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THE IMPACT OF GLOBAL VALUE CHAINS PARTICIPATION ON COUNTRIES' PRODUCTIVITY

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The impact of Global Value Chains participation on countries' productivity

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Abstract

Participation in Global Value Chains (GVC) is widely considered a potential driver for productivity growth due to the advantages gained by the firms through technology transfers, vertical specialization, and access to new markets. However, in the last years, a series of consecutive shocks have led to a reduction in the volume of global trade and this trend is likely to have long-term consequences. Relying on the latest available data, we empirically investigate the relationship between labour productivity and GVC inclusion to assess the potential impact of the global trade slowdown on countries' productivity. The analysis is performed using an augmented production function framework applied to a sample of 76 countries over the period 1995-2019. Our findings add new insights into the ongoing debate on the uneven distribution of GVC participation advantages across different trade partners depending on their development stage. On average, developed countries benefit from a larger production efficiency from both upstream and downstream connections. On the other hand, in developing countries, the influence of the major economies seems to have harmful effects on productivity through forward participation, as domestic production is influenced by foreign demand for low-cost inputs, which can make developing economies stuck in low-value-added activities.

Keywords: Global Value Chains, global trade, labour productivity, forward linkages, backward linkages
Jel classification: F62, O47, F14

1. Introduction

The COVID-19 pandemic has led to an unprecedented collapse in global economic activities, generating an ongoing shortage in supply chains and slowing down people and materials flows. The crisis has highlighted the role played by Global Value Chains (GVC), renewing the debate on the costs and benefits of globalization (OECD 2021).

GVC refer to the entire network of activities involved in the production and delivery of goods and services, from raw materials to final consumption and beyond (Ponte and Sturgeon, 2014). The process involves numerous firms and workers located in different parts of the world, each contributing to different stages of the chain. The connectivity at the industry level turns out very complex. GVC inclusion effects are usually assessed in empirical literature using two measures of inter-sectoral linkages: backward (or downstream) links and forward (or upstream) links. As we will discuss in section 3, backward linkages measure the extent to which a particular industry relies on foreign intermediate inputs; forward linkages measure the extent to which an industry supplies intermediate inputs to foreign industries.

The ultimate goal of GVC is to maximize efficiency. Firms involved in production networks aim to increase their competitiveness and reduce costs by taking advantage of other firms' specialization in tasks, skills, and expertise. By specializing in the most efficiently provided tasks, firms can offshore less efficient parts of the production process abroad, importing at lower cost higher quality and more variety of foreign inputs (Grossman and Rossi-Hansberg, 2008). However, GVC involve more than simply trading goods and services at the global level: the know-how of lead firms and suppliers is also spread along all the stages of production (Nishioka and Ripoll, 2012). Foreign inputs can embody a higher technology content compared to domestic ones, promoting technology transfer to local firms and knowledge spillovers, also providing an opportunity to enhance vertical specialization efficiency gain.

On the other hand, since linkages effects mainly depend on the specific country pattern, the distribution of the productivity gain due to GVC inclusion may be asymmetric across countries and industries. Some countries may benefit more than others from participating in GVC, depending on factors such as technological capabilities, institutional frameworks, and comparative advantages but it can also result in negative effects on productivity in different parties involved. For instance, GVC can foster dependency relationships in developing countries to large global economies that manage supply chains, depriving firms in less developed countries of their innovation capability (Morrison et al., 2008; Sturgeon et al., 2011).

Moreover, trade integration increases firms' exposure to global shocks. Modern GVC have proven to be more resilient to the Covid-19 shocks than they did in the 2008 financial crisis (Choksy et al. 2022). However, over the last 10 years, several political and economic events have had a significant impact on global trade and may continue to spread their effect in the future. In addition to Covid-19, other external events have affected the possibility of easily moving production factors worldwide. Among them, is the rise of protectionism, the political events in the former Soviet Union countries, and the increasing concerns about environmental sustainability. In 2018, US President Donald Trump started a trade war with China and other commercial partners imposing restrictions on imports that hurt trade liberalism. The EU Green Deal, to achieve zero net emissions by 2050, reduced the "carbon leakages" by taxing imports from countries with lower environmental standards. Brexit is another relevant threat to global trade, especially to the European trade market. The recent Russo-Ukrainian war is just the latest and most dramatic event that is going to reshape the global trade market.

A reduction in countries/industries GVC involvement due to previous occurrences could potentially lead to a decrease in global productivity. By extending the analysis to the newly available trade data, it is possible to identify emerging trends and patterns that may affect future economic performance and identify different contests in which trade changes contribute to productivity growth or decline.

We use the recently updated data on bilateral country-industry trade to analyse the GVC effects on labour productivity (LP) by incorporating GVC trade determinants into an augmented production function framework, to examine how a reduction in globally fragmented production may affect country-industry efficiency over the period 1995-2019. A further contribution is using the Wang et al. (2017, 2022) mathematical framework to derive GVC participation indices, which measure both backwards and forward GVC linkages as a share of the VA generated by country-industry couples, putting the light on countries' production dimension. We retain that those indicators can capture a more comprehensive picture of a country's position in GVC than traditional measures often used in the literature. Compared to the extant literature, this is one of the first attempts to use these indicators for an empirical analysis of GVC participation effects on productivity at the country-industry level[1].

The production function model requires including macroeconomic determinants that are difficult to obtain at the sector level. In particular, concerns about obtaining net-capital data and related price indexes (to convert variables in real terms) have forced us to include the sectoral dimension only for the major OECD developed countries. The analysis is carried out first considering the whole economy of 76 developed and developing countries, and then examining separately 28 OECD developed countries for which it was possible to include the industrial dimension.

Our results confirm the positive effects of GVC participation, in both upstream and downstream channels, on LP in developed countries when the sectoral dimension is also considered. Instead, developing countries present less clear results with positive backward participation effects on productivity while forward linkages are negatively correlated with LP. We argue that input re-importing strategies implemented by developed countries are the main cause of this result. In particular, the use of production-based indicators has made it possible to highlight, with a high level of detail, the interdependent relationships between different countries that influence commercial behaviors.

The rest of the paper is organized as follows. Section 2 analyses the background literature. Section 3 discusses backwards and forward participation measures and presents the econometric model. Section 4 provides a detailed descriptive analysis of the data. Econometrics results and robustness tests are discussed in Section 5. Section 6 concludes.

[1] Yanikkaya et al. (2022) use this decomposition model to perform an analysis on the effect of GVC inclusion on Total Factor Productivity (TFP).

2. Literature

In the economic literature concerning GVC integration, many scholars put particular emphasis on the composition and changes in GVC structure, analyzing the configuration and development of GVC flows. Baldwin and Lopez-Gonzales (2014) carry out a complete description of the GVC flows structure and their evolution trend, investigating how the variation of the trade network is coincident with the main radical changes that the global economy has experienced. Criscuolo and Timmies (2018) use metrics to reflect changes in GVC structure on firms' performance. Matching GVC centrality metrics at the country-industry level the authors measure their positions within GVC, locating central hubs and peripheral country-sectors. Results show that changing positions within GVCs can play a role in firms' performance: becoming more central is associated with faster productivity growth of firms. Adarov and Stehrer (2021) and Adarov et al. (2022) assess the impact of foreign direct investment (FDI), and capital structure and dynamics, on firms' GVC participation, finding a robust and positive correlation, especially regarding Information and Communication Technologies (ICT). The authors also test for the presence of larger marginal returns due to intangible ICT capital in GVCs confirming their hypothesis.

