Drivers of Participation in Global Value Chains: International Evidence on What Matters

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ABSTRACT

Globalization and technological progress induce an unprecedented commercial interdependence between countries: world trade and production are increasingly structured around Global Value Chains (GVCs). These GVCs create an international production fragmentation, allowing higher efficiency and competitiveness, and exposure to global shocks, so trade policies must more proactively consider this new reality of business. This paper analyzes the plausible determinants of insertion in global production, in terms of forward and backward participation in GVCs. It is verified by using static panels, that FDI flows, education, and economic activity affect both types of linkages, although in different ways. It is also confirmed that the distance to the largest hub and the exchange rate are important in backward participation, while the size of the economy and the quality of logistics determine the forward one. Based on this diagnosis, this work guides academicians, practitioners, and policymakers to promote successful insertion in GVCs.

I.   INTRODUCTION

In recent decades, international trade has experienced exponential growth accompanied by structural change. Technological and telecommunications advancements have facilitated the commercial integration of various countries, driven by competitive pressure and the consequent search for cost-reduction opportunities and access to resources and new markets. The result has been globalization or, in other words, the internationalization of the production processes of goods and services.

World trade and production are increasingly structured around global value chains (GVCs), which make up a set of links to generate a good or service, from its conception to the final sale, and even, in some instances, to the recycling of waste. These GVCs create an international production fragmentation, allowing companies greater efficiency and competitiveness. Today, more than half of manufacturing imports are intermediate goods in the world, and close to three-quarters are in large emerging economies such as China and Brazil. In services, this figure exceeds 70%. Furthermore, on average, more than half of exports are products traded in a global context (OECD, 2022a). A large part of this commercial interdependence is promoted by cross-border investments, which operate globally through transnational companies and determine the productive evolution of countries and regions. Hence the close relationship between trade, foreign direct investment (FDI), and the flow of inputs that make up GVCs with varying degrees of complexity, both intra-firm and inter-firm (Ferrando, 2013).

GVCs have become a research priority, particularly in recent years, due to various natural, socioeconomic, and political challenges with broad global impact. These are subject to more risks than ever, as they are getting increasingly more global and digital, which introduces additional complexities in their operation and requires greater analysis to face crises and assess their resilience. This became relevant, particularly during the COVID-19 pandemic, which represented an unprecedented challenge to the world economy: in 2020 alone, international trade fell by 8% and exposed the vulnerabilities of GVCs, while questioning their benefits, versus the most regionalized (Engel et al., 2021). Although there is broad consensus that well-functioning GVCs are more a source of resilience than vulnerability, the COVID-19 pandemic and the consequent disruption of supply chains, not only in the commercial sphere but in sectors such as food, health or humanitarian aid, revitalize the debate on whether the benefits of international specialization in GVCs outweigh the risks associated with the transmission of disturbances between countries. As a result, some nations choose to incentivize the regionalization of supply chains, protectionism, and national self-sufficiency of key inputs, particularly in the face of various geopolitical conflicts.

The level of fragility in the GVCs revealed by COVID-19 will undoubtedly lead to its reconfiguration and could accelerate trends in relocation, diversification, and automation. The study of backward and forward linkages independently provides a critical framework to address post-pandemic effects as it fundamentally challenges the understanding of the variables that are believed to determine today the positioning of a country, particularly on its forward participation, allowing economies to make better-informed decisions on alternative measures such as the extension of supplier base, and the adoption of new technologies.

The analysis of the GVCs gives an understanding of the interdependence between economies and the effect of their decisions in the global sphere; Understanding them is

important for formulating policies in trade, industry, and innovation, as well as determining how they affect companies and the location of their activities. Its study can involve identifying a country's position and level of participation in GVCs to understand to what extent it is involved in a vertically fragmented production process. It also reveals the result of the regionalization of a supply chain and questions protectionist trade measures. For example, many US imports from China are products of US companies made in Asian countries. Therefore, an increase in import tariffs would have negative consequences for these companies, since their products will cross borders several times (Ferrando, 2013).

The GVCs analysis is based on two factors that constitute the so-called value-added and, therefore, the participation of a country in the GVCs: the foreign value-added contribution to an economy's (or economy sector's) exports (backward participation), and the value-added to the exports of other countries (forward participation), which makes it possible to understand the length of the value chain and the position of an economy in it. Countries positioned *upstream* in the chain produce the raw materials or intangibles involved at the beginning of the production process (e.g. design), while countries positioned further down the chain assemble the processed products or specialize in customer service. The position of countries in GVCs affects the value that countries and firms are capturing in them (De Backer and Miroudot. 2013).

COVID-19 has tested the resilience and flexibility of these GVCs, now recognized as drivers of export-led growth and a lifesaver in times of crisis while experiencing a technological shift. A wide range of research focuses on understanding a country's positioning in GVCs. However, there is very little research around decoupling backward and forward linkages, while providing practical frameworks to respond to the profound shifts in the ecosystem of GVCs post-COVID. Furthermore, there is also very little research on how engineering variables play a critical role in the quality of these responses.

This paper attempts to identify the factors that determine both backward and forward participation in GVCs and build two models that allow them to be validated statistically, incorporating both economic and engineering variables, obtaining key results that can help companies make better decisions given changes in the business landscape expected to have a deep impact on how economies transact and participate in GVCs moving forward.

Instead of setting up a new method to estimate an index of participation, positioning, or resilience level in the supply chain, this document takes advantage of existing measures to explore multidisciplinary factors with solid theoretical support, highlighted in the specialized literature as determinants of a country's participation in GVCs. This allows defining and estimating a behavioral function of this participation, using unconventional variables, or at least, so far, little integrated into the analysis of the GVCs, advancing in their understanding and looking to answer the following questions: What are the similarities and differences in the determinants of forward and backward participation in GVCs? What elements of the traditional theoretical framework of trade affect them? What role do factors indicated in the gravitational models of trade play? How do logistics, human capital, research and development (R&D), and information technologies influence them? What can countries and firms do to promote their participation in GVCs and increase the value they extract from them? The hypotheses to be tested are the following:

Ho$_1$: backward participation in the GVCs depends on factors indicated in classical

international trade theory (exchange rate, factor endowments, and growth of the domestic economy) and gravitational factors (distance to the closest hub), but also on elements of the socioeconomic field (human capital).

Ho$_2$: forward participation in the GVCs depends on factors indicated in classical international trade theory (exchange rate, factor endowments, and world economic growth) and gravitational (importance of the country in the global economy), but also of elements of the socioeconomic (human capital) and engineering fields (logistics services and R&D).

The work is structured as follows: In the first section, a review of the GVCs literature is provided, deep diving into its meaning and distinguishing the forward from the backward linkages of the countries in them, the most used indices to measure both, as well as the variables identified as critical for explaining them. The main concerns that arise because of the COVID-19 pandemic are also mentioned. In the second section, the research methodology is presented, which justifies the techniques applied to estimate the models included here, while, in the third part, empirical data is described, and results are discussed. Finally, we conclude with a summary of the research, its limitations, and its application. The main contributions of this study, its implications, and future lines of research are also included.

