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Declaration of Originality

I hereby declare that this PhD thesis is my own work and has not been submitted, wholly or in part, for the award of a degree at any other institution. All sources used are duly acknowledged.

15 November 2025

To Lorenzo and Marco

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Abstract

This dissertation investigates how participation in global and regional value chains (GVCs) affects domestic value creation and economic growth. Over the past three decades, the fragmentation of production across borders has transformed the world economy into a network of interdependent production systems. Yet, despite growing evidence of the importance of GVCs, the channels through which countries capture value and translate international integration into domestic output gains remain only partially understood.

Building on the OECD Trade in Value Added (TiVA) database, this thesis develops an econometric framework to estimate the relationship between forward and backward GVC participation and GDP growth across a large panel of countries. Forward participation – measuring the domestic value added embodied in other countries' exports – captures a country's role as an upstream supplier within global production networks. Backward participation – reflecting the foreign value added embodied in domestic exports – represents a country's reliance on imported intermediates. By distinguishing between these two forms of integration, the thesis provides a comprehensive assessment of how value-chain participation contributes to economic performance.

The global analysis (Chapter 2), covering 80 countries over 2006-2022, reveals a strong and statistically significant positive effect of forward GVC participation on GDP, while the backward channel yields smaller and more variable effects. These results confirm that the benefits of globalization depend not only on how much countries trade, but on how they are integrated – particularly their ability to supply high-value intermediate goods and services.

The regional analysis (Chapter 3) extends the framework to the NAFTA and ASIA-13 blocs. The findings show that integration with NAFTA generates stronger and more stable growth effects for external partners, reflecting the bloc's technological depth and institutional maturity. In contrast, linkages with ASIA-13, though positive, are more heterogeneous, mirroring the diversity of industrial structures across East and Southeast Asia.

Overall, the thesis demonstrates that participation in GVCs is a powerful driver of growth when accompanied by domestic capabilities that enable economies to move upstream within global and regional production systems. The results carry clear policy implications:

sustainable benefits from globalization require upgrading strategies focused on innovation, skills, and local linkages, ensuring that participation in global production networks translates into enduring domestic value creation.

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GENERAL INTRODUCTION

Over the last three decades, the expansion and deepening of global value chains (GVCs) have fundamentally reshaped how production, trade, and innovation are organized worldwide. The increasing fragmentation of production processes across borders has blurred the boundaries between domestic and international economic activity, leading to a new global division of labor in which value is created and captured through complex networks of intermediate inputs and tasks. This evolution has transformed the logic of globalization itself: rather than exchanging final goods, countries now trade value added embedded in multi-stage production networks that often span several continents.

Understanding how countries participate in and benefit from these production networks has therefore become a central question in international economics and development policy. Traditional trade indicators based on gross flows fail to capture the real sources of competitiveness, since they do not distinguish between foreign and domestic value added or between upstream and downstream positions along global supply chains. In contrast, GVC-based analyses offer a more accurate and policy-relevant view of how trade integration contributes to domestic economic performance.

The purpose of this thesis is to assess whether, and to what extent, participation in global and regional value chains fosters domestic value creation and GDP growth. It develops a set of econometric models using value-added trade data from the OECD Trade in Value Added (TiVA) database to quantify how different modes of integration – forward and backward – affect national output across a wide sample of countries and time.

Forward participation measures the domestic value added embodied in other countries' exports, reflecting an economy's ability to supply intermediate goods and services to downstream production abroad. Backward participation, in turn, captures the foreign value added embodied in domestic exports, indicating the extent to which a country relies on imported intermediates to produce for foreign markets. These two dimensions together provide a comprehensive view of a country's position within global production networks and its potential for upgrading.

This research is motivated by three interrelated questions.

First, does deeper GVC integration systematically lead to higher domestic output, and are the effects symmetric between forward and backward linkages?

Second, do the benefits of GVC participation depend on where and how countries are integrated – globally or regionally, upstream or downstream?

Third, can the empirical patterns observed globally be reconciled with theoretical expectations about learning-by-exporting, technology diffusion, and structural upgrading?

Addressing these questions is particularly relevant at a time when global production networks are being reconfigured under pressures of technological change, geopolitical realignment, and rising protectionism.

Chapter 1 provides the conceptual and empirical foundations of the thesis. It reviews the evolution of the literature on GVCs, from early contributions focusing on production fragmentation and vertical specialization to more recent approaches emphasizing upgrading, governance, and policy complementarities. The chapter highlights how GVC participation affects productivity, employment, and income distribution, and discusses the channels through which domestic economies capture value from international production. It also synthesizes key empirical findings from previous studies that link GVC participation to growth and upgrading, thereby framing the research gap that this thesis seeks to fill – namely, a systematic cross-country assessment of how forward and backward GVC integration affect GDP growth using consistent, value-added-based data.

Chapter 2 develops the global empirical analysis. Using a balanced panel of 80 countries over the period 2006-2022, it estimates the relationship between GVC participation and domestic output through a fixed-effects (FE) model with lagged regressors to mitigate simultaneity and reverse causality. Both forward and backward GVC linkages are included as main explanatory variables, alongside controls for trade openness, foreign direct investment, domestic value added in pure exports, and GDP growth. Robustness is ensured through clustered and Driscoll–Kraay standard errors, and a comprehensive set of diagnostic tests assesses heteroskedasticity, serial correlation, and cross-sectional dependence.

The results consistently reveal that forward GVC participation exerts a strong and statistically significant positive effect on GDP, while the backward channel is weaker and more context-dependent. This finding suggests that countries that supply intermediate goods and services to the global market benefit more from integration than those primarily engaged in assembling imported components. The analysis thus provides empirical support to the notion that upstream specialization and technological capabilities are central to sustained value creation.

Chapter 3 extends the empirical framework to the regional level. The analysis investigates how integration with major regional production systems – specifically, the NAFTA and ASIA-13 blocs – affects the economic performance of countries outside these hubs. By excluding member economies from the sample, the chapter isolates the external spillover effects of regional GVC participation, enabling direct comparison with the global benchmark estimated on the same country subset.

The findings reveal that forward linkages with NAFTA have the strongest and most robust association with GDP growth, reflecting the high technological intensity and stability of the North American production network. Forward integration with ASIA-13 also yields positive effects but with smaller magnitudes, consistent with the more heterogeneous industrial structure and variable technological depth of the Asian bloc. In both regions, backward linkages produce weaker effects, underscoring that growth gains from GVCs primarily flow through upstream participation.

By combining global and regional perspectives, the thesis contributes to the empirical understanding of how value-chain participation supports economic performance. It bridges the gap between macro-level studies of globalization and meso-level analyses of regional production systems. Moreover, it provides new insights for trade and industrial policy: the results emphasize that successful integration into global production networks requires more than openness — it demands capability building, strategic positioning, and the development of domestic linkages that enhance value retention.

CHAPTER 1 – LITERATURE REVIEW

1.1. GVCs definition

Global Value Chains (GVCs) refer to the full range of activities that firms and workers perform to bring a product or service from its conception to end use and beyond, with the key characteristic that at least two stages of production occur in different countries. These activities include research and development, design, production, marketing, distribution, and support to the final consumer, and can be carried out within a single firm or divided among different firms operating globally or regionally. GVCs emphasize the international dimension of production processes and the contractual relationships between buyers and sellers across borders, often coordinated by lead firms that manage the chain through networks of foreign affiliates, contractual partners, and external suppliers. The concept highlights the complex interactions among firms, the geographic dispersion of production stages, and the governance structures that influence value creation and capture along the chain (Gereffi & Fernandez-Stark, 2018a; Taglioni & Winkler, 2016; Cattaneo et al., 2013; Horner & Nadvi, 2018).

In the context of global value chains (GVCs) production is fragmented into multiple stages, with each stage adding value along the chain in a process of Vertical Specialization (VS). This specialization involves countries or firms focusing on specific tasks or segments of the production process rather than producing entire goods domestically. It reflects the international dispersion of production activities, where intermediate goods and services cross borders multiple times as they move through various stages of production before becoming final products.

Vertical specialization highlights how countries exploit their comparative advantages by specializing in particular stages of production within GVCs, enabling more efficient allocation of resources and integration into global production networks. This concept is closely linked to the fragmentation of production and the lengthening of production chains, where production stages are segmented and geographically dispersed, often coordinated by multinational corporations or lead firms.

In economic literature GVCs are described as involving the slicing of production into specific tasks distributed globally, with vertical specialization capturing the international division of labor within these chains (Ponte et al., 2019b; Qiang et al., 2021).

With the emergence of global value chains, the traditional foreign trade accounting system based on gross trade has proved to be ineffective to describe the actual contribution of each country to global trade.

Trade in Value Added (TiVA) is an analytical approach that measures the value added by each country in the production of goods and services that are traded internationally. Unlike traditional gross trade statistics, which record the full value of exports and imports, TiVA accounts for the fact that intermediate goods and services cross borders multiple times during the production process. This approach uses input-output tables and firm-level data to trace the origin of value added embedded in exports, providing a more accurate picture of international production sharing and the real economic contributions of countries in global trade. TiVA helps to understand the factor content of trade, value-added exchange rates, and the distribution of gains from trade, and it addresses issues such as the overestimation of trade deficits by traditional measures (Qiang et al., 2021) chapter 1, (Inomata, 2017).

1.2. The evolution of world trade and the emergence of Global Value Chains

The evolution of world trade over the last decades has been marked by significant expansion, structural transformation, and increasing complexity, largely driven by the rise and integration of global value chains (GVCs). The most relevant transformations can be summarized as follow:

- Rapid growth in trade flows and investment

Global gross exports of goods increased tenfold between 1980 and 2013, with services exports growing nearly tenfold as well. Foreign direct investment (FDI) net inflows surged by 34 times during the same period. This expansion reflects the deepening integration of economies worldwide into global production and trade networks (Taglioni & Winkler, 2016).

- Shift from traditional trade to fragmented production

Trade has evolved from the exchange of finished goods produced entirely within one country to complex, internationally fragmented production processes. GVCs now involve multiple stages of production spread across different countries, with firms specializing in specific tasks or segments rather than entire products. This fragmentation has been facilitated by advances in technology, logistics, and trade facilitation, enabling countries to participate in global production networks even without mastering full production processes (Taglioni & Winkler, 2016; Cattaneo et al., 2013; Horner & Nadvi, 2018; De Marchi et al., 2018).

- Emergence of new global economic powers and polycentric trade

The global trade landscape has shifted from being dominated by a few large economies to a more multipolar and polycentric system. The triad of China, the European Union, and the United States accounts for over half of world goods and services exports and imports. Emerging economies such as China, India, and Brazil have become key drivers of global trade and GVCs, reshaping demand patterns and production networks. This has led to a trend toward regionalization of value chains alongside globalization, with production increasingly organized at local, national, regional, and global scales (Horner & Nadvi, 2018; Taglioni & Winkler, 2016; De Marchi et al., 2018).

- Consolidation and concentration in GVCs

Global value chains have become more consolidated and concentrated organizationally. Lead firms have reduced their supplier base to fewer, larger, and more capable suppliers strategically located to access major markets. This consolidation increases competitive pressures and economic risks for countries and firms that lack the scale, skills, or strategic positioning to compete effectively (Gereffi & Luo, 2018).

- Changing nature of trade and production networks

Trade is no longer a simple sequence of market transactions but a coordinated network of complex relationships among firms and countries. Lead firms govern these networks, influencing how value is created and captured. The governance structures of GVCs affect the distribution of gains from trade and the opportunities for economic upgrading in participating countries (Frederick, 2023; Horner & Nadvi, 2018).

- Impact of economic crises and structural trends

The 2008–2009 global economic recession reinforced existing trends such as GVC consolidation and the growing importance of developing world markets. Emerging economies have become engines of global economic recovery, and GVCs have adapted by shifting supply toward these markets, reflecting changing global demand and production patterns (Gereffi & Luo, 2018).

1.3. Different types of GVCs

Global value chains (GVCs) can be categorized into different types based on the structure of power relations between contracting parties and the nature of transactions within the chain. According to the typology developed by Gereffi et al., 2005, there are five main types of GVC governance structures:

1. Market-type Global Value Chain
    - This type involves the production of generic commodities that do not require specific investments in production facilities.
    - Both customers and suppliers have many alternative partners, and transactions occur mainly through open spot-markets with minimal formal cooperation.
    - Product specifications are simple and easily communicated, often with preset prices found in catalogs.
    - The transaction cost of switching partners is very low, leading to a high degree of price elasticity and constant flux in the chain.
2. Modular-type Global Value Chain
    - In this type, production involves modules, which are composite of subcomponents grouped by function.
    - Producers can design multiple product variants by combining differentiated modules.

- Suppliers can accommodate complex transactions by adjusting multipurpose equipment without incurring transaction-specific investments, allowing them to serve a wide range of clients.
- Although information exchange between contractors can be considerable, the transactions are relatively codifiable, enabling suppliers to control their production processes with limited intervention from buyers.

3. Relational-type Global Value Chain
    - This type is characterized by complex interactions and mutual dependence between buyers and suppliers.
    - Relationships are often based on trust, social ties, and frequent communication, which are necessary due to the complexity and specificity of transactions.
    - Suppliers have specialized capabilities, and the governance involves significant coordination and information sharing
4. Captive-type Global Value Chain
    - Here, suppliers are dependent on a few powerful buyers who exert strong control over their activities.
    - Suppliers often have limited capabilities and face high switching costs, making them "captive" to lead firms.
    - The governance is hierarchical, with lead firms closely monitoring and directing supplier performance.
5. Hierarchy-type Global Value Chain
    - This type involves vertical integration where a parent company exercises absolute and unidirectional control over its subsidiaries.
    - Activities and performance of subsidiaries are strictly monitored and aligned with the headquarters' strategies.

- This governance structure reflects a hierarchical organization with strong centralized control.

These governance types are influenced by three key parameters known as the "3 C's model":

- Complexity of transactions
- Ability to codify transactions
- Capabilities in the supply base

The combination of these factors determines the appropriate governance structure for a given GVC (Inomata, 2017).

1.4. Key theories related to Global Value Chains (GVCs) and Vertical Specialization (VS)

Theories related to GVCs and VS provide a comprehensive understanding of the organization, governance, and economic implications of fragmented global production.

Global Value Chains (GVCs):

- Governance and power relations:

GVC theory emphasizes the role of lead firms in coordinating and governing dispersed production activities across countries. As previously pointed out, Gereffi, Humphrey, and Sturgeon (2005) developed a typology of governance structures – market, modular, relational, captive, and hierarchical – based on the complexity of transactions, codifiability, and supplier capabilities. This typology explains how power asymmetries and coordination mechanisms shape value distribution and upgrading opportunities within GVCs (Horner & Nadvi, 2018).

- Fragmentation and production networks:

The fragmentation of production into distinct tasks or stages, often geographically dispersed, is central to GVC theory. This fragmentation allows countries and firms to specialize in specific segments of the production process, exploiting comparative advantages and enabling more efficient resource allocation. The concept of vertical specialization captures this international division of labor, where intermediate goods cross borders multiple times before final assembly (Ponte et al., 2019b; Inomata, 2017).

- Relational and network perspectives:

Beyond linear chains, GVCs are increasingly understood as complex networks involving multiple actors, including non-chain actors such as governments, NGOs, and labor organizations, which influence governance and outcomes. This broadens the analytical scope to include social, political, and institutional dimensions of global production (Yeung & Coe, 2015; Horner & Nadvi, 2018).

- Firm heterogeneity and organizational choices:

Building on New Trade Theory and contract theory, Antrà & Helpman, 2004 and Antràs & Chor, 2013 introduced models incorporating firm heterogeneity and technological ordering of production stages. These models explain firms' decisions on foreign direct investment, outsourcing, and governance forms along the value chain, highlighting how transaction costs and contract incompleteness influence vertical integration and arm's-length relationships (Mahutga, 2019).

Vertical Specialization (VS):

Vertical specialization refers to the process where production is fragmented internationally, with countries specializing in particular stages of production rather than entire products. It is characterized by the repeated crossing of borders by intermediate goods as they move through various production stages before becoming final products.

This concept highlights how countries exploit their comparative advantages within GVCs, leading to more efficient global production networks. Vertical specialization is closely linked to the rise of offshoring, outsourcing, and the international division of labor, which have transformed traditional trade patterns.

Early economic models, such as those by Feenstra (1998) and Baldwin (2006), formalized vertical specialization by analyzing how tasks and production stages are allocated internationally to exploit comparative advantages. Vertical specialization is closely linked to the rise of GVCs, as it explains the microeconomic foundations of global production fragmentation and the resulting trade patterns (Szymczak, 2024).

Theories integrating vertical specialization with firm heterogeneity and governance structures explain how firms decide which production stages to internalize or outsource internationally, balancing transaction costs, capabilities, and market conditions (Ponte et al., 2019b; Inomata, 2017).

The concepts of global value chains (GVCs) and vertical specialization (VS) have evolved significantly in economic literature, reflecting the increasing complexity and fragmentation of international production.

The notion of GVCs emerged from earlier concepts such as commodity chains and global commodity chains (GCCs) in the 1980s and 1990s. Gereffi (1994, 2018) was foundational in defining commodity chains as sequences of production stages linked by value addition. Over time, the focus shifted from commodity trade to the governance and organization of spatially dispersed production activities, emphasizing how multinational enterprises (MNEs) coordinate and control these dispersed activities.

The GVC framework integrates insights from economic sociology, international economics, economic geography, and international business, focusing on inter-firm networks, governance structures, and upgrading opportunities for firms and regions. Gereffi et al., 2005) developed a typology of GVC governance that explains how lead firms orchestrate global production networks without direct ownership, highlighting power asymmetries and coordination mechanisms (Kano et al., 2020, De Marchi et al., 2020).

More recent literature has expanded GVC analysis to include extra-firm actors (e.g., state agencies, NGOs), multi-scalar territorial embeddedness, and the dynamic evolution of global production networks (GPNs), as seen in Coe and Yeung's GPN 2.0 framework (Yeung & Coe, 2015).

1.5. Trade in value added and double-counting problem

Trade in value added (TiVA) emerged as a response to the limitations of traditional gross trade statistics, which often double-count intermediate goods crossing borders multiple times. TiVA measures the value added by each country in the production of goods and services consumed worldwide, providing a clearer picture of countries' actual contributions to global production.

This approach has been supported by international organizations like the World Bank and OECD, and it complements GVC analysis by quantifying the economic significance of each stage in the chain. TiVA data have enabled more precise assessments of the geographic distribution of value creation and capture, as well as the impact of GVC participation on wages, employment, and productivity (Szymczak, 2024).

The double-counting problem arises in the measurement of trade and global value chains (GVCs) when gross trade flows are used without accounting for the value added at each stage of production. This issue occurs because intermediate goods and services cross borders multiple times during the production process, and their full value is counted repeatedly in gross export statistics. As a result, gross trade data can significantly overstate the actual economic contribution of countries and industries involved in GVCs.

To address this, value-added trade measures have been developed, which decompose gross exports into domestic and foreign value added. This approach allows for a more accurate representation of the economic contributions by tracing the value added at each stage of production and avoiding counting the same value multiple times. For example, the OECD-TiVA (Trade in Value Added) database provides indicators of value added embodied in final demand, which help to overcome the double-counting problem by focusing on the value actually created by each country in the production chain rather than the gross flows of goods (Taglioni & Winkler, 2016).

The double-counting problem is particularly relevant when analyzing the length and complexity of GVCs, as intermediate inputs may cross borders several times before reaching final consumption. Using gross trade data without adjustment can mislead policymakers and researchers about the true extent of a country's participation and position in GVCs. Therefore, methodologies based on input-output tables and value-added decomposition are essential to provide a clearer picture of global production networks and to inform trade and industrial policies effectively (Inomata, 2017).

Double-counting in trade involving two or more countries occurs when the same value of intermediate goods or services is counted multiple times in gross trade statistics as these goods cross borders repeatedly during production.

Here are a few examples illustrating this phenomenon (Johnson et al., 2012), (Koopman et al., 2012).

- Sequential intermediate trade across multiple countries

Consider a final good consumed in the United States that incorporates value added from the U.S. itself and five other countries. Suppose each of the five countries sequentially sends parts to the next country for assembly before the final product reaches the U.S. In this case, the total gross trade value considers the value of each intermediate shipment, resulting in a total trade value equal to the final product price. However, the value added from each country is counted multiple times as the intermediate goods cross borders, inflating gross trade figures beyond the actual value created

- Circular trade flows with value added returning home

Another scenario is when the U.S. exports a basic component (e.g. raw materials), which then passes through several countries sequentially for further processing, and the final assembled good is shipped back to the U.S. Here, the gross trade value might possibly reach a much higher total than the actual value added due to the various borders crossed. This circular flow causes significant double counting in gross trade statistics because the same value added is recorded multiple times as the good moves internationally.

- Domestic value-added returning via processing trade

In cases like China and the U.S., domestic value added can be embedded in intermediate goods exported abroad for processing and then re-imported as part of final goods. For example, U.S. product designs or machinery used in final goods produced abroad but sold in the U.S. market lead to double counting of domestic value added in gross trade data. This reflects the complexity of global value chains where domestic inputs cross borders multiple times before final consumption.

- Triangular production chains in Asia

The U.S.–China trade deficit measured in gross terms is significantly larger than when measured in value-added terms because China's exports often include value added from Japan, Korea, and Taiwan. These intermediate inputs cross multiple borders before reaching the final

consumer, causing double counting in gross trade flows. Value-added trade measures reveal that a substantial portion of China's gross exports actually represent value added from other countries, reducing the apparent trade imbalance.

These examples highlight how gross trade statistics can overstate the economic contribution of countries due to repeated counting of intermediate goods crossing borders multiple times. Value-added trade accounting frameworks, using multi-country input-output tables, are essential to identify and correct for such double counting, providing a more accurate picture of global production and trade (Koopman et al., 2012).

1.6. GVCs: research areas and literature streams

The analysis of global value chains (GVCs) spans multiple research areas and literature streams, reflecting the multidisciplinary nature of the phenomenon. Key research areas and literature streams involved in GVC analysis include:

- International Business (IB) and management studies:

IB literature focuses on why, how, and where firms internalize activities, while GVC research emphasizes how activities are externalized and coordinated across borders.

Studies investigate firm-level strategies, governance structures, and the role of multinational enterprises (MNEs) as lead firms managing dispersed production networks.

Theoretical approaches include business network theory, internalization theory, resource-based view, dynamic capabilities, organizational learning, and innovation theories.

Empirical research often uses case studies, surveys, and archival data to explore firm upgrading, inter-firm learning, and governance mechanisms (De Marchi & Alford, 2021; Kano et al., 2020).

- Economic sociology and political economy:

Early work in economic sociology examined global commodity chains, focusing on governance structures and power asymmetries between buyers and producers.

The literature explores the political-economic systems within GVCs, including the interplay of market and political powers, and the role of non-market actors such as NGOs and state agencies. Concepts such as buyer-driven and producer-driven chains, power relations, and governance typologies are central (Kano et al., 2020).

- Economic geography and regional development studies:

This stream investigates the spatial distribution of value chain activities, regional upgrading, and the territorial embeddedness of GVCs. Research addresses the geographic scope of GVCs, the role of clusters and local linkages, and uneven development outcomes.

