support inclusive development, barriers to integration must continue to be lowered and measures must be put in place that prevent firms from exploiting their market power at the expense of small suppliers.

The *GVC Development Report 2023* examines all these developments and highlights how GVCs are critical factors in the megatrends shaping today's global economy. It is a joint effort of four institutions: the Research Institute for Global Value Chains at the University of International Business and Economics, the Asian Development Bank, the Institute of Developing Economies - Japan External Trade Organization, and the World Trade Organization. As the Asian Development Bank did in the previous report, the Research Institute for Global Value Chains at the University of International Business and Economics has taken the lead this time. The report benefits from extensive collaboration among GVC researchers worldwide. Over 60 authors from more than 30 research institutions in 20 economies contributed 37 background papers that form the basis for this report. We look forward to expanding this research joint venture by including more partner institutions in the future.

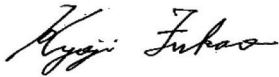
We hope that the *Global Value Chain Development Report 2023* will contribute to a deeper understanding of the recent development of GVCs and help build consensus to maintain an open, sustainable, and resilient global trading system in the service of human well-being.



**Zhongxiu Zhao**  
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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 committed to achieving a prosperous, inclusive, resilient, and sustainable Asia and the Pacific, while sustaining its efforts to eradicate extreme poverty. Established in 1966, it is owned by 68 members—49 from the region. Its main instruments for helping its developing member countries are policy dialogue, loans, equity investments, guarantees, grants, and technical assistance.

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 does research on the economics, politics, and societies of developing countries and regions. Through its research, IDE-JETRO contributes to knowledge and a better understanding of developing economies.

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

4IR	fourth industrial revolution
ADB	Asian Development Bank
ADB I	Asian Development Bank Institute
AE	advanced economies
AI	artificial intelligence
AIDCP	Agreement on the International Dolphin Conservation Program
AIRS	atmospheric infrared sounder
AMD	Advanced Micro Devices
AMNE	activities of multinational enterprises
APT	assembly, packaging and testing
ASEAN	Association of Southeast Asian Nations
ASMI	Advanced Semiconductor Materials International
ASML	Advanced Semiconductor Material Lithography
BCG	Boston Consulting Group
BDA	big data analytics
BPO	business process outsourcing
BRIC	Brazil, Russia, India and China
CBAM	carbon border adjustment mechanism
CBDR	common but differentiated responsibilities
CCL	Controlled Commodity List
CEIC	China Economic Information Center
CEO	chief executive officer
CER	central east region
CF	carbon footprint
CGE	computable general equilibrium
CIS	Commonwealth of Independent States
CO <sub>2</sub>	carbon dioxide
COP	conference of the parties
COVID-19	corona virus disease 2019
CPA	Center For Preventive Action
CPI	consumer price index
CPU	central processing unit
CSM	Chartered Semiconductor Manufacturing
CSO	civil society organization
CSR	corporate social responsibility
DAO	discrete, analog, and optoelectronics
DARPA	Defense Advanced Research Projects Agency

DDRs	due diligence requirements
DML	dolphin mortality limit
DOE	domestically owned enterprise
DRAM	dynamic random access memory
DS	dispute settlement
DSB	dispute settlement body
DSU	dispute settlement understanding
DVA	domestic value added
DVAR	domestic value-added ratio
EAR	Export Administration Regulations
ECRA	Export Control Reform Act
ECT	Energy Charter Treaty
EDA	electronic design automation
EEBT	emissions embodied in bilateral trade
EEC	European Economic Community
EIA	Energy Information Administration
EMDEs	emerging markets and developing economies
EoS	elasticity of substitution
EPR	extended producer responsibility
ERSO	Electronics Research and Service Organization
ESPRIT	European Strategic Programme for Research and Development in Information Technology
ETP	eastern tropical Pacific
ETRI	Electronics and Telecommunications Research Institute
ETS	carbon emissions trading system
EU	European Union
EU-ETS	European Union Emission Trading Scheme
EUV	extreme ultraviolet
EVs	electric vehicles
FDI	foreign direct investment
FIBA	factor income-based accounting
FIE	foreign affiliate
FSC	Forest Stewardship Council
FVA	foreign value added
G7	Group of Seven
GaAs	gallium arsenide
GATS	General Agreement on Trade in Services
GATT	General Agreement on Tariffs and Trade
GCF	Green Climate Fund
GDP	gross domestic product