II.   LITERATURE REVIEW

A.   Global Value Chains

Global Value Chains (GVCs) are complex production networks whose main characteristic is the geographical dispersion of their links in the production of a final good or service. It includes activities of design, production, commercialization, distribution, customer support, and even, management of residues that emanate from them. They can be conducted by one or more companies and, as they extend beyond national borders, they are considered global. The fragmentation and externalization of production are not new: almost a hundred years ago, Ohlin (1933) commented that production is generally divided not into two stages, raw materials and finished products, but into many and, over the next forty years, several examples of these processes were documented (De Backer and Miroudot, 2013). However, the value chain concept appeared in the late 1970s, with studies on the set of commodity processes (Hopkins and Wallerstein, 1977). Years later, Gereffi (1994) introduced the concept of a global commodity chain, describing the clothing production chain. Later, based on the studies of Porter (1985), the concept of a value-added chain arises, breaking down its activities into five: internal logistics, production, external logistics, marketing, and post-sales service (Daudin et al., 2011).

After twenty years, Gereffi et al. (2005) analyzed the types of governance of GVCs, distinguishing between those driven by the producer or the buyer. The former is usually found in highly technological sectors, such as semiconductors or pharmaceuticals, where the companies that coordinate geographically dispersed activities are in the links of the chain with the greatest value generation, generally found in the initial phases (R&D, design, and engineering) and final (positioning, promotion, and final sale). In contrast, in shopper-driven chains, brand retailers and marketers take control of production, which may be fully outsourced, focusing on marketing and sales. These GVCs tend to have lower capital needs and require less skilled staff, as illustrated by the garment commodity

chain. Production and assembly constitute the activities with the lowest value contribution and are generally fragmented in different countries, where the leading companies obtain some type of competitive advantage (lower labor costs, lower risks, and proximity to resources or key final markets). This behavior called the *smile curve* (Shih, 1992) represents the relationship between the distinct stages of the value chain and its impact in terms of generating value added (Campos-Romero and Rodil-Marzábal, 2021).

Subsequently, Frederick (2010) defines supply chains as production-related input-output links that are part of an ecosystem, which she describes in her Value Chain Reference Model (VCRM) diagram as consisting of four parts: value-adding activities, the supply chain, end-use markets, and the business support environment.

The concept of GVCs is the international extension of these definitions, responding to the growing phenomenon of the fragmentation of global production (APEC, 2021). Under this new GVCs paradigm, says Melitz (2003), what is relevant is no longer the industries, but the business functions throughout the chain (R&D, acquisitions, operations, marketing, and customer service, among others), therefore, countries tend to specialize in them. Today, production is more like a complex network structure in which components are produced in multiple stages across different economies that are linked horizontally, vertically, and diagonally. Firms or countries are specialized in some but not all stages of the production process (Hummels et al., 1998).

B.   Input-Output Relationships

The starting point of the current framework on the contribution of value in global production chains is based on Leontief's input-output matrix (I-O) (1970). He defined the I-O matrix as an adaptation of the general equilibrium theory to the study of the quantitative interdependence between economic activities that have a reciprocal relationship and whose purpose is to evaluate the existing relationships between the various sectors of production and consumption that make up the economy of a nation. The open input-output) system I-O introduced by Leontief (1951) allows the analysis of economic interactions, considering the origin and destination of the goods and services produced and intermediate sales.

Hummels et al. (2001) took this input-output study framework to estimate the content of foreign value added through backward participation, that is, by the value of imported inputs in a country's exports. Hummels et al. (2014) proposed an alternative measure that refers to the percentage of exported goods and services that are used as imported inputs for exports of other countries: the so-called forward participation. Subsequent studies by Koopman et al. (2010 and 2014) have refined and disaggregated this framework of analysis. Koopman et al. (2010), for example, proposed an indicator that includes both linkages, so it is possible to have a comprehensive evaluation of a country's participation in GVCs, both as a user of foreign inputs or as a provider of intermediate goods and services used in the exports of other countries.

Indicators such as countries' participation in GVCs, their duration (chain links), and the position of countries in them have also been tested. Particularly important to mention are the studies by Fally (2012) and Antràs et al. (2012), who created complementary indicators such as the distance to final demand, which aim to find the location of countries in the value chain. Depending on the specialization, an economy

can be in the initial or final links. The nations located in the first links produce the raw materials or intangibles involved at the beginning of the production process (for example, research, and design), while the countries that are located further down the chain assemble the processed products or specialize in client services. These investigations introduce an *upstream* measure that reports on how many processes remain before the goods or services are finished to determine whether a country has managed to move up or down in the GVCs. However, the availability of information on this indicator is limited, so it will not be used in this work.

C.   Global Value Chains and their Determinants

This section outlines the main determinants of countries' participation in GVCs explored in the theoretical and empirical literature. This review highlights that, even when there are common factors that determine the backward or forward participation of an economy in GVCs, whether socioeconomic or commercial, engineering or R&D fields, their relative importance is not the same, and differentiated items may exist, at least a priori, to explain them.

The traditional international trade theory, applicable to GVCs, sets up that variables such as the exchange rate, as well as the income of the countries, act differently on backward participation, linked to imports, or forward participation, more related to exports. A priori, a depreciation of the local currency or an improvement in the income of the rest of the world tends to promote the forward linkage of the country, but not the backward one, which is stimulated by improvements in the domestic currency and economy. This framework of analysis also emphasizes the importance of trade agreements, which usually translate into preferential tariff treatment, based on both the absolute and relative advantages of each country and its resource endowments (Blanchard, 2021).

Arvis et al. (2016) highlight the importance of geographical location in line with gravitational models (Walter, 1954), which have established for more than half a century that international flows of goods and services are positively related to the size of economies and inversely to the distance between the two. Currently, the distance to main global manufacturing hubs gets relevance over the distance between countries, in the context of GVCs as pointed out by Banerjee and Zeman (2020), who also reiterate the importance of inputs endowment and trade liberalization. This distance is not, however, a definitive factor and loses importance as logistics performance gains it or, in other words, efficiency in customs and border clearance, the quality of commercial and transport infrastructure, the ease of organizing, competitively tracking, and deliver shipments and the competition of these services (Lambert and Stock, 1993). In addition, transporting, storing, and handling merchandise are labor-intensive activities, so the availability of qualified labor in different occupational fields, for example, operational, administrative, or managerial, constitutes a key element for a country that intends to insert itself in the GVCs or that seeks to position itself at a greater value added (OECD, 2021).

From the foregoing, it is evident that joining GVCs requires significant investments, which repeatedly need flows of foreign direct investment (FDI), essential for these linkages. However, there is no consensus on how the FDI affects the insertion of countries in the GVCs. Authors such as Kowalski et al. (2015) suggest that these flows

constitute an essential element in backward participation, but not in forward one. Other authors (Banerjee and Zeman, 2020; Qiang et al., 2021), consider that FDI flows also favor the forward participation of economies, by easing their insertion in global GVCs outside their territory, as suppliers of intermediate goods and services.