For what concerns the evaluation of GVC involvement effects in different economic sectors' performance, in the last years the interest in GVC has increased significantly extending the empirical analysis on multiple aspects of the value chains' role in enhancing productivity. Although this issue has been always examined by scholars, the increasing globalization and the recent trade dispute between the USA and China have renewed the interest. Kummirtz (2015) shows that GVC participation impact on value-added is only significant for middle-high- and high-income countries, finding evidence that in low and middle-low-income nations GVC enhances efficiency only if countries have a sufficient level of absorption capacity. Jona-Lasinio and Meliciani (2019) analyze the influence of intangible assets in GVC participation on productivity. They prove the existence of synergies between intangible capital accumulation and GVC participation in the productivity of European economies in 1998-2013. Their results show that marginal productivity returns to backward participation are stronger in intangible-intensive countries-industries. Jangman and Rath (2021) find empirical evidence of GVC trade's positive effect on economic growth (especially in high technology-intensive industries), but they highlight a strong heterogeneity at the country-industry level. Constantinescu et al. (2019) focus on the global impact of vertical specialization on productivity using a cross-country, cross-industry and cross-year panel. There is evidence of the positive effect of backward and forward linkages measures on labour productivity. On the other hand, Veermani and Dhir (2022) investigate the impact of backward participation on employment, total export, and domestic VA considering 56 manufacturing sectors in India from 1993 to 2013. Results suggest a positive impact of GVCs on all three dimensions, but they also note that those effects are not homogeneous within sectors. For this reason, the authors put light on the importance of promoting flows of technology, intellectual property, and good managerial practices from the parent firms, especially in countries not fully developed with low labour costs. Cai et al (2022) analyze the effect of a more intensive GVC participation on income inequality. Although GVC participation may have some negative effects on income distribution, the overall impact on income inequality tends to be positive, as the benefits of increased labour shares can outweigh the negative effects of a widening wage gap. Some scholars rely in their empirical works on the same indicators synthesized by Wang et al (2017) we also use in our analysis. Chen et al. (2021) investigate the impacts of offshore and onshore outsourcing on China, also building a theoretical model to calibrate China's positioning in GVC. Sunghun (2019) focus on the impact of GVC participation in the agricultural sector on structural transformation, noting that modern developing economies are bypassing manufacturing production to directly develop service sectors. Yanikkaya et al. (2022) perform an empirical analysis of GVC effects on TFP considering a sample of 40 developed and developing countries over the period 1996-2009. Their results show positive effects on GVC participation in manufacturing industries, but no significant relationship concerning forward GVC inclusion on services productivity.

Although many previous studies also link their empirical results to policy intervention opportunities, some works focus more on policy guidelines. Andrews et. al (2015) argues about the role of R&D tax incentives, business-university R&D collaboration and patent protection. But trade-offs emerge which can inform the design of innovation-specific policies. Bolea et al. (2022) concentrate on GVC effects on regional economies arguing that global production processes are influenced by regional and local factors conditionally to GVC engagement, providing important insights for the development of regional policies. Taglioni and Winkler (2016) propose a strategic framework to guide policy makers in identifying the key objectives of GVC participation for development and selecting suitable economic strategies. They argue the critical issue is how GVC integrate into the whole economy and how to maximize the benefits from technology transfers and knowledge spillovers, but it is equally important to ensure that participation in GVC benefits through well-paid jobs, better living conditions, and social cohesion to attract the "right" foreign investors. Ma et al. (2022) examine the relationship between national entrepreneurial dynamism and a country's participation in GVC, also taking into account some elements of national innovation systems such as intellectual property rights protection and R&D employment. Authors find a stronger positive association between entrepreneurship and GVC, and this suggests that entrepreneurship can help countries overcome institutional weaknesses and improve their globalization performance through GVC participation, opening a wide range of possibilities for industrial policy.

Finally, there is a significant amount of work focused on developing new mathematical frameworks to better understand and measure the participation of countries in GVCs. These frameworks aim to decompose the VA to derive more precise indicators of GVC participation, including the extent of involvement in upstream and downstream stages of production. We go deeper into this topic in Section 3.

Overall, the GVC trade literature highlights the positive role of GVC engagement on economic performance, especially in high technology-intensive industries and well-developed countries. However, many scholars underline a strong heterogeneity at the country-industry level for which the effects of wider participation in global production networks mainly depend on the specific country-industry pattern.

3. Decomposition framework and econometric model

3.1 Backward and Forward Linkages

The empirical literature has developed two standard measures of GVC linkages: backward linkages and forward linkages. The concept of forward and backward connections was first proposed by Hirschman (1958), who defines backward linkages effects (or input-provision effects) as every nonprimary economic activity that induces attempts to supply inputs through domestic production. On the other hand, the forward linkages effects (or output-utilization effects) concern attempts to use outputs as inputs in some new activities.

In the field of Input-Output (IO) analysis, there is a specific branch of literature, focusing on sectoral IO linkages, which aims to better understand the importance of intersectoral interrelations between different economies. Products and services are produced not only to satisfy the final demand but they are also used as intermediate goods in production processes, which may also involve firms from different countries. The notions of forward and backward connections have been integrated into the concept of GVC and IO analysis. The idea behind GVC engagement is that globalization motivates firms to restructure their operations internationally through outsourcing and offshoring of activities, to optimize their production processes by locating the various stages of production across different countries. The production of an industry's output requires inputs from domestic and foreign supply industries (which embodies their own VA). At the same time, supplier industries' outputs usually depend on inputs from other suppliers as well. This process sets in motion a second round of indirect value-added creation in the supplying industries of the suppliers (Kummritz, 2016).

In a pioneering work, Hummels et al. (2001) refer to the use of imported inputs in the production of exported goods as a vertical specialization, suggesting measuring the imported foreign content in a country's exports based on a country's IO table. They propose two measures of vertical specialization: 1) VS: the foreign VA in imports embodied in goods that are exported; 2) VS1: the foreign VA in exports that are embodied in a second country's exports. These indicators are often expressed as a share of gross exports to also consider the propensity of a country to export/import.

Koopman et al (2010, 2014), relying on Leontief's (1936) work, provide a conceptual framework for decomposing the VA components integrating all previous measures of vertical specialization in literature. Since their mathematical decomposition is fully concordant with the System of National Accounts (SNA), this has allowed a wide application in empirical works. Based on these previous works, Wang et al (2017, 2022) propose a more powerful and detailed framework for the decomposition of VA, and two new indicators of backward and forward linkages able to improve upon the GVC participation measures in the existing literature (such as those used by Constantinescu et al 2019 and Kummritz 2015). The new decomposition framework allows breaking down the total production activities at the country-sector level depending on whether they are for pure domestic demand, traditional international trade, simple GVC activities, and complex GVC activities.

To compute the backward and forward linkages indicators, we follow Wang et al (2022) approach applied to the ICIO (Inter-Country-Input-Output) 2021 OECD tables, and we decompose the VA generated from each country-industry considering trade flows from both the upstream and downstream prospection to derive the forward and backward participation measures proposed by the authors. To explain the derivation process of GVC indicators we consider a world economy with G countries and N sectors. For simplicity, in the description of the model, we assume there are only two countries (s, r) and two industries (1, 2).