Empirical studies often focus on location choice, regional versus global governance, and the impact of GVC participation on local economies. The need for firm-level GVC mapping to clarify geographic breadth and depth is emphasized (Kano et al., 2020).

- International economics and trade:

This literature stream contributes to understanding the fragmentation of production and trade in value added. It formalizes concepts such as vertical specialization, where intermediate goods cross borders multiple times.

Trade in value added (TiVA) statistics have been developed to overcome limitations of gross trade data, providing clearer insights into countries' contributions to global production. Theoretical models analyze how tasks and production stages are allocated internationally to exploit comparative advantages (De Marchi & Alford, 2021).

- Supply chain and operations management:

It focuses on the coordination, control, and orchestration of complex global production networks. Studies examine contractual choices, relational governance, knowledge transfer, and innovation within GVCs.

Empirical research highlights the importance of informal relationships, communication strategies, and long-term collaboration for effective network management (Kano et al., 2020).

- Institutional and organizational studies:

They investigate the influence of institutional quality, political stability, norms, and cultural values on GVC governance and firm behavior and explore how institutional contexts shape upgrading opportunities and governance modes.

Theories such as institutional theory, resource dependency theory, and cultural frameworks are applied (Kano et al., 2020).

- Development studies:

Examine the implications of GVC participation for economic development, industrial upgrading, employment, and wage dynamics in developing countries.

Studies assess how GVCs affect local sourcing, innovation, and policy interventions aimed at enhancing value capture and upgrading *(De Marchi et al., 2020) (Szymczak, 2024).*

1.7. Different approaches and methodologies for the analysis of GVCs

The methodologies used to analyze global value chains (GVCs) encompass a range of qualitative and quantitative approaches that integrate multiple disciplinary perspectives and data sources. Key methodologies include:

- Value chain mapping and analysis

This approach involves identifying and mapping the structure of the value chain, including the geography and activities of stakeholders involved in bringing a product or service from conception to end use.

Mapping focuses on the input-output structure, identifying firms, products, markets, and geographic locations. Analysis then evaluates governance, institutions, and inter-firm relationships that influence the organization and competitiveness of the chain.

This methodology is widely used by academics and practitioners to understand economic, social, and environmental value creation and distribution, and to identify leverage points for policy or strategic interventions (Frederick, 2014; Gereffi & Fernandez-Stark, 2018a).

- Input-Output (I-O) tables and quantitative trade data

Input-output tables are used to measure value added rather than gross trade flows, allowing for a more accurate depiction of the economic contributions of different countries and firms within GVCs.

Multicountry input-output (MCIO) tables enable researchers to analyze the flow of intermediate goods and services across borders and to construct detailed industry supply chains. Advances in data availability and computing power have facilitated the use of large datasets and network analysis techniques to study GVCs quantitatively (Inomata, 2017; Ponte et al., 2019a).

- Inter-disciplinary qualitative research

GVC research draws from management science, sociology, and geography, often employing qualitative field research, small sample surveys, and secondary sources such as market reports and press articles.

This stream emphasizes tracing vertical and horizontal business relationships, governance modes, power dynamics, and institutional influences across global industries (Sturgeon, 2019; Frederick, 2014).

- Firm-level business records and product-level analysis

Some studies use firm-specific data, such as procurement and sales records and reports, to map the composition of inputs and value added in specific products.

This approach provides detailed insights into production sharing and value distribution but has limitations in addressing broader macroeconomic or trade policy questions (Inomata, 2017).

- Governance and power structure analysis

Governance analysis examines how control and coordination occur within GVCs, focusing on lead firms and their influence over suppliers.

Typologies of governance structures (market, modular, relational, captive, hierarchy) are used to understand the complexity of information exchange, codifiability, and supplier competence in the chain (Gereffi & Fernandez-Stark, 2018a).

- Stakeholder and institutional context analysis

This involves mapping the roles of various actors such as firms, industry associations, workers, government agencies, and educational institutions, and understanding how local institutions and policies affect GVC participation and upgrading (Gereffi & Fernandez-Stark, 2018a).

GVC studies employ different modes of analysis: spot analysis (one-to-one firm transactions), sequence analysis (production stages), and network analysis (complex interconnections). The diversity of methods reflects the complexity of GVCs and the need to combine approaches depending on the research question.

In summary, GVC analysis integrates qualitative mapping and governance studies with quantitative input-output and firm-level data analysis, supported by interdisciplinary frameworks. This combination allows for a comprehensive understanding of the structure, dynamics, and development implications of global value chains.

The analysis of global value chains (GVCs) employs as well micro and macro approaches, each with distinct characteristics, strengths, and limitations (Johnson, 2018).

Micro approaches focus on firm-level data and transactions:

- They use firm-specific business records, procurement and sales data, and firm surveys to observe input sourcing, export participation, and firm-to-firm transactions. This allows detailed mapping of production networks and understanding of firm behavior within GVCs.
- Micro data can reveal how multinational firms organize production, the nature of offshoring and outsourcing decisions, and the interactions between affiliates and suppliers.
- However, micro data often cover only parts of the chain or specific countries, limiting the ability to capture the entire global production process.

Macro approaches use aggregated data and input-output frameworks:

- National and multi-country input-output tables aggregate industry-level data to analyze value added flows across countries and industries, capturing the broader structure and dynamics of GVCs
- Macro approaches enable measurement of trade in value added, vertical specialization, and the overall configuration of global production networks.
- They are well-suited for addressing policy questions and macroeconomic issues but lack detailed information on firm-level transactions and qualitative aspects of governance and institutional context.

Quantitative and qualitative methods, as well as micro and macro approaches, are complementary rather than mutually exclusive. For example, product-level firm data provide detailed insights into specific chains and governance, while input-output analysis offers a systematic overview of GVCs at the global level Combining these approaches allows for a comprehensive understanding of GVC structure, dynamics, governance, and development implications (Frederick, 2014; Gereffi & Fernandez-Stark, 2018a; Inomata, 2017).

1.8. Key indicators to measure GVCs

The measurement of Global Value Chains (GVCs) involves several key indicators that capture the length of production processes, as well as the participation and position of countries and industries within these chains. These measures provide insights into the complexity, fragmentation, and economic roles of actors in GVCs.

- Length of Global Value Chains

The length of GVCs refers to the number of production stages or the fragmentation degree in the production process, reflecting how many times intermediate inputs cross borders before reaching final consumption.

The Average Propagation Length Model, developed by Dietzenbacher, Romero, and Bosma (2005), see (Dietzenbacher et al., 2005), measures the average number of production stages in a production network branch, effectively capturing industry fragmentation. It was extended to international contexts by Dietzenbacher & Romero, 2007, using European multi-country input-output tables.

The approach of Fally, 2011, measures fragmentation by calculating the average number of production stages from the point of production to final consumption, pegging the endpoint at final demand. It allows measuring the "distance to final demand" along production chains and has been applied to national and international input-output tables (e.g., OECD data covering 56 countries),

Production length indicators include total production length, domestic production length, and production length related to trade activities. For example, Wang et al., 2017a developed country-sector level indicators distinguishing production activities by whether value added is generated and absorbed domestically or crosses borders once or multiple times. Their findings show that the global average production length has increased over time, indicating longer and more fragmented GVCs, especially in complex production activities Upstreamness. This concept measures the relative position of a country or industry in the production network, based on the average distance of its production stages to final demand. A higher upstreamness indicates a more upstream position (closer to raw material extraction or initial production stages), while lower upstreamness indicates a downstream position, closer to final consumption (Duarte et al., 2022).

- Participation in Global Value Chains

Participation measures capture the extent to which countries or industries are involved in GVCs, both as users of foreign inputs incorporated in domestic exports and as suppliers of intermediate goods or services used in other countries' exports.

Backward and Forward linkages. Backward linkages measure the foreign value added embodied in a country's exports, indicating reliance on imported inputs. Forward linkages measure the domestic value added embodied in other countries' exports, indicating the country's role as a supplier in GVCs.

The GVC participation index combines backward and forward linkages to provide a comprehensive measure of a country's overall involvement in GVCs. It reflects the share of foreign value added in exports plus the share of domestic value added used in other countries' exports. A higher index indicates deeper integration in vertically fragmented production (Taglioni & Winkler, 2016; Wang et al., 2017b).

- Vertical Specialization (VS) measures.

Introduced by Hummels et al., 2001, and Koopman et al., 2010, these measures quantify the share of imported intermediate inputs in gross exports, capturing the degree of vertical fragmentation and participation in GVCs. Participation measures can be computed at various levels, including country-wide, sector-specific, and bilateral trade relationships, allowing detailed analysis of GVC involvement patterns (Wang et al., 2017b).

- Position of countries and industries in GVCs

The position reflects where a country or industry is located along the value chain, indicating whether it is upstream (early production stages) or downstream (Koopman et al., 2010; Inomata, 2017; Duarte et al., 2022).

Upstreamness and downstreamness are measured by comparing the average production length toward final products versus toward primary inputs. Countries or sectors with longer production chains toward final products are considered upstream, while those with shorter chains are downstream.

Forward and backward lengths. By measuring average propagation lengths in both forward (cost-push) and backward (demand-pull) directions, researchers can identify the relative position of countries or industries within global production networks.

Some studies develop indices that combine participation and position metrics to characterize countries' roles in GVCs, such as whether they are primarily suppliers of intermediate goods or final producers.

1.9. Researchers and papers in GVCs' analysis

Most researchers in the field of GVCs' analysis have focused on three main topics: a) the advantages of participation in global value chains for countries and industries, highlighting benefits such as productivity growth, technology transfer, job creation, and economic upgrading; b) the critical role played by lead firms and multinationals in shaping GVCs; c) the role of governments and public agencies within GVCs, emphasizing their importance in

shaping, regulating, and supporting GVC participation and development. Hereinafter a few exemples:

- Daria Taglioni and Deborah Winkler

Their work (Taglioni & Winkler, 2016) extensively discusses the benefits of GVC participation, including pro-competitive market restructuring effects, knowledge and technology spillovers, infrastructure improvements, and labor market benefits such as higher demand for skilled labor and training effects. They emphasize how GVC participation can raise overall productivity and sustain economic development. They stress that governance decisions influence the form of GVC participation and mediate the impacts on development outcomes, highlighting the importance of understanding governance for policy design. Their comprehensive report discusses how governments must create a world-class climate for foreign tangible and intangible assets, improve drivers of investment, protect foreign assets, and foster domestic value chains and infrastructure. They emphasize the complexity of policy coordination across trade, investment, labor markets, education, and infrastructure to support GVC integration and upgrading. They also highlight the challenges governments face in regulating standards and competition within GVCs, which often involve voluntary and private codes of conduct.

- Olivier Cattaneo, Gary Gereffi, Stefano Miroudot, and Daria Taglioni

Their strategic framework in (Cattaneo et al., 2013) addresses how countries can maximize the benefits of GVC participation by improving backward linkages, enhancing competitiveness, and managing risks. They emphasize the role of public policies and multi-stakeholder cooperation in capturing more value-added and fostering economic upgrading. Moreover, they highlight the critical role of public policies and multi-stakeholder cooperation in maximizing the benefits of GVC participation. They discuss how governments can improve backward linkages, enhance competitiveness, and manage risks by designing policies that align with the governance structures of GVCs. They also stress the need for cooperation with the private sector to regulate business behavior, especially given the rise of private standards and borderless trade barriers in GVCs.

- Victor Kummritz, Daria Taglioni and Deborah Winkler

In Kummritz et al., 2017, the authors analyze policies that increase value-added gains from GVC participation, highlighting the importance of national policies in mediating the effects of GVC integration on economic upgrading, including technology spillovers, skills upgrading, and infrastructure investments. Their research focuses on how national policies mediate the effects of GVC participation on economic upgrading. They find that policies related to input quality, infrastructure, skills upgrading, and market competition significantly influence the value-added gains countries derive from GVC integration. This underscores the importance of government action in creating an enabling environment for GVC benefits to materialize.

- Vito Amendolagine, Andrea F. Presbitero, Roberta Rabellotti and Marco Sanfilippo

Their study in (Amendolagine et al., 2019) investigates local sourcing in developing countries and the role of foreign direct investment (FDI) and GVCs in improving local supplier capabilities, production quality, and knowledge transfer, which contribute to economic benefits for host countries.

- Davide Del Prete, Giorgia Giovannetti, and Enrico Marvasi

Their research in Del Prete et al., 2018 focuses on North African countries and discusses how integration into GVCs can lead to increased productivity and growth through knowledge and technology flows, although benefits depend on the positioning within the value chain. They also stress the importance of trade facilitation and favorable regulations to boost GVC participation.

- Aleksandra Kordalska and Magdalena Olczyk

In Kordalska & Olczyk, 2023 the authors explore the functional specialization approach and the "smile curve" concept, showing that participation in GVCs is linked to productivity growth and job creation, especially in middle- and high-income countries. They discuss how countries can move up the value chain to capture higher value-added activities.

- Artur Klimek

The author (Klimek, 2024), analyzes economic upgrading through GVC participation, particularly for Central and Eastern European economies. He highlights that GVC

participation offers long-term cooperation opportunities, stability in firm-to-firm relations, and specialization in specific production stages, which can foster economic upgrading and growth.

- Gary Gereffi and Karina Fernandez-Stark

Their foundational work (Gereffi & Fernandez-Stark, 2018b). defines GVC governance in terms of power and authority relationships that determine resource allocation within the chain. They introduced the distinction between buyer-driven and producer-driven chains, highlighting how lead firms – such as large retailers or integrated industrial enterprises – control and coordinate global production networks. This typology has been further elaborated into five governance structures: market, modular, relational, captive, and hierarchy, based on transaction complexity, codifiability, and supplier capabilities Stacey Frederick

The author emphasizes the role of lead firms in setting standards and controlling supplier relationships, which can be supportive or exploitative. Their research discusses how governance shapes the distribution of value and power asymmetries in GVCs, particularly in producer-driven (capital- and technology-intensive) versus buyer-driven (labor-intensive consumer goods) chains (Frederick, 2014)

- Stefano Ponte, Gary Gereffi, and Gale Raj-Reichert

In their handbook on GVCs, they analyze governance as the organizational and strategic decisions by lead firms that manage access to final markets globally. They highlight how governance involves choices about in-house production versus outsourcing and the management of supplier networks, including the role of states and other actors in shaping governance dynamics They also analyze the governance of GVCs and the role of states and international organizations as key actors that construct and maintain GVCs through facilitative, regulatory, and distributive interventions. They note that states can act as intentional architects of GVCs by regulating or deregulating their functioning and choosing whether to redistribute the wealth generated through GVCs. States also participate directly in GVCs through state-owned enterprises and public procurement (Ponte et al., 2019b).

- Satoshi Inomata

Inomata's work provides an analytical framework focusing on governance structures and power relations between firms in GVCs. He discusses the spectrum of governance types from hierarchical vertical integration to more leveled outsourcing relationships, emphasizing how governance affects value distribution and firm boundaries. The framework on GVC governance includes the role of public agencies in shaping power relations and governance structures within GVCs. He discusses how governance affects value distribution and firm boundaries, implying a role for government regulation and policy in influencing these dynamics (Inomata, 2017).

1.10. Current global trends affecting Global Value Chains

Current global trends affecting Global Value Chains (GVCs) reflect significant structural shifts in trade, production, and the organization of global industries. These trends have significant implications for trade in value added, reshaping how value is created, distributed, and measured across countries and industries. The key impacts of these trends on GVCs and trade in value added are as follows (van Zijl & Koster, 2024; Eissa & Zaki, 2022); VV.AA., 2019):

- Declining trade intensity in goods-producing value chains

Although global trade volumes continue to grow in absolute terms, the share of goods produced that cross borders has declined. Between 2007 and 2017, the trade intensity in goods-producing value chains fell from 28.1% to 22.5%. This decline is particularly pronounced in complex and highly traded value chains such as automotive and electronics. The trend reflects emerging economies like China consuming more of their own production domestically, leading to less cross-border trade relative to output. The observed decline in the share of goods crossing borders relative to gross output means that a smaller portion of value added embodied in goods is traded internationally. This reflects emerging economies, notably China, increasingly consuming domestically produced goods rather than exporting them. Consequently, the composition of value added trade shifts, with more value added being retained domestically and less embodied in cross-border shipments of goods

- Rising importance and growth of services in GVCs

Services trade is growing more than 60% faster than goods trade and contributes significantly to the value added in GVCs. Services include not only traditional trade in services but also value-added services embedded in goods, intangibles sent to foreign affiliates, and free digital services. This shift highlights the increasing knowledge intensity and complexity of GVCs, with intangible assets such as R&D, brands, and intellectual property becoming more central. This trend increases the share of value added in trade that is service-based, highlighting the need to account for services value added in GVC analysis beyond conventional goods trade measures.

- Shift toward regional concentration and proximity to markets

Goods-producing value chains are becoming more regionally concentrated, especially within Asia and Europe. Companies are increasingly locating production closer to demand centers to improve responsiveness, reduce logistics costs, and manage risks. This regionalization trend is accompanied by a strategic emphasis on flexibility, speed to market, and building closer supplier relationships, including digital integration and upgrading of supplier capabilities. This regional clustering reduces the number of border crossings for intermediate goods, potentially lowering the measured trade in value added across distant countries but increasing intra-regional value-added trade. Regional trade agreements and harmonization of standards facilitate this process, enhancing the efficiency and value capture within regions.

- Increasing knowledge intensity and skill requirements

GVCs are becoming more knowledge-intensive, relying more on high-skill labor and investment in intangible assets. This trend is linked to the growing role of innovation, technology transfer, and learning within GVC participation. Firms embedded in GVCs face competitive pressures that stimulate innovation and technological upgrading, especially through backward linkages that incorporate foreign knowledge and inputs. The growing reliance on intangible assets such as R&D, brands, and intellectual property raises the knowledge content of value added traded. This shift means that value added embodied in exports increasingly includes high-skill, innovation-driven components, which are often less visible in traditional trade statistics but critical for economic upgrading. It also implies that countries with strong capabilities in knowledge-intensive activities can capture higher shares of value added in GVCs.

- Changing nature of trade barriers and governance

Traditional trade barriers such as tariffs and quotas have declined, but new barriers have emerged behind borders and beyond, including non-tariff measures (NTMs), private standards, and voluntary codes of conduct imposed by lead firms. These borderless and private regulations create complex governance challenges for countries and firms participating in GVCs. Effective policy responses require cooperation between public agencies and the private sector to manage these evolving barriers and ensure competitiveness. The rise of NTMs introduces new forms of trade costs that affect the flow and measurement of value added. These barriers can increase the cost and complexity of cross-border value-added trade, influencing firms' sourcing and production decisions and potentially fragmenting value chains differently than traditional tariff-based barriers. This evolution requires more nuanced policy and governance approaches to facilitate value-added trade (Cattaneo et al., 2013).

In recent years, however, traditional trade barriers have re-emerged with renewed force. A notable wave of tariff increases and strategic industrial policy measures began in 2025 in the United States, with the introduction of "reciprocal tariffs" and sector-specific duties on steel, aluminium, semiconductors, vehicles, and other key inputs (White House Presidential Memorandum, 2 April 2025). These actions—justified by national security, trade deficit concerns and supply-chain resilience—have prompted firms to reconsider global production architectures by shifting toward near-shoring, friend-shoring or diversification strategies. The combined effect of new non-tariff regulation and the revival of tariff-based protectionism suggests a gradual reconfiguration of global value chains: production networks may become less globally integrated and more regionally concentrated, reducing efficiency gains from specialization and limiting the diffusion of technological spillovers that value-chain participation has historically enabled.

- Policy and institutional environment as a key mediator of GVC benefits

The gains from GVC participation are not automatic and depend heavily on country-specific policies, institutions, and infrastructure. National policies related to connectivity, education, skills development, standards, and trade facilitation significantly influence the extent to which countries can upgrade economically through GVCs. Governments play a critical role in

creating an enabling environment for firms to capture value and innovate within GVCs (Kummritz et al., 2017), (Del Prete et al., 2018), (Taglioni & Winkler, 2016)

- Emergence of a multipolar GVC world with diverging performances

The global economy is increasingly multipolar, with major GVC hubs including China, the European Union, and the United States dominating trade flows. However, there is significant heterogeneity in GVC participation and benefits across regions and countries, with developing countries often positioned in lower value-added segments. As for impact on value added traded, countries positioned upstream (with more forward linkages) tend to export value added that is further processed abroad, while downstream countries (with more backward linkages) import foreign value added embedded in their exports. This positioning affects the distribution and measurement of value added in trade flows and underscores the importance of strategic policies to foster upgrading and integration into higher-value segments of GVCs (Taglioni & Winkler, 2016).

- Digitalization and technological innovation transforming GVCs

Advances in digital technologies such as cloud computing, the Internet of Things, and big data are reshaping GVCs by enabling new business models, enhancing productivity, and altering power relations within value chains. Digital tools facilitate coordination, reduce transaction costs, and open opportunities for smaller firms and developing countries to participate more effectively in GVCs. Moreover, digitalization increases the share of intangible value added, which is often embedded in services and intellectual property (van Zijl & Koster, 2024).

1.11. Policy implications

Global Value Chains (GVCs) have significant implications for policymakers, requiring a nuanced and multi-dimensional approach to maximize benefits and address challenges associated with participation in GVCs.

- Policy coordination and integration

Policymakers need to adopt a global or regional perspective rather than a purely national one, as GVCs involve cross-border production and trade in tasks rather than entire products. This shift demands coordination across multiple policy areas and government ministries, including

trade, investment, infrastructure, education, and innovation policies (Engel & Taglioni, 2017; Qiang et al., 2021).

- Economic upgrading and firm capabilities

GVC participation offers opportunities for economic upgrading, moving from low-value to higher-value activities such as product, process, functional, and intersectoral upgrading. Policymakers should focus on creating an enabling environment that supports firms in acquiring skills, technology, and capabilities to move up the value chain. This includes fostering innovation systems, improving labor skills, and supporting domestic firms to engage with multinational corporations (Gereffi, 2019; Engel & Taglioni, 2017).

- Investment policies and market failures

Governments play a critical role in attracting Foreign Direct Investment (FDI) and linking multinational corporations (MNCs) with domestic firms to stimulate GVC participation. Investment policies should address market failures such as coordination problems, information asymmetries, and externalities by providing targeted incentives, improving infrastructure, and facilitating strategic alliances (Qiang et al., 2021).

- Trade agreements and regulatory harmonization

Deep preferential trade agreements (PTAs) that go beyond tariff reductions to include regulatory cooperation in services, investment, intellectual property, and competition policy are essential to support GVCs. Such agreements reduce cross-border policy frictions and enhance the smooth functioning of fragmented production networks. Policymakers should aim to negotiate and implement deep trade agreements with partners that have complementary GVC positions and similar policy preferences to reduce coordination costs (Ruta, 2017).

- Addressing uneven development and inclusion

GVCs can reproduce uneven development geographically and socially. Policymakers must be aware of the risks of exclusion and downgrading in certain regions or sectors. Strategies should include supporting small and medium enterprises (SMEs), promoting inclusive labor market policies, and ensuring social and environmental standards to create sustainable and equitable growth (Gereffi, 2019; Engel & Taglioni, 2017).