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GFC	global financial crisis
GHG	greenhouse gas
GISS	Goddard Institute for Space Studies
GISTEMP	GISS surface temperature analysis
GPS	global positioning system
GRS	global recycle standard
GSCM	green supply chain management
Gt	gigaton
GTAP	global trade analysis project
GVCs	global value chains
GW	gigawatt
HHI	Hirschmann-Herfindahl index
HR	human resources
HS	Harmonized System
IBM	International Business Machines Corporation
IC	integrated circuits
ICT	information and communications technology
IDE-JETRO	Institute of Developing Economies – Japan External Trade Organization
IDM	integrated device manufacturing
IEA	International Energy Agency
IFC	international finance centre
IFS	Intel Foundry Services
ILO	International Labour Organization
IMF	International Monetary Fund
IMO	International Maritime Organization
IO	input–output
IoT	internet of things
IP	intellectual property
IPCC	Intergovernmental Panel on Climate Change
IPDC	Industrial Parks Development Corporation
IRP	International Review Panel
ISCO	International Standard Classification of Occupations
ISO	International Standards Organization
IT	information technology
ITC	investment tax credit
ITRI	Industrial Technology Research Institute
LCA	life cycle assessment
LCR	local content requirement
LEED	Leadership in Energy and Environmental Design

LNG	liquefied natural gas
LSI	large scale integration circuit
M&S	Marks & Spencer
MIMIC	microwave and millimeter wave integrated circuit
MMPA	Marine Mammal Protection Act
MNC	multinational corporation
MNEs	multinational enterprises
MRIO	multiregional input–output
MRIOTs	multiregional input-output tables
MSMEs	micro, small, and medium-sized enterprises
MTS	multilateral trading system
NAFTA	North American Free Trade Agreement
NASA	National Aeronautics and Space Administration
NBER	National Bureau of Economic Research
NDC	nationally determined contribution
NEUVLP	National Extreme Ultraviolet Lithography Program
NGOs	non-governmental organizations
nm	nanometer
NOAA	National Oceanic and Atmospheric Administration
NT	no-trade
NTMs	non-tariff measures
NTPs	non-trade provisions
OECD	Organisation for Economic Co-operation and Development
OEM	original equipment manufacturer
OPEC	Organization of the Petroleum Exporting Countries
PBA	production-based accounting
PC	personal computer
PDC	pure double counting
PEFC	Programme for the Endorsement of Forest Certification
PET	polyethylene terephthalate
PPI	producer price index
PRC	People’s Republic of China
PTA	preferential trade agreement
PV	photovoltaic
PVH	Phillips-Van-Heusen
R&D	research and development
RBC	responsible business conduct
RBI	Reserve Bank of India
RCA	Radio Corporation of America
REACH	Registration, Evaluation, Authorization and Restriction of Chemicals



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REDII	Renewable Energy Development Directive
RFID	radio frequency identification technology
ROW	rest of the world
RRF	Recovery and Resilience Facility
RTA	regional trade agreement
RVCs	regional value chains
SAC	Sustainable Apparel Coalition
SCEnAT	supply chain environmental analysis tool
SDG	sustainable development goals
SEMATECH	semiconductor manufacturing technology
SGS	Société Générale de Surveillance
SIA	Semiconductor Industry Association
SME	semiconductor manufacturing equipment
SMEs	small and medium enterprises
SMIC	Semiconductor Manufacturing International Corporation
SPS	sanitary and phytosanitary
SVS	scientific visualization studio
TBTs	technical barriers to trade
TiFI	trade in factor income
TIVA	trade in value added
TREND	TRadeand ENvironment Database
TRIPS	Agreement on Trade-Related Aspects of Intellectual Property Rights
TV	television
UIBE	University of International Business and Economics
UK	United Kingdom of Great Britain and Northern Ireland
UMC	United Microelectronics Company
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNFCCC	United Nations Framework Convention on Climate Change
UPS	United Parcel Service
US	United States
US DoJ	US Department of Justice
US FTC	US Federal Trade Commission
USA	United States of America
USD	United States dollar
USPTO	United States Patent and Trademark Office
VLSI	very large scale integration circuit
WBCSD	World Business Council for Sustainable Development
WBES	World Bank Enterprise Survey
WHO	World Health Organization

WMS	World Management Survey
WRAP	Worldwide Responsible Accredited Production
WRI	World Resources Institute
WTO	World Trade Organization

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## Key Messages and Findings

### I. Benefits of GVCs

- GVCs foster positive outcomes for firms in developing economies by improving productivity and alleviating information and finance constraints; workers benefit from higher wages and better working conditions.
- When GVC integration fails to deliver expected benefits, it is often due to underlying market failures such as labour market frictions, market power by large firms, and structural disparities.
- Policies for inclusive development should focus on facilitating entry into GVCs and increasing spillovers to the domestic economy. Current efforts are too often limited to improving inclusiveness exclusively within GVCs.