The companies that makeup GVCs are today more exposed than ever to systemic risks related to external shocks of various kinds. In turbulent times such as the current ones, international competition, geopolitical conflicts, strikes, illnesses, climate changes, and saturation of containers and some roads and means of communication, make closures and delays in some plants more likely. These events have given rise to increased trade costs and the recent slowdown in the integration of emerging economies. In response, transnational companies expand their R&D activities, the effects of which have still been little explored, particularly those linked to Machine Learning (ML) or Artificial Intelligence (AI) (Rodrik, 2018). Information technologies, or ITs, particularly the adoption of 4.0 technologies, represent critical enablers to transfer information virtually from one entity to another and allow digitizing the supply chain, visualizing the network, anticipating failures in manufacturing and logistics through prediction methods on ML and AI, as well as the use of robotics to improve productivity and standardize work. All these technologies are nascent, and their high cost can be perceived as elitist, but it is only a matter of time before their adoption becomes widespread, particularly in countries where the vast majority of a GVC's value-added is produced, such as China (Bughin et al., 2017). R&D processes, the presence of researchers, and qualified personnel are prerequisites for the development of this type of technology.

Once the foundations of the GVCs study and its recent evolution have been presented, in the following section we continue to statistically validate them, through the construction of models that allow testing the hypotheses raised at the beginning of this investigation, with a solid theoretical and empirical framework.

III. DATA AND RESEARCH METHODOLOGY

In this second part of the research, the variables incorporated into the estimates, the methodology that was used, given the nature of the data, and the estimations are presented, to subsequently discuss, in the following section, the implications of the results and compare against what was obtained by other research studies on GVCs.

A. Foundational Data

This section describes the variables that were tentatively included in the estimates, as well as their brief description. In regards to the dependent variable, the most used input-output information sources in the study of GVCs are the UNCTAD-Eora (2022) GVC Database, the trade data set from the Trade in Value Added Database (TiVA) of the OECD (2022a) and The World Input-Output Database (WIOD) GGDC (2022), which consider the value added by each country in the production of goods and services for final consumption (OECD, 2021) to get a clearer picture of international trade flows. In this work, the TIVA indices are used due to their greater accessibility and the ease of integrating them into a larger database. In its 2021 version, it includes input-output tables (ICIO) up to 2018 between OECD countries and the rest of the world (European Union, ASEAN, and the G20). Given that the bibliographical review presented above suggests

it, a distinction is made between forward and backward participation, hence two models are estimated: one for each type of linkage.

Regarding the explanatory variables, the literature review suggests the inclusion of variables of a different nature. This requires integrating different databases, then choosing the variables that work through factorial-style statistical analysis, grouping the indicators into categories, and through correlation analysis, excluding those that seem to capture the same information.

First, traditional international trade variables are incorporated, such as economic activity and the exchange rate slide of the local currency versus USD, which determines the terms of trade and alters the linkages of the countries to the GVCs. Variables that reflect trade liberalization and tax arbitrage are also tested, both on foreign trade and on income or profits. All these indicators were obtained from the World Bank (2022).

Second, variables related to gravitational trade models are added: the size of the economy, measured as the country's GDP as a percentage of global GDP, as well as its distance from the largest manufacturing centers (distance to major hubs). The inclusion of this last variable requires three steps. The first is to define the most important manufacturing hubs in goods and services in the world, determined based on the criteria used by the OECD, which through its input-output database (ICIO) calculates the total centrality of a country concerning the average of the centrality of its forward and backward participation. OECD (2021) recognizes five manufacturing hubs for goods and services, whose importance is higher than that of others: The United States, China, Germany, the United Kingdom, and France. These are the hubs considered in this study, since including more would unnecessarily complicate the statistical analysis, given their lower relative importance. The second step is to obtain the distance from each country to these hubs (by most populated city and by capital), which is done using the CEPII (2021) database, calculated based on the gravitational analysis of Head and Mayer (2014) and Mayer and Zignago (2011). Finally, the distance from each country to the nearest hub is found. As an alternative to the categories of variables already mentioned, the effect of the DHL Global Connectivity Index is inspected, which evaluates the openness and diversification in commercial matters of the countries, through an analysis of both the depth and the breadth of international flows. Depth shows international flows relative to domestic activity, and breadth measures the extent to which flows are distributed around the world (DHL, 2022).

Third, indicators of FDI flows from the International Monetary Fund (IMF) are included, since GVCs have sharpened the interdependence between trade, strategic alliances, and FDI from multinational companies (Khandelwal et al., 2018; OECD, 2021) This is the sum of share capital, reinvestment of profits, and other capital and refers to a cross-border investment associated with a resident in one economy that has control or a significant degree of influence in the management of a company residing in another economy. Ownership of 10 percent or more of the common voting shares is the criteria for determining the existence of a direct investment relationship. Net FDI inflows are the value of the inward direct investment by non-resident investors in the reporting economy (WB, 2022). The figures are divided by the GDP of the country, to assess its importance in the national economy.

Fourth, and following the review of the literature, variables from the field of engineering are included, representative of the quality of logistics services, through the Logistics Performance Index (LPI), used in the aggregation but also broken down into its

different dimensions (dispatch efficiency, quality of commercial and transportation infrastructure, organization of shipments, competence, quality of logistics services, shipment tracking capacity, and delivery timeliness), which measures the efficiency of logistics supply chains based on surveys to exporting companies and their suppliers (WB, 2022).

Fifth, since transporting, storing, and handling merchandise are labor-intensive activities, the availability of labor in different occupational fields, for example, operational, administrative, or managerial, is essential for the countries that are part of or that intend to be inserted in the GVCs (OECD, 2021). Different representative variables of the endowment and quality of this productive factor were tested for the model, to incorporate human capital, repeatedly pointed out in the literature as an essential variable to explain these linkages, both backward and forward, using figures from the World Bank, International Labor Organization (ILO) and World Economic Forum (WEF). Additionally, variables related to the availability of other resources are tested (fossil and non-fossil natural resources and capital formation, among others) indicated in the framework of international trade analysis as a relevant factor of the absolute and relative advantages.

Sixth, in the same line, other variables that affect competitiveness were tested, such as institutional variables. For this, the Global Competitiveness Index (GCI) of the WEF was used, which evaluates the economic fundamentals of competitiveness in 12 pillars, such as the set of institutions, policies, and factors that affect the productivity of a country. It was necessary to use it in a disaggregated way and test with its different sub-indices, since the general one uses indicators related to aspects already contemplated in other explanatory variables, such as the quality of the transport infrastructure incorporated into the Logistics Performance Index (LPI).