- Institutional development and policy sequencing

As countries develop and deepen their GVC engagement, institutions must evolve to support more complex activities such as R&D, branding, and coordination. Predictability, policy stability, and coordination among different government levels become increasingly important. Sequencing reforms – such as developing infrastructure before liberalizing trade or investment – can enhance the effectiveness of policies aimed at upgrading within GVCs (Engel & Taglioni, 2017).

- Managing risks and building trust

The future of GVCs depends on trust and cooperation among countries. Policymakers face a "trust dilemma" where the willingness to maintain open trade policies and deep agreements is crucial to avoid protectionism and re-nationalization of production. Maintaining a cooperative equilibrium requires credible commitments and managing expectations to sustain GVC integration (Ruta, 2017).

1.12. Conclusions

World trade has evolved from traditional bilateral exchanges of finished goods to complex, geographically dispersed production networks coordinated by lead firms. This evolution has been accompanied by the rise of emerging economies, regionalization alongside globalization, and increasing organizational concentration within GVCs, all of which have reshaped the global economic landscape over recent decades

The five types of global value chains—market, modular, relational, captive, and hierarchy—reflect varying degrees of power asymmetry, complexity, and coordination between lead firms and suppliers, shaping how value is created and distributed across global production networks.

The key theoretical frameworks on GVCs and VS collectively explain the fragmentation and governance of global production, the measurement of value added across borders, and the strategic organizational decisions by firms within these complex networks. These theories provide critical insights into the economic, social, and policy implications of globalization and international trade in the contemporary world economy.

Economic literature has evolved from viewing international trade as the exchange of finished goods to a more nuanced understanding of fragmented production processes coordinated through GVCs. The development of TiVA statistics and the concept of vertical specialization have provided empirical and theoretical tools to analyze the complex interdependencies in global production, governance, and economic outcomes. This evolution reflects a multidisciplinary approach integrating economics, sociology, geography, and international business studies.

The study of global value chains integrates insights from international business, economic sociology, economic geography, international economics, supply chain management, institutional studies, and development economics. This multidisciplinary approach enables a comprehensive understanding of the governance, spatial organization, economic impacts, and strategic management of GVCs

Current global trends in GVCs are characterized by a shift toward less trade-intensive but more knowledge and service-intensive production, greater regionalization, evolving governance challenges with new types of trade barriers, and the critical role of national policies and digital technologies in shaping participation and upgrading opportunities. These trends reflect a complex and dynamic global trade environment where competitiveness increasingly depends on innovation, institutional quality, and strategic integration into global networks.

Many researchers in the field of GVCs studies and analysis have addressed the topic of advantages for countries to be part of GVCs. These authors collectively contribute to a nuanced understanding of GVC governance, emphasizing the pivotal role of lead firms and multinationals in controlling production networks, shaping supplier relations, and influencing economic and developmental outcomes within global industries. They show that governments and public agencies are pivotal in shaping the institutional, regulatory, and policy environments that enable countries and firms to participate effectively in GVCs, capture more value, and achieve sustainable development outcomes.

Policymakers must adopt integrated, multi-sectoral strategies that combine horizontal improvements in the business environment with targeted sectoral policies. They should foster

skills development, innovation, and institutional quality while engaging in deep trade agreements that facilitate cross-border production. Addressing social inclusion and environmental sustainability alongside economic upgrading is essential for leveraging GVC participation for long-term development

CHAPTER 2 – THE ROLE OF GLOBAL GVCs LINKAGES ON ECONOMIC UPGRADING

Abstract

This chapter investigates whether countries' participation in global value chains (GVCs) fosters domestic output growth. Using the OECD–TiVA country-year panel for 80 economies over 2006–2022, the analysis estimates fixed-effects models with lagged GVC indicators to address potential reverse causality. The results show a positive and statistically significant relationship between forward GVC participation and GDP, whereas backward linkages exhibit a weaker effect. These findings highlight the asymmetric role of upstream versus downstream positions in shaping the gains from global production networks.

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2.1. Introduction

Over the past two decades, the international fragmentation of production has profoundly reshaped the geography of economic activity and the nature of trade integration. Global Value Chains (GVCs) have become the dominant mechanism through which countries participate in global flows of goods, services, capital, and knowledge. This increasing interdependence has complicated the traditional relationship between trade openness and economic growth, highlighting the need for analytical frameworks that explicitly account for how countries create and capture value within global production networks. In this context, a focus on value-added linkages rather than gross trade flows is essential to assess how globalization translates into domestic output gains.

This chapter investigates whether deeper participation in GVCs fosters domestic GDP growth, considering both forward linkages—the domestic value added embodied in foreign exports which reflect a country's upstream position and its capacity to supply inputs to downstream production abroad—and backward linkages, the foreign value added embodied in domestic gross exports.

Forward participation is interpreted as an indicator of structural competitiveness and productive capability, since it measures the degree to which domestic industries are embedded

in the downstream segments of global value chains as suppliers of intermediate goods and services to other countries' exports. A high level of forward integration suggests that national firms contribute significantly to the global production process through the provision of inputs with higher technological or knowledge content. This position allows economies to benefit from economies of scale, learning-by-exporting dynamics, and international knowledge spillovers, thereby fostering productivity and upgrading opportunities across sectors. Forward linkages thus capture the ability of a country to position itself as a relevant provider of value added within global production networks.

Backward participation, in turn, reflects the extent to which domestic production relies on foreign intermediate inputs, embodying a country's capacity to access, combine, and upgrade imported technologies, components, and services within its own value creation process. High backward integration indicates strong connections to international supply networks and facilitates efficiency gains through exposure to advanced inputs and process innovations. However, excessive dependence on foreign value added may also reveal limited domestic embedding and weaker local spillovers, underscoring the importance of a balanced integration strategy that combines openness with domestic capability development.

In this study, both measures of GVC participation are defined as trade flows that cross at least two international borders – that is, value added originating in country *i* and embodied in intermediate or final goods that are subsequently re-exported by country *j*. This definition captures the essence of global value chains as multi-stage production processes spanning several economies.

The empirical analysis relies on the OECD Trade in Value Added (TiVA) database, using the country–year panel version, which enables a consistent reconstruction of domestic and foreign value-added flows. The use of TiVA data at the country level provides a distinctive methodological advantage: it allows coverage of all available economies and, crucially, the possibility to derive bilateral or regional aggregates of GVC linkages—thus going beyond the "world-as-partner" limitation of the sectoral three-dimensional TiVA dataset.

Before presenting the econometric results, Appendix B provides a detailed overview of the descriptive evidence. It documents the evolution of key value-added trade indicators –

domestic value added (DVA), foreign value added (FVA), and forward and backward GVC participation – over the 1995–2022 period. The appendix reports both global aggregates and country-level trajectories for selected major economies, illustrating the increasing international fragmentation of production and the progressive rise of cross-border value-added trade. These descriptive trends help contextualize the empirical analysis by highlighting the structural differences in how countries integrate into global production networks and the relative importance of domestic versus foreign contributions to exports.

Methodologically, the chapter pursues two main goals. First, it estimates the relationship between GVC participation and domestic economic performance, assessing whether greater integration into global production networks translates into higher levels of output. Second, it evaluates the robustness of this relationship to alternative specifications and extensive post-estimation diagnostics. To mitigate potential endogeneity and reverse causality—since higher GDP could itself stimulate GVC integration—the preferred identification strategy uses a fixed-effects (FE) specification with key regressors lagged by one year ($t-1$). This approach ensures temporal coherence and reduces mechanical feedback from contemporaneous output changes.

The baseline model includes, in addition to the main explanatory variable (GVC_F), a comprehensive set of control variables capturing relevant macroeconomic dimensions: domestic value added in pure exports (EX_VA), overall trade openness (exports + imports over GDP), GDP growth, and foreign direct investment (FDI). All models include country and year fixed effects to control for unobserved heterogeneity and global shocks, while extended versions incorporate country-specific linear trends to capture slow-moving structural dynamics.

The empirical design follows a logic of increasing complexity. It starts with a naive FE model estimated with conventional standard errors, then progressively introduces corrections for heteroskedasticity and serial correlation through clustered standard errors at the country level, and finally employs Driscoll–Kraay (DK) standard errors robust to cross-sectional dependence. Country-specific trends and lagged regressors are subsequently added, defining the benchmark model adopted throughout the chapter.

Alongside the main estimations, a comprehensive post-estimation diagnostic framework is implemented to validate model assumptions and assess robustness. The tests include: the Modified Wald test for heteroskedasticity, the Wooldridge test for serial correlation, the Pesaran CD test for cross-sectional dependence, the placebo lead test for reverse causality, Variance Inflation Factors (VIF) for multicollinearity, the Linktest and Ramsey RESET for functional-form validity, and graphical inspections of residuals. All diagnostics confirm the consistency and reliability of the lagged FE specification as the preferred empirical model.

The main findings, discussed in Section 2.4.3, reveal a positive and statistically significant effect of forward GVC participation on domestic GDP, supporting the hypothesis that upstream integration in global production networks fosters productivity, efficiency, and value-creation capacity. The stability of the estimated coefficient for *L.GVC_F* across specifications, together with its economic significance, reinforces the interpretation of GVC participation as a durable driver of growth.

2.2. Literature Review of empirical works on the specific topic

A growing body of empirical work has investigated how countries' participation in global value chains (GVCs) affects their capacity to generate and upgrade domestic value added. Early contributions such as Cattaneo et al. (2013) framed GVC integration as a strategic process of joining, learning, and upgrading, emphasizing the interplay between trade and investment policies, and the growing role of non-tariff barriers and private standards in shaping competitiveness. Building on this conceptual foundation, more recent empirical studies have quantified the economic effects of GVC participation using multi-country input–output databases such as OECD-TiVA, WIOD, and Eora.

For instance, Kummritz, Taglioni, and Winkler (2017) show that participation in GVCs fosters domestic value creation, particularly through the forward channel, where economies specialize as suppliers of intermediate inputs to global production networks. They also highlight that complementary policies—such as improved infrastructure, quality standards, and human capital—amplify these gains. Similarly, Klimek (2024) finds that in Central and Eastern Europe, backward linkages help countries build integration into global production, yet foreign

direct investment (FDI) may reduce the domestic content of exports when it locks economies into low value-added assembly stages.

Regional and sectoral heterogeneity emerges as a recurrent theme. Del Prete et al. (2018), examining North African economies, identify significant differences across industries: extractive and resource-based sectors tend to occupy upstream (forward) positions, while manufacturing sectors—especially textiles and food—are predominantly downstream (backward). Amendolagine et al. (2019) further document that participation in GVCs and FDI inflows foster local sourcing in developing countries, suggesting that the development of domestic supply capabilities can mediate the benefits of global integration.

Beyond value creation, other studies explore broader structural outcomes. Duarte et al. (2022) find a non-linear relationship between GVC position and inequality: moving toward either end of the value chain tends to reduce between-country inequality, but may amplify within-country disparities. Kordalska and Olczyk (2023) link functional specialization to upgrading, showing that Central and Eastern European economies with stronger backward linkages and wage convergence shift gradually toward R&D and management activities. Finally, van Zijl and Koster (2024) provide complementary evidence that greater GVC embeddedness is associated with higher innovation performance among European economies, underscoring the knowledge-diffusion dimension of cross-border production networks.

Taken together, this literature consistently finds that GVC participation contributes positively to growth and upgrading, though the magnitude and channels of transmission depend on structural characteristics such as sectoral composition, policy environment, and technological capability. The empirical framework adopted in this chapter builds on these foundations, extending the analysis to a global country–year panel based on OECD-TiVA data to test whether forward and backward integration exert distinct and robust effects on domestic GDP across the world economy.

2.3. Research question, data and variables construction

This chapter investigates whether deeper participation in global value chains (GVCs) fosters domestic output. The empirical analysis relies on the OECD-TiVA country–year panel, which allows for a consistent measurement of both forward and backward linkages in international

production networks. The central research question is whether increased integration into global production systems enhances a country's economic performance by expanding the domestic value added generated along global supply chains.

Specifically, the analysis examines whether countries that are more strongly involved in GVCs – either as suppliers of intermediate inputs to foreign production (forward participation) or as users of foreign inputs in their own exports (backward participation) – exhibit higher levels of output, proxied by current-price GDP. The approach tests the hypothesis that deeper GVC engagement can act as a channel for productivity spillovers, technology diffusion, and greater specialization advantages, ultimately contributing to domestic growth.

The dependent variable is current GDP. The key regressors capture forward GVC participation (domestic value added supplied to foreign exporters, hereinafter GVC_F) and backward GVC participation (foreign value added embodied in domestic gross exports, hereinafter GVC_B).

In order to distinguish between different types of trade linkages, the analysis includes domestic value added in pure exports (EX_VA) and foreign value added in domestic final consumption (IM_VA) as control variables. These indicators help to separate trade flows that are part of Global Value Chain (GVC) activities – both Forward and Backward linkages – from more traditional import and export flows that do not involve GVC participation. This distinction allows for a clearer understanding of how global production networks contribute to trade dynamics compared to standard international exchanges.

By controlling for EX_VA and IM_VA, the specification accounts for the distinct role of value-chain integration in shaping trade patterns, thus avoiding potential bias arising from conflating GVC and conventional trade dynamics.

Other control variables include trade openness (exports+imports over GDP), GDP growth, and FDI stock from World Bank-WDI and Unctad.

All series are aligned to ensure consistent units. All continuous variables have been log-transformed to reduce skewness and interpret coefficients as elasticities. Throughout the text, log denotes the natural logarithm (ln).

The construction of the variables follows the OECD TiVA (Trade in Value Added) methodological framework. Forward and backward GVC participation measures are derived from the decomposition of gross exports into domestic and foreign value-added components. Participation measures are expressed in levels (current $ mln). Forward participation (GVC_F) reflects the domestic value added embodied in foreign countries' exports, while backward participation (GVC_B) measures the foreign value added incorporated into a country's own exports. Control variables such as EX_VA, IM_VA, and FDI stock are expressed in levels as well (current $ mln). All monetary variables are transformed into logarithms to reduce skewness and interpret coefficients as elasticities. The analysis relies on a balanced panel covering 80 countries over the period 2006–2022 (T=17). Further details on variable definitions and construcion, data sources, non-TiVA indicators and country coverage are provided in the dedicated Appendix A.

Consistent with identification concerns, the main specification uses regressors lagged by one year $(t-1)$ for GVC_F, GVC_B to mitigate reverse causality. Calendar-year fixed effects control for global shocks, while country fixed effects absorb time-invariant heterogeneity.

The model employs the stock of foreign direct investment (FDI stock) in lagged form (t−1) rather than contemporaneous, for both economic and econometric reasons. From an economic standpoint, the impact of FDI on domestic output typically materializes with a time lag, since productive investments require time to translate into installed capacity, technological transfer, and stronger integration in global production networks.

By introducing the stock of FDI at time t−1, the model reduces simultaneity bias and strengthens the causal interpretation of the estimated coefficient. Moreover, the stock measure reflects the persistent level of external financial openness and the country's absorptive capacity to benefit from global production linkages, ensuring greater temporal stability and robustness of the estimates.

2.4. Results for Forward GVC linkages

2.4.1. Empirical strategy

The baseline fixed-effects (FE) model is:

$$GDP_{it} = \beta\, GVC\_F_{i,t-1} + \gamma' X_{i,t} + \alpha_i + \tau_t + \varepsilon_{it},$$

where α_i are country fixed effects and τ_t year fixed effects; $X_{i,t}$includes controls (e.g., EX_VA, Open, GDP_g, $L.FDI$). In extended specifications, we allow for country-specific linear trends ($\delta_i \cdot t$) to capture slow-moving country-level dynamics.

$$GDP_{i,t} = \beta\, GVC\_F_{i,t-1} + \gamma' X_{i,t} + \alpha_i + \tau_t + \delta_i \cdot t + \varepsilon_{i,t}$$

Backward linkages:

$$GDP_{i,t}) = \beta\, GVC\_B_{i,t-1} + \gamma' X_{i,t} + \alpha_i + \tau_t + \delta_i \cdot t + \varepsilon_{i,t}$$

Identification. Within-country variation over time identifies β. Lagging key regressors (t−1) reduces mechanical feedback from output to GVC integration; remaining concerns from time-varying omitted variables are mitigated by rich time FE, country trends (when used), and an extensive diagnostics/robustness program (Section 2.4.2).

Model choice (FE vs RE). FE and RE are compared using Hausman (sigmamore) and the Mundlak correlated random-effects (CRE) test. Significant Mundlak means imply correlated unit effects, favoring FE; this is the maintained specification throughout.

Inference is based on country-clustered robust standard errors vce(cluster CountryID), which are consistent under heteroskedasticity and AR(1) within panels. As a robustness check, we also report Driscoll–Kraay (DK) SE (provided in Appendix D, Tables D1, D2), robust to heteroskedasticity, serial correlation, and cross-sectional dependence. Point estimates are comparable; differences in p-values reflect alternative error structures.

We implement a compact but comprehensive diagnostics plan on the main lagged FE model:

- Heteroskedasticity across panels. Modified Wald test on FE residuals; rejection motivates cluster-robust SE (our baseline choice).
- Serial correlation. Wooldridge AR(1) test; if present, cluster SE remain appropriate; DK is shown as robustness.
- Cross-sectional dependence. Pesaran CD test; non-rejection supports cluster SE; if detected, DK provides a robustness benchmark.
- Placebo timing (lead test). Inclusion of $GVC_F_{i,t+1}$checks for reverse causality; non-significance supports the causal direction from GVC to GDP.
- Multicollinearity. Variance inflation factors (VIF); high VIF among trade/GVC indicators is documented and handled via careful interpretation and alternative specifications.
- Functional form. Linktest and Ramsey RESET; when RESET flags sensitivity, we verify with quadratic terms and interactions; lack of significance of non-linear terms supports linearity.
- Residual diagnostics. Visual checks and normality (asymptotic) for completeness; inference relies on robust SE, not normality (see Appendix D, Tables D1).

2.4.2. Post-estimation diagnostics results

All diagnostic outcomes are summarized in Table 1.

The Modified Wald test indicates strong heteroskedasticity across countries ($\chi^2(80)$ = 46,810.8; $p < 0.001$), confirming the appropriateness of using cluster-robust standard errors at the country level. The Wooldridge test reveals first-order serial correlation in the panel ($F(1,79) = 241.55$; $p < 0.001$), implying temporal dependence that is likewise handled through clustered standard errors. In contrast, the Pesaran CD statistic (CD = 0.853; p = 0.393) provides no evidence of cross-sectional dependence, suggesting that contemporaneous correlations across countries are limited within this specification.

The placebo lead test returns a non-significant coefficient for GVC_F(t+1) (p = 0.104), supporting the absence of reverse causality between GVC participation and domestic output.

The Variance Inflation Factors (VIF) show moderately high values for some regressors—particularly L.GVC_F and EX_VA—indicating a strong structural correlation but not an alarming level of multicollinearity. In this case, the stability of signs and the persistence of significance across specifications suggest that multicollinearity does not compromise the robustness of the results, although it should be acknowledged as a limitation.

The link test and the non-significant quadratic term confirm the plausibility of the linear functional form, while the Ramsey RESET test detects some degree of sensitivity, already accounted for through model respecification and inclusion of interaction terms. Finally, the Shapiro–Wilk normality test suggests non-normal residuals ($z = 7.68$; $p < 0.001$), but this does not affect inference validity given the use of robust variance estimators.

Table 1 – Forward linkages. Post-estimation diagnostic tests (benchmark FE model, lagged regressors t − 1).

Test	Purpose	Statistic / Test Value	p-value	Outcome	Economic / Inference Implication
Modified Wald test (FE)	Heteroskedasticity across panels	$\chi^2(80)$ = 46,810.80	0.0000	✗ Present	Heteroskedasticity detected → cluster-robust SE required
Wooldridge test for serial correlation (xtserial)	First-order autocorrelation within panels	F(1,79) = 241.6	0.0000	✗ Present	Serial correlation present → cluster-robust SE still valid; DK errors shown as robustness
Pesaran CD test	Cross-sectional dependence	CD = 0.853	0.393	☑ Not present	No evidence of cross-sectional dependence → clustered SE sufficient
Placebo lead test (t+1)	Reverse causality check	Coeff. on GVC_F(t+1) = 0.062 (p=0.104)	0.104	☑ Non-significant	No evidence of reverse causality from GDP to GVC
VIF test for multicollinearity	Multicollinearity among regressors	VIF avg ≈ 8.0, max = 200.7 (GVC_F), 169.6 (EX_VA)	–	⚠ High for some variables	Strong linear association between GVC_F and EX_VA; interpret coefficients with caution
Linktest	Functional-form specification test	_hat² = 0.0005	0.265	☑ Non-significant	plausible linearity
Ramsey RESET (ovtest)	Omitted variables / functional form	F(3,1256) = 22.67	0.000	⚠ Sensitivity detected	Possible misspecification → quadratic term added and not significant
Quadratic term for L.GVC_F	Direct test for non-linearity	Coeff. on $(L.GVC\_F)^2$ = 0.0037	0.647	☑ Non-significant	Relationship between GVC_F and GDP confirmed as linear
Shapiro–Wilk W test for normal data	Normality check	z = 7.68	0.000	⚠ Deviation from normality	Inference based on robust SE remains valid
Residual diagnostics	Visual and normality checks	Graphical inspection	_	☑ Acceptable	No systematic outlier pattern; inference based on robust SE remains valid

Overall, the diagnostic results confirm that, despite heteroskedasticity and serial correlation, the fixed-effects specification with clustered standard errors provides reliable and internally

consistent estimates for the relationship between GVC forward participation and domestic output.

2.4.3. Regressions results

The empirical analysis covers the period 2006–2022. Although TiVA data are available since 1995, the earlier years were excluded because of missing values in some control variables and to ensure a balanced and consistent panel. This period also captures the most recent phase of GVC expansion, providing a more relevant picture of current global trade dynamics.

Table 2 presents the main estimation results for the fixed-effects (FE) panel models, incorporating clustered standard errors and country-specific trends. We report, for each specification: coefficients with robust SE, stars for conventional significance levels, within- and overall R^2, F-statistics, number of observations and countries. Full results of all models specifications and variables are provided in the dedicated Appendix D (Tables D1).

Across all specifications, the coefficients associated with forward GVC participation (GVC_F; $L.GVC\_F$) is positive and statistically significant, confirming that stronger integration into global production networks enhances countries' output performance. The estimated elasticity remains remarkably stable across models, ranging between 0.25 and 0.29 depending on the specification, and retains its significance under all inference corrections. This stability indicates that the relationship is not driven by particular assumptions on the error structure and that the within-country variation in GVC participation is a consistent predictor of subsequent GDP levels. The models including lagged regressors exhibit slightly higher within-R^2, suggesting that controlling for reverse causality improves explanatory power and the temporal coherence of the estimated effect.

Table 2. Effects of forward GVC linkages on current GDP – FE models of increasing complexity.