### II. Vulnerability

- The export value and share of potential bottleneck products had been increasing since 2000, contributing to the vulnerability of GVCs. Also, there was considerable concentration in sources of foreign value added.
- Trade in services was particularly affected by the pandemic and merchandise trade was negatively impacted by the rising trade tensions.
- The trade tensions and the COVID-19 pandemic highlighted the need to improve economies' resilience and mitigate dependence on a limited number of suppliers.
- Digitalization was a key tool for resilience and recovery during the pandemic and facilitated access to labor supply for certain industries, especially the services sector.
- GVC-related trade increased in 2021 and 2022, occurring alongside considerable growth in exports. A general shortening of GVCs is also observed during these years relative to the overlapping periods of PRC-US trade tensions and the COVID-19 pandemic.

### III. Potential for deglobalization

- The PRC-U.S. trade tensions and the ongoing Russian war in Ukraine are having huge impacts on global energy supply chains, making geopolitical concerns the dominant factor in the policies governing energy trade.

- The escalating trade weaponization and trade sanctions will lead to segmented regional energy supply chains, such as the EU-US energy supply chain and the Eurasia energy supply chain.
- Renewable energies are expected to play a pivotal role in reshaping the energy global supply chains and even the political landscape.
- Semiconductor GVCs are highly complex and well integrated across the world with many locations involved, such that no single economy can fully control or monopolize them.
- The US remains the dominant player in most key segments of these semiconductor GVCs, in particular chip design through American “fabless” firms.
- Current trade-distorting industrial policies pursued by many governments attempting to “reshore” and/or “shore up” domestic semiconductor manufacturing are unlikely to be effective.

#### **IV. Greening of GVCs**

- Since 2001, developing economies’ CO<sub>2</sub> emissions from purely domestic value chains have doubled. To reduce these emissions, they need more effective policy tools. Greening their domestic production can also green their exports in GVC.
- To a certain extent, GVCs are more carbon-intensive than domestic activities, as they require multiple stages of production and transportation across borders. It is important to introduce carbon pricing along GVCs to substantially raise the cost of emissions globally in the Paris Agreement era.
- Current emission reduction targets do not explicitly define the different roles and responsibilities of GVC actors. MNEs generally capture more value added of GVCs and should play more active roles to fight climate change.
- Institutional drivers such as national environmental regulations still play the leading role in GVC greening. Market and technological drivers tend to be driven by institutional drivers.
- If lead firms do not provide their suppliers with enough financial, managerial, and knowledge resources for implementing green strategies, smaller firms risk being left out of the chain.
- Accounting, monitoring, disclosing the environmental outcomes, and multilateral efforts to orchestrate and harmonize private and national initiatives are crucially important.

## Executive Summary

The main theme of the *2023 Global Value Chain Development Report* is the resilience and sustainability of value chains in response to the diverse shocks of recent years. It provides an overview of the most recent trends in GVCs (chapter 1), in particular the effects of trade tensions and the COVID-19 pandemic (chapter 2), as well as geopolitical tensions on GVCs. It illustrates some of the effects by providing case studies on energy supply chains (chapter 3) and semiconductor value chains (chapter 4). The report then turns to challenges brought about by the climate crisis. It first shows results of different methods tracing CO<sub>2</sub> emissions through GVCs (chapter 5) and then offers a framework to help greening GVCs (chapter 6). The report concludes with emphasizing the immense potential of GVCs for supporting inclusive development (chapter 7).

### Examining GVCs in Times of Global Shocks

Chapter 1 provides an overview of recent developments in GVCs from the perspective of recent major global shocks to international trade. Recent data showed some potential for recovery, with gross exports and GVC participation increasing from 2020—an observation that holds true in both nominal and real terms. However, the presence of ongoing global shocks – including the Russian war in Ukraine, lingering economic effects of the COVID-19 pandemic, and trade tensions between the United States and the People’s Republic of China (PRC) – may threaten to derail this trajectory, thereby promoting the need to assess potential sources of the vulnerability that GVCs have towards shocks.