Excluding the temporal dimension, the economic structure is represented in Table 1. We define Z as a GNxGN matrix of intermediate input flows produced in the source country and used for the destination country production. Y^{FD} is a GNxG matrix of the final demand of a specific country (for instance, Y_{r1s} represent country *s* demand for final goods produced by industry 1 in country *r*). X is a GNx1 vector representing the gross output produced by the sourcing country, and VA is a 1xGN vector including the direct value-added.

The first step is to build the VA origin matrix, to decompose the VA originated from a source country-sector pair and directly or indirectly used in the final goods production of a particular country-sector. To do that, we derive the matrix $A = Z\hat{X}^{-1}$, a GNxGN matrix containing the technical input-output coefficients[2], where $\hat{X}$ is a diagonal matrix with the vector X in its diagonal, obtaining the well-known classical Leontief inverse matrix $B = (I - A)^{-1}$, and we also compute the value-added coefficient vector as $V = VA\hat{X}^{-1}$.

At this point, under the framework of Koopman et al (2014), we could already obtain the VA multiplier as $\hat{V}B = \hat{V}(I - A)^{-1}$, where $\hat{V}$ is a diagonal matrix of direct VA coefficients from V, and then decomposes the VA by its origin. However, the most recent approaches require identifying separately, for each country-sector, three types of production activities:

1. Value added domestically produced and consumed without cross borders.
2. Value added embodied in final product exports.
3. Value-added embodied in exports/imports of intermediate goods and services. Based on whether the VA crosses borders once or more, we can split this last term into simple and complex GVC activities.

To proceed in the decomposition of the value-added and derive the Wang et al (2022) indicators we need to derive a further VA multiplier, $\hat{V}L$, that only considers the VA shares of domestically produced products in home sectors. $L = (I - A_D)^{-1}$ is the Local Leontief inverse matrix, which is computed using a block matrix only involving the domestic input coefficient of A:

$$A_D = \begin{bmatrix} A_{s1s1} & A_{s1s2} & 0 & 0 \\ A_{s2s1} & A_{s2s2} & 0 & 0 \\ 0 & 0 & A_{r1r1} & A_{r1r2} \\ 0 & 0 & A_{r2r1} & A_{r2r2} \end{bmatrix} \tag{1}$$

and we get a GNxGN block matrix of the imported input coefficient $A_F = A - A_D$. Then, summing by row Y^{FD} we compute the GNx1 final goods vector produced by source countries and the GNx1 final goods vector produced for domestic consumption $Y^D = [Y_{s1s},\ Y_{s2s},\ Y_{r1r},\ Y_{r2r}]'$, where ' denote the transpose operation. We also define $Y^F = Y - Y^D$ as the vector of final product exports. Moreover, to allow matrix products we convert the three previous final goods and service production vectors Y, Y^D, Y^F into four respective GNxGN diagonal matrix $\hat{Y}$, $\hat{Y}^D$, $\hat{Y}^F$.

We finally build the VA origin and destination matrix as the sum of the four GNxGN production matrices mentioned before:

[2] The technical coefficients express the value of industry product (input), produced by a specific country-industry pair, required to produce a unit or a money value (output) of the product of a specific country-industry pair.

$$\hat{V}\mathrm{B}\hat{Y} = \underset{1.}{\hat{V}\mathrm{L}\hat{Y}^{D}} + \underset{2.}{\hat{V}\mathrm{L}\hat{Y}^{F}} + \underset{3.}{\hat{V}\mathrm{L}A^{F}\mathrm{B}\hat{Y}} = \hat{V}\mathrm{L}\hat{Y}^{D} + \hat{V}\mathrm{L}\hat{Y}^{F} + \underset{3.a.}{\hat{V}\mathrm{L}A^{F}\mathrm{L}\hat{Y}^{D}} + \underset{3.b.}{\hat{V}\mathrm{L}A^{F}\left(B\hat{Y} - L\hat{Y}^{D}\right)} \tag{2}$$

Each element of $\widehat{\mathrm{V}}\mathrm{B}\hat{Y}$ represent the VA from a source country-industry directly or indirectly used in the production of the final good in a particular country-industry. $\hat{V}\mathrm{L}\hat{Y}^{D}$ is the VA produced and consumed domestically in those sectors which do not involve international trade. In $\hat{V}\mathrm{L}\hat{Y}^{F}$ the embodied domestic factor content crosses borders for consumption only, hence without involving any production activity in the importer country. The third term $\hat{V}\mathrm{L}A^{F}\mathrm{B}\hat{Y}$ is the VA embodied in exports/imports of intermediate products, which is composed of simple sharing activities $\hat{V}\mathrm{L}A^{F}\mathrm{L}\hat{Y}^{D}$, and complex sharing activities $\hat{V}\mathrm{L}A^{F}\left(B\hat{Y} - L\hat{Y}^{D}\right)$. Complex cross-country production activities also include the VA exported and eventually returned home; it's represented by diagonal elements of the last *3.b.* term of Equation (2).

Summing $\hat{V}\mathrm{B}\hat{Y}$ matrix along the columns, we can decompose the VA generated from each country-industry concerning its destination while summing by row we can decompose the country-sector final production in terms of where the VA is sourced. This allows us to derive both downstream and upstream participation measures from the same matrix:

$$Fw = \frac{V_{GVC}}{Va'} = \frac{\hat{V}LA^{F}BY}{\hat{V}BY} = \frac{\hat{V}LA^{F}LY^{D}}{\hat{V}BY} + \frac{\hat{V}LA^{F}\left(BY - LY^{D}\right)}{\hat{V}BY} \tag{3}$$

$$Bw = \frac{V_{GVC}}{Y'} = \frac{VLA^{F}B\hat{Y}}{VB\hat{Y}} = \frac{VLA^{F}L\hat{Y}^{D}}{VB\hat{Y}} + \frac{VLA^{F}\left(B\hat{Y} - L\hat{Y}^{D}\right)}{VB\hat{Y}} \tag{4}$$

Fw in Equation (3) is our forward linkages indicator. We can define it as VA in intermediate export production as a share of the country/sector total value-added. V_{GVC} is computed as the row sum of the $\hat{V}\mathrm{L}A^{F}\mathrm{B}\hat{Y}$ matrix and VA' is the total value-added generated in production from a specific country-sector pair obtained by the sum of the row of $\hat{V}\mathrm{B}\hat{Y}$ matrix. Similarly, Bw in Equation (4) is the backward linkages indicator defined as the domestic and foreign VA in intermediate imports as a share of final production in a country-sector. Y_{GVC} is computed summing $\hat{V}\mathrm{L}A^{F}\mathrm{B}\hat{Y}$ matrix by the column, and Y' is the country-sector final production.

The two participation indices, built according to the above mathematical framework, have two interesting properties:

1) They are based on the production concept rather than the trade concept, so they are not expressed as a share of the gross country-industry exports. This allows us to better address the problem of double counting, as the magnitude of the indicators does not depend on country-industry direct exports of final goods and services. Koopman et al (2014) identify two ways in which double counting can occur: first, the production for its exports may contain foreign value added or imported intermediate goods. Second, part of the domestic value added that is exported may return home after being embodied in the imported foreign goods rather than being absorbed abroad. For these reasons, double counting may overestimate the extent

of participation in GVC as it happens using measures of forward participation as a share of gross exports.