	(1) GDP	(2) GDP	(3) GDP	(4) GDP
GVC_F	0.293***	0.246***		
	(0.081)	(0.067)		
L.GVC_F			0.269***	0.233***
			(0.058)	(0.031)
EX_VA	0.424***	0.384***	0.474***	0.468***
	(0.111)	(0.100)	(0.089)	(0.074)
Open	-0.659***	-0.697***	-0.651***	-0.680***
	(0.112)	(0.090)	(0.110)	(0.090)
N. Observations	1360	1360	1360	1360
N. Countries	80	80	80	80
R^2 (within)	0.8582	0.9375	0.8630	0.9409
R^2 (overall)	0.9734	0.9740	0.9750	0.9769
F-stat	234.98	.	245.32	.
Prob > F	0.000	.	0.000	.

Standard errors in parentheses

All regressions include country and year fixed effects.
Col.1 = FE + Cluster (modello base);
Col.2 = FE + Cluster + trend;
Col.3 = FE + Cluster (t−1), modello principale;
Col.4 = FE + Cluster + trend (t−1);
All models estimated with xtreg or xtscc (FE).
Robust or clustered standard errors as indicated in the specification.
* p < 0.10, ** p < 0.05, *** p < 0.01

Note:
The high F-statistics observed in the fixed-effects models (in the order of more than two hundreds) reflect the strong joint significance of the regressors and the rich informational structure of the panel (large number of observations and time-specific variables). The F-statistic measures the joint explanatory power of the independent variables, and high values indicate that they consistently explain the variation in GDP across countries and over time. Differences in F-values across models (e.g., between clustered and Driscoll–Kraay estimates) arise solely from the different estimation methods for the variance–covariance matrix and do not imply substantive changes in the model's explanatory capacity.

Economically, the positive and significant coefficient of $L.GVC\_F$ (lagged version) implies that greater forward integration – measured as the domestic value added embodied in foreign exports – contributes positively to national output in the following year. A 10% increase in forward GVC participation is associated, on average, with a 2.3-2.7% rise in current GDP, holding other factors constant. This magnitude is consistent with previous evidence (Johnson & Noguera 2017; Constantinescu et al. 2018; Kummirits at al. 2017) and reflects the

productivity and income gains deriving from upstream positions in global value chains. Countries that supply intermediate inputs to foreign producers benefit from knowledge spillovers, scale effects, and higher efficiency in domestic industries, translating into stronger aggregate performance. The use of lagged regressors reinforces the causal interpretation: participation in GVCs at time $t-1$ precedes and contributes to higher domestic output at time t, rather than the reverse.

Among control variables, domestic value added in pure exports (EX_VA**)** displays a positive and significant coefficient, confirming that exports based on domestic content—rather than on re-exports of foreign inputs—support GDP growth.

By contrast, trade openness ($Open$) shows a negative and significant coefficient (approximately -0.65), indicating that, once GVC participation is controlled for, higher trade-to-GDP ratios are associated with lower output levels. This result is not paradoxical: it suggests that purely quantitative trade expansion, unaccompanied by deeper integration in production networks, may entail limited domestic value creation or even leakage of value added through imported intermediates.

2.5. Results for Backward GVC linkages

Backward participation in GVCs reflects the extent to which a country's exports embody foreign value added through imported intermediates.

Unlike forward participation – which captures the domestic value added incorporated into foreign exports – backward integration highlights the reliance on external inputs within the national production process.

While both forms of participation indicate global integration, they represent distinct economic mechanisms: forward linkages emphasize the domestic contribution to global value chains, whereas backward linkages capture the benefits of foreign technology and intermediate inputs.

From a growth perspective, backward participation may support productivity by improving efficiency, facilitating technology transfer, and enabling access to higher-quality inputs. However, excessive reliance on imported intermediates can also constrain domestic value creation, particularly when domestic firms specialize in low-value-added segments of the chain.

2.5.1. Empirical specification

The empirical specification for backward linkages mirrors that used for the forward model, replacing the variable L.GVC_F with L.GVC_B, representing lagged backward GVC participation (t−1).

The estimation framework remains based on fixed effects (FE) with country and year controls:

$$GDP_{it} = \beta\, GVC\_B_{i,t-1} + \gamma' X_{i,t} + \alpha_i + \tau_t + \varepsilon_{it},$$

where α_i are country fixed effects and τ_t year fixed effects; $X_{i,t}$includes controls (e.g., IM_VA, Openness, GDP_g, $L.FDI$).

In extended specifications, a country-specific linear trends ($\delta_i \cdot t$) in introduced to capture slow-moving country-level dynamics.

$$GDP_{i,t}) = \beta\, GVC\_B_{i,t-1} + \gamma' X_{i,t} + \alpha_i + \tau_t + \delta_i \cdot t + \varepsilon_{i,t}$$

In the set of control variables X_{it}, Exports net of GVC (EX_VA) is replaced by imported foreign value added absorbed domestically (IM_VA), while the other controls — trade

openness (Open), GDP growth (GDP_g), and foreign direct investment lagged by one year (L.FDI) — remain unchanged. All models are estimated with clustered robust standard errors at the country level, and robustness is checked using Driscoll–Kraay corrections and country-specific linear trends.

2.5.2. Post-estimation diagnostics results

As in the forward-linkage model, a comprehensive post-estimation diagnostic analysis was carried out to assess the econometric validity of the backward regressions. The results, reported in Table 3, confirm that the preferred lagged FE specification (with clustered SEs) satisfies all major econometric requirements.

Table 3 – Backward linkages. Post-estimation diagnostic tests (benchmark FE model, lagged regressors t − 1)

Test	Purpose	Statistic / Test Value	p-value	Outcome	Economic / Inference Implication
Modified Wald test (FE)	Heteroskedasticity across panels	$\chi^2(80)$ = 21,028.22	0.000	✗ Present	Heteroskedasticity detected → cluster-robust SE required
Wooldridge test for serial correlation (xtserial)	First-order autocorrelation within panels	F(1,79) = 27.91	0.000	✗ Present	Serial correlation present → cluster-robust SE still valid; DK errors shown as robustness
Pesaran CD test	Cross-sectional dependence	CD = 0.414	0.904	☑ Not present	No evidence of cross-sectional dependence → clustered SE sufficient
Placebo lead test (t+1)	Reverse causality check	Coeff. on GVC_F(t+1) = 0.031 (p=0.257)	0.257	☑ Non-significant	No evidence of reverse causality from GDP to GVC
VIF test for multicollinearity	Multicollinearity among regressors	VIF avg ≈ 6.2, max = 117.9 (IM_VA), 80.4 (L.GVC_B), 45,0 (L.FDI)	–	⚠ High for some variables	Strong linear association between GVC_F and EX_VA; interpret coefficients with caution
Linktest	Functional-form specification test	_hat² significant (p=0.000)	0.903	☑ Non-significant	indicazione di possibile non-linearity; tested with quadratic term
Ramsey RESET (ovtest)	Omitted variables / functional form	F(3, 1256) = 6.37	0.000	⚠ Sensitivity detected	Possible misspecification → quadratic term added and not significant
Quadratic term for L.GVC_F	Direct test for non-linearity	Coeff. on $(L.GVC\_F)^2$ = 0.0002 (p>0.10)	0.951	☑ Non-significant	Relationship between GVC_F and GDP confirmed as linear
Shapiro–Wilk W test for normal data	Normality check	z = 7.53	0.000	⚠ Deviation from normality	Inference based on robust SE remains valid
Residual diagnostics	Visual and normality checks	Graphical inspection	–	☑ Acceptable	No systematic outlier pattern; inference based on robust SE remains valid

The Modified Wald test strongly rejects the null hypothesis of homoskedasticity ($\chi^2(80)$ = 21,028.22; $p < 0.001$), indicating the presence of heteroskedasticity across countries.

Accordingly, all regressions are estimated with cluster-robust standard errors at the country level to ensure consistent inference.

Similarly, the Wooldridge test rejects the null of no first-order serial correlation ($F(1,79) = 27.9$; $p < 0.001$), suggesting the presence of autocorrelation within panels. This result further justifies the use of robust or Driscoll–Kraay standard errors as an additional robustness check.

In contrast, the Pesaran CD test (CD = 0.414; p = 0.904) fails to reject the null of cross-sectional independence, suggesting that contemporaneous correlation across countries is not a major issue in the backward model.

The placebo lead regression (coefficient on L.GVC_B(t+1) = 0.031; p = 0.257) yields a non-significant coefficient for the one-period-ahead GVC variable, indicating the absence of reverse causality from GDP to GVC participation.

The VIF diagnostics reveal a high collinearity among certain regressors, particularly IM_VA (VIF ≈ 118) and L.GVC_B (VIF ≈ 80). This result is not unexpected in TiVA data, where imported foreign value added and backward GVC participation tend to move closely together across time and countries. High VIF values do not bias the estimated coefficients, but they do inflate their standard errors, potentially reducing statistical significance.

The linktest (_hatsq non-significant, p = 0.903) confirms that the model is correctly specified in terms of functional form.

By contrast, the Ramsey RESET test ($F(3,1,256) = 6.37$; $p < 0.001$) detects mild sensitivity to omitted variables or higher-order terms. However, a follow-up regression including a quadratic term for L.GVC_B yields a non-significant coefficient (p = 0.951), confirming that the relationship between GVC participation and GDP is linear.

Finally, the Shapiro–Wilk normality test suggests non-normal residuals ($z = 7.53$; $p < 0.001$), but, as for forward linkages, this does not affect inference validity given the use of robust variance estimators.

Overall, these diagnostic results indicate that the econometric specification is statistically sound and robust. Heteroskedasticity and autocorrelation are appropriately corrected, cross-

sectional independence is not violated, reverse causality is absent, and the relationship between backward GVC participation and GDP growth can be considered linear and well specified.

2.5.3. Regressions results

Table 4 presents the main estimation results for the fixed-effects (FE) panel models and reports, for each specification: coefficients with robust SE, stars for conventional significance levels, within- and overall R^2, F-statistics, number of observations and countries.

Table 4. Effects of backward GVC linkages on current GDP – FE models of increasing complexity.

	(1) **GDP**	**(2)** **GDP**	**(3)** **GDP**	**(4)** **GDP**
GVC_B	0.133***	0.133***		
	(0.039)	(0.039)		
L.GVC_B			0.128***	0.098***
			(0.031)	(0.023)
IM_VA	0.638***	0.547***	0.642***	0.556***
	(0.075)	(0.039)	(0.071)	(0.042)
Open	-0.719***	-0.887***	-0.680***	-0.766***
	(0.157)	(0.096)	(0.126)	(0.076)
Constant	3.857***	5.384***	3.858***	5.562***
	(0.632)	(0.291)	(0.655)	(0.357)
N. Observations	1360	1360	1360	1360
N. Countries	80	80	80	80
R^2 (within)	0.8737	0.9553	0.8752	0.9536
R^2 (overall)	0.9794	0.9704	0.9799	0.9704
F-stat	227.54	.	203.42	.
Prob > F	0.000	.	0.000	.

Standard errors in parentheses

All regressions include country and year fixed effects.
Col.1 = FE + Cluster (modello base);
Col.2 = FE + Cluster + trend;
Col.3 = FE + Cluster (t−1);
Col.4 = FE + Cluster + trend (t−1);
All models estimated with xtreg or xtscc (FE).
Robust or clustered standard errors as indicated in the specification.
* p < 0.10, ** p < 0.05, *** p < 0.01

Note:
The high F-statistics observed in the fixed-effects models (in the order of more than two hundred) reflect the strong joint significance of the regressors and the rich informational structure of the panel (large number of

observations and time-specific variables). The F-statistic measures the joint explanatory power of the independent variables, and high values indicate that they consistently explain the variation in GDP across countries and over time. Differences in F-values across models (e.g., between clustered and Driscoll–Kraay estimates) arise solely from the different estimation methods for the variance–covariance matrix and do not imply substantive changes in the model's explanatory capacity.

Complete estimation outputs, including all control variables and fit statistics, are provided in Appendix D (Tables D2).

Across all model specifications, the coefficient associated with L.GVC_B is positive and statistically significant, though smaller in magnitude compared to forward linkages.

The estimated elasticity lies between 0.10 and 0.13, suggesting that a 1% increase in backward GVC participation is associated with a 0.10–0.13% rise in GDP in the subsequent year.
This indicates that integration through imported intermediates contributes positively to domestic output by enhancing efficiency and promoting technology diffusion.

However, the smaller elasticity relative to forward participation suggests that the growth effects are more limited when the domestic economy depends heavily on imported value added.
This pattern aligns with the literature (Johnson and Noguera, 2017; Constantinescu et al., 2018; Kummrits et al., 2017), which finds that forward participation – associated with the export of domestic intermediates – tends to generate more persistent productivity gains.

Among control variables, IM_VA remains positive and significant, indicating that foreign inputs complement domestic production when adequately integrated.
Openness retains a negative coefficient once GVC variables are included, consistent with the idea that trade openness alone, without deep integration into production networks, may yield weaker domestic growth effects.

Taken together, the results from the forward and backward GVC analyses reveal a clear asymmetry in how different types of global integration affect domestic growth.
While both forms of participation foster GDP growth, forward participation generates stronger, more stable, and more persistent effects, as it reflects domestic value added embedded in foreign production. By contrast, backward participation – although beneficial

through efficiency and learning channels – produces smaller and less durable effects, since part of the value created accrues abroad.

This evidence underscores that the quality of integration, i.e. the position of a country along the global value chain, matters more than its intensity.

Economies that develop upstream capabilities and contribute domestic value added to international production processes are better positioned to capture the long-term gains from globalization.

2.6. Conclusions

This chapter has examined the relationship between global value chain (GVC) participation and domestic economic performance across eighty economies over the period 2006–2022.

Building on the OECD–TiVA framework and a fixed-effects identification strategy with lagged regressors, the analysis provides robust evidence that deeper integration into global production networks contributes positively to national output. By distinguishing between forward and backward linkages, the chapter has highlighted the asymmetric roles that upstream and downstream forms of integration play in shaping growth outcomes.

The results reveal a strong, positive, and statistically significant elasticity between forward GVC participation and GDP. Countries that expand their domestic value added embodied in foreign exports experience higher subsequent levels of output, confirming that upstream integration functions as a key channel of productivity gains. A 10% increase in forward GVC participation is associated, on average, with a 2.3-2.7% increase in GDP in the following year. This magnitude is consistent across model specifications and robust to alternative inference corrections, including clustered and Driscoll-Kraay standard errors. The stability of the coefficient reinforces the interpretation that supplying intermediate inputs to global production processes enhances efficiency, facilitates knowledge spillovers, and supports technological upgrading within domestic industries.

By contrast, the results for backward participation– capturing the use of foreign value added in domestic exports – remain positive but smaller in magnitude, with elasticities between 0.10 and 0.13. This suggests that reliance on imported intermediates promotes efficiency and

technology transfer, but the domestic value captured from such integration is more limited and potentially less persistent. The comparison between forward and backward linkages underscores a crucial asymmetry: while both forms of participation integrate economies into the global production system, only forward linkages consistently translate into higher domestic value creation. The quality of integration, rather than its intensity, appears to determine the long-term growth payoff from globalization.

Control variables behave consistently with theoretical expectations.

From a broader perspective, these findings contribute to the growing evidence that integration into global production networks can serve as a structural engine of economic development.

However, the benefits are not automatic. Forward-oriented integration – characterized by domestic value added embodied in foreign exports – appears to yield more stable and durable gains, as it reflects domestic capabilities, innovation, and the ability to embed national firms in international production hierarchies. In contrast, growth strategies relying predominantly on imported intermediates risk generating limited domestic spillovers if not accompanied by policies that foster upgrading, skill formation, and linkages with local suppliers.

In sum, the results of this chapter suggest that countries' position within global value chains matters as much as their degree of openness. The capacity to generate and export domestic value added to the rest of the world represents a key determinant of sustained economic performance in an era of global interdependence. Strengthening upstream participation in global production networks thus emerges as a strategic avenue for enhancing national value creation, resilience, and long-term growth potential.

CHAPTER 3 – REGIONAL GVC LINKAGES WITH NAFTA AND EAST/SOUTH-EAST ASIA ECONOMIC BLOCS AND THEIR DIFFERENTIATED EFFECT ON ECONOMIC GROWTH

Abstract

The chapter examines whether participation in regional global value chains (GVCs) fosters domestic output growth, focusing on two major production blocs: NAFTA and ASIA-13. Using the OECD–TiVA country-year panel for 2006–2022, the analysis extends the global benchmark model by decomposing GVC linkages into regional components. Fixed-effects estimations with lagged GVC indicators and clustered standard errors are employed to address potential endogeneity and serial correlation. The results confirm that forward linkages have a stronger and more robust effect on GDP than backward linkages, consistent with the global analysis presented in Chapter 2. Moreover, participation in GVCs with the NAFTA area exhibits higher and more stable coefficients than those associated with the Asia-13 bloc, suggesting that the benefits from regional integration are greater in more mature and vertically integrated production systems.

3.1. Introduction

Following the global analysis presented in the previous chapter, this section investigates whether the relationship between participation in global value chains (GVCs) and domestic economic performance varies when countries integrate into specific regional production systems rather than the world economy as a whole. While the global specification captures the aggregate impact of worldwide production networks, it may obscure meaningful differences in how regional hubs transmit growth impulses to economies that are integrated into their supply chains.

Empirical evidence increasingly shows that global value chain activity is highly geographically concentrated, with most cross-border value-added flows occurring within a limited number of regional production poles – most notably North America and East/Southeast Asia. These hubs are characterized by distinctive industrial structures, governance mechanisms, and degrees of technological sophistication.

To explore these differences, the analysis focuses on two major geo-economic clusters: NAFTA (the United States, Canada, and Mexico) and ASIA-13 (China, Hong Kong, and Taipei, together with the ten ASEAN economies). Both represent deeply integrated regional production systems that account for a substantial share of world trade in intermediate goods and manufacturing value added.

The North American production system is among the most mature and technologically advanced in the world. Originating with the North American Free Trade Agreement (NAFTA, 1994) and later deepened through the United States–Mexico–Canada Agreement (USMCA), it forms a highly interconnected manufacturing platform linking upstream and downstream activities across borders. The United States serves as the technological and demand hub, while Mexico and Canada provide complementary strengths in assembly, automotive production, and resource-intensive industries. Extensive empirical work (Feenstra & Hanson, 1997; Hummels, Ishii & Yi, 2001; Timmer et al., 2014) has documented this vertically specialized architecture, where sophisticated cross-border task allocation underpins high productivity and technological diffusion.

In East and Southeast Asia, production networks have evolved into the so-called *Factory Asia*, a dense regional web of intermediate trade, sequential processing, and cross-border specialization. The system connects ASEAN economies with China (including Hong Kong and Taipei) along complex manufacturing chains, particularly in electronics, machinery, and transport equipment. These linkages have been strengthened by successive policy agreements – such as the ASEAN–China FTA and the more recent RCEP and ASEAN–China FTA "3.0" – which aim to harmonize trade rules and promote supply-chain connectivity across the region.

Before turning to the econometric estimations, Appendix B provides a descriptive overview of regional GVC participation patterns. It reports the evolution of forward and backward linkages with the NAFTA and ASIA-13 blocs, as well as the dynamics of domestic (DVA) and foreign (FVA) value added embodied in trade between 1995 and 2022.

The appendix also documents intra-regional shares within each hub, illustrating the degree of regional concentration and the differing intensity of integration across partner economies. These descriptive statistics complement the empirical analysis by contextualizing how global

production networks are geographically structured and how their regional components interact with the world economy.

Methodologically, the regional analysis estimates the impact of participation in GVCs linked to these two hubs for countries outside the blocs themselves.

For the NAFTA case, the sample includes 77 countries (80 in total, excluding the United States, Canada, and Mexico). This ensures that the coefficients capture the external growth effects of integration with the North American production system, rather than intra-bloc trade. Similarly, for ASIA-13, the 13 regional economies are excluded, leaving 67 external partner countries.

This design isolates the *outward spillover effects* of regional production hubs – that is, how participation in the value chains centered on NAFTA or ASIA-13 affects the GDP growth of external economies. The global benchmark models are estimated on the same reduced samples (77 and 67 countries, respectively) to guarantee strict comparability between regional and global participation effects.

This specification allows for a direct evaluation of whether integration into the production systems of major regional hubs yields growth effects that are comparable to, or distinct from, those associated with broader global GVC participation.

3.2. Model Structure

The regional models replicate the empirical specification used in the global analysis but decompose GVC participation into its regional and global components.

In both regional specifications, the analysis focuses on how countries outside each bloc benefit from their integration with it. The NAFTA regressions are estimated on a sample of 77 countries excluding the United States, Canada, and Mexico, while the Asia-13 models include 67 countries excluding the thirteen Asian economies forming the bloc. The main explanatory variables capture the domestic value added of each country embodied in the exports of the partner region (forward linkages) or the foreign value added imported from it (backward linkages). This design isolates the external spillover effects of integration with major regional hubs, rather than the intra-bloc dynamics.

Specifically: variables GVC_F_NA and GVC_B_NA measure, respectively, the *forward* and *backward* GVC participation of countries with NAFTA region, while variables GVC_F_AS

and GVC_B_AS measure the same GVC linkages but with ASIA-13 area. Data are expressed in log-transformed monetary terms. Variables GVC_F_W and GVC_B_W capture the overall level of global integration.

The baseline fixed-effects (FE) model is:

Forward linkages (NAFTA region):

$$GDP_{it} = \beta\, GVC\_F\_NA_{i,t-1} + \gamma' X_{i,t} + \alpha_i + \tau_t + \varepsilon_{it},$$

Backward linkages (NAFTA region):

$$GDP_{it} = \beta\, GVC\_B\_NA_{i,t-1} + \gamma' X_{i,t} + \alpha_i + \tau_t + \varepsilon_{it},$$

Forward linkages (ASIA-13 region):

$$GDP_{it} = \beta\, GVC\_F\_AS_{i,t-1} + \gamma' X_{i,t} + \alpha_i + \tau_t + \varepsilon_{it}$$

Backward linkages (ASIA-13 region):

$$GDP_{it} = \beta\, GVC\_B\_AS_{i,t-1} + \gamma' X_{i,t} + \alpha_i + \tau_t + \varepsilon_{it}$$

World benchmark:

$$GDP_{it} = \beta\, GVC\_F\_W_{i,t-1} + \gamma' X_{i,t} + \alpha_i + \tau_t + \varepsilon_{it}$$

$$GDP_{it} = \beta\, GVC\_B\_W_{i,t-1} + \gamma' X_{i,t} + \alpha_i + \tau_t + \varepsilon_{it},$$

with 77 and 67 countries included for NAFTA and ASIA-13 analysis, respectively.

where α_i are country fixed effects and τ_t year fixed effects; $X_{i,t}$includes controls (e.g., EX_VA, IM_VA, Open, GDP_g, $L.FDI$). As in chapter 2, in the extended specifications, country-specific linear trends ($\delta_i \cdot t$) is included to capture slow-moving country-level dynamics.

The present chapter keeps identical identification and inference of the previous (FE with country and year fixed effects, main regressors lagged at $t-1$, country-clustered SE; country trends when indicated).

For each region, three specifications are estimated for both forward and backward GVC linkages:

1. Baseline FE model, including country and year fixed effects with clustered standard errors by country.
2. FE model with country-specific linear trends, capturing slow-moving unobserved heterogeneity.
3. Driscoll–Kraay (DK) robust specification, accounting for potential cross-sectional dependence.