One such contributor is the trade in potential bottleneck products, which are characterized as having a limited number of suppliers, few substitutes, yet constituting a considerable share of international trade. A total of 1,075 (out of 5,384) analyzed products were identified as potential bottlenecks in 2021, which had an increasing share in total export value throughout the years. Another potential source of vulnerability is geographic concentration in value and frequency of trade. Considerable concentration in sources of foreign value added (FVA) in exports is seen even before the Global Financial Crisis (GFC) hit, though this persisted even beyond the shock and well into the post-pandemic onset world. From a frequency perspective, around 80 percent of all pass-throughs in supply chains were accounted for by only a handful of economies. Though this share decreased in 2020, which may be due to the restrictions imposed on trade and mobility, the change was only marginal and considerable concentration is still observed. The economies belonging atop the rankings in FVA sources were not necessarily the same ones that recorded the most pass-throughs, and vice versa.

The calls for GVC resilience were examined through an analysis of reshoring measures and other trajectories for GVC reconfiguration. Emphasis was placed on diversification of intermediate inputs as a potential risk mitigation strategy. There is still much room to diversify away from domestic sources of input, suggesting that there is already substantial home bias across economies, regions, and sectors. Looking at the case of the PRC, which recently enforced measures to encourage furthering the domestic content of its products, mixed results are seen across different types of exports, trade destinations, and sectors. Ambiguity surrounding the impact of such policies warrants further statistical analysis to unveil the facilitating factors as well as barriers for realizing the goal of localization. To complement this analysis, looking at MNEs' participation in GVCs through the lens of trade in factor income (TiFI) is suggested for future research. Several studies including Gao et al (2023) found that dissimilarities exist in the activities of domestic owned versus foreign owned firms along global supply chains. For example, regional characteristics of current GVCs were discovered to be mostly attributable to domestic owned firms in each economy and that these enterprises were mostly involved in the three regional centers of North America (centered on the US), Europe (centered on Germany), and East Asia (centered on PRC), serving as the driving force for the regionalization of current supply chains. On the other hand, the value-added creation of foreign-owned MNEs typically exhibited more global characteristics.

The calls for GVC resilience were also examined through an analysis of reshoring activities. Emphasis is placed on reshoring from the perspective of domestic agglomeration. Backward and forward agglomeration indices have been on the downtrend from 2019 to 2021 in many economies, providing little evidence of reshoring activities in this period. The United States, however, showed some signs of reshoring for some of its sectors that registered increases in their backward agglomeration indices.

## Effect of Trade Tensions and the Pandemic on GVCs

Chapter 2 primarily focuses on the effects of trade tensions and the COVID-19 pandemic on GVCs, as well as the effects of digital technology on the recovery and trend toward reshoring. This chapter shows that both trade tensions and the pandemic have led to substantial changes in GVCs as they led to higher tariffs and non-tariff measures (NTMs). NTMs and tariffs can accumulate along GVCs as intermediate goods cross border several times, leading to higher costs for downstream producers. Global trade tensions have led to significantly higher trade costs since 2018 and pose a threat to the development of GVCs. Similarly, the shocks to GVCs caused by the COVID-19 pandemic has brought significant disruption to the global economy.

The trade tensions increased the tariff burden of global production, especially for downstream producers. The tariffs of some intermediate inputs imported by the PRC jumped 47%, due to the PRC's retaliatory measures and cumulative effect along GVCs. The US and the PRC incurred an additional indirect tariff burden of 10 and 6.5 billion dollars, respectively, while third-party countries incurred additional indirect tariff burden of 30%–70%. Interestingly, indirect tariffs in most sectors in the PRC increased by around 50%, while they increased by more than 150% in the US. Additional non-tariff burdens induced by the trade tensions and the COVID-19 pandemic mainly affected less-flexible firms.

While the trade tensions do not appear to have affected total global trade volumes, they led to significant changes in the geographical patterns of GVCs. The PRC shifted its export focus to East Asia and Pacific region and Europe and Central Asia region, while the US forged closer trade ties with Canada and Mexico. Both the PRC and the US reorganized their imports from the Europe & Central Asia region, the East Asia and the Pacific region, and Latin America & Caribbean region.

In contrast, the COVID-19 pandemic led to sharp decline in global trade volumes, but the process reversed quickly. Numerical modeling suggests that all economies should have fully recovered by 2025, albeit at different speeds. The data also shows that non-GVC trade and trade-related activities significantly contracted during the COVID-19 pandemic, leading to an increase in pure domestic consumption. Meanwhile, cross-border trade involving MNEs slightly increased as a result of stronger links between MNEs and domestic firms.