Finally, variables related to research and development (R&D) were evaluated to capture the impact of innovative technologies. To do this, indicators published by the World Bank on R&D spending and density of patents and researchers based on the number of inhabitants, and some sub-indices of the Global Competitiveness Index (GCI) of the WEF (2020) and Huawei statistics (2022) were explored. The Huawei Global Connectivity Index shows the level of investment of 79 economies in industries 4.0 at four key enabling technologies (broadband, cloud computing, Internet of Things, and artificial intelligence).

The next step is to describe the methodology, and then present and discuss the results obtained.

B.   Research Methodology: A Panel Analysis

This section describes the methodology for estimating the backward and forward participation of the countries in the GVCs, the sample used, as well as the results obtained. The use of information from a wide variety of sources makes it necessary to eliminate several years and countries, as well as to estimate some missing isolated data through linear extrapolation (Scott et al., 1993). In the end, the sample includes, for backward participation in GVCs, 53 countries, and for forward participation, 52, both for twelve years (2007-2018).

GVCs backward participation sample: Argentina, Australia, Austria, Belgium. Brazil. Bulgaria, Canada, Chile, Colombia, Costa Rica, Croatia, Cyprus, Czech Republic,

Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong SAR, China, Hungary, India, Indonesia, Italy, Korea, Rep., Latvia, Lithuania, Luxembourg, Malaysia, Mexico, Netherlands, New Zealand, Norway, Peru, Philippines, Poland, Portugal, Romania, Russian Federation, Saudi Arabia, Singapore, Slovak Republic, Vietnam, Slovenia, South Africa, Spain, Sweden, Switzerland, Thailand, Tunisia, Turkey, United Kingdom, and the United States.

GVCs forward participation sample: Argentina, Australia, Austria, Belgium. Brazil. Bulgaria, Canada, Chile, Colombia, Costa Rica, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong SAR, China, Hungary, India, Indonesia, Italy, Japan, Korea, Rep., Latvia, Lithuania, Luxembourg, Malaysia, Mexico, Netherlands, New Zealand, Norway, Philippines, Poland, Portugal, Romania, Russian Federation, Singapore, Slovak Republic, Vietnam, Slovenia, South Africa, Spain, Sweden, Switzerland, Thailand, Tunisia, Turkey, United Kingdom, and the United States.

A priori, the theoretical framework presented in the previous section suggests that the estimated behavior functions should include, for backward participation of a country, the exchange rate slip, the growth and importance of its economy, the distance to the closest hub, trade liberalization, tax commitment, R&D activities, the quality of its logistics services, its endowments and/or quality of production factors, as well as FDI flows. On the other hand, for the forward participation of a country, the function must include the exchange rate slide, the growth of the world economy and its importance in it, the distance to the nearest large hub, trade liberalization, the tax commitment, the R&D activities, the quality of its logistics services, its endowments and/or quality of productive factors, as well as FDI flows.

As a first step, the possible correlation between related variables is explored, to avoid including those that could generate multicollinearity problems that panel estimation could not solve. Subsequently, the Breusch and Pagan test is performed to see if panel data is preferred over pool data. Once the individual effects have been verified for both estimates, it is checked whether they should be treated with fixed or random effects (Hausman test). However, the detection of autocorrelation and heteroskedasticity in both cases (modified Wald test and Wooldridge test, respectively), suggested the use of Feasible Generalized Least Squares (FGLS) or Panel Corrected Standard Errors (PCSE) estimators:

$$y_{it} = x_{it}\beta + \epsilon_{it} \qquad\qquad (1)$$

Where y_{it} is the dependent variable and x_{it} is a set of regressors or exogenous variables, $i = 1...m$ is, in this case, the number of countries; $t = 1...T$ is the number of years, β is a parameter and ϵ_{it} is a disturbance term, that can be correlated along time (t) or across countries (i).

FGLS fits linear panel data models using feasible generalized least squares, as it allows estimation in the presence of AR(1) autocorrelation within panels and cross-sectional correlation and heteroskedasticity between them. However, for feasibility, the periods must be at least as large as the number of countries, to avoid optimistic standard errors (SE) estimates, which is not the case in this model. Beck and Katz (1995) then suggest using Ordinary Least Squares (OLS) parameter estimates with asymptotic SE corrected for correlation between panels (PCSE). The parameters estimation is made using the Prais-Winsten equation, or Cochrane-Orcutt (with first-order autocorrelation),

since the disturbances are not independent and identically distributed (iid), either because they are heteroscedastic and/or because they are correlated between countries. All Prais-Winsten estimates are conditional on the autocorrelation estimates, that is, the parameter variance-covariance matrix estimator is asymptotically efficient under the assumed covariance structure of disturbances and uses the Feasible Generalized Least Squares for its estimation (Kmenta, 1997; Stata, 2019). The models finally estimated are:

For the backward participation of the country in the GVCs:

$$BP_{it} = \alpha + \beta \breve{e}_{it} + \gamma GDPGrowth_{it} + \delta Dist_i + ¥ FDI_{it} + \zeta LFBE_{it} + \varepsilon_{it} \qquad (2)$$

For the forward participation of the country in the GVCs:

$$FP_{it} = \theta + \phi R\&D_{it} + \eta WorldGrowth_{it} + \tau EconomySize_{it} + \Omega DFDI_{it} + \qquad (3)$$
$$\Psi LPI_{it} + \lambda LFAE_{it} + \epsilon_{it}$$

Where:
BP_{it}: Backward participation of country i in time t.
FP_{it}: Forward participation of country i in time t.
$LFBE_{it}$: Labor force with basic education of country i in time t.
$LFAE_{it}$: Labor force with advanced education of country i in time t.
$R\&D_{it}$: Researchers in R&D per million of country i in time t.
$\breve{e}_{it}$: Change (%) in the exchange rate of i country currency vs USD in time t.
$GDPGrowth_{it}$: Economic growth (%) of country i in time t.
$Dist_i$: Distance to closer major hub (capital to capital) of country i.
FDI_{it} : Net foreign direct investment inflows to country i in time t.
LPI_{it} : Logistic performance index of country i in time t (1 High to 5 Low).
$WorldGrowth_t$:Percent world economic growth in time t.
$EconomySize_{it}$: Size of economy i as a percentage of the global economy in time t.
$\alpha, \beta, \gamma, \delta, \eta, \Psi, ¥, \theta, \lambda, \phi, \tau, \Omega, \zeta$: Parameters.
$\varepsilon_{it}, \epsilon_{it}$: Disturbance terms.

IV.   KEY RESULTS AND DISCUSSION

In this section results obtained are introduced and discussed. Table 1 corresponds to the most relevant estimates of the backward participation model of the countries in the GVCs: two static panels. The results, which are consistent in both estimates, confirm the robustness of the model and suggest that backward participation in GVCs depends, as indicated by the traditional theory of international trade, on relative prices: a depreciation of the local currency makes the use of imported inputs more expensive and discourages their use.