3.3. Model Diagnostics and Reporting Standards

Baseline diagnostic tests are replicated for the regional specifications to ensure the robustness of the econometric framework. In particular, we re-examine heteroskedasticity, first-order autocorrelation [AR(1)], and cross-sectional dependence for each regional sample and partner block (NAFTA and ASIA-13).

The results are fully consistent with those reported in Chapter 3 for the global model, confirming that the residual structure does not introduce additional bias at the regional level. In all cases, heteroskedasticity across panels remains present, while serial correlation and mild cross-sectional dependence are detected—features typical of macro-panel data with country and time fixed effects.

Accordingly, all regional regressions are estimated using clustered standard errors (by CountryID) to correct for within-country heteroskedasticity and serial correlation, and Driscoll–Kraay standard errors as a robustness check to account for possible contemporaneous correlation across panels. This dual correction strategy ensures that statistical inference remains valid under general forms of dependence, maintaining consistency and comparability with the global baseline model.

Detailed results of all post-estimation diagnostic tests for the four regional specifications – Forward-NAFTA, Backward-NAFTA, Forward-ASIA-13 and Backward-ASIA-13 – are reported in Appendix C, Table C1 to C4).

Results for the main models and variables are reported in two separate tables (Table 5, for NAFTA region and Table 6 for ASIA-13 region), each including:

- Estimated coefficients with clustered or robust standard errors and country specific trend;
- Within and overall R^2, F-statistics, and number of observations/countries;
- Notes specifying fixed effects structure and significance thresholds.

Full results, including DK robust standard errors and estimation results for all variables, are provided in Appendix D (Table D3, D4).

All models were estimated using xtreg and xtscc in *Stata 18 SE,* maintaining complete consistency with the baseline global specification.

Methodological Note – Interpreting Regional GVC Coefficients

This section clarifies how to interpret the coefficients estimated in the regional GVC models for ***NAFTA and ASIA-13****. The specifications mirror those used in the global analysis (Chapter 2) and are estimated in log form, allowing all coefficients to be read as* ***elasticities****.*

All variables related to GVC participation, value-added trade, and FDI are expressed in ***current U.S. dollars and transformed using the natural logarithm****. Hence, each coefficient represents the percentage change in domestic GDP associated with a 1% change in the corresponding GVC flow.*

The regional models capture the ***marginal impact of forward and backward GVC*** *participation with each regional hub (NAFTA or ASIA-13) on domestic output for external partner countries – that is, economies outside the blocs themselves.*

A positive and significant coefficient on forward participation (e.g., GVC_F_NA) indicates that stronger integration as a supplier of intermediate inputs to that region is associated with ***higher domestic value creation****, suggesting learning-by-exporting or technology-transfer effects.*

Similarly, a positive coefficient on backward participation (e.g., GVC_B_NA or GVC_B_ASIA13) points to productivity or ***efficiency gains arising from the import and use of intermediate inputs*** *sourced from the respective regional bloc.*

Insignificant or negative coefficients, by contrast, may signal limited domestic spillovers, weak technological absorption, or dependence on low-value-added tasks.

To ensure comparability, regional and global regressions are estimated on identical country samples – 77 countries for the NAFTA comparison and 67 for ASIA-13 – so that differences in magnitude primarily reflect the structure of integration rather than differences in coverage.

Finally, interpreting cross-bloc differences allows a structural reading of global production asymmetries. Integration into NAFTA-centered networks typically involves high-income economies with established technological capacities and stable governance frameworks, resulting in robust but moderate returns.

In contrast, linkages with ASIA-13 often connect countries to dynamic, export-oriented manufacturing chains where growth and scale effects are larger, but domestic value capture may be more heterogeneous and volatile.

This distinction highlights how the composition, governance, and technological depth of regional hubs shape the extent to which GVC participation contributes to national growth.

3.4. NAFTA vs World: regression results and interpretation

After establishing, in the baseline model of chapter 2, a positive and statistically significant relationship between countries' participation in global value chains (GVCs) and GDP dynamics, the analysis now turns to a more granular exploration of the geographical heterogeneity of this relationship. To this end, the GVC participation indicators (forward and backward linkages) are reconstructed to distinguish flows directed towards specific geo-economic areas, overcoming the aggregate "country vs. world" view. In particular, we separately examine GVC linkages with the NAFTA area (United States, Canada, and Mexico) and with ASIA-13 area (ASEAN countries, China, Hong Kong and Taipei), two production and trade hubs that jointly account for more than 36% of global intermediate trade in 2022 (OECD-TiVA, 2025).

The econometric specification remains identical to the baseline setup: a fixed-effects panel model with country and year effects, regressors lagged at $t-1$, country-clustered robust standard errors, and, in some specifications, country-specific linear trends. The goal is to assess whether the direction and intensity of the GVC–GDP relationship vary depending on the regional partner.

The following section provides a regional decomposition of GVC effects. All estimates are reported with country and year fixed effects and country-clustered standard errors. Tables 5 and 6 report the results for the NAFTA and ASIA-13 partner groups, respectively.

The results for GVC linkages with the NAFTA area confirm the robustness of the positive effect of GVC participation on economic growth, even when focusing exclusively on trade and production flows with the three North American economies.

3.4.1. Forward GVC participation

The estimated elasticity for NAFTA forward linkages (≈ 0.20-0.29) reveals a strong and statistically robust relationship between upstream integration with the North American production system and domestic output growth in non-member economies. Specifically, a 1 percent increase in the domestic value added embodied in NAFTA partners' exports is associated with roughly a 0.29 percent rise in GDP, holding other factors constant.

When compared with the global benchmark estimated on the same 77-country sample, the global forward coefficient (≈ 0.23–0.27) remains positive and significant but slightly smaller. This result indicates that external participation in the North American value-chain network yields growth effects comparable to, and in some specifications stronger than, those obtained from global integration. The finding underscores NAFTA's role as a major demand and innovation hub, where technological sophistication, scale, and institutional coordination amplify the indirect benefits accruing to external suppliers. In this sense, countries providing intermediate inputs embodied in NAFTA exports capture substantial spillovers through learning-by-exporting dynamics, exposure to high-quality standards, and access to advanced production networks.

3.4.2. Backward GVC participation

The estimated elasticity for NAFTA backward linkages (≈ 0.06–0.07) is positive and statistically significant but notably smaller than the forward effect. This implies that importing intermediate inputs from the North American bloc contributes to domestic efficiency and product quality, yet generates more limited value-added retention in the domestic economy. When compared with the global backward elasticity (≈ 0.10–0.13), the smaller magnitude for NAFTA suggests that the growth gains from regional input sourcing are narrower than those achieved through diversified global supply networks, which combine a wider range of technologies, costs, and complementarities.

Overall, the results highlight the dominance of the forward channel: countries that act as upstream suppliers to the North American export system experience the largest and most reliable growth effects. This reflects NAFTA's structural role as a high-value demand center in global production networks. In contrast, backward participation delivers positive but smaller benefits, as regional sourcing provides quality improvements but limits the breadth of domestic spillovers compared with fully globalized supply relationships.

Table 5. Effects of GVC linkages with the NAFTA region on current GDP, compared to Global GVC linkages – FE models

	FE + Cluster				FE + Cluster + country trend			
	Forward GVC		Backward GVC		Forward GVC		Backward GVC	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	GDP	GDP	GDP	GDP	GDP	GDP	GDP	GDP
L.GVC_F_ NA	0.292***				0.201***			
	(0.043)				(0.030)			
EX_VA_ NA	0.002				-0.001			
	(0.003)				(0.004)			
L.GVC_F_ W		0.268***				0.233***		
		(0.058)				(0.031)		
EX_VA_ W		0.475***				0.469***		
		(0.090)				(0.075)		
L.GVC_B_ NA			0.068***				0.062***	
			(0.023)				(0.022)	
IM_VA_ NA			0.511***				0.389***	
			(0.056)				(0.039)	
L.GVC_B_ W				0.129***				0.099***
				(0.031)				(0.023)
IM_VA_ W				0.643***				0.554***
				(0.071)				(0.042)
N. Observations	1309	1309	1309	1309	1309	1309	1309	1309
N. Countries	77	77	77	77	77	77	77	77
R^2 (within)	0.758	0.863	0.828	0.876	0.904	0.941	0.930	0.954
R^2 (overall)	0.923	0.974	0.937	0.978	0.827	0.976	0.900	0.967
F-statistic	81.22	265.95	123.95	199.18	.	.	.	.
Prob > F	0.000	0.000	0.000	0.000	.	.	.	.

Standard errors in parentheses

All regressions include country and year fixed effects.
Col.1 = Forward_NA FE + Cluster
Col.2 = Forward_W FE + Cluster
Col.3 = Backward_NA FE + Cluster
Col.4 = Backward_W FE + Cluster
Col.5 = Forward_NA FE + Cluster + trend
Col.6 = Forward_W FE + Cluster + trend
Col.7 = Backward_NA FE + Cluster + trend
Col.8 = Backward_W FE + Cluster + trend
All models estimated using xtreg or xtscc (FE)
Standard errors clustered at the country level (CountryID).
Driscoll–Kraay standard errors used for robustness check.
*, **, *** = significant at the 10%, 5%, and 1% levels.
* p < 0.10, ** p < 0.05, *** p < 0.01

Note:
The high F-statistics observed in the fixed-effects models (in the order of more than two hundreds) reflect the strong joint significance of the regressors and the rich informational structure of the panel (large number of observations and time-specific variables). The F-statistic measures the joint explanatory power of the independent variables, and high values indicate that they consistently explain the variation in GDP across countries and over time. Differences in F-values across models (e.g., between clustered and Driscoll–Kraay

estimates) arise solely from the different estimation methods for the variance–covariance matrix and do not imply substantive changes in the model's explanatory capacity.

3.5. ASIA-13 vs World: regression results and interpretation

3.5.1 Forward GVC participation

Forward linkages with the Asian bloc (ASIA-13) are positive and statistically significant, with elasticities around 0.17–0.21, but slightly lower than those estimated for NAFTA. This consistency across regions confirms that participation in upstream stages of value chains – where a country's domestic value added is embodied in the exports of major partner blocs – constitutes a general driver of growth. The smaller coefficient magnitude in the ASIA-13 case likely reflects the region's internal production structure, where a larger share of value added is retained within member economies, limiting the extent of spillovers to external suppliers. In comparison, the corresponding global forward elasticity (0.25–0.28) estimated on the same 67-country sample is higher, indicating that participation in worldwide production networks yields broader and more diffuse growth effects than integration through a single regional hub. Nevertheless, the ASIA-13 coefficients remain economically meaningful and robust, suggesting that even external partners connected to the Asian manufacturing platform benefit from its strong export orientation and regional technological upgrading.

3.5.2. Backward GVC participation

Backward linkages with ASIA-13, although positive, are generally weaker and only significant in some specifications. This asymmetry is economically intuitive: for countries importing intermediate inputs from the Asian bloc, the domestic output gains are limited, as these flows often involve standardized, low-cost components that generate modest local spillovers. Conversely, backward integration with the NAFTA area tends to produce stronger coefficients, reflecting the higher technological intensity and value content of inputs sourced from North American industries. Overall, the contrast between forward and backward linkages reinforces the conclusion that growth benefits for non-member economies primarily arise when their domestic value added contributes to the exports of dynamic regional hubs, rather than when they rely on imported inputs from them.

Table 6. Effects of GVC linkages with the ASIA-13 region on current GDP, compared to Global GVC linkages – FE models

	FE + Cluster				FE + Cluster + country trend			
	Forward GVC		Backward GVC		Forward GVC		Backward GVC	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	GDP	GDP	GDP	GDP	GDP	GDP	GDP	GDP
L.GVC_F_ AS	0.206***				0.171***			
	(0.034)				(0.032)			
EX_VA_ AS	0.110***				0.104***			
	(0.034)				(0.025)			
L.GVC_F_ W		0.283***				0.246***		
		(0.057)				(0.033)		
EX_VA_ W		0.425***				0.427***		
		(0.098)				(0.074)		
L.GVC_B_ AS			0.021				0.057***	
			(0.031)				(0.015)	
IM_VA_ AS			0.470***				0.389***	
			(0.065)				(0.035)	
L.GVC_B_ W				0.114***				0.086***
				(0.030)				(0.021)
IM_VA_ W				0.697***				0.556***
				(0.083)				(0.052)
N. Observations	1139	1139	1139	1139	1139	1139	1139	1139
N. Countries	67	67	67	67	67	67	67	67
R^2 (within)	0.705	0.825	0.758	0.861	0.886	0.928	0.924	0.944
R^2 (overall)	0.901	0.973	0.952	0.980	0.846	0.976	0.901	0.972
F-statistic	78.16	282.50	155.84	225.84	-	-	-	-
Prob > F	0.000	0.000	0.000	0.000	-	-	-	-

Standard errors in parentheses

All regressions include country and year fixed effects.
Col.1 = Forward_ASIA13 FE + Cluster
Col.2 = Forward_W FE + Cluster
Col.3 = Backward_ASIA13 FE + Cluster
Col.4 = Backward_W FE + Cluster
Col.5 = Forward_ASIA13 FE + Cluster + trend
Col.6 = Forward_W FE + Cluster + trend
Col.7 = Backward_ASIA13 FE + Cluster + trend
Col.8 = Backward_W FE + Cluster + trend
All models estimated using xtreg or xtscc (FE)
Standard errors clustered at the country level (CountryID).
Driscoll–Kraay standard errors used for robustness check.
*, **, *** = significant at the 10%, 5%, and 1% levels.
* p < 0.10, ** p < 0.05, *** p < 0.01

Note:
The high F-statistics observed in the fixed-effects models (in the order of more than two hundreds) reflect the strong joint significance of the regressors and the rich informational structure of the panel (large number of

observations and time-specific variables). The F-statistic measures the joint explanatory power of the independent variables, and high values indicate that they consistently explain the variation in GDP across countries and over time. Differences in F-values across models (e.g., between clustered and Driscoll–Kraay estimates) arise solely from the different estimation methods for the variance–covariance matrix and do not imply substantive changes in the model's explanatory capacity.

3.6. Comparative Discussion of Regional GVC Results

The regional analysis offers a more granular perspective on how countries benefit from their integration into global value chains (GVCs) through specific regional hubs. In both regional exercises – NAFTA and ASIA-13 – the estimated coefficients confirm that forward linkages generate stronger effects on domestic output than backward linkages, in line with the global benchmark presented in chapter 2. This pattern underscores the greater growth potential associated with upstream participation in value chains, where domestic value added is embodied in the exports of partner regions, rather than in downstream production based on imported inputs.

In the NAFTA-focused regressions, where the sample includes 77 countries excluding the United States, Canada, and Mexico, the estimated coefficients for forward participation are both higher and more robust than those obtained for backward linkages. The results indicate that countries supplying value added to the exports of the NAFTA area experience significant positive effects on their own GDP. This finding highlights the role of the North American production system as a major global demand hub: its technological sophistication, high import intensity of intermediate inputs, and deep intra-regional integration amplify the indirect gains for external partners embedded in its export networks. In contrast, the coefficients associated with backward linkages – capturing the domestic output effects of exporting value added imported from NAFTA – are smaller and less stable, suggesting limited domestic spillovers from reliance on inputs sourced from the bloc.

The results for ASIA-13 (based on 67 countries excluding the thirteen Asian economies forming the bloc) confirm the positive but weaker relationship between regional GVC participation and domestic output. Forward linkages with ASIA-13 yield smaller coefficients than those associated with NAFTA, while backward linkages remain marginal. This pattern may reflect the internal structure of the Asian production network, which is more hierarchical and vertically fragmented, with a higher share of value added retained within the region itself.

Consequently, while integration with ASIA-13 still supports growth for external partners, the benefits are less pronounced, as much of the value creation occurs within the bloc's own economies.

Comparing the two regional blocs, the evidence suggests that NAFTA acts as a stronger transmission channel for global value added, generating broader and more stable spillovers to non-member economies. The ASIA-13 network, though dynamic and rapidly expanding, appears to internalize a larger portion of production and technological gains. Overall, these results reinforce the asymmetry found in the global model: forward participation systematically enhances domestic output, but the magnitude of the effect crucially depends on the geographical configuration and functional position of the partner region within global production networks.

Regional estimations confirm that global value chain participation exerts significant and heterogeneous effects on domestic growth, depending on the nature of linkages (forward vs backward) and the regional hub considered. Across all specifications, forward integration – measured as the domestic value added of each country embodied in the exports of a partner bloc – emerges as the dominant transmission channel. Countries supplying intermediate goods and services that feed into the export systems of major hubs such as NAFTA and ASIA-13 experience consistent and economically meaningful growth gains. These effects reflect the role of forward participation as a vehicle for technology diffusion, learning-by-exporting, and stable external demand.

For the NAFTA bloc, forward elasticities (≈ 0.20–0.29) are particularly strong and statistically robust: even for non-member economies, contributing value added to NAFTA exports translates into substantial output gains, driven by access to high-value demand and the adoption of advanced production standards. The backward channel is positive but weaker (≈ 0.06–0.07), suggesting that importing intermediate inputs from NAFTA enhances efficiency and product quality but yields smaller domestic spillovers compared with supplying inputs to the bloc.

The ASIA-13 results show a similar pattern, though with smaller magnitudes. Forward linkages remain positive and significant, confirming that integration into the Asian export

network fosters growth even for external economies. However, the lower coefficients likely reflect the heterogeneity of the region's production structure, where a large share of value creation remains concentrated within member economies. Backward linkages with ASIA-13 are positive but less stable, pointing to the limited domestic spillovers associated with the import of low-cost, standardized components from Asian manufacturing hubs.

Taken together, these findings highlight a consistent hierarchy of effects: forward linkages dominate backward ones, and regional hubs such as NAFTA and ASIA-13 serve as powerful but asymmetric engines of growth for external economies embedded in their value-chain ecosystems.

3.7. Regional GVC Integration and Trade Policy Implications

The regional analysis reveals that integration into major production hubs such as NAFTA and ASIA-13 generates measurable growth benefits for partner economies, primarily through forward linkages – that is, when domestic value added is embedded in the exports of dynamic regional blocs. This evidence suggests that policies promoting upstream participation, technological upgrading, and export diversification toward high-value markets can yield stronger and more sustainable growth effects than strategies focused solely on importing inputs.

The findings suggest that the growth effects of forward GVC participation are substantially stronger when economies are integrated with technologically advanced and institutionally stable hubs such as NAFTA. In contrast, linkages with the Asian production network (ASIA-13), though positive, yield smaller output gains due to the region's more fragmented production structure and uneven distribution of technological capabilities.

This asymmetry carries relevant policy implications in the current context of trade tensions and tariff realignments. Should trade frictions with North American partners reduce European access to NAFTA-centered value chains, a potential reorientation toward Asian production networks might not fully compensate the growth benefits lost through diminished upstream integration with North America.

While diversification of value-chain linkages remains desirable, the empirical evidence underscores that the quality and depth of production relationships matter more than their geographic scope. Hence, policies aimed at strengthening transatlantic industrial cooperation, technological complementarity, and standards alignment could play a key role in preserving the productivity gains associated with forward GVC participation.

CHAPTER 4 – GENERAL CONCLUSIONS

This thesis set out to explore how countries' participation in global and regional value chains translates into domestic value creation and economic growth. Using a consistent analytical framework based on OECD TiVA data, the research demonstrated that the nature and direction of integration — forward or backward, global or regional — significantly shape the growth outcomes associated with GVC participation. The results consistently highlight the primacy of forward linkages, suggesting that economies benefit most when they occupy upstream positions as suppliers of intermediate goods and services to international production systems.

At the global level, the findings show a robust and positive elasticity between forward GVC participation and GDP, confirming that countries embedded as upstream suppliers capture larger shares of global value added. The backward channel, while still positive, is smaller in magnitude and more dependent on complementary factors such as technological capacity and absorptive capabilities. This asymmetry reinforces the view that integration alone is not sufficient: what matters is how countries integrate — whether they are positioned to provide technologically intensive inputs or remain confined to low value-added assembly.

At the regional level, the comparison between NAFTA and ASIA-13 provides further nuance. Integration with NAFTA-centered production systems yields higher and more stable growth payoffs for external partners. This likely reflects the bloc's structural maturity, advanced industrial base, and deeply institutionalized trade governance. The ASIA-13 linkages, though economically significant, exhibit greater heterogeneity, mirroring the diversity of industrial structures within the region. In both cases, the evidence underscores that regional hubs act as transmission centers for growth and knowledge diffusion — but the scale and stability of these effects depend on the technological sophistication and institutional coherence of the hub itself.

From a policy perspective, these results carry several implications. First, economies seeking to maximize the benefits of global integration should focus on upgrading toward upstream, knowledge-intensive activities. Policies that enhance human capital, innovation capacity, and export sophistication are key to increasing domestic value capture. Second, governments should pursue targeted strategies to strengthen domestic supply networks, enabling local firms

to link effectively with multinational production systems. Third, given the recent resurgence of trade protectionism and the reconfiguration of global supply chains, policymakers must balance diversification and resilience – ensuring participation in both global and regional networks while mitigating exposure to geopolitical shocks and tariff escalation.

At a broader level, the thesis contributes to the understanding of globalization in transition. The post-2020 era has seen mounting pressures on the open trading system, from geopolitical fragmentation and reshoring strategies to the proliferation of regional trade agreements and "friend-shoring" initiatives. In this evolving landscape, the capacity to retain and generate domestic value within global production networks is becoming a central determinant of national competitiveness.

While the empirical evidence presented here provides robust insights, several avenues for future research remain open. Future work could incorporate sectoral heterogeneity and firm-level microdata to explore how firms' positions within value chains mediate aggregate outcomes. Further extensions might also consider the role of digital trade, services value chains, and green technologies in reshaping GVC structures.

In conclusion, this thesis underscores that participation in global value chains is neither inherently beneficial nor detrimental: its effects depend on the structural characteristics, capabilities, and policy choices of each economy. In a world of fragmented production and shifting trade architectures, the challenge for policymakers is not simply to join global value chains but to shape them – ensuring that integration translates into sustained domestic value creation and inclusive growth.

APPENDICES

APPENDIX A – DATA AND VARIABLE CONSTRUCTION

A.1. Data sources and coverage

The empirical analysis is based on data from the OECD Trade in Value Added (TiVA) database, two-dimensional version (country × year), which provides internationally comparable indicators of value-added trade for 80 economies over the period 2005–2021. The choice of the two-dimensional dataset, rather than the industry-level (three-dimensional) TiVA version, allows the reconstruction of global value chain (GVC) linkages at the country level and enables the aggregation of flows by specific regional blocs. This feature is particularly relevant for the second part of the analysis, which examines GVC relationships between each country and selected regions — namely NAFTA and ASIA-13 (the latter including ASEAN economies, China, Hong Kong, and Chinese Taipei).

The two-dimensional TiVA dataset provides, for each country and year, value-added trade flows decomposed into domestic and foreign contributions. It includes detailed information on forward and backward GVC participation shares, gross exports, imports, and domestic value added (DVA) embodied in trade. Complementary macroeconomic variables — such as GDP, GDP growth, openness, and FDI inflows — were retrieved from the World Bank World Development Indicators (WDI) and UNCTAD. All variables were harmonized in consistent country–year format.