The effects of digitalization on the recovery were also analyzed and further evidence was obtained in support of the hypothesis that economies with superior digital infrastructure were less affected than other economies during the COVID-19 pandemic. Global demand for digital technology led to increased investment in high-tech industries, thereby boosting FDI-related activities.

## Disruptions of World Energy GVCs

Chapter 3 takes up the issue of how these shifts in value chains affect the world energy transition and climate governance. One major possibility is that the EU countries may use the Russian war in Ukraine as an opportunity to speed up the development of renewable energy and realize energy transition earlier than expected. On the other hand, due to the energy crisis and the huge energy demand, some economies gave up their phasing-out-coal policy and began to increase the use of coal and to restart coal-fired power generations. These shifts led to a temporary increase of carbon emissions and may delay the UN's net-zero emission strategy and carbon neutrality timetables.



The long-lasting PRC-US trade tensions and the ongoing Russian war in Ukraine are fueling geopolitical tensions. These geopolitical tensions have made geopolitical concerns surpass economic interests and become the dominant factor affecting world energy trade and economic development. All these dynamic movements are giving huge impacts on global energy supply chains.

Our CGE scenario analyses demonstrate that the Russian war in Ukraine and various sanctions against Russia will reshape the patterns of the world energy trade and formulate some new regional energy supply chains: the EU-US energy supply chain, the Eurasia energy supply chain, and the diamond shaped energy supply chains of US-Japan-Australia-India.

## The Semiconductor Supply Chain

In 2023, the global semiconductor industry has clearly reached a new critical juncture, where supply chain resilience, national security, and competition for technology leadership are challenging the highly popular and efficient “fables” model through which chip design and semiconductor manufacturing (known as wafer fabrication in “fabs”) can be separated organizationally and geographically. The recent COVID-19 pandemic, global chip shortages, and the US export restrictions on semiconductor technologies have accentuated worldwide attention to this important high-tech sector and its supply chain configurations. Many national governments in advanced economies have now placed far greater urgency on, and enacted specific industrial policies for, (re)building their domestic semiconductor manufacturing capacity. The rise of this new techno-nationalism is transforming the highly internationalized semiconductor industry into the age of “real nation-states should have fabs”.

Chapter 4 provides substantial empirical evidence for several key observations on the global semiconductor supply chain. We find that vertical disintegration has driven the globalization of semiconductor production over time. The rise of fabless chip design firms and their manufacturing suppliers, known as foundry fabs, represents one such key driver. This “fabless revolution” starting in the US since the 1980s can be explained by high costs in chip design and production, financial market pressures for short-term profits, and the rise of efficient foundry fabs in East Asia. We show that government support was crucial in the initial development of East Asian memory chip producers (e.g. Samsung) and foundry fabs (e.g. TSMC) in the 1980s. Since 2010s, important market shifts in industrial applications towards computers/data storage and wireless communications have been crucial in explaining the rapid growth of leading fabless firms, foundry producers, and integrated manufacturing firms in microprocessors and memory chips.

Meanwhile, massive innovations in semiconductor technologies have resulted in extremely high costs of cutting-edge chip design and manufacturing since 2010. Only a few market leaders from the US, the EU, and East Asia now dominate in the different segments of semiconductor global value chains, from design software and intellectual properties to materials and equipment suppliers. By the turn of 2020s, the ever-more sophisticated processes of chip design and production and their concomitant ecosystems of highly specialized firms mean that no single economy can be self-sufficient in the entire semiconductor value chain. In this context, semiconductor GVCs in the post-pandemic era are in transition as more national economies want to have their own fabs for national security and risk mitigation reasons. Nevertheless, we note that this pursuit of “fabs everywhere” through technological sovereignty is unlikely to be realistic because of the complex organization of existing semiconductor GVCs and the extreme demand for technological capabilities and capital investment in cutting-edge chipmaking. It will likely result in a fragmented rather than integrated global semiconductor market, which would inevitably undermine the sector’s economies of scale and trust relationships and, even worse, lead to excess capacity, underutilized fabs, and technological bifurcation worldwide.

## GVCs and Climate Change

Chapter 5’s point of departure is that GVCs have led to a surge in CO<sub>2</sub> emissions from international production sharing through both trade and investment (e.g., FDI) channels. The GVC phenomenon, which involves multiple cross-border flows of intermediate goods, may complicate the implementation of the Paris Agreement, which relies on a patchwork of national policies. A persistent challenge in international climate change negotiations is how to allocate responsibility for global warming among various participants in GVCs, such as producers, consumers, exporters, importers, investors, and investees.