2) They can accurately identify both "simple" and "complex" GVC share activities. The former considers the VA originated by a country-sector that crosses the domestic border to be used in the final production by the partner country without being re-exported. In complex GVC activities, the VA originated by a country-sector crosses the border two or more times. Value-added creation is only classified as a GVC link when the embodied factor content crosses the national border for production purposes. Therefore, the VA domestically produced and consumed without crossing the borders, as well as the VA embodied in domestic exports of final goods that cross national borders for consumption only, cannot be considered either complex GVCs or simple GVCs.

3.2 The econometric model

We develop the empirical analysis adopting an augmented production framework. Following Constantinescu et al. (2019) and Jona-Lasinio and Meliciani (2019), we rely on a standard production function that expresses the value added (VA) of country c, industry *i*, in year *t*, as a function of capital *K*, labour *L*, and augmented with the trade participation determinants related to the technological shifter *A*:

$$VA_{c,i,t} = \mathcal{F}\left(K_{c,i,t}, L_{c,i,t}\right) \times A_{c,i,t}\left(Fw_{c,i,t}, Bw_{c,i,t}\right) \tag{5}$$

where A measures the production efficiency and it is affected by GVC trade determinants: the forward participation Fw from Eq. (3), and the backward participation Bw from Eq. (4). Dividing Eq. (6) by L, taking logs, and adding country, sector and time fixed effects (λ), yields the following reduced function form:

$$\ln(\mathrm{LP})_{c,i,t} = \beta_0 + \beta_1 \ln(\mathrm{K/L})_{c,i,t} + \beta_2\, ln(\mathrm{Fw})_{c,i,t-1} + \beta_3\, ln(\mathrm{Bw})_{c,i,t-1} + \lambda_c + \lambda_i + \lambda_t + \epsilon_{c,i,t} \tag{6}$$

where LP is the labour productivity, computed by dividing VA by total employment. The inclusion of country and sector fixed effects allows controlling for contextual factors omitted from the model but is useful to estimate the effect on productivity while controlling for the unobserved heterogeneity (such as human capital, institutional quality, and technological capital).

4. Data

To investigate the causal relationship between labour productivity and GVC participation we use the latest update (2022) of the OECD-ICIO tables[3] to compute the VA decomposition and derive the backward and forward indices described above. For the empirical analysis, we assembled the following two panel datasets.

[3] The OECD Inter-Country Input-Output (ICIO) database is a flexible analytical tool that allows to measure different inter country-industry flows of intermediate and final goods and services that underpin a range of applications related to GVCs.

1) A cross-country panel covering 76 countries and 24 years (1995-2019), built by combining trade variables computed from ICIO-OECD, total employment data from World Bank, and net capital data from IMF.
2) A tridimensional panel involving 37 industries from 28 countries over 1995-2019. Trade and value-added determinants from ICIO-OECD have been merged with data on labour and net capital from the STAN (2021) and EU-KLEMS (2022) database[4].

The number of countries considered is determined by the data availability in the primary data sources.[5] Tables A.1 and A.2 in the Appendix report the complete list of countries and industries considered. Conversion rates (PPP - USD 2017) from World Bank are applied to all current values.

In Section 4.1, we first examine the overall structure of the global production networks to better understand the dynamics of the origin and destination of world trade (section 4.1.1). Next, we focus on our exogenous variables of interest describing the forward and backward linkages indicators (section 4.1.2). Finally, in Section 4.2 we concentrate on our dependent variables that is the productivity dimension and the country-industry efficiency performance.

4.1 The world GVC

Some previous works (Constantinescu et al. 2015, 2019) show a slower expansion of GVC after the 2008 crisis, resulting not only from the general slowdown of GDP growth but also from a less vertical specialization in global production.

In Figure 1 we confirm this trend by looking at the aggregate ICIO-OECD production structure of GVC as a share of global GDP. We also distinguish total GVC in complex and simple GVC, depending on whether the VA crosses multiple national borders or is directly absorbed by a partner country to produce not re-exported final goods (see Section 3.1 for complex and simple GVC description)[6].

After 2011, the global GDP started to grow more than proportionally compared to GVC activities, resulting in an average decrease of total GVC share of -1.6% per year in 2011-2019. Simple GVCs are more widespread than complex GVCs. This is not a surprise, as complex production networks require a greater effort in terms of coordination and organization activities, tasks mostly carried out by large multinational firms (Miller and Temurshoev, 2015). Multiple production links also proved to be less resilient than simple connections: the decreasing trend affects both simple and complex GVC, although complex networks show a larger average contraction of -2.5% per year compared to the -1.3% of simple production chains in the same period.

[4] The STructural ANalysis (STAN) database is an OECD comprehensive tool for analyzing industrial performance at a relatively detailed level of activity across countries. EU-KLEMS database (rev. 2022) is run by the Luiss Lab of European Economics and includes various categories of capital (K), labour (L), energy (E), material (M) and service inputs (S).

[5] We exclude industry T (activity of households) in OECD data because of the large number of missing values. Moreover, we exclude the year 2020 to avoid the abrupt shock in the global trade flows produced by the Covid-19 pandemic. NACE Rev.2 to ISIC Rev.4 conversion between industry codes of various data sources follow the RAMON (Eurostat) conversion tables.

[6] Note that GVC only concern intermediate traded goods, which represented the 58% of the whole global trade market in 1995-2019.

Country level. In Section 3 we identified GVC as the VA embodied in the global trade of intermediates. In Figure 2 we report the average 2013 -2019 values of intermediates' gross imports and exports at the country level considering the complete ICIO-OECD data structure. We consider an average value to avoid the volatility of the time series and the most recent years after the 2008 crisis and the following recovery. Upstream and downstream flows are again separated into complex and simple GVC to provide further qualitative and quantitative information.

Figure 2 displays VA flows considering production chains both from an upstream and downstream perspective and therefore, looking at the origin (exports) and the destination (imports) of the VA embodied in traded intermediates. More specifically, from 2013 to 2019 the USA generated about 13% of the GVC production with an average absolute value of 983 USD (2017) billions per year, 3% of which refers to complex GVs and is embodied in exported inputs used by more than one country before being transformed into final goods or services. At the same time, more than 15% of the inputs produced and traded worldwide have crossed the US borders to be used in domestic production. This gives an idea of how strongly global production networks are connected to the US market. [7]

Firms' participation in GVCs is highly heterogenous depending on the specific country-industry pattern. Activities involved in the production process ranging from research and development (R&D) to assembly, and due to the international vertical specialization, they tend to be carried out by the more efficient firms worldwide. Different tasks may require different inputs with technological content; this also means that, because of technological disparity, various countries play different roles in the supply chains. Particularly, Baldwin and Lopez-Gonzales (2014) emphasize the technological asymmetry in global production networks and the distinction between "headquarter" and "factory" economies. They define headquarter economies as those technologically advanced countries, more specialized in high value-added sophisticated tasks, able to export goods and services to a wide range of partner countries. Oversimplifying, they organize the international supply chains and stay at the head of the global technological flows. On the other hand, factory economies provide the labour and tend to heavily depend on a single or a few partner countries.