A.2. Construction of GVC indicators

The core indicators of GVC participation were derived or reconstructed from TiVA data as follows.

Absolute values reconstruction

Because TiVA provides participation shares but not absolute values of forward and backward linkages by partner country, total and regional GVC flows in value terms were reconstructed by applying the available participation shares to the corresponding country-level gross exports.

Forward GVC participation (GVC_F)

Forward participation measures the domestic value added (DVA) embodied in foreign countries' exports. For global analysis, absolute values of forward linkages were reconstructed as for regional analysis. These measures were computed by applying the TiVA-provided GVC_F shares of country (i) with each partner country ($j \neq i$) in the two areas to country (i) gross exports.

Backward GVC participation (GVC_B)

Backward participation captures the foreign value added (FVA) embodied in a country's own exports. Similarly, regional backward linkages were obtained by applying the corresponding partner countries' shares to total gross exports.

Domestic value added in pure exports (EX_VA)

The TiVA database does not directly report the value added in pure (non-GVC) exports. This indicator was reconstructed as EX_VA = Gross exports – Domestic value added in foreign gross exports, representing the exports that are not re-exported through foreign production chains.

Foreign value added in domestic final consumption (IM_VA)

The TiVA database directly report this measure. This indicator represents the foreign value added consumed at home through intermediate or final products imports.

A.3. Control variables and additional data

The baseline model includes a set of control variables commonly used in the empirical literature on trade and growth:

- Openness, measured as the ratio of exports plus imports to GDP ((EX + IM) / GDP), to capture trade integration.
- GDP growth rate, as an indicator of short-run macroeconomic performance.
- Foreign Direct Investment stock (FDI), expressed as a share of GDP, to account for international capital linkages.

- GDP (current prices), used in logarithmic form when required to control for country size and scale effects.

The model employs the stock of foreign direct investment (FDI stock) in lagged form (t−1) rather than contemporaneous, for both economic and econometric reasons.

From an economic standpoint, the impact of FDI on domestic output typically materializes with a time lag, since productive investments require time to translate into installed capacity, technological transfer, and stronger integration in global production networks. Using the lagged value therefore captures the medium-term effect of accumulated foreign capital, rather than the short-run response to new inflows.

From an econometric perspective, the lag helps mitigate potential endogeneity due to reverse causality, as current GDP performance may itself attract FDI inflows. By introducing the stock of FDI at time t−1, the model reduces simultaneity bias and strengthens the causal interpretation of the estimated coefficient.

Moreover, the stock measure reflects the persistent level of external financial openness and the country's absorptive capacity to benefit from global production linkages, ensuring greater temporal stability and robustness of the estimates.

All variables in current prices are log-transformed to mitigate skewness and improve model stability.

A.4. Summary of variables

Variable	**Description**	**Transformation / Construction**	**Source**
GDP	Gross domestic product (current prices)	log	World Bank, WDI
GVC_F	Forward GVC participation (DVA in foreign exports)	$\log(FEXGR\_DVA \times EX\_GR)\#$	Author's calculation based on TiVA
L.GVC_F	Lagged forward participation (t–1)	$\log(FEXGR\_DVA \times EX\_GR)\#$ Shifted one period	Author's calculation
GVC_B	Backward GVC participation (FVA in domestic exports)	$\log(EXGR\_FVA)\#$	OECD TiVA
L.GVC_B	Lagged backward participation (t–1)	$\log(EXGR\_FVA)$ # Shifted one period	Author's calculation

Variable	**Description**	**Transformation / Construction**	**Source**
GVC_F_NAFTA / GVC_B_NAFTA	Forward/Backward GVC linkages with NAFTA	log($FEXGR\_DVA\_PHS \times EX\_GR$) # log($EXGR\_FVA\_PHS \times EX\_GR$) #	Author's calculation based on TiVA
L.GVC_F_NAFTA / L.GVC_B_NAFTA	Forward/Backward GVC linkages with NAFTA	log($FEXGR\_DVA\_PHS \times EX\_GR$) # log($EXGR\_FVA\_PHS \times EX\_GR$) # shifted one period	Author's calculation based on TiVA
GVC_F_ASIA13 / GVC_B_ASIA13	Forward/Backward GVC linkages with Asia13	log($FEXGR\_DVA\_PHS \times EX\_GR$) # log($EXGR\_FVA\_PHS \times EX\_GR$) #	Author's calculation based on TiVA
L.GVC_F_ASIA13 / L.GVC_B_ASIA13	Forward/Backward GVC linkages with Asia13	log($FEXGR\_DVA\_PHS \times EX\_GR$) # log($EXGR\_FVA\_PHS \times EX\_GR$) # shifted one period	Author's calculation based on TiVA
EX_VA	Value added in pure exports (net of GVC_F)	log($EXGR\_DVA - FEXGR\_DVA$) #	Author's calculation based on TiVA
IM_VA	Foregn value added consumed home	log(DFD_FVA)#	OECD TiVA
Openness	(Exports + Imports) / GDP	Ratio	OECD TiVA / World Bank, WDI
GDP_g	GDP growth rate	Percentage	World Bank, WDI. Unctad (TWN)
L.FDI	Foreign Direct Investment stock	Log shifted one period	UNCTAD
Year_c	Centered year (trend variable)	Year − mean(Year)	Author's calculation
CountryID	Country identifier	Numeric code	OECD TiVA

#
(FEXGR_DVA) = Domestic value added in foreign gross exports
(FEXGR_DVA_PSH) = Domestic value added in foreign gross exports, exporting partner shares
(EXGR_DVA) = Domestic value added in gross exports
(EXGR_FVA) = Foreign value added in gross exports
(EXGR_FVA_PSH) = Foreign value added in gross exports, value added origin partner shares
(EX_GR) = Gross exports
(IM_GR) = Gross imports
(DFD_FVA) = Foreign value added in domestic final demand

Note:
All variables were aligned in country–year panel format (balanced for 80 economies, 77 and 67 countries in the regional version, 2006–2022). Author's calculations are based on OECD-TiVA (2025 edition), World Bank WDI and UNCTAD data.

A.5. Country coverage

ISO/ID	Country/Area
AGO	Angola
ARG	Argentina
AUS	Australia
AUT	Austria
BGD	Bangladesh
BLR	Belarus
BEL	Belgium
BRA	Brazil
BRN	Brunei Darussalam
BGR	Bulgaria
KHM	Cambodia
CMR	Cameroon
CAN	Canada
CHL	Chile
CHN	China (People's Republic of)
TWN	Chinese Taipei
COL	Colombia
CRI	Costa Rica
CIV	Côte d'Ivoire
HRV	Croatia
CYP	Cyprus
CZE	Czechia
COD	Democratic Republic of the Congo
DNK	Denmark
EGY	Egypt
EST	Estonia
FIN	Finland
FRA	France
DEU	Germany
GRC	Greece
HKG	Hong Kong (China)
HUN	Hungary
ISL	Iceland
IND	India
IDN	Indonesia
IRL	Ireland
ISR	Israel
ITA	Italy
JPN	Japan
JOR	Jordan
KAZ	Kazakhstan

ISO/ID	Country/Area
KOR	Korea
LAO	Lao People's Democratic Republic
LVA	Latvia
LTU	Lithuania
LUX	Luxembourg
MYS	Malaysia
MLT	Malta
MEX	Mexico
MAR	Morocco
MMR	Myanmar
NLD	Netherlands
NZL	New Zealand
NGA	Nigeria
NOR	Norway
PAK	Pakistan
PER	Peru
PHL	Philippines
POL	Poland
PRT	Portugal
ROU	Romania
RUS	Russia
STP	Sao Tome and Principe
SAU	Saudi Arabia
SEN	Senegal
SGP	Singapore
SVK	Slovak Republic
SVN	Slovenia
ZAF	South Africa
ESP	Spain
SWE	Sweden
CHE	Switzerland
THA	Thailand
TUN	Tunisia
TUR	Türkiye
UKR	Ukraine
ARE	United Arab Emirates
GBR	United Kingdom
USA	United States
VNM	Viet Nam
NAFTA	CAN, MEX, USA
ASIA13	BRN, KHM, CHN, TWN, HKG, IDN, LAO, MYS, MMR, PHL, SGP, THA, VNM

APPENDIX B: DESCRIPTIVE STATISTICS

B.1. General descriptive statistics from OECD-TiVA database 2025.

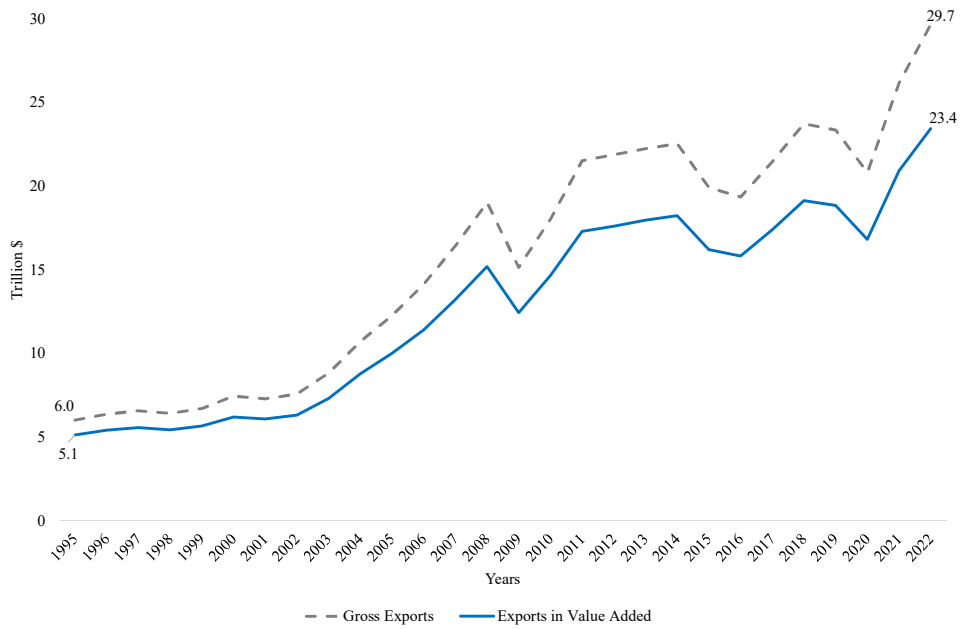


Figure B.1.1. World Gross Exports and Exports in Value Added. Trend 1995-2022
Note: "World" indicates the full sample of countries (80) average

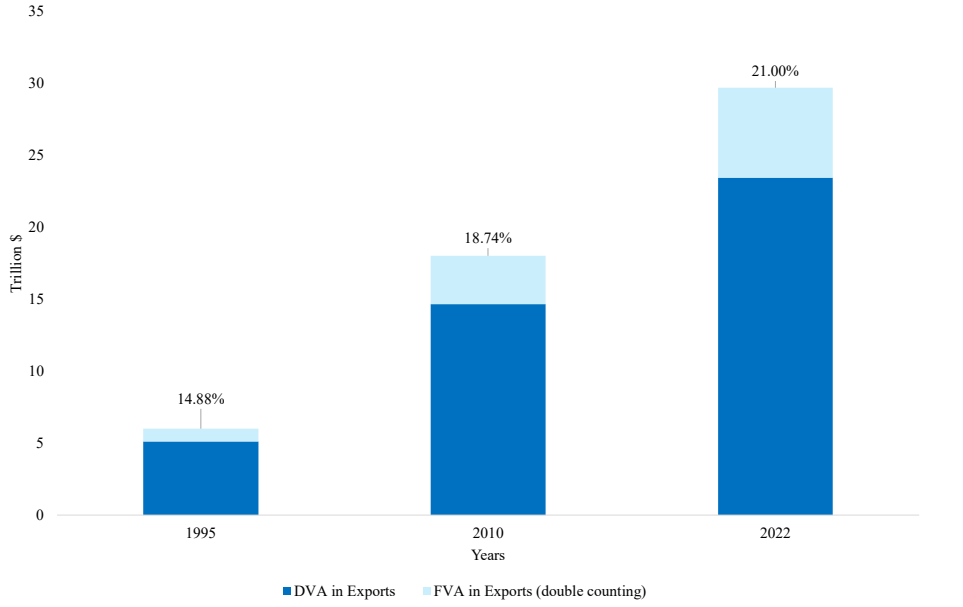


Figure B.1.2. DVA vs. FVA in Exports. World.
Note: data labels indicate the share of foreign value added in gross exports. "World" indicates the full sample of countries (80) average.

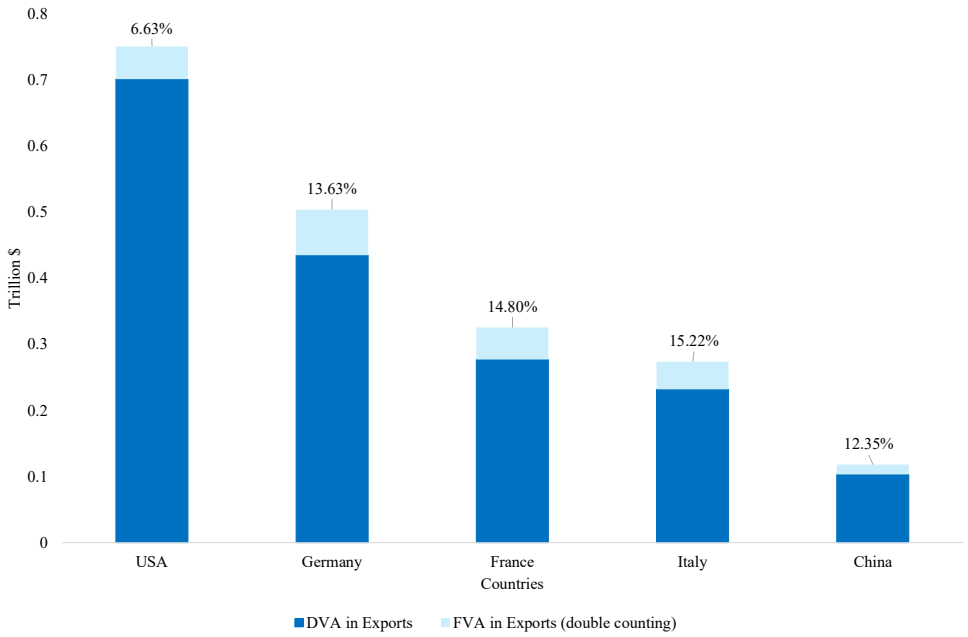


Figure B.1.3. DVA vs. FVA in Exports. USA, China and main European countries. Year 1995
Note: data labels indicate the share of foreign value added in gross exports

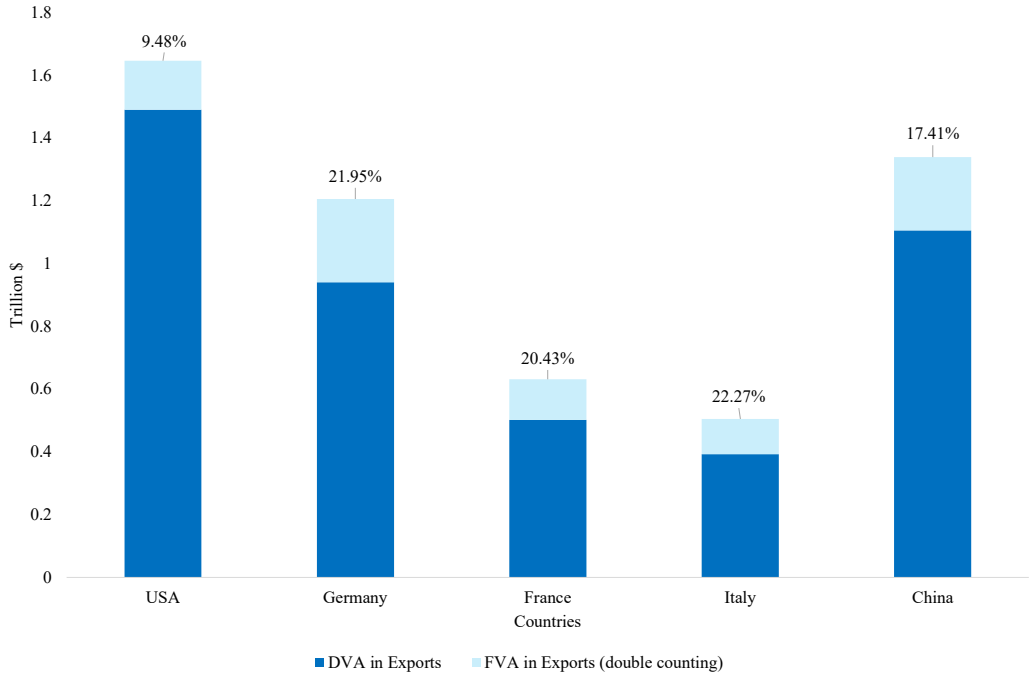


Figure B.1.4. DVA vs. FVA in Exports. USA, China and main European countries. Year 2010
Note: data labels indicate the share of foreign value added in gross exports

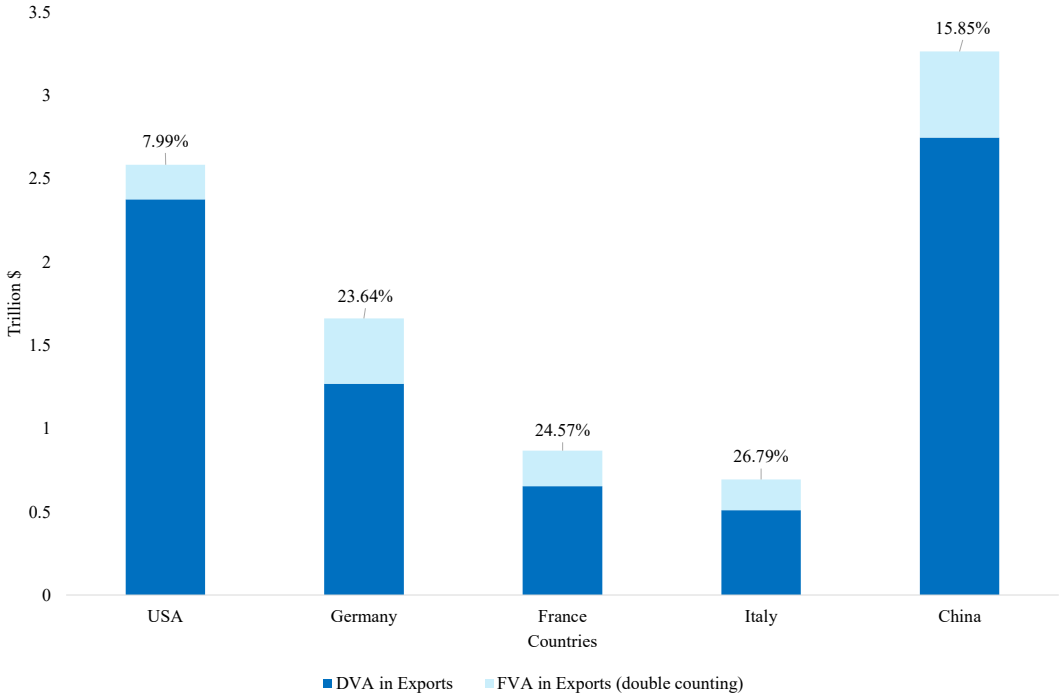


Figure B.1.5. DVA vs. FVA in Exports. USA, China and main European countries. Year 2022
Note: data labels indicate the share of foreign value added in gross exports

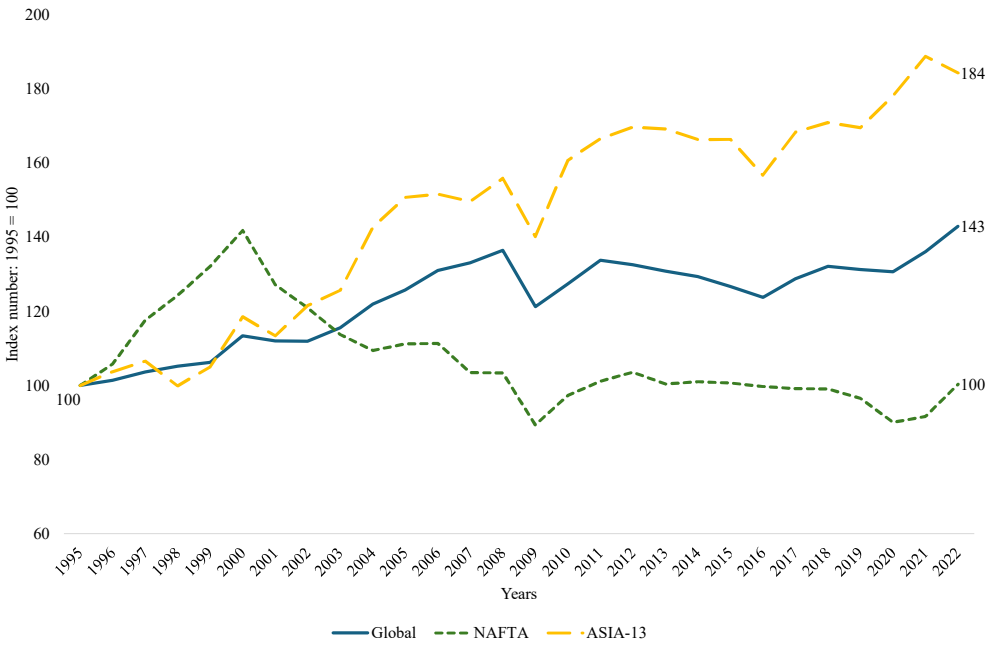


Figure B.1.6. World Forward GVC linkages: Global vs. Regional. Index number (1995=100)
Note: "World" indicates the full sample of countries (80) average

Figure B.1.7. World Forward GVCs. Regional shares: NAFTA and ASIA-13
Note: "World" indicates the full sample of countries (80) average

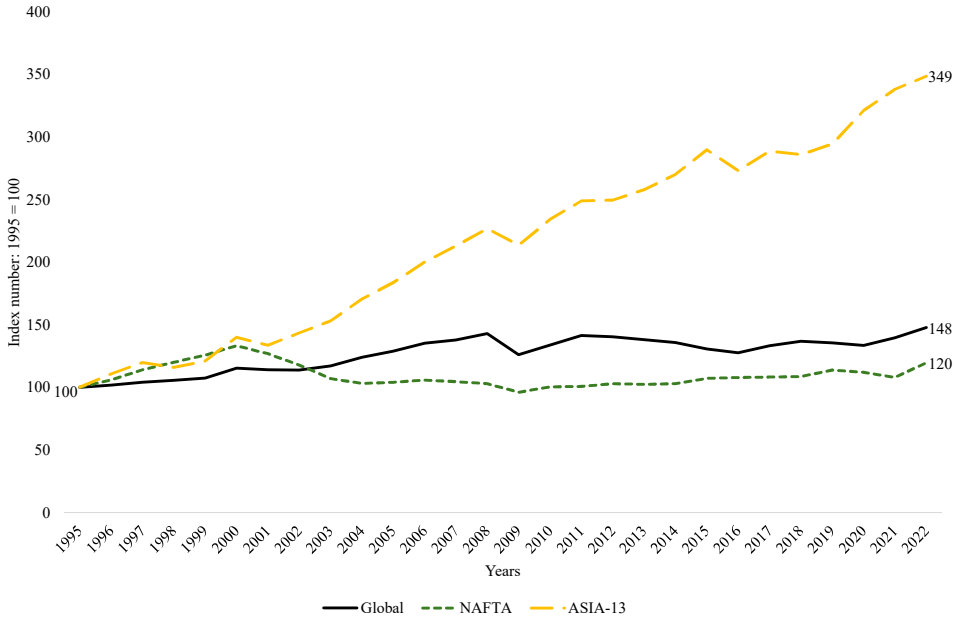


Figure B.1.8. World Backward GVC linkages: Global vs. Regional. Index number (1995=100)
Note: "World" indicates the full sample of countries (80) average