This chapter presents a consistent GVC accounting framework (Meng et al, 2023) that allows us to trace the CO<sub>2</sub> emissions responsibility of different country-sector-bilateral combinations through various trading routes. Our results show that the emissions from production processes in developing countries, based on their own responsibility for CO<sub>2</sub> emissions, have accounted for a large share of global emissions growth since 2001 and reached a peak in 2019. This is worrisome because most developing countries have weaker environmental regulations and lower enforcement levels. Given the fact that GVCs are rooted in domestic sources, it is imperative to curb these emissions with more effective tools including environmental regulation, taxation, and the introduction of carbon trading schemes (ETS) domestically. Taking the PRC as an example (see Tang et al. 2020), if more balanced regulations coverage and more equal access to the financial system for heterogeneous firms (no matter they are large-scaled or SMEs, state-owned, foreign-invested, or private firms) could be introduced, the PRC’s 2030 commitment to reduce carbon emissions could be achieved more efficiently with less GDP loss (its

green investment would be 64% lower, and its energy efficiency would be 71% higher than in the business-as-usual scenario). Once the PRC can get “greener” in its domestic production, its exports via GVCs will also be greener.

Although the carbon intensity of GVCs, as measured by emissions per unit of value-added, has decreased in both developed and developing countries between 1995 and 2021, generating GDP through international trade is still a more carbon-intensive process than generating GDP through purely domestic value chains. In this regard, introducing a Carbon Border Adjustment Mechanism (CBAM) in the context of a trade-investment-environment nexus, should be an option to promote the formation of green GVCs in the Paris Agreement era. However, a well designed CBAM at the global level is crucial for getting consensus to increase carbon cost and reduce carbon leakage. For example, applying a GVC-based CGE simulation analysis to the EU’s CBAM, (Qian et al. 2023) show that GDP would rise in several EU countries, while CO<sub>2</sub> emissions outside the EU would be reduced. However, the EU’s CBAM would also trigger a slight increase in total CO<sub>2</sub> emissions within EU due to the “rebound effects” and carbon leakage across EU countries; most countries, especially the non-EU countries, would suffer a larger decline in consumers’ welfare. Therefore, our suggestion is that carbon border adjustment should be designed along GVCs at the country-sector-bilateral level, based on each country’s share of responsibility for CO<sub>2</sub> emissions, rather than a simple one-way imposition like a trade tariff.

In addition to looking at responsibility at the country level, we also examine the roles of MNEs, who are the main actors in GVCs. Based on MNEs’ complex production arrangements, global CO<sub>2</sub> emissions are transferred not only between investing countries (home countries) and producing countries (host countries), but also among other consuming countries (third countries) in the GVC network, which adds to the complexity of global carbon transfer. From a global perspective, about 30%-40% of MNEs’ carbon emissions are embodied in their exports to third countries, but these shares vary across different economies due to different FDI motivations and GVC production arrangements of MNEs. Of all these third-country induced emissions, nearly 80% of them are related to GVC activities, but this share is only 60% in India and over 90% in Australia, and the GVC position of host countries is an important factor for this difference. In the textile sector, for example, nearly 1/3 of MNEs’ emissions are generated in the PRC, and 50% of them are induced by third countries, while this share is only 14% in the US and more than 90% in Viet Nam. In the motor vehicle sector, the largest emissions of MNEs are generated in South Africa, followed by the PRC and Mexico; however, in South Africa, over 50% of MNEs’ emissions are induced by third countries, while in the PRC, this share is merely 20%, and in Mexico, nearly half of MNEs’ emissions are induced by their home countries.

The transnational investment of MNEs also affects the distribution of emission responsibility and economic benefits across countries. Overall, during 2005-2016, the factor income-based accounting (FIBA) value-added and CO<sub>2</sub> emissions of advanced

economies are underestimated by 415.37 billion USD to 489.63 billion USD and 287.23Mt to 766.50Mt, respectively, while those of emerging markets and developing economies are overestimated. The latter bears some of the emission responsibility of the former, which partly supports the pollution haven hypothesis. From the national perspective, major FDI-outflowing economies receive more factor income and incur less environmental cost, while major FDI-inflowing economies receive less factor income and incur more environmental cost. As of 2016, the cumulative net carbon transfers from advanced economies to emerging markets and developing economies through MNEs' investment amounted to 1800.80 Mt. If this environmental cost is converted into incentive funding, it would provide an additional 26.61 billion USD to supplement the Green Climate Fund (GCF). Our research provides a useful reference point for future negotiations of carbon responsibility sharing across countries and offers a feasible way for financing the GCF, which will facilitate the achievement of the net-zero emission target consistent with the Paris Agreement.