The USA, Japan, Germany and China are generally considered by the literature as the main headquarters economies. They generate around 36% of the total global VA flows and count for 71% of global complex connections. Complex upstream flows tend to be larger in technologically advanced countries, this goes well with the headquarters economies innovators' role since they require trade relationships that link together more than a pair of countries. Complex tasks tend to stay at the top or the end of the chain (Taglioni and Winkler, 2016). This means that they usually cross not only the national border but also one or more foreign borders, forming complex value chains.

Offshoring can increase the competitiveness of firms and it allows them to combine domestic technologies with foreign inputs, highlighting the role of central hubs in exporting

[7] Note that import and exports of intermediates in Figure 2 are in gross terms, so they also included countries re-imported and re-exported VA embodied in complex GVC. As a result, the sum of the VA embodied in gross trade determinants by countries counts for more than 100% of the total VA embodied in total global exports.

technologically advanced inputs of difficult reproduction to a wide share of partners. However, several factors influence the emergence of simple and complex connections. Sectoral specialization influences significantly the complex upstream flows, with particular emphasis on the countries that specialized in mining (Saudi Arabia, Russia, Kazakhstan, etc.). Mining is an activity which favors the generation of complex links, since energy sources are first converted into energy and then used to produce every kind of goods, incorporating value-added to each step. On the other hand, political relations and geographical proximity from the partners affect the bilateral trade of inputs between two countries, encouraging particularly downstream and upstream simple GVC networks.

Table 2 provides information on the foreign VA absorbed by an importing country from each partner as a percentage share of its total gross imports of intermediates in 2019. Trade data focus only on complex GVC flows, to consider the VA that can be effectively re-imported. Reading the table by columns, countries that in Figure 2 export the highest shares of VA in complex GVCs, in Table 2 are the ones more connected with a higher number of countries. At the same time, their dependence on inputs exported from a single economy tends to be generally very low. This is consistent with previous literature as dependence would be a more typical feature of factory economies (see Kummritz, 2016; Baldwin et al. 2014).

Participation in GVC inevitably creates interdependence with foreign countries' input supply. Supply chains also generate inclusion in the same network of very different economic systems. At the same time, a dependent bilateral partnership may prevail with 30-40% of the weaker partner imports coming from a single country. There are at least two reasons why balanced relationships should be preferred. First, according to D'Aguanno et al. (2021), the concentration of GVC around more central hubs reduces the volatility generated by exogenous shocks. Second, where the dependence is strong, it likely generates the presence of "exclusive GVC". A chain is inclusive if leading countries tend to promote the diffusion of new technologies to the smaller partner countries, and exclusive when headquarters economies limit the diffusion of their technologies through heavy systems of property rights that make partner countries' absorption more expensive (Sampson, 2022).

Obviously, in exclusive GVC, the distribution of the productivity gain tends to be much more asymmetrical across partners. Leading countries can take advantage of partners' lower wages or sectoral specialization without losing their technology headquarters' role. Accordingly, part of low-middle income countries' exports in Figure 2 may originate from large and stronger partners re-importing inputs, rather than their ability to integrate into global production networks. This should be the case in Mexico. The United States-Mexico-Canada Agreement (USMCA) and the previous North America Free Trade Agreement (NAFTA) are known for have amplified Mexico's dependence on the US over time. Free trade agreements allow North American firms to introduce their inputs into Mexican territory to exploit the lower labour cost and then re-importing assembled products at home.

The USA, China, as well as Russia, tend to establish very strong supply relations with closer weaker partners, which become highly dependent on their imports. The 34% and 30%, respectively, of total VA embodied in Canada and Mexico's imports of intermediates come from the US, which is their common neighbour and trading partner in USMCA. The same trend results in observing the shares of Russian intermediates' exports in imports of former USSR members (Belarus, Lithuania, Latvia, Ukraine), or considering shares of China's Asian trade partners (Hong Kong, Bangladesh, Malaysia, Thailand and Vietnam). On the other hand, EU members have quite balanced supply links with both extra-UE and UE countries, although Germany results as their common largest partner.

Black diagonal boxes in Table 2 represent the VA re-imported by the country of origin. Looking at the USA, 19% of VA embodied in complex intermediate import flows comes from the US itself (13.5% of which consists of VA first embodied in US exports to Mexico). Clearly, headquarters economies are more likely to show such a high value due to vertical specialization with many partners. However, returned VA shares are significantly larger in countries that tend to establish strong dependence links with factory economies. This is particularly evident looking at Russia's returned VA share, which is twice larger as Japan's and even larger than Germany, which is the second largest economy for intermediates exports in complex GVC.

Industry level. We can further explore the structure of GVC by looking at the industry side. As we have discussed in the previous section, a firm's inclusion in value chains can be affected by multiple factors related to the country's economic structure. At the same time, the idiosyncratic industries' characteristics determine a strong influence on GVC participation. Figure 3 shows the sectoral engagement as a share of total GVC production for 2000-2006 and 2013-2019. [8]

In both periods it's clear that some manufacturing sectors, such as mining (B), and computer electronic and optical equipment (C26), as well as certain complex services including scientific and technical activities (M) and financial services (K), tend to be highly involved in global production networks. On the other hand, traditional services are barely involved in complex GVC, since they do not include exported intermediates. This is the case of local service activities like hair salons, tailors, laundry, etc., grouped into other services (S). The same interpretation can be extended to other industries such as accommodation and food services (I) and water supply sewerage (E).

Particular attention should be paid to sector G (retail and wholesale; repair of motor vehicles) where trade engagement appears notably high in almost all countries. This mainly depends on two factors: 1) G is the sector that generates annually the largest amount of added value; 2) it includes both wholesale and retail trade and also the huge online shops. Therefore, sector G covers all possible supply channels of physical inputs for manufacturing production and service activities.

Sector engagement in GVC greatly changes over time. Particularly, the average share of IT and information services (J62-63) has increased by 120% (raising from generating the 1.2% of total GVC production in 2000-2006, to 2.6% in 2013-2019). Other notable examples are publishing and broadcasting activities (J58T60), which increased by around 30%, and paper products and printing (C16-18), which decreased by - 45%. GVCs are not static entities but, on the contrary, flexibility and adaptability are necessary features for their existence. For example, during the COVID-19 pandemic, many companies tried to support their suppliers by accelerating payments to reduce cash flow problems or implementing flexible working hours and working platforms to maximize efficiency (Arriola et al., 2020).

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[8] We report time averages to address volatility in industry GVC production time series. The years 2007-2012 are excluded to avoid distortions due to the global shocks. The list of sectors is reported in Table A2 in the Appendix.

Country-industry connections only rarely seem to depend on the characteristics of only one of the two dimensions. More likely, the structure of GVC is affected by the specific country-industry pattern. Table 3 represents a heatmap of the VA flows generated by a country-industry pair in 2019 to highlight the complexity of the structure of global production networks. Reading Table 3 by columns we have a picture of the involvement of each specific industry in the total GVC production by country. Values are grouped into four classes depicted with different colours. The mining sector (B) is highly involved in global production although these linkages mostly depend on the intense participation of a few specialized countries which show an engagement higher than 50% of their total connections. The high degree of heterogeneity at the country-industry level appears also for the scientific and technical activities (M). Sector M has a good degree of involvement in the European countries: nevertheless, in Belgium and UK, the involvement in complex GVC is more than two times larger than in Germany which, however, tends to distribute its flows across all sectors with very low sectoral concentration.