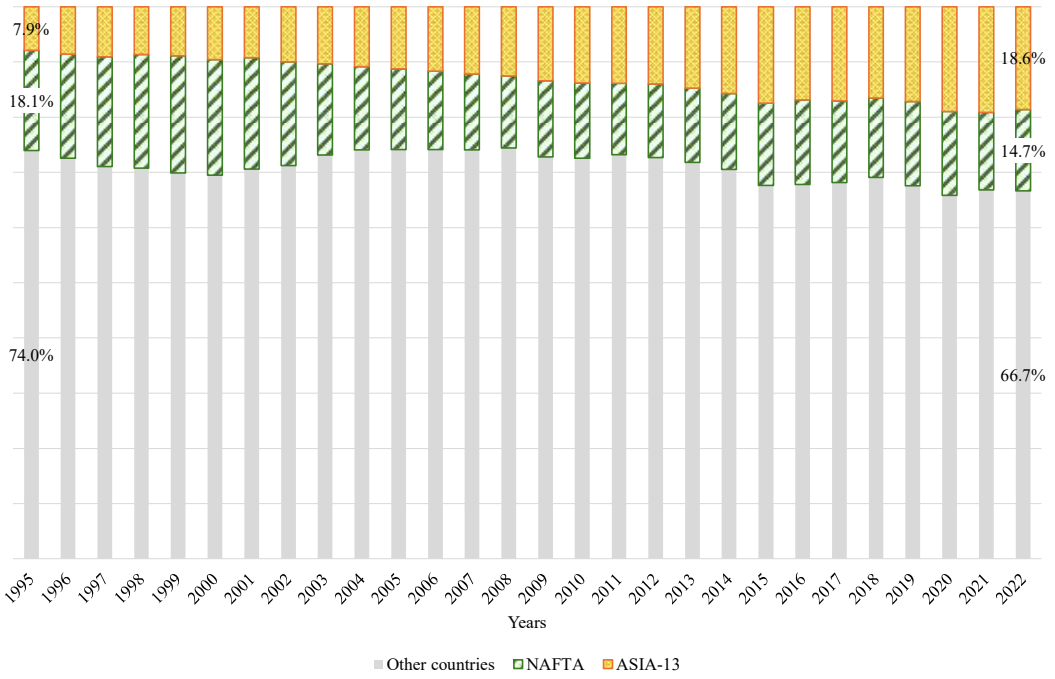


Figure B.1.9. World Backward GVCs. Regional shares: NAFTA and ASIA-13
Note: "World" indicates the full sample of countries (80) average

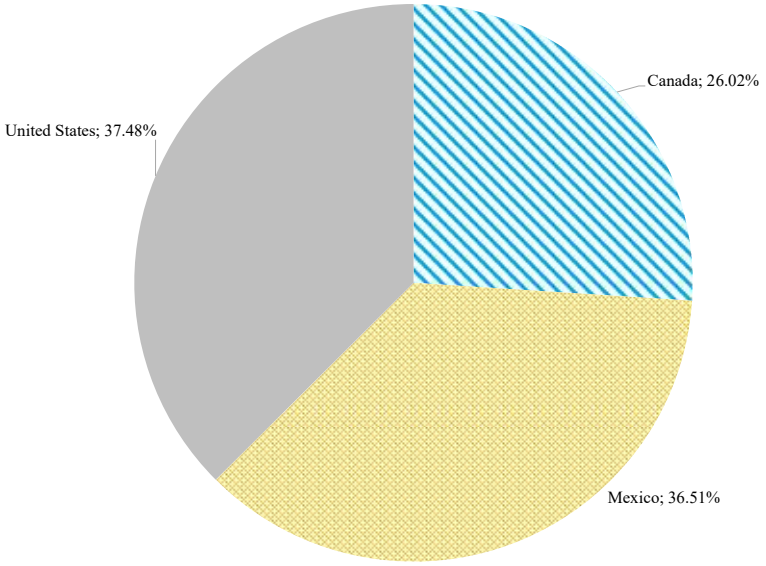


Figure B.1.10. World Forward GVC linkages with NAFTA: intra-regional shares. Year 2022
Note: "World" indicates the full sample of countries (80) average

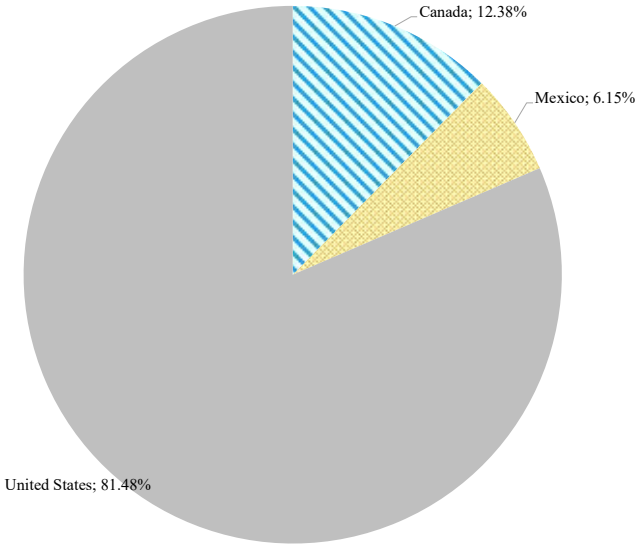


Figure B.1.11. World Backward GVC linkages with NAFTA: intra-regional shares. Year 2022
Note: "World" indicates the full sample of countries (80) average

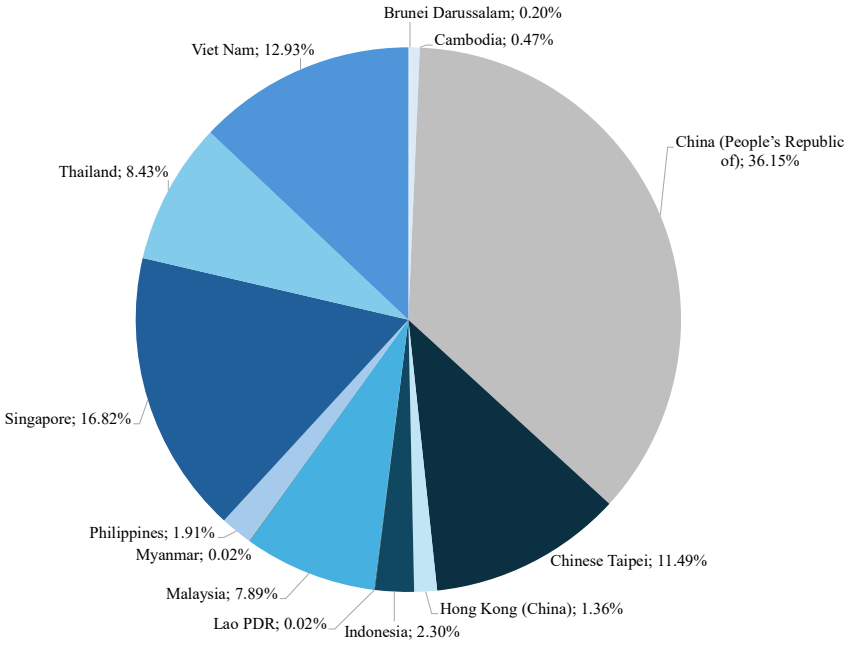


Figure B.1.12. World Forward GVC linkages with ASIA-13: intra-regional shares. Year 2022
Note: "World" indicates the full sample of countries (80) average

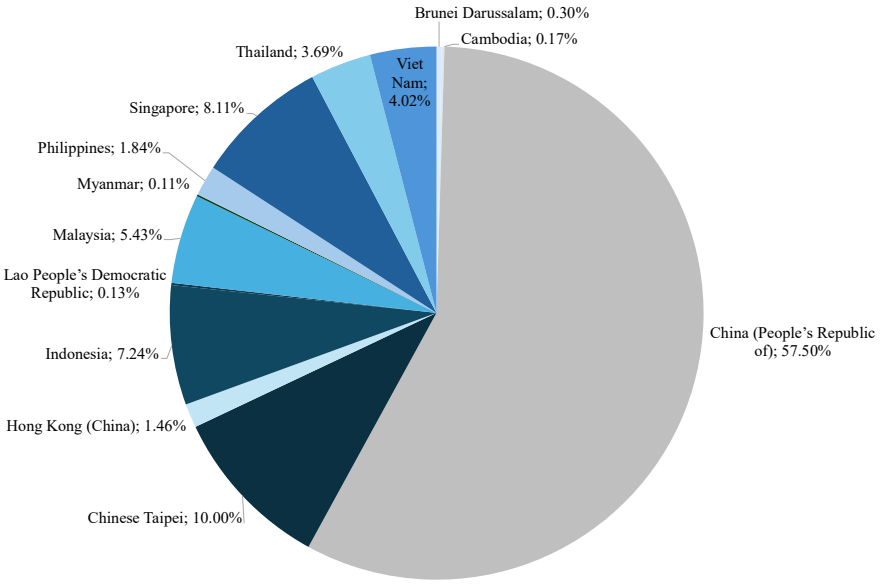


Figure B.1.13. World Backward GVC linkages with ASIA-13: intra-regional shares. Year 2022

Note: "World" indicates the full sample of countries (80) average

B.2. Descriptive statistics of chaper 2 variables.

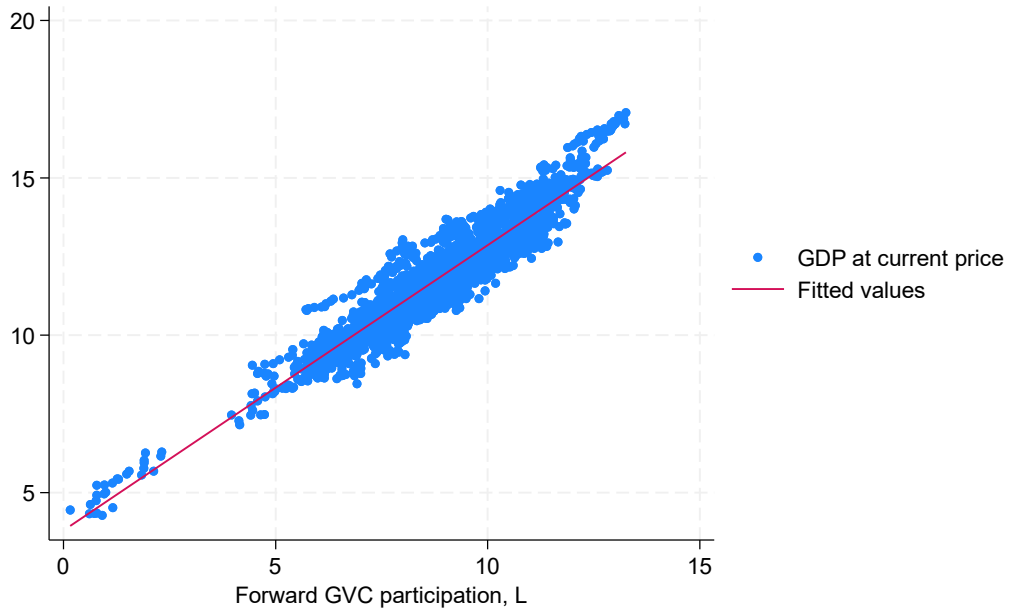


Figure B.2.1. Scatter plot log(GDP) vs log(GVC_F)

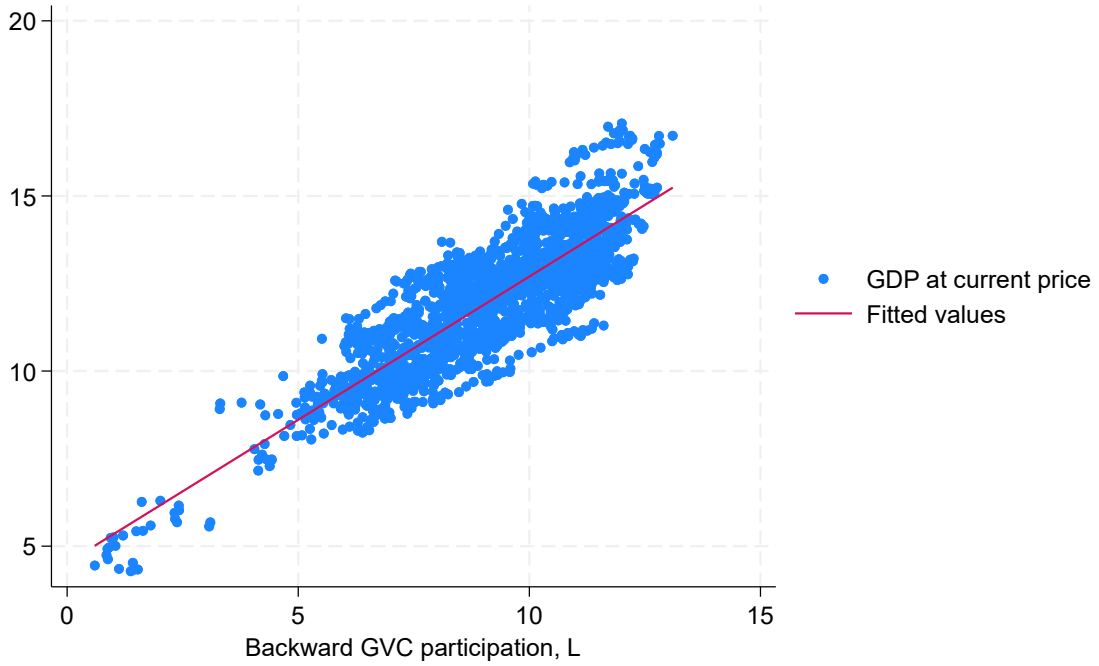


Figure B.2.2. Scatter plot log(GDP) vs log(GVC_B)

Table B.2.1. Descriptive statistics. Global GVC analysis in chapter 2

	mean	sd	min	max	observations
Log(GDP current)	12.305	1.783	4.96	17.07	1360
Log(Forward GVC)	9.529	1.829	0.78	13.47	1360
Log(Backward GVC)	9.616	1.867	0.95	13.16	1360
Log(EX_VA)	10.673	1.711	2.13	14.56	1360
Log(IM_VA)	10.945	1.608	4.28	14.96	1360
Openness	0.792	0.444	0.20	3.52	1360
GDP Growth Rate	3.056	4.053	-28.76	24.62	1360
Log(FDI)	11.417	1.747	4.37	16.39	1360

Table B.2.2. Descriptive statistics. Regional GVC analysis in chapter 3: NAFTA region

	mean	sd	min	max	observations
Log(GDP)	12.200	1.717	4.96	16.72	1309
Log(GVC_F_NA)	6.484	2.081	-4.33	11.23	1309
Log(GVC_B_NA)	7.140	2.043	-1.36	11.18	1309
Log(GVC_F_W)	9.451	1.808	0.78	13.36	1309
Log(GVC_B_W)	9.535	1.855	0.95	13.16	1309
Log(EX_VA_NA)	8.277	2.775	-13.82	13.16	1309

Log(IM_VA_NA)	8.582	1.778	1.55	12.56	1309
Log(EX_VA_W)	10.581	1.672	2.13	14.56	1309
Log(IM_VA_W)	10.852	1.556	4.28	14.58	1309
Open	0.804	0.447	0.20	3.52	1309
GDP_g	3.107	4.087	-28.76	24.62	1309
Log(FDI)	11.313	1.683	4.37	15.11	1309

Table B.2.3. Descriptive statistics. Regional GVC analysis in chapter 3: ASIA-13 region

	mean	sd	min	max	observations
Log(GDP)	12.339	1.775	4.96	17.07	1139
Log(GVC_F_ASIA13)	7.340	2.141	-3.36	11.83	1139
Log(GVC_B_ASIA13)	7.227	1.960	-2.25	11.27	1139
Log(GVC_F_W)	9.528	1.842	0.78	13.47	1139
Log(GVC_B_W)	9.591	1.803	0.95	12.88	1139
Log(EX_VA_ASIA13)	8.140	2.015	-1.36	12.49	1139
Log(IM_VA_ASIA13)	8.854	1.817	1.13	13.61	1139
Log(EX_VA_W)	10.662	1.700	2.13	14.33	1139
Log(IM_VA_W)	10.965	1.582	4.28	14.96	1139
Open	0.761	0.431	0.20	3.52	1139
GDP_g	2.743	3.991	-28.76	24.62	1139
Log(FDI)	11.439	1.713	4.37	16.39	1139

APPENDIX C – POST-ESTIMATION DIAGNOSTIC TESTS

Appendix C reports the complete set of diagnostic test results for regional specifications (NAFTA and ASIA-13).

Table C1. Diagnostic tests – NAFTA Forward linkages

Test	Null hypothesis (H_0)	Model tested	Test statistic	p-value	Outcome	Interpretation
Forward GVC participation with NAFTA region (77 countries)						
Modified Wald (heteroskedasticity)	$\sigma^2_i = \sigma^2$ (no groupwise heteroskedasticity)	FE + cluster	$\chi^2(77)$ = 4,886.49	0.000	Reject H_0	Heteroskedasticity present → cluster-robust SE appropriate
Wooldridge (autocorrelation)	No AR(1) within panels	FE + cluster	F(1,76) = 433.54	0.000	Reject H_0	First-order autocorrelation detected → use cluster or DK SE
Pesaran CD (cross-section dep.)	No cross-sectional dependence	FE + cluster	CD = -0.474	0.635	Fail to reject	No significant cross-sectional dependence
Forward GVC global participation (77 countries)						
Modified Wald (heteroskedasticity)	$\sigma^2_i = \sigma^2$ (no groupwise heteroskedasticity)	FE + cluster	$\chi^2(77)$ = 36,077.02	0.000	Reject H_0	Heteroskedasticity present → cluster-robust SE appropriate
Wooldridge (autocorrelation)	No AR(1) within panels	FE + cluster	F(1,76) = 234.90	0.000	Reject H_0	First-order autocorrelation detected → use cluster or DK SE
Pesaran CD (cross-section dep.)	No cross-sectional dependence	FE + cluster	CD = 0.662	0.508	Fail to reject	No significant cross-sectional dependence

Table C2. Diagnostic tests – NAFTA Backward linkages

Test	Null hypothesis (H_0)	Model tested	Test statistic	p-value	Outcome	Interpretation
Backward GVC participation with NAFTA region (77 countries)						
Modified Wald (heteroskedasticity)	$\sigma^2_i = \sigma^2$ (no groupwise heteroskedasticity)	FE + cluster	$\chi^2(77)$ = 7,863.14	0.000	Reject H_0	Heteroskedasticity present → cluster-robust SE appropriate
Wooldridge (autocorrelation)	No AR(1) within panels	FE + cluster	F(1,76) = 58.44	0.000	Reject H_0	First-order autocorrelation detected → use cluster or DK SE
Pesaran CD (cross-section dep.)	No cross-sectional dependence	FE + cluster	CD = -0.273	0.785	Fail to reject	No significant cross-sectional dependence
Backward GVC global participation (77 countries)						
Modified Wald (heteroskedasticity)	$\sigma^2_i = \sigma^2$ (no groupwise heteroskedasticity)	FE + cluster	$\chi^2(77)$ = 52,572.75	0.000	Reject H_0	Heteroskedasticity present → cluster-robust SE appropriate
Wooldridge (autocorrelation)	No AR(1) within panels	FE + cluster	F(1,76) = 27.54	0.000	Reject H_0	First-order autocorrelation detected → use cluster or DK SE
Pesaran CD (cross-section dep.)	No cross-sectional dependence	FE + cluster	CD=0.460	0.646	Fail to reject	No significant cross-sectional dependence

Table C3. Diagnostic tests – ASIA-13 Forward linkages

Test	Null hypothesis (H_0)	Model tested	Test statistic	p-value	Outcome	Interpretation
Forward GVC participation with ASIA-13 region (67 countries)						
Modified Wald (heteroskedasticity)	$\sigma^2_i = \sigma^2$ (no groupwise heteroskedasticity)	FE + cluster	$\chi^2(67)$ = 28,716.84	0.000	Reject H_0	Heteroskedasticity present → cluster-robust SE appropriate
Wooldridge (autocorrelation)	No AR(1) within panels	FE + cluster	F(1, 66) = 319.76	0.000	Reject H_0	First-order autocorrelation detected → use cluster or DK SE
Pesaran CD (cross-section dep.)	No cross-sectional dependence	FE + cluster	CD = -0.769	0.442	Fail to reject	No significant cross-sectional dependence
Forward GVC global participation (67 countries)						
Modified Wald (heteroskedasticity)	$\sigma^2_i = \sigma^2$ (no groupwise heteroskedasticity)	FE + cluster	$\chi^2(67)$ = 25,450.07	0.000	Reject H_0	Heteroskedasticity present → cluster-robust SE appropriate
Wooldridge (autocorrelation)	No AR(1) within panels	FE + cluster	F(1, 66) = 227.06	0.000	Reject H_0	First-order autocorrelation detected → use cluster or DK SE
Pesaran CD (cross-section dep.)	No cross-sectional dependence	FE + cluster	CD = 1.065	0.287	Fail to reject	No significant cross-sectional dependence

Table C4. Diagnostic tests – ASIA-13 Backward linkages

Test	Null hypothesis (H_0)	Model tested	Test statistic	p-value	Outcome	Interpretation
Backward GVC participation with ASIA-13 region (67 countries)						
Modified Wald (heteroskedasticity)	$\sigma^2_i = \sigma^2$ (no groupwise heteroskedasticity)	FE + cluster	$\chi^2(67)$ = 21,749.29	0.000	Reject H_0	Heteroskedasticity present → cluster-robust SE appropriate
Wooldridge (autocorrelation)	No AR(1) within panels	FE + cluster	F(1, 66) = 33.56	0.000	Reject H_0	First-order autocorrelation detected → use cluster or DK SE
Pesaran CD (cross-section dep.)	No cross-sectional dependence	FE + cluster	CD = -0.503	0.615	Fail to reject	No significant cross-sectional dependence
Backward GVC global participation (67 countries)						
Modified Wald (heteroskedasticity)	$\sigma^2_i = \sigma^2$ (no groupwise heteroskedasticity)	FE + cluster	$\chi^2(67)$ = 36,851.89	0.000	Reject H_0	Heteroskedasticity present → cluster-robust SE appropriate
Wooldridge (autocorrelation)	No AR(1) within panels	FE + cluster	F(1, 66) = 18.89	0.000	Reject H_0	First-order autocorrelation detected → use cluster or DK SE
Pesaran CD (cross-section dep.)	No cross-sectional dependence	FE + cluster	CD = 1.799	0.072	Fail to reject	No significant cross-sectional dependence

APPENDIX D – FULL REGRESSION RESULTS

This appendix D presents the full regression outputs for all model specifications. Each table reports coefficient estimates, standard errors, and fit statistics (R^2 within, R^2 overall, F-statistic, and Prob > F).