Although there is a general agreement on the principle of “common but differentiated responsibilities” (CBDR) among the international community, many challenges remain in implementing it effectively. Given the increasing difficulty of limiting global warming to 1.5°C and the fact that most developing countries have no absolute emissions reduction targets and relatively weak environmental regulations, it is crucial to help these countries set appropriate and ambitious targets for reducing carbon emissions and/or achieving carbon neutrality, which could help curb the current rapid rise in global CO<sub>2</sub> emissions. The Paris Agreement allows countries to start from different points and pursue different ambitions toward their own carbon neutrality goal, and uses production-based accounting to measure their emissions (e.g., the original idea of carbon neutrality at the individual country level means taking full responsibility for all direct and indirect emissions), without explicitly considering the responsibility sharing of carbon leakage caused directly and indirectly by international trade and investment. This implies that a net carbon exporting country and a net FDI inflow country might bear more responsibility in achieving its own carbon neutrality goal, while a net carbon importing country and a net FDI outflow country might bear less responsibility than needed. In this sense, negotiating about responsibility sharing for carbon leakage across countries is inevitable if we want to achieve the global goal of net-zero emissions.

## GVC Greening: A Conceptual Framework for Policy Action

The environmental impact of GVCs can be decomposed into three different mechanisms. First, a *scale effect*, whereby an increased level of production leads to increased transport volumes and travels, waste production, and overexploitation of scarce resources, with detrimental effects on the environment. The second mechanism is the *composition effect*, whereby GVCs break up the production process into tasks that can be shifted from one location to another. This leads to environmental benefits

when production tasks are relocated where it is the most efficient, or environmental costs when carbon-intensive tasks are relocated to jurisdictions with lax regulations. The third and last mechanism is the *technique effect*, whereby knowledge flows among firms along a value chain facilitate the development, adoption, and adaptation of environment-friendly production techniques. The phenomenon of net environmental gains from the introduction of environmental innovation into GVCs is commonly referred to as ‘GVC greening.’

Chapter 6 presents a conceptual framework to investigate: (i.) why GVC greening occurs; (ii.) the types of environmental innovation undertaken in GVCs; (iii.) the actors involved; (iv.) how the greening occurs in GVCs and their different stages; and (v.) the outcomes of GVC greening. The framework lays the foundation for a discussion of policy actions aimed at maximizing net environmental gains through the technique effect (GVC greening) and establishing strong accountability mechanisms to discourage pollution outsourcing.

The chapter reaches three key conclusions. First, while GVC greening has institutional, market, and technological drivers, institutional drivers still play the leading role. New policies and legislation related to domestic or global sustainability transformation agendas are central to GVC greening. Market and technological drivers are also important, but tend, ultimately, to be driven by institutional issues.

Promoting such drivers requires a shared effort among institutional actors at national and global levels. However, as advanced economies are increasingly competing to gain competitive advantage in new green technologies, domestic policies play a greater role than global concerns.

Governments turning sharply away from multilateral cooperation may pose a major challenge to promoting environmentally friendly GVCs. A way forward to safeguard multilateralism and global institutional drivers sustaining GVC greening is to invest in initiatives developed among smaller groups of like-minded economies. One example is the Breakthrough Agenda, involving 45 economies and the private sector to accelerate the shift to green technology in different industries. Coordination at the global level, e.g., a single international carbon tax rate, might also help promote the transition towards the net-zero emission goal.

The second key message is that several actors, not only lead firms but also suppliers, national and local governments, and often a combination of them, contribute to GVC greening. In some cases, suppliers anticipate future environmental requirements to leverage their environmental upgrading initiatives as a competitive factor to access new buyers and markets.

However, the greening opportunities may not be equal among suppliers. Several studies show that lead firms do not always provide enough financial, managerial and knowledge resources for their suppliers to implement green strategies, leaving them out of the chain if they are unable to meet such requirements. This risk is particularly high for small firms in developing economies but also in developed ones.

Uneven distribution of costs, benefits, and rewards for greening value chains poses a challenge for policymakers to address this supplier-squeeze. Actors external to the GVC, such as national or local governments, NGOs, and independent certification bodies, can provide technical and financial support to suppliers in GVCs to implement environmental innovations. National or sub-national public actors can provide the basic infrastructure that contributes to GVC greening.