Table 1
Backward Participation in GVCs Static Panel Results

Variables	Feasible Generalized Least Squares		Prais-Winsten Regression	
	Coefficients	Standard Errors	Coefficients	Standard Errors
Dependent				
BP_{it}				
Explanatory				
$LFBE_{it}$	0.5959547 ***	0.0086034	0.5893288 **	0.0187578
$\breve{e}_{it}$	-0.0061446 ***	0.0049241	-0.0010570 **	0.0126924
$GDPGrowth_{it}$	0.2260613 **	0.0219742	0.2481157 *	0.0509377
$Dist_i$	-0.0022882 ***	0.0000836	-0.0018351 ***	0.0002565
FDI_{it}	0.0203670 ***	0.0073761	0.0018340 **	0.0102886
Coefficient of determination R^2			0.7172	
Wald Test				
Chi^2	7509.67		1964.05	
Prob > Chibar^2	0.0000		0.0000	
Breusch and Pagan LaGrange Multiplier Test				
Chibar^2			2403.75	
Prob > Chibar^2			0.0000	
Hausman Test				
Chibar^2			13.07	
Prob > Chibar^2			0.0110	
Observations			580	
Groups			53	

Notes: Statistically significant at *10%, **5%, ***1% levels. The model passes tests for the non-existence of omitted or redundant variables and not over-identification.
Source: Author with data from CEPII (2021); OECD (2021;2022a), WB (2022) and GGDC (2022).

Likewise, in line with the gravitational theory of trade, the distance to the major hub is an influencing factor, since the use of imported inputs is more expensive the further away the country of origin is. This result coincides with Fernandes, Looi, and Winkler (2019). The strong participation of the manufacturing sector in the estimates of value added also explains this result. Countries with higher domestic production capacity exhibit a lower share of backward participation in GVCs since domestic inputs can be used to substitute imports. Similarly, trade costs derived from geography and distance can determine which country to import products from and can influence a country's position in GVCs. In long, snake-shaped GVCs, trade costs due to the distance to the main hubs accumulate in the links and have a greater incidence in later stages, relative to shorter value chains that use fewer imported inputs to produce intermediate products. Regarding this type of variable, alternative distance indicators were also tested, such as those of DHL Connectivity (2022). However, due to problems of multicollinearity and lack of significance, they were discarded.

FDI flows drive this linkage modality since they take advantage of the most abundant and least expensive inputs in the country where they are installed. These effects have already been pointed out in earlier studies (e.g., Khandelwal et al, 2018). Finally, the provision of a local labor force is relevant, although it must have a basic education, which reiterates what was found by Wang and Thangavelu (2021) on the importance of training the workforce, even for simple processes. In GVCs, labor-intensive activities with a lower value-added are in emerging countries, which explains why the labor demand is for workers with basic education. Following the OECD (2022a), given the

importance of emerging countries in the manufacturing field, their low-skilled and low-cost labor is usually their gateway to GVCs, since they start with assembly and maquila activities, with an elevated import content which is then exported.

The size of the country and its endowment of natural resources, its R&D and logistics activities, tax or tariff advantages, the state of law, or a higher educational level do not seem to be relevant in the sample and period of study for backward participation. This makes sense considering that a high imported content in exports is associated with maquila countries close to large manufacturing hubs, as shown by the significance of the coefficient of this variable. This distance is crucial in this participation modality, but it will lose relevance as aspects such as education, logistics quality or R&D activities gain importance in forward participation.

Table 2 presents the estimation of the forward participation function of the countries in the GVCs. The results suggest that this depends, as indicated by the traditional theory of international trade, on the dynamism of the world economy. This sets the pace for exports, particularly those meant to be inserted in GVCs for future exports. The changes in relative prices generated by exchange rate slippages do not seem to have a significant effect on forward participation, showing that it incorporates them as part of its production costs. Likewise, by the gravitational theory of trade, the size of the economy is relevant to a country's position as a supplier of inputs for export to third countries.

Table 2
Forward Participation in GVCs. Static Panel Results

Variables	Feasible Generalized Least Squares		Prais-Winsten Regression	
	Coefficients	Standard Errors	Coefficients	Standard Errors
Dependent				
FP_{it}				
Explanatory				
$LFAE_{it}$	0.2284937 ***	0.0068031	0.2284937 **	0.0129864
$R\&D_{it}$	0.0005411 ***	0.0001129	0.0002093 ***	0.0086034
$WorldGrowth_t$	0.2088982 **	0.0217727	0.2487934 **	0.0049241
EconomySize	0.3076952 *	0.0535346	0.3416697 *	0.0219742
FDI_{it}	0.0052580 ***	0.0005258	0.0004937 ***	0.0073761
LPI_{it}	- 0.0094573 ***	0.0068627	- 0.0097161 **	0.0124485
Coefficient of determination R^2			0.8083	
Wald Test				
Chi^2	9300.99		3097.89	
Prob > Chibar^2	0.0000		0.0000	
Breusch and Pagan LaGrange Multiplier Test				
Chibar^2			2093.43	
Prob > Chibar^2			0.0000	
Hausman test				
Chibar^2			5.23	
Prob > Chibar^2			0.5151	
Observations			571	
Groups			52	

Notes: Statistically significant at *10%, **5%, ***1% levels. The model passes tests for the non-existence of omitted or redundant variables and not over-identification.
Source: Author with data from CEPII (2021); OECD (2021;2022a), WB (2022) and GGDC (2022).

The FDI and the GVCs linkages promote a technological catch-up that leads to the specialization and training of local workers. As already mentioned, the gateway for emerging countries to these chains is usually labor and other low-cost inputs through backward participation. Gradually, this requires a higher qualification of the local labor force that allows the emerging country to advance towards higher value-added links in the GVCs, with more technical tasks that position it closer to the final product (*upstream*). In this way, the country increases its presence as a supplier of inputs for exports from third countries (forward participation), if this specialization constitutes a competitive advantage in the specific industry. For example, as China's workforce upskills, wages rise, and the country is increasingly specializing in complex manufactured goods that are supplied to exporters around the world.

In the same way, and unlike backward participation, FDI flows promote R&D activities that give rise to technological, logistical, and telecommunications advances that allow countries to become suppliers of intermediate inputs and have a strong presence in GVCs; hence the high significance of FDI, logistics quality, and R&D activities in the estimate. There is a close relationship between them. The relocation of production processes has been changing and multinational companies no longer transfer only low value-added activities outside their territory, but also knowledge-intensive and sophisticated commercial functions, with increasingly autonomous R&D in foreign subsidiaries. This interconnection allows knowledge to be shared and developed, which in turn stimulates innovative activity in GVCs (Grossman and Helpman, 1991), translating into the adoption of information technologies. Particularly Industry 4.0, offers unprecedented solutions to GVCs in terms of interconnectivity, automation, machine learning, and real-time data access. However, its development is recent, and therefore, the availability of data is limited. R&D variables are, for now, the available proxy.