Table D1. Full regression output – Global Forward (80 countries)

	(1) GDP	(2) GDP	(3) GDP	(4) GDP	(5) GDP	(6) GDP	(7) GDP	(8) GDP	(9) GDP
GVC_F	0.293***	0.293***	0.246***	0.293***	0.246***				
	(0.027)	(0.081)	(0.067)	(0.026)	(0.039)				
L.GVC_F						0.269***	0.233***	0.269***	0.233***
						(0.058)	(0.031)	(0.022)	(0.034)
EX_VA	0.424***	0.424***	0.384***	0.424***	0.384***	0.474***	0.468***	0.474***	0.468***
	(0.026)	(0.111)	(0.100)	(0.038)	(0.047)	(0.089)	(0.074)	(0.030)	(0.034)
Open	-0.659***	-0.659***	-0.697***	-0.659***	-0.697***	-0.651***	-0.680***	-0.651***	-0.680***
	(0.026)	(0.112)	(0.090)	(0.081)	(0.071)	(0.110)	(0.090)	(0.077)	(0.068)
GDP_g	0.001	0.001	0.003**	0.001	0.003*	0.003**	0.004***	0.003**	0.004**
	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)
L.FDI	0.095***	0.095*	0.050	0.095***	0.050***	0.083	0.034	0.083***	0.034***
	(0.010)	(0.054)	(0.035)	(0.015)	(0.009)	(0.050)	(0.029)	(0.016)	(0.009)
Constant	4.384***	4.384***	5.711***	4.483***	5.734***	4.242***	5.168***	4.279***	5.190***
	(0.153)	(0.610)	(0.737)	(0.261)	(0.415)	(0.615)	(0.802)	(0.258)	(0.377)
N. Observations	1360	1360	1360	1360	1360	1360	1360	1360	1360
N. Countries	80	80	80	80	80	80	80	80	80
R^2 (within)	0.8582	0.8582	0.9375	0.8582	0.9375	0.8630	0.9409	0.8630	0.9409
R^2 (overall)	0.9734	0.9734	0.9740	-	-	0.9750	0.9769	-	-
F-stat	362.98	234.98	.	1020.72	162364.09	245.32	.	907.08	51807.80
Prob > F	0.000	0.000	.	0.000	0.000	0.000	.	0.000	0.000

Standard errors in parentheses

All regressions include country and year fixed effects.
Col.1 = FE naive;

Col.2 = FE + Cluster (modello base);
Col.3 = FE + Cluster + trend;

Col.4 = FE + DK;

Col.5 = FE + DK + trend;

Col.6 = FE + Cluster (t−1), modello principale;

Col.7 = FE + Cluster + trend (t−1);
Col.8 = FE + DK (t−1);

Col.9 = FE + DK + trend (t−1).

All models estimated with xtreg or xtscc (FE).

Robust or clustered standard errors as indicated in the specification.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table D2. Full regression output – Global Backward (80 countries)

	(1) GDP	(2) GDP	(3) GDP	(4) GDP	(5) GDP	(6) GDP	(7) GDP	(8) GDP	(9) GDP
GVC_B	0.133***	0.133***	0.133***	0.133***	0.133***				
	(0.014)	(0.039)	(0.039)	(0.021)	(0.015)				
L.GVC_B						0.128***	0.098***	0.128***	0.098***
						(0.031)	(0.023)	(0.014)	(0.019)
IM_VA	0.638***	0.638***	0.547***	0.638***	0.547***	0.642***	0.556***	0.642***	0.556***
	(0.018)	(0.075)	(0.039)	(0.018)	(0.017)	(0.071)	(0.042)	(0.016)	(0.020)
Open	-0.719***	-0.719***	-0.887***	-0.719***	-0.887***	-0.680***	-0.766***	-0.680***	-0.766***
	(0.031)	(0.157)	(0.096)	(0.042)	(0.039)	(0.126)	(0.076)	(0.030)	(0.031)
GDP_g	0.001	0.001	0.001	0.001	0.001**	0.002	0.002	0.002*	0.002**
	(0.001)	(0.002)	(0.001)	(0.001)	(0.000)	(0.002)	(0.001)	(0.001)	(0.001)
L.FDI	0.060***	0.060	0.021	0.060***	0.021***	0.060	0.018	0.060***	0.018**
	(0.010)	(0.056)	(0.025)	(0.015)	(0.007)	(0.053)	(0.022)	(0.014)	(0.008)
Constant	3.857***	3.857***	5.384***	3.970***	5.410***	3.858***	5.562***	3.933***	5.596***
	(0.151)	(0.632)	(0.291)	(0.244)	(0.227)	(0.655)	(0.357)	(0.256)	(0.246)
N. Observations	1360	1360	1360	1360	1360	1360	1360	1360	1360
N. Countries	80	80	80	80	80	80	80	80	80
R^2 (within)	0.8737	0.8737	0.9553	0.8737	0.9553	0.8752	0.9536	0.8752	0.9536
R^2 (overall)	0.9794	0.9794	0.9704	-	-	0.9799	0.9704	-	-
F-stat	414.62	227.54	.	768.20	398569.20	203.42	.	1054.40	12582.41
Prob > F	0.000	0.000	.	0.000	0.000	0.000	.	0.000	0.000

Standard errors in parentheses

All regressions include country and year fixed effects.
Col.1 = FE naive;

Col.2 = FE + Cluster (modello base);

Col.3 = FE + Cluster + trend;

Col.4 = FE + DK;

Col.5 = FE + DK + trend;

Col.6 = FE + Cluster (t−1);

Col.7 = FE + Cluster + trend (t−1);

Col.8 = FE + DK (t−1);

Col.9 = FE + DK + trend (t−1).

All models estimated with xtreg or xtscc (FE).

Robust or clustered standard errors as indicated in the specification.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table D3. Full regression output – NAFTA Forward/Backward (77 countries)

	FE + Cluster				FE + Cluster + country trend				FE + Driscoll–Kraay			
	Forward GVC		Backward GVC		Forward GVC		Backward GVC		Forward GVC		Backward GVC	
	(1) GDP	(2) GDP	(3) GDP	(4) GDP	(5) GDP	(6) GDP	(7) GDP	(8) GDP	(9) GDP	(10) GDP	(11) GDP	(12) GDP
L.Forward GVC participation, NAFTA	0.292***				0.201***				0.292***			
	(0.043)				(0.030)				(0.019)			
Exports (non-GVC) , NAFTA	0.002				-0.001				0.002			
	(0.003)				(0.004)				(0.001)			
L.Forward GVC participation, World		0.268***				0.233***				0.268***		
		(0.058)				(0.031)				(0.022)		
Exports (non-GVC) , World		0.475***				0.469***				0.475***		
		(0.090)				(0.075)				(0.030)		
L.Backward GVC participation, NAFTA			0.068***				0.062***				0.068***	
			(0.023)				(0.022)				(0.014)	
Imports (non-GVC), NAFTA			0.511***				0.389***				0.511***	
			(0.056)				(0.039)				(0.042)	
L.Backward GVC participation, World				0.129***				0.099***				0.129***
				(0.031)				(0.023)				(0.013)
Imports (non-GVC), World				0.643***				0.554***				0.643***
				(0.071)				(0.042)				(0.016)
Trade Openness	-0.451***	-0.647***	-0.634***	-0.675***	-0.480***	-0.680***	-0.626***	-0.766***	-0.451***	-0.647***	-0.634***	-0.675***
	(0.130)	(0.110)	(0.101)	(0.126)	(0.091)	(0.091)	(0.082)	(0.077)	(0.087)	(0.079)	(0.060)	(0.030)
GDP growth rate	0.005**	0.003*	0.003*	0.002	0.008***	0.004***	0.005***	0.002	0.005***	0.003**	0.003*	0.002*
	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
L.FDI	0.195**	0.082	0.111*	0.058	0.100**	0.031	0.039	0.015	0.195***	0.082***	0.111***	0.058***
	(0.078)	(0.051)	(0.066)	(0.053)	(0.050)	(0.029)	(0.038)	(0.022)	(0.032)	(0.016)	(0.020)	(0.015)
Constant	8.286***	4.219***	6.488***	3.843***	9.870***	5.159***	8.258***	5.564***	8.639***	4.262***	6.640***	3.922***
	(0.645)	(0.615)	(0.461)	(0.656)	(0.537)	(0.803)	(0.367)	(0.355)	(0.316)	(0.255)	(0.330)	(0.256)
N. Observations	1309	1309	1309	1309	1309	1309	1309	1309	1309	1309	1309	1309
N. Countries	77	77	77	77	77	77	77	77	77	77	77	77
R^2 (within)	.	.	.	.	.	.	.	.	.	.	.	.
R^2 (overall)	0.923	0.974	0.937	0.978	0.827	0.976	0.900	0.967	.	.	.	.
F-statistic	81.22	265.95	123.95	199.18	.	.	.	.	163.17	731.56	836.82	4198.34
Prob > F	0.000	0.000	0.000	0.000	.	.	.	.	0.000	0.000	0.000	0.000

Standard errors in parentheses

All regressions include country and year fixed effects.

Col.1 = Forward_NA FE + Cluster

Col.2 = Forward_W FE + Cluster

Col.3 = Backward_NA FE + Cluster

Col.4 = Backward_W FE + Cluster

Col.5 = Forward_NA FE + Cluster + trend

Col.6 = Forward_W FE + Cluster + trend

Col.7 = Backward_NA FE + Cluster + trend

Col.8 = Backward_W FE + Cluster + trend

Col.9 = Forward_NA FE + DK

Col.10 = Forward_W FE + DK

Col.11 = Backward_NA FE + DK

Col.12 = Backward_W FE + DK

All models estimated using xtreg or xtscc (FE)

Standard errors clustered at the country level (CountryID).

Driscoll–Kraay standard errors used for robustness check.

*, **, *** = significant at the 10%, 5%, and 1% levels.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table D4. Full regression output – ASIA-13 Forward/Backward (67 countries)

	FE + Cluster				FE + Cluster + country trend				FE + Driscoll–Kraay			
	Forward GVC		Backward GVC		Forward GVC		Backward GVC		Forward GVC		Backward GVC	
	(1) GDP	(2) GDP	(3) GDP	(4) GDP	(5) GDP	(6) GDP	(7) GDP	(8) GDP	(9) GDP	(10) GDP	(11) GDP	(12) GDP
L.Forward GVC participation, ASIA-13	0.206***				0.171***				0.206***			
	(0.034)				(0.032)				(0.035)			
Exports (non-GVC)	0.110***				0.104***				0.110***			
	(0.034)				(0.025)				(0.025)			
L.Forward GVC participation, World		0.283***				0.246***				0.283***		
		(0.057)				(0.033)				(0.029)		
Exports (non-GVC) , World		0.425***				0.427***				0.425***		
		(0.098)				(0.074)				(0.028)		
L.Backward GVC participation, ASIA-13			0.021				0.057***				0.021	
			(0.031)				(0.015)				(0.021)	
Imports (non-GVC), ASIA13			0.470***				0.389***				0.470***	
			(0.065)				(0.035)				(0.023)	
L.Backward GVC participation, World				0.114***				0.086***				0.114***
				(0.030)				(0.021)				(0.018)
Imports (non-GVC), World				0.697***				0.556***				0.697***
				(0.083)				(0.052)				(0.028)
Trade Openness	-0.498***	-0.689***	-0.428**	-0.645***	-0.566***	-0.734***	-0.693***	-0.783***	-0.498***	-0.689***	-0.428***	-0.645***
	(0.170)	(0.156)	(0.183)	(0.155)	(0.114)	(0.117)	(0.108)	(0.094)	(0.098)	(0.087)	(0.073)	(0.045)
GDP growth rate	0.007***	0.004**	0.005**	0.000	0.006***	0.004***	0.002**	0.002	0.007***	0.004**	0.005***	0.000
	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)
L.FDI	0.143*	0.066	0.104	0.038	0.090*	0.041	0.047	0.024	0.143***	0.066***	0.104***	0.038**
	(0.079)	(0.054)	(0.072)	(0.051)	(0.048)	(0.031)	(0.031)	(0.024)	(0.027)	(0.015)	(0.018)	(0.015)
Constant	8.626***	4.851***	7.216***	3.623***	9.528***	5.473***	8.474***	5.619***	0.000	4.985***	7.106***	0.000
	(0.610)	(0.765)	(0.472)	(0.746)	(0.531)	(0.835)	(0.303)	(0.421)	(.)	(0.219)	(0.220)	(.)
N. Observations	1139	1139	1139	1139	1139	1139	1139	1139	1139	1139	1139	1139
N. Countries	67	67	67	67	67	67	67	67	67	67	67	67

R^2 (within)	0.705	0.825	0.758	0.861	0.886	0.928	0.924	0.944	0.705	0.825	0.758	0.861
R^2 (overall)	0.901	0.973	0.952	0.980	0.846	0.976	0.901	0.972	-	-	-	-
F-statistic	78.16	282.50	155.84	225.84	-	-	-	-	10278.86	1031.89	2514.24	1126.53
Prob > F	0.000	0.000	0.000	0.000	-	-	-	-	0.000	0.000	0.000	0.000

Standard errors in parentheses

All regressions include country and year fixed effects.

Col.1 = Forward_ASIA13 FE + Cluster

Col.2 = Forward_W FE + Cluster

Col.3 = Backward_ASIA13 FE + Cluster

Col.4 = Backward_W FE + Cluster

Col.5 = Forward_ASIA13 FE + Cluster + trend

Col.6 = Forward_W FE + Cluster + trend

Col.7 = Backward_ASIA13 FE + Cluster + trend

Col.8 = Backward_W FE + Cluster + trend

Col.9 = Forward_ASIA13 FE + DK

Col.10 = Forward_W FE + DK

Col.11 = Backward_ASIA13 FE + DK

Col.12 = Backward_W FE + DK

All models estimated using xtreg or xtscc (FE)

Standard errors clustered at the country level (CountryID).

Driscoll–Kraay standard errors used for robustness check.

*, **, *** = significant at the 10%, 5%, and 1% levels.

$^{*}\ p < 0.10$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$

APPENDIX E – GRAPHICAL DIAGNOSTICS

This appendix includes graphical diagnostics for the global fixed-effects models. Residuals versus fitted plots are shown for both forward and backward specifications.

Figure D1. Residuals vs. fitted values – Global Forward model

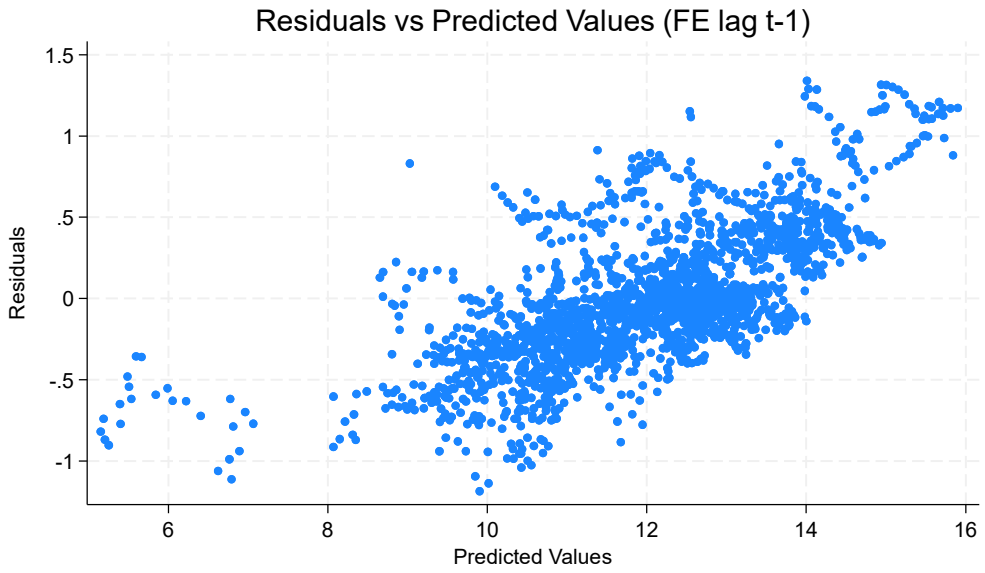
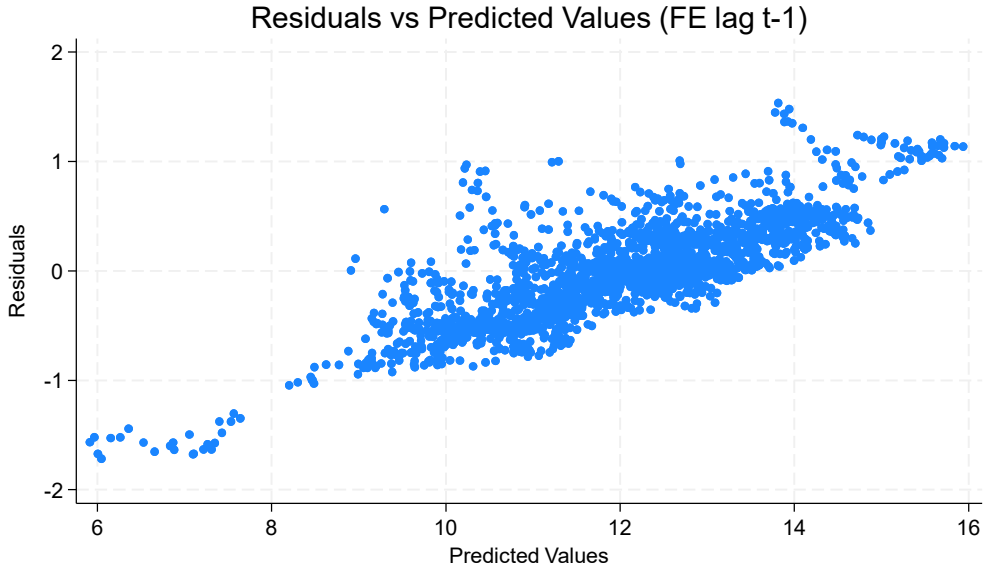


Figure D2. Residuals vs. fitted values – Global Backward model



APPENDIX F – ECONOMETRIC IMPLEMENTATION (SUMMARY OF STATA ROUTINES)

This appendix provides an overview of the Stata routines used for the empirical analysis of the relationship between global value chain (GVC) participation and domestic output. Only the essential components of the econometric implementation are reported here, in order to document the structure of the estimation, model selection, and diagnostic checks, while omitting purely procedural details (e.g., file management or labeling commands). All estimations were performed in **Stata 18 SE** using panel data techniques with country and year fixed effects.

Panel Setup and Construction of Lagged Variables

```
xtset CountryID Year
gen GVC_F_L1 = L1.GVC_F
gen GVC_B_L1 = L1.GVC_B
gen FDI_L1   = L1.FDI
```

Each observation is defined by a country–year pair. Lagged variables (t−1) are constructed to mitigate potential reverse causality between GVC integration and GDP. All variables were expressed in consistent units and aligned across years before estimation.

Benchmark Fixed-Effects Specification (Lagged Model)

The main specification evaluates the impact of GVC participation (forward or backward) on current GDP, controlling for trade openness, domestic or foreign value added, FDI, and GDP growth. Country and year fixed effects are included in all models.

Forward GVC participation:

```
xtreg GDP L1.GVC_F EX_VA Open GDP_g L1.FDI i.Year, fe vce(cluster CountryID)
```

Backward GVC participation:

```
xtreg GDP L1.GVC_B IM_VA Open GDP_g L1.FDI i.Year, fe vce(cluster CountryID)
```

The use of lagged regressors (t−1) ensures a more credible temporal ordering and reduces simultaneity bias. Clustered standard errors are computed at the country level.

Model Selection: Fixed Effects vs Random Effects

The choice between fixed- and random-effects specifications was assessed using both the Hausman and Mundlak (correlated random effects) tests.

```
hausman F_fe_lag F_re_lag, sigmamore
xtreg GDP L1.GVC_F EX_VA Open GDP_g L1.FDI i.Year, re vce(cluster CountryID)
testparm m_GVC_F_L1 m_FDI_L1 m_EX_VA m_Open m_GDP_g
```

A significant Hausman statistic ($p < 0.05$) and significant Mundlak means confirmed that unobserved heterogeneity is correlated with the regressors, supporting the use of **fixed effects** as the preferred specification.

Post-Estimation Diagnostic Tests

Diagnostic tests were conducted on the benchmark FE model with lagged regressors to assess the validity of the estimation assumptions.

```
xttest3                 // Modified Wald test for heteroskedasticity
xtserial GDP GVC_F_L1 EX_VA Open GDP_g FDI_L1 // Wooldridge test for serial correlation
xtcsd, pesaran abs                  // Pesaran test for cross-sectional dependence
```

Cluster-robust or Driscoll–Kraay standard errors were used to address any detected violations. A placebo timing test with a lead variable (F1.GVC_F) was also implemented to verify the absence of anticipatory reverse causality.

Specification and Linearity Checks

The functional form of the model was tested using link and RESET tests, followed by a quadratic extension to assess nonlinearity.

```
linktest
ovtest
gen GVC_F_L1_sq = GVC_F_L1^2
```

xtreg GDP GVC_F_L1 GVC_F_L1_sq EX_VA Open GDP_g FDI_L1 i.Year, fe vce(cluster CountryID)

Non-significance of the squared term confirmed the appropriateness of the linear specification.

Residual Diagnostics

A graphical inspection of residuals was performed to ensure that no systematic pattern or variance distortion was present.

predict u_lag, resid
predict yhat_lag, xb
scatter u_lag yhat_lag, title("Residuals vs Predicted Values (FE lag t−1)")

The residual plot (see Appendix D, Figure D1, D2) shows no clear trend or heteroskedastic pattern, visually supporting the robustness of the fixed-effects estimation.

Export of Regression Tables

Final estimation outputs were exported using the **esttab** package to generate publication-ready tables in RTF format for inclusion in the dissertation.

esttab F_fe_naive F_fe_clu F_fe_clu_tr F_fe_dk F_fe_dk_tr F_fe_clu_lag F_fe_clu_lag_tr F_fe_dk_lag F_fe_dk_lag_tr using "Table_GVC_F.rtf", ...

Each table reports coefficients with robust or clustered standard errors, R^2 statistics (within and overall), F-statistics, and the number of observations and countries.

Summary

The appendix demonstrates the rigorous econometric implementation underlying the analysis. By systematically combining lagged specifications, multiple robustness corrections (clustered and Driscoll–Kraay errors), and extensive diagnostic testing, the empirical strategy ensures that the estimated relationship between GVC participation and GDP is statistically sound, temporally credible, and economically interpretable.

The full Stata do-files for all specifications (Global, NAFTA, and ASIA13; Forward and Backward participation) follow the same structure described above and are available upon request or through the dissertation's supplementary materials repository.

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