4.2 The forward and backward linkages indicators

This paper aims to investigate whether part of the reduction in production efficiency (Figure 1) can be explained by the slowdown in the GVC expansion. As a measure of participation in GVC, we rely on the indicators in Section 3, which allow us to distinguish between backward and forward participation. Backward participation concerns engagement in GVC realized through backward linkages (therefore, looking at VA flows from a downstream perspective); forward participation is the inclusion in value chains realized through forward linkages (hence, considering VA flows from an upstream perspective). These indicators put more emphasis on the productive dimension compared to standard measures of vertical specialization focused on gross exports.

Analyzing jointly forward and backward participation in global value chains provides valuable insights into a country's economic structure. The sectoral specialization, as well as the geographic location and the country size, also play a role in determining the country's position in GVC. Table 4 compares the average backward and forward participation by countries for 2013-2019.

Countries with a significantly large domestic demand (USA, Germany, Japan, France, UK, Italy etc.) tend to offshore a smaller share of their domestic production, showing a lower involvement in forward participation. At the same time, they show low backward participation levels since they can produce internally complex inputs without depending on external production.

Comparing forward and backward GVC indices we can identify some recurring trends. From Table 3 and Table 4, we notice that countries specialized in mineral resources tend to have forward participation levels higher than backward ones (Norway, Saudi Arabia, Russia, Australia, Mexico). Natural resources are in the most upstream-connected sectors; specialization in mining also cuts off imports of energy resources for domestic production. As confirmation of this, countries of West and Central Asia (among them the major oil producers), are also those with GVC participation levels more oriented towards forward linkages.

European countries tend to be quite balanced between forward and backward inclusion, although countries highly specialized in the export of manufacturing inputs (Portugal, Italy, Spain, Greece, Czech Republic) show backward linkages significantly higher than forward linkages. Luxembourg is highly specialized in financial (K) GVC activities, as well as Switzerland and Ireland. Unlike the last two, which have higher levels of forward than backward participation, Luxembourg's inclusion in global production networks is biased towards backward connections as its strong specialization in services makes this small country highly dependent on European manufacturing inputs.

In Figure 4 the perspective on GVC links changes from the cross-country dimension to the cross-industry dimension. Industries with higher levels of forward linkages tend to export more inputs abroad, while higher levels of backward linkages result in a higher share of foreign inputs used for domestic production. Similarly, industries with larger forward than backward connections export more intermediates abroad compared to the foreign inputs that are used to produce them. This is the case, for instance, of complex services such as financial (K), scientific activities (M), and high-tech services (J62-63), and especially the mining sectors (B).

The manufacturing sectors (C) have a more balanced connection, with a prevalence of forward and backward linkages depending on the kind of output produced. As discussed before, simple services are not usually widely involved in GVC, and they tend to show low levels of both forward and backward participation. Nonetheless, downstream connections tend to be much higher than upstream connections in services as they use to produce mostly for domestic consumption or direct exports of finished goods. The same goes for energy distribution services (D), which incorporate a large amount of foreign inputs from the mining sector, and construction services (F) with many foreign inputs originating from many manufacturing sectors.

4.3 Labour productivity

Global productivity suffered a setback after the 2008 financial crisis compared to the beginning of the 2000s. Figure 5 shows this trend by looking at labour productivity (LP) worldwide in constant price over the time 1995-2019. Apart from the global recession and recovery years (2008-2011), in 2011-2019 global labour productivity has grown by an average annual rate of 1.7% while considering the 2000s pre-crisis period (2000-2007) it grew by 8.2% per year. [9] The good part of the slowdown is caused by the negative dynamics of the service productivity (-1.1% per year since 2011) which, in turn, may depend on the structural change process. From 2011 to 2019, employment in service activities grew by around 9%, while employment shows a sharp decrease in manufacturing (-3%) ed in agriculture (-12%).[10]

Table 5 compares labour productivity by country in two years, 2007 (pre-crisis) and 2019 (post-crisis). The highest levels of average productivity are shown by Northern European countries, especially those characterized by the strong presence of multinational firms' headquarters (Norway, Ireland, Switzerland, Luxemburg) and the USA.

We note that labour efficiency is not much high in Germany. According to Elstner et al. (2018), a reasonable explanation is that German productivity growth is being held back by the structural shift from the highly productive manufacturing sector to technological services.

[9] Labour productivity rose significantly in the first decade of the 2000s due to the expansion of information technologies and their more frequent use in production processes (Intartaglia et al., 2018).
[10] Services, especially in developed countries, are counting over time for an increasingly large part of GDP (Hauser and Matoo, 2017).

Therefore, complex service activities in Germany tend to strongly stimulate aggregate employment that grows in step with production.

African and South American countries show productive performances opposite to the more developed Western economies. Between the selected years, the developing countries grew much more because of the decreasing marginal dynamics. On the other hand, in Eastern European countries, production efficiency increased at the same rate as in Western Europe nations, although they did not have particularly high levels of labour productivity before the financial crisis.

5. Econometric results

Table 6 reports the results of our baseline estimates on the panel dataset including the full set of 76 countries over 24 years (1995-2019). In all specifications, trade determinants are considered lagged by one period. This is a widely used approach in literature as the engagement effects in productivity are unlikely to be contemporaneous and it also alleviates concerns due to endogeneity. Even using lags of two and three succeeding periods, the results of estimates do not vary significantly.

In column 1, we control for the unobserved heterogeneity using time and country fixed effects (FE). Results show no evidence of positive GVC participation effects on productivity. Since model 1 might be considered with too many restrictions, in column 2 the time FE are omitted, but we control for the financial crisis using dummies for the years 2008 and 2009. Using this specification, the coefficient of backward linkages turns positive, but not statistically significant.

In columns 3 and 4, we split the time series considering two sub-periods 1995-2007 in column 3 and 2010-2019 in column 4, excluding thus the financial crisis years 2008 and 2009. We continue to obtain negative evidence regarding the link between productivity and forward participation, and positive but no significant evidence for backward linkages. We also note that, in the post-crisis period, the effectiveness of both participation measures decreases (this is consistent with all the following regression tables).

Columns 5 and 6 distinguish two sub-samples based on the countries' development level revealing significant heterogeneity in the country participation pattern.[11] Considering the developing countries (column 5), the upstream inclusion negatively affects LP, while backward linkages have positive and statistically significant effects. Results for the developed countries are reported in column 6 and show that both forward and backward participation coefficients are positive although not statistically significant.

We have previously remarked (Table 3 in Section 4) the huge heterogeneity across countries in the GVC participation at the sectoral level. The relationship between productivity and GVC inclusion may be difficult to assess without including the country's economic structure as we have done in Table 6 considering the ample dataset with 76 countries.

Therefore, we now consider a smaller set of 28 countries for which data are available at the sectoral level. Table 7 presents the results of the panel estimation which also include the

[11] Following the OECD developing countries classification (February 2023) we divide the cross-country dimension in 40 developing countries and 36 developed countries.

cross-industry dimension. Since the 28 countries included in the three-dimensional dataset are all developed countries, the results of column 6 in Table 6 can be roughly compared with those of Table 7. In column 1, we display results with FE by countries and industries, and dummies for 2008 and 2009. It turns out that, in developed countries' sectoral analysis, both trade GVC determinants are positive and significantly correlated with labour productivity.