The distance to the nearest hub influences backward participation due to the high share of manufacturing processes. But in forwarding participation, logistics processes and R&D activities replace the relevance of distance. The Economic and Social Commission for Asia and the Pacific estimates that less than 10% of trade costs are tariffs, 10%-30% correspond to geographical and cultural factors, and the remaining 60-80% are related to indirect costs of trade procedures, connectivity, maritime services, regulations, exchange rate fluctuations and availability of information technology services (ESCAP, 2014). Efficient transportation, logistics, and infrastructure systems are essential to maintain the average cost of access to markets at competitive levels, so their evaluation and continuous improvement are essential. Specifically, logistic quality appears as the main factor in achieving forward insertion in GVCs. This attracts capital and fosters the opening of new supply channels, such as additional ports or increasing cargo capacity. Each additional day in delivery time for imports or exports reduces international trade by about 4.5%. Therefore, the lack of logistics solutions can offset other traditional competitive advantages such as low labor costs (OECD, 2011).

The last step in this section is to determine, using the Akaike (AIC), Schwarz (SBIC), and Hannan-Quinn (HQIC) information criteria, which of the estimates is more accurate in the two types of participation. The analysis shows that the Prais–Winsten regression is more suitable for forward participation in GVCs and the Feasible Generalized Least Squares for backward since it minimizes the information criteria, so its goodness of fit is higher., although, as already pointed out, this last methodology can produce an optimistic standard error (SE) of the estimate. In any case, both methods are

useful because the sign and significance stability of the explanatory variables in them is an unequivocal sign of the robustness and validity of models.

Table 3
Selection of the Optimal Model for Participation in GVCs Using Information Criteria

	Information Criteria		
	Akaike (AIC)	Schwarz (SBIC)	Hannan – Quinn (HQIC)
Backward participation			
Feasible Generalized Least Squares	5.275239	5.312852	5.289903
Prais-Winsten regression	5.295016	5.332628	5.309680
Forward participation			
Feasible Generalized Least Squares	3.543015	3.588697	3.560838
Prais-Winsten regression	3.512404	3.558086	3.530226

Source: Author.

V. CONCLUSIONS

A. Research Findings and Discussions

This work describes the development of terminology in parallel to the evolution of supply chains until they became GVCs, and reviews the most relevant literature around them, distinguishing between forward and backward linkages. Then, it presents the most used indices to measure them, exploring the elements indicated in the literature as critical for a country to be inserted in them. It is evident that, even though there are significant elements common to both types of linkages, it is to be expected that their effects will be different in each one, in addition to the fact that there are undoubtedly elements that exclusively affect one or the other, so it is convenient to use two models that, due to the nature of the data, are estimated using feasible generalized least squares and heteroskedastic panels with corrected standard errors.

The estimation of two behavioral functions allowed testing the two hypotheses raised at the beginning of this research, namely, that participation of countries in the GVCs, both backward and forward, depends on factors indicated in classical international trade theory and gravitational factors, but also on elements of the socioeconomic and engineering fields. although these relationships are different depending on the type of participation.

Economic growth, FDI flows, and human capital affect both types of linkages, albeit in a different way: local economic activity is relevant in the backward linkages, while the world dynamism is for forward ones. The FDI favors both types of participation, by promoting the globalization of production processes, and therefore the flow of input-output between countries, taking advantage of the inputs of the country where FDI is installed, to then export products to its country of origin, part of which is inserted as intermediate goods for later export. The country's human capital is also relevant, although the requirements for forward participation are greater since they presuppose the existence of highly qualified personnel and R&D researchers and not just a basic education as in backward participation.

It is also verified that differentiated elements are significant in each model. Thus, the distance to the largest hubs is important in backward participation, since it directly affects the costs of imported inputs, hence the exchange rate changes are also relevant.

However, it is the size of the economy and the quality of logistics that determine forward linkages to a greater extent.

B.   Limitations and Future Research

Even though this work is limited to exploring some plausible determinants of the participation of the countries in the GVCs, it allows for advancement in the integration of an analysis framework, which leads to more complex and robust modeling in multidisciplinary environments once databases enable these statistical treatments. The availability of figures is the main limitation of this work since it has been generated in a scattered manner, with little compatibility between sources, data lags and gaps, and opacity of intermediate production processes, which makes their temporary and transversal integration in a database difficult.

Additionally, the weaknesses attributed to the panel analysis must be remembered, which, although it allows the identification of determinants and general trends, presupposes that the economies share the same stable function over time. Case studies or sector analyzes are a natural complement to this work.

Furthermore, the properties of FGLS and PCSE fall as the transverse dimension of the panel increases concerning the temporal dimension and therefore it is suggested to use complementary estimation methodologies. For example, Driscoll and Kraay (1998) show that the standard error estimates can be modified by a Newey-West (1994) style correction and obtain robust results in panels with cross-sectional dependence (SCC). Likewise, given that the models show signs of endogeneity, corrected in this work using the aforementioned methods, it would be convenient to estimate dynamic panels as System GMM by Arellano-Bond and Bover (1995) and Roodman (2006), to learn more about its nature and verify that it has been adequately treated. For the time being, this paper only seeks to explore whether there is a significant effect on forward and backward linkages in GVCs of some widespread characteristics and not an exact quantitative relationship for statistical inference purposes.

GVCs are complex, and their exploration leads to a gradual development of indicators to measure their nature, determinants, and resilience, while also revealing areas of opportunity to face global challenges. The OECD (2021) indicates priority areas for research, such as the concentration of specific linkages in certain countries (e.g., microprocessors in China), or the design and analysis of more detailed indicators on business operations and information technologies, which could help define the integration of GVCs and their areas of vulnerability.

Another critical area of research in the current context is the creation of early warnings for interruptions of GVCs, derived from increasingly frequent disturbances of public health, geopolitical, social, climatic, or saturation of roads and media. For now, the literature on these topics is incipient (Cigna et al., 2022) since, until 2019, the main motivation for GVCs was the reduction of production times and costs, sometimes at the expense of their flexibility, which took its toll during the COVID-19 pandemic.

C.   Global Business and Economic Issues Implications

The pandemic damaged world trade and questioned its contributions, showing that, without accompanying policies, not all countries benefit from trade, and some,

particularly low-income ones, may be exposed to global shocks if they are part of GVCs. As a result, some GVCs tend to simplify and shorten, since they are perceived as transmitters of disturbances from one country to another, both in the supply of inputs, as happened with the shortage of microprocessors, in the container congestion derived from concentrated demand in a short period globally, or in sales of final goods, such as Bangladesh. The increasingly frequent natural disasters due to global warming and recent geopolitical conflicts have exacerbated this trend.

However, global shocks have also created a greater awareness that companies can be more competitive if they act together and if the interconnection between public and private entities from different countries is improved: for global problems global answers. In this context, engineering factors become essential to offset global constraints. For instance, seeking alternative supply sources and enabling new logistics networks is essential to mitigate the risk and consequences of GVC interruptions. This is even under the premise that the inclusion of new actors and the apparent duplication of functions could generate, at least in the short term, additional costs or less response capacity. GVCs require superior resilience in the face of global risks in the post-COVID era.