Finally, there is very limited evidence on the biophysical outcomes of GVC greening. There are important tradeoffs between environmental and socioeconomic outcomes, and the final assessment of whether GVC greening happens or not generally remains a research gap in most of the existing studies. Therefore, accounting, monitoring, and disclosing the environmental outcomes and the possible tradeoffs with socioeconomic outcomes are challenging but essential dimensions to investigate along the entire value chain. However, once again the transboundary nature of GVCs poses a challenge that requires multilateral efforts to orchestrate and harmonize private and national initiatives to monitor environmental outcomes.

## **Towards Inclusive GVCs**

Chapter 7 explores the role of GVCs in driving inclusive development within developing economies. Inclusiveness is a key aspect of resilient and sustainable GVCs. As the backlash against globalization in advanced economies has shown, rising inequality can lower political support for trade and increase barriers to GVC integration. Moreover, since the impacts of shocks tend to be unevenly distributed within economies, it is important that all parts of society are able to recover quickly for the economy as a whole to be resilient. GVCs can also accelerate (green) technology diffusion from technological leaders to the less innovative. Therefore, by prioritizing inclusiveness, GVCs can play a pivotal role in building sustainable and resilient economies for the benefit of all stakeholders.

The topic of this chapter holds more significance than ever for two reasons. First, the negative shocks prompted by the COVID-19 pandemic, geopolitical tensions, and the environmental crisis have been shown to disproportionately hurt certain groups within developing economies, such as low-skilled workers, female employees and MSMEs. Second, consumers are increasingly aware of the spillover effects of their choices on workers in developing economies. This has triggered renewed efforts by policymakers and investors

to address inclusiveness in supply chains. Ensuring that the resulting policy responses are grounded in solid evidence is important for them to achieve lasting improvements.

The chapter has two key messages: First, GVC integration leads, on average, to better outcomes for firms and workers in developing economies. The evidence consistently shows that local suppliers to MNCs and firms exporting intermediates outperform other firms in developing economies. In particular, GVCs provide MSMEs with chances for quality upgrading, knowledge spillovers, technology transfers, and innovation through their affiliations with lead firms. The chapter shows in this regard that firms in developing economies with higher GVC integration tend to have substantially better management practices. Furthermore, becoming part of GVCs can assist in alleviating credit constraints, a substantial challenge encountered by MSMEs.

The performance premium spills over to workers as well. Being employed at MNCs or their suppliers generally results in higher wages and better working conditions, including a higher likelihood of formal employment. For instance, in Cambodia, a surge in garment exports to the EU induced a 16-22 percent increase in employment at formal establishments. Women often benefit from these developments in particular. However, several non-trade related constraints, like access to education, limit their upgrading opportunities. In this regard, the chapter shows that GVC integration lowers gender wage gaps in low-skill occupations but has essentially no effect on inequality at high-skill occupations such as managerial positions.

The second key message is that where GVC integration fails to deliver or underdelivers on benefits, it tends to be caused by underlying market failures and policy barriers rather than GVC integration itself. An important example is market power. Both monopolistic/oligopolistic and monopsonistic/oligopsonistic behaviour of firms on product and labour markets can severely skew the distribution of profits in value chains and put undue pressure on local suppliers to cut costs with negative implications for workers. The chapter highlights a study showing that the income of Ecuadorian farmers in agricultural GVCs would be 77% higher if intermediaries behaved competitively. Other key factors are limited adaptive capacity due to incomplete financial or labour markets in developing economies.

These two findings have important policy implications. Since GVC integration tends to benefit firms and workers, the focus should be on facilitating entry into GVCs and spillovers to the domestic economy to ensure that GVCs are truly inclusive. To maximize the potential of GVCs for inclusive development, it is crucial to address the underlying market failures and barriers that lead to an uneven distribution of the gains from GVCs.

The current policy focus is on non-trade provisions (NTPs) in regional trade agreements, import bans and restrictions, and due diligence requirements (DDRs). However, these policies often aim at improving working conditions exclusively within GVCs even though the evidence suggests that workers and firms within GVCs already enjoy better outcomes. As a result, they might aggravate existing differences between those inside and those outside GVCs. Moreover, many of these policies have been shown to produce adverse effects. The inclusion of NTPs in trade agreements can potentially hinder country-level inclusion in GVCs by raising costs and uncertainty. DDrs appear to assume that firms willingly underpay workers or refuse to improve working conditions, but this is not in line with the evidence. To make sure that these policies work in favour of inclusive development, they should be accompanied by more cooperation and take into account the lessons from the academic literature.

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