Comparing results in Table 6 and Table 7, the productive fragmentation seems to ensure a boost to innovation and an increase in competitiveness which positive impact on developed countries' productivity. The complex and multifaced relationships between GVC and productivity is better assessed using the sectoral approach as the outcome depends on a multitude of factors and specific trade determinants which may vary significantly among different country-industry pairs.

Developing countries' analysis shows clearer results even without including sectoral dimensions. As we argued in Section 1, one key way in which GVC can affect productivity is through technology transfer, which can lead to improvements in efficiency and innovation. Foreign input absorption can facilitate technology transfer by exposing domestic firms to new technologies and production methods. Developing countries may experience stronger innovation effects from GVC compared to developed economies, as evidenced by the positive and statistically significant backward linkages.

At the same time, although forward linkages show very strong evidence of a positive causal relationship with productivity in developed countries, in developing economies, evidence is strong in the opposite way. In discussing Table 2 in Section 4 we highlight a strong trend for developed countries to re-import their inputs to exploit the lower labour cost of low-income countries (which compose the larger part of the full sample). As we argued, much of the forward connections of developing countries to the world are driven by dependence on foreign demand rather than the country's ability to integrate into global production networks. The re-importation procedures by developed countries assume that tasks offshored to developing countries are mainly low VA tasks. At the same time, to satisfy the demand for intermediates by the large partners, the use of a greater workforce is necessary. In this way, the upstream GVC participation (measured with indicators strongly focused on the productive dimension) turns harmful to labour productivity.

In Tables 8 and 9 we try a further approach to assess the causal relationship between GVC engagement and productivity performance using dynamic models which also consider as dependent variables the annual labour productivity growth controlling for the productivity initial level. All other variables are set at the beginning of the growth period following. Furthermore, to control for the 2008 financial crisis shocks, we add a dummy for the 2008-2009 years.

In Table 8 we resume the specifications of Table 6 on the same full sample and sub-samples. There continues to be mixed evidence regarding forward linkages between developed and non-developed countries in columns 3 and 4, while the relationship between backward linkages and labour productivity growth is positive and significant across all the specifications. There is also evidence of both downstream and upstream GVC participation effects in the developed sub-sample.

Finally, Table 9 presents the estimation results also including the cross-industry dimension. Both GVC indicators result positively and significantly correlated with LP growth. Consistently with Tables 6, 7, and 8, in columns 2 and 3 of Table 9, the incisiveness of effects is lower in the post-crisis period. However, despite our efforts to avoid endogeneity issues, the estimates may still suffer from bias due to omitted variables and reverse causality.

6 Conclusions

This study provides valuable insights into the relationship between GVC and productivity, remarking the importance of considering country and industry-level heterogeneity as well as the specific nature of upstream and downstream linkages.

Our findings suggest that developed countries tend to benefit more from global connections in terms of productivity gains, as they often occupy higher value-added positions in the chain and have greater access to advanced technologies and knowledge. The use of foreign inputs in domestic production has been found to have a significant positive effect on productivity also in developing countries.

On the other hand, due to their lower value-added positions in GVC, forward participation in GVC appears to harm developing countries' productivity. High-income economies are generally characterized by developed infrastructure, institutions, and education systems that support the training of skilled workers (Taglioni and Winkler, 2016): those conditions are often lacking in developing countries. The absence of those necessary conditions can hinder their ability to fully exploit the advantages of increased integration into production networks. The influence of a large economy may surely extend market opportunities, but re-importing procedures restrict the chances for innovation and sectoral specialization from forward participation, as their domestic production may be driven by the headquarters economies' demand for low-cost inputs thus limiting the technological enhancement of developing countries.

Overall, evidence shows that GVC prove to be a powerful driver of productivity growth, and a reduction in their participation could have undesirable effects on global production efficiency. Nonetheless, it is crucial to ensure that the advantages of global economic integration are distributed in a more balanced and equitable way, taking more balanced approaches to minimize negative consequences. Further research to consider the phenomenon through a spatial economic approach could shed more light on the global value chain effects.

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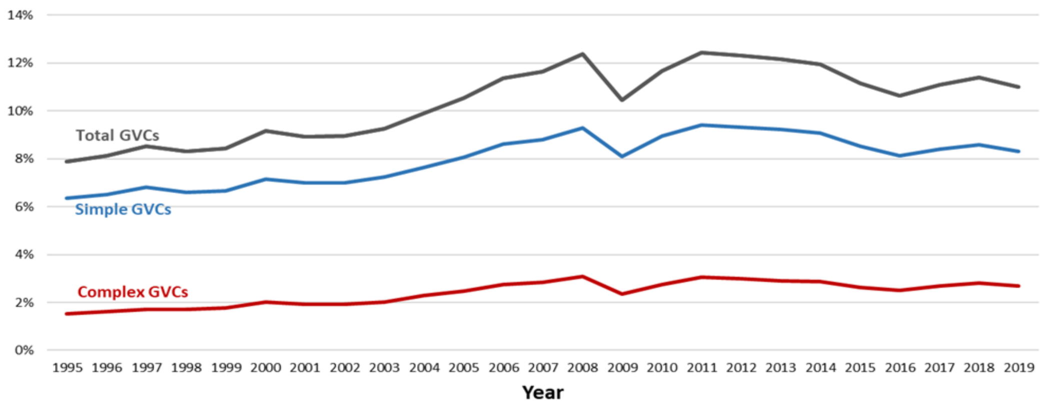
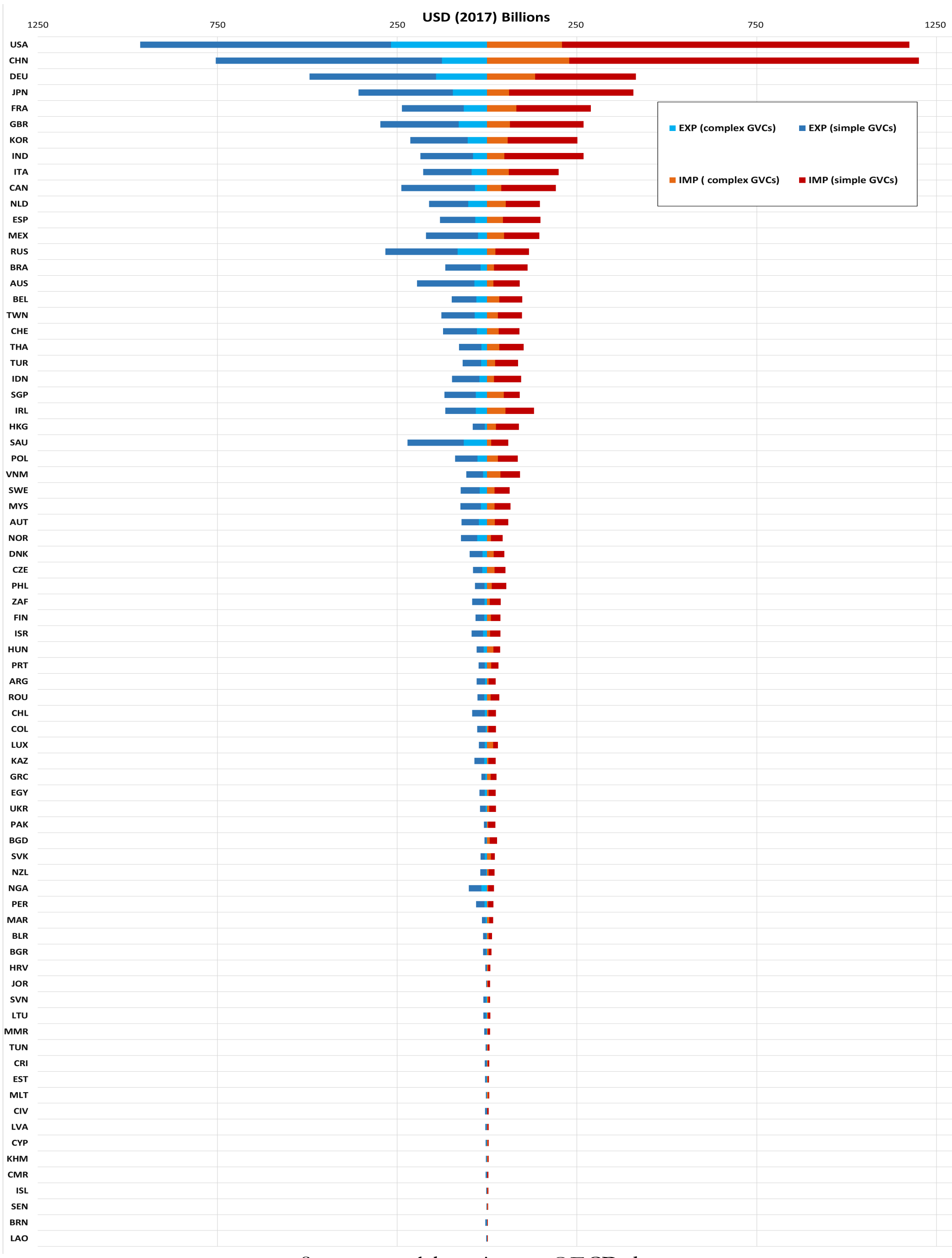
FIGURES AND TABLES