As GVCs become more complex, greater transparency is needed, which is why having tools such as digital visualization of the supply chain with technologies such as 4.0, simulation analysis, dynamic optimization tools, Big Data and Cloud becomes essential. Decisions such as relocating production to a more distant entity, or introducing alternative sources of supply, give greater prominence to the quality of logistics services and telecommunications, and therefore, to the qualification of the workforce and the activities of R&D.

Furthermore, the democratization of education and increasing access to technology, including 3D printers and computer numerical control systems (CNC), make economies of scale and scope less significant than before. It is then possible to replace some linkages of GVCs, with opportunities for smaller companies and countries. These trends may alter the geography of GVCs and the volumes and direction of international trade flows. The current situation could then encourage greater participation of small and medium-sized enterprises (SMEs) and the emerging world in GVCs, induce improvements in their productivity, boost economic activity and the generation of quality jobs, through upstream in GVCs, and the transition from exports of basic products to more sophisticated goods and services, with a more active role on productive sectors previously excluded from international trade, fostering inclusive economic growth. These positive effects are especially relevant in an environment of economic slowdown and geopolitical tensions that exacerbate global systemic risks.

But to achieve this, this work makes evident the need for a paradigm shift in policy because of the current globalization and the progressive proliferation of GVCs. The belief that goods and services need to be produced in the country and that they compete with foreign products must be reconsidered since these are increasingly "made in the world". Protectionism and overregulation do not make sense in sophisticated production processes that involve multiple border crossings, nor when competition is found, no longer in specific goods or services or the low cost of inputs, but in human talent and economic roles within GVCs. From this perspective, trade policies must more proactively consider the new reality of business.

REFERENCES

Antràs, P., Chor, D., Fally, T., and Hillberry, R., 2012, "Measuring the Upstreamness of Production and Trade Flows", *American Economic Review*, 102, 412-416.

APEC, Asia Pacific Economic Cooperation, 2021, Better Understanding Global Value Chains in the APEC Region. Committee on Trade and Investment (CTI), No. 2902, Retrieved 2022-01-03 from https://www.apec.org/publications/2021/02/apec-tiva-initiative-report-two---better-understanding-global-value-chains-in-the-apec-region. 1-218.

Arellano-Bond, M., and Bover, O., 1995, "Another Look at the Instrumental Variable Estimation of Error-components Models", *Journal of Econometrics*, 68, 29-51.

Scott Armstrong, J., and Collopy, F., 1993, "Causal Forces: Structuring Knowledge for Time‐Series Extrapolation", *Journal of Forecasting*, 12, 103-115.

Arvis, J., Saslavsky, D., Ojala, L., Shepherd, B., Busch, C., Raj, A., and Naula, T., 2016, "Connecting to Compete: Trade Logistics in the Global Economy", Retrieved 2021-11-13 from https://openknowledge.worldbank.org/handle/10986/ 24598.

Banerjee, B., and Zeman, J., 2020, "Determinants of Global Value Chain Participation: Cross-country Analysis", WP 1/2020, *Working and Discussion Papers, Research Department, National Bank of Slovakia,* 1-28.

Beck, N., and Katz, J.N., 1995, "What to Do (and Not to Do) with Time-Series Cross-Section Data", *The American Political Science Review*, 89, 634-647.

Blanchard, O., 2021. *Macroeconomics*. 8th Edition eBook. Pearson.

Bughin, J., Hazan, E., Ramaswamy, S., Chui, M., Allas, T., Dahlström, P., Henke, N., and Trench, M., 2017. "Artificial intelligence: The next digital frontier?", *McKinsey and Company Global Institute Discussion Pape*r, 1-80.

Campos-Romero, H., and Rodil-Marzábal, Ó., 2021, "Las dos caras de la inserción de México en la cadena de valor automotriz: dimensión económica e impacto medioambiental", *El Trimestre Económico*, 88, 1153-1187.

CEPII, Research, and Expertise of World Economy, 2021, Gravity Database. Retrieved 2022-02-22 from http://www.cepii.fr/CEPII/en/bdd_modele/bdd_modele_item. asp?id=8.

Cigna, S., Gunnella, V., and Quaglietti, L., 2022, "Global Value Chains: Measurement, Trends, and Drivers". *Occasional Paper Series. European Central Bank Eurosystem*, 1-57.

Daudin, G., Rifflart, C, and Schweisguth, D., 2011, "Who produces for whom in the world economy?", *Canadian Journal of Economics/Revue Canadienne d'Économie*, 44, 1403-1437. https://doi.org/10.1111/j.1540-5982.2011.01679.x, 1-35.

De Backer, K., and Miroudot, S., 2013, "Mapping Global Value Chains", *OECD Trade Policy Paper* 159, OECD Publishing, 1-45, Retrieved 2021-06-01 from https://www.oecd. org/dac/aft/ MappingGlobalValueChains_web_usb.pdf

DHL, 2022, Global Connectedness Index. Retrieved 2022-02-26 from https://www.dhl.com/global-en/delivered/globalization/global-connectedness-index.html.

Driscoll, J., and Kraay, A., 1998, "Consistent Covariance Matrix Estimation with Spatially Dependent Panel Data", *The Review of Economics and Statistics*, 80, 549-560.

Engel, J., Kokas, D., Lopez-Acevedo, G., and Maliszewska, M., 2021. *The Distributional*

Impacts of Trade: Empirical Innovations, Analytical Tools, and Policy Responses. World Bank, Retrieved 2022-05-02 from http://hdl.handle.net/10986/35552, 1-131.

ESCAP, Economic and Social Commission for Asia and the Pacific. *Asia-Pacific Trade Investment Report 2014*. United Nations, Retrieved 2022-05-02 from https://www.unescap.org/sites/default/files/APTIR%202014%20-%20Full%20Report.pdf. 1-124.

Fally, T., 2012, *Production Staging: Measurement and Facts*, University of Colorado Boulder, May, Retrieved 2021-07-03 from https://citeseerx.ist.psu.edu /viewdoc/download?doi=10.1.1.717.7092&rep=rep1&t ype=pdf, 155-168.

Fernandes, A., Looi, H., and Winkler, D., 2019, "Determinants of Global Value Chain Participation: Cross-Country Evidence", *Policy Research Working Paper 9197*, 1-54. Retrieved March 3, 2020, from http://hdl.handle.net/10986/33519

Ferrando, A., 2013, "Las Cadenas Globales de Valor y la medición del comercio internacional en valor agregado", *Serie Comercio Internacional*, EI Instituto de Estrategia Internacional, Buenos Aires Argentina, 1-23. Retrieved 2021-07-03 from https://www.redalyc.org/pdf/ 866/86632964007.pdf

Frederick, S.E., 2010, "Development and Application of a Value Chain Research Approach to Understand and Evaluate Internal and External Factors and Relationships Affecting Economic Competitiveness in the Textile Value Chain", *North Carolina State University ProQuest Dissertations Publishing*, 3425901.

Gereffi, G., Humphrey, J., and Sturgeon, T., 2005. "The governance of global value chains", *Review of international political economy*, 12, 78-104.

Gereffi, G., 1994, *The Organization of Buyer-Driven Global Commodity Chains: How U.S. Retailers Shape Overseas Production Networks*, in Gereffi and Korzeniewicz (eds.), Commodity Chains and Global Capitalism. Westport, Connecticut London: Praeger. 1-16.

Groningen Growth and Development Centre (GGDC), 2022. The World Input-Output Database (WIOD). Faculty of Economics and Business. Retrieved 2021-07-03 from https://www.rug.nl/ggdc /valuechain/wiod/

Grossman, G.M., and Helpman, E., 1991, *Innovation and Growth in the Global Economy*, Massachusetts, London, England, MIT Press Cambridge. 1-384.

Head, K. and Mayer, T., 2014. "Gravity Equations: Toolkit, Cookbook, Workhorse". *Handbook of International Economics*, Elsevier, 4, 131-195.

Hopkins, T.K., and Wallerstein, I., 1977, "Patterns of Development of the Modern World- System", *Fernand Braudel Center*, 1, 111-145.

Hummels, D., Jørgensen, R., Munch, J., and Xiang, Ch., 2014. "The Wage Effects of Offshoring: Evidence from Danish Matched Worker-Firm Data", *American Economic Review*, 104, 1597-1629.

Hummels, D., Jun, I. and Yi, K.M., 2001, "The Nature and Growth of Vertical Specialization in World Trade", *Journal of International Economics*, 54, 75-96.

Hummels, D., Rapoport, D., and Yi, K.M., 1998, "Vertical Specialization and the Changing Nature of World Trade", *FRBNY Economic Policy Review*, 4, 79-99.

Khandelwal, A., Louise, G., Rocco, M., and Matthieu, T., 2018, "Communication Frictions and Knowledge Transfers: Evidence from FDI", *Macroeconomics, Trade, and Finance*.

Kmenta, J., 1997, *Elements of Econometrics*. 2nd ed. Ann Arbor: University of Michigan Press, 127.

Koopman, R., Wang, Z., and Wei, S.J., 2014, "Tracing Value-added and Double Counting in Gross Exports", *American Economic Review*, 104, 459-494.

Koopman, R., Powers, W., Wang, Z., and Wei, S.J., 2010, "Give Credit Where Credit Is Due: Tracing Value Added in Global Production Chains", *National Bureau of Economic Research*.

Kowalski, P., Gonzalez, J.L., Ragoussis, A., and Ugarte, C., 2015, "Participation of Developing Countries in Global Value Chains: Implications for Trade and Trade-Related Policies", *OECD Trade Policy Papers*, 326-353. https://doi.org/10.1787 /5js33lfw 0xxn-en

Lambert, D., and Stock, J., 1993, *Strategic Logistics Management*. McGraw-Hill Marketing and Advertising Series. 1-862.

Leontief, W., 1970, *Análisis Económico Input-Output*. Barcelona: Gustavo Gili S. A. 1-359.

Leontief, W., 1951, T*he Structure of American Economy, 1919-1939: An Empirical Application of Equilibrium Analysis*. Nueva York: International Arts and Sciences Press. 1-264.

Lundquist, K., 2019, "The Digital Economy, GVCs, and SMEs", *WTO Global Value Chain Development Report*. https://doi.org/10.30875/2894deeb-en, 1-66.

Melitz, M., 2003, "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity", *Econometrica*, 71, 1695-1725.

Newey, W., and West, K., 1994, "Automatic Lag Selection in Covariance Matrix Estimation", *Review of Economic Studies*, 61, 631-653.

OECD, Organization for Economic Cooperation and Development, 2022a. *Trade in Value Added (TiVA)*. Retrieved 2022-02-26 from https://www.oecd.org/sti /ind/measuring-trade-in-value-added.htm.

OECD, 2022b, OECD Statistics. Retrieved 2022-02-26 from https://stats.oecd.org/Index .aspx?DataSetCode=TIVA _2021_C1.

OECD, 2021, Global Value Chains: Efficiency and Risks in the Context of COVID-19. OECD Policy Responses to Coronavirus (COVID-19), Tackling Coronavirus (COVID-19) Policy Responses, *Global Value Chains*, 1-17.

OECD, 2020, Trading for Development in the Age of Global Value Chains, International Bank for Reconstruction and Development / The World Bank, Washington, DC.

OECD, 2018, Inter-Country Input-Output (ICIO) database. Retrieved2022-02-26 from http://www.oecd.org /sti/ind/inter-country-input-output-tables.htm.

OECD, 2011, "To What Extent Are High-Quality Logistics Services Trade Facilitating?", *Trade Policy Working Paper,* 108. https://doi.org/10.1787/5kggdthrj1zn-en, 1-42

Ohlin, B., 1933, *Interregional and International Tra*de, Cambridge: Harvard University Press, 1-324.

Qiang, C.Z., Liu, Y., and Steenbergen, V., 2021, "An Investment Perspective on Global Value Chains", World Bank Publications, Washington, DC, World Bank. http://hdl.handle.net/10986/35526.

Rodrik, D., 2018, "New Technologies, Global Value Chains, and Developing Economies", *NBER Working Paper* 25164, National Bureau of Economic Research, 1-30.

Roodman, D., 2006, "How to Do Xtabond2: An Introduction to Difference and System GMM in Stata", *The Stata Journal*, 9, 86-136.

Saslavsky, D., and Shepherd, B., 2014. "Facilitating International Production Networks:

The Role of Trade Logistics", *Journal of International Trade and Economic Development*, 23, 979-999.

Shih, S., 1992, "Empowering Technology – Making your Life Easier", Acer's Report.

Stata, 2019, *Longitudinal Data/ Panel Data Reference Manual*, Texas, USA, 313-372.

Švarcová J., Urbánek, T., Povolná, L., and Sobotková, E., 2019, "Implementation of R&D Results and Industry 4.0 Influenced by Selected Macroeconomic Indicators". *Applied Sciences,* 9, 1846. https://doi.org/10.3390/app9091846

UNCTAD – Eora, 2022, Global Value Chain Database. Retrieved 2022-02-26 from https://worldmrio.com/unctadgvc/

Walter, I., 1954, "Location Theory and Trade Theory: Short-Run Analysis". *Quarterly Journal of Economics* 68, 305-320. https://doi.org/10.2307/1884452

Wang, W., and Sh. Thangavelu, 2021. "Trade and Human Capital in Global Value Chain in Developed and Developing Countries". *Asian Economic Papers* 20, 1-15. https://doi.org/ 10.1162/asep _a_00834

WB, World Bank, 2020. World Development Report 2020: Trading for Development in the Age of Global Value Chains. Washington, DC, World Bank, 1-293. Retrieved 2021-09-04 from https://www.worldbank.org/en/publication/wdr2020

WB, 2022, World Bank Data. Retrieved 2022-02-03 from https://databank.worldbank .org/databases.