Figure 1. GVC production as a share of global GDP (1995-2019)



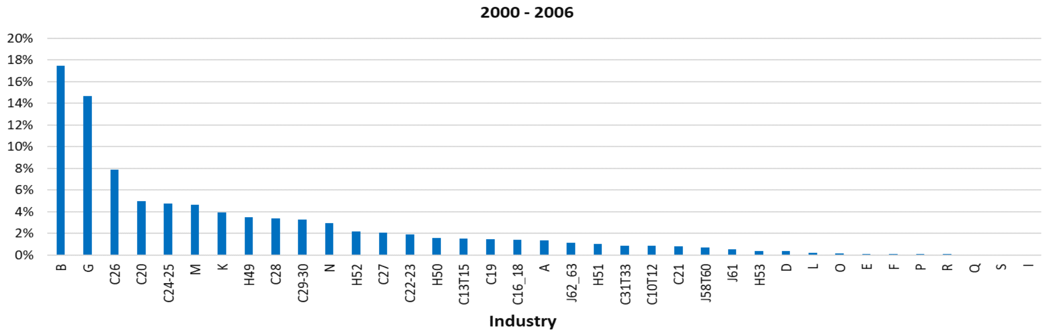
Source: own elaboration on OECD data.

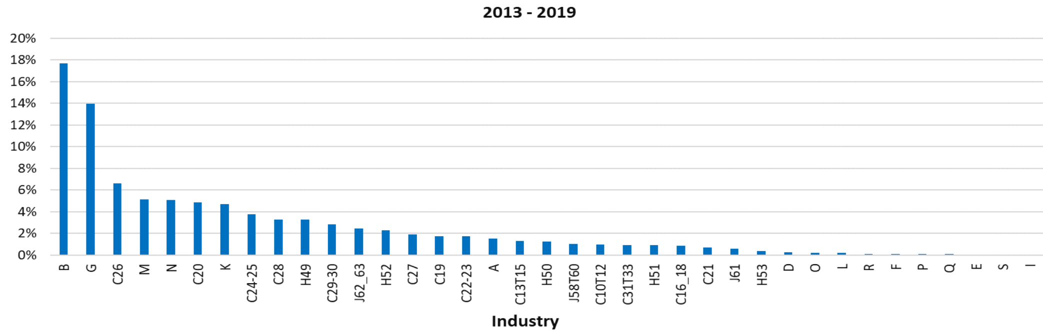
Figure 2. Gross import and gross export of intermediates (average values 2013-2019)



Source: own elaboration on OECD data.

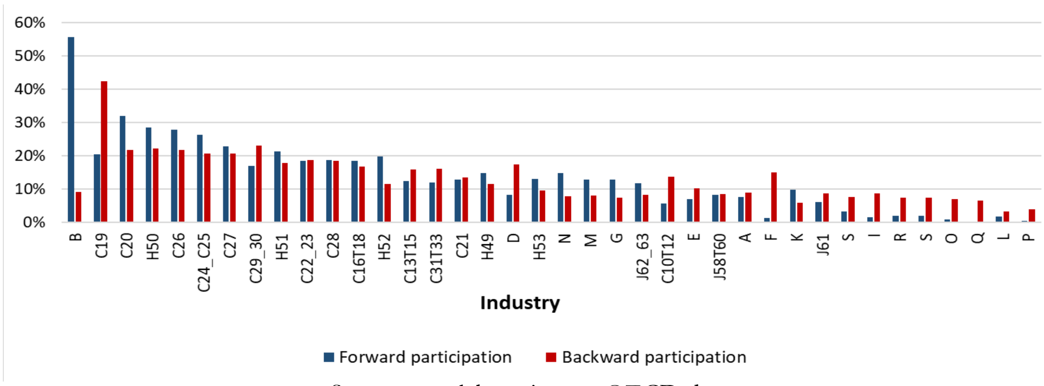
Figure 3. Industry engagement as shares of GVC production (aver. 2000-06, 2013-19)





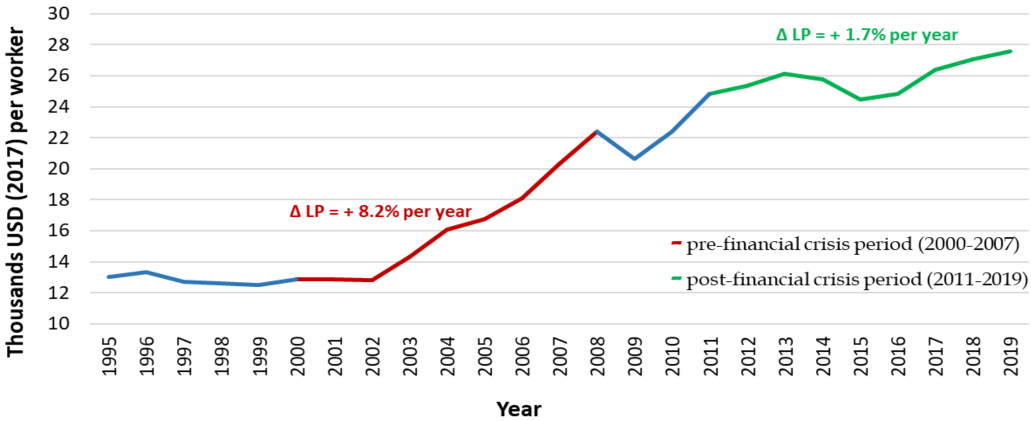
Source: own elaboration on OECD data.

Figure 4. Backward and forward participation by industry (averages, 2013-2019)



Source: own elaboration on OECD data

Figure 5: World labour productivity, 1995-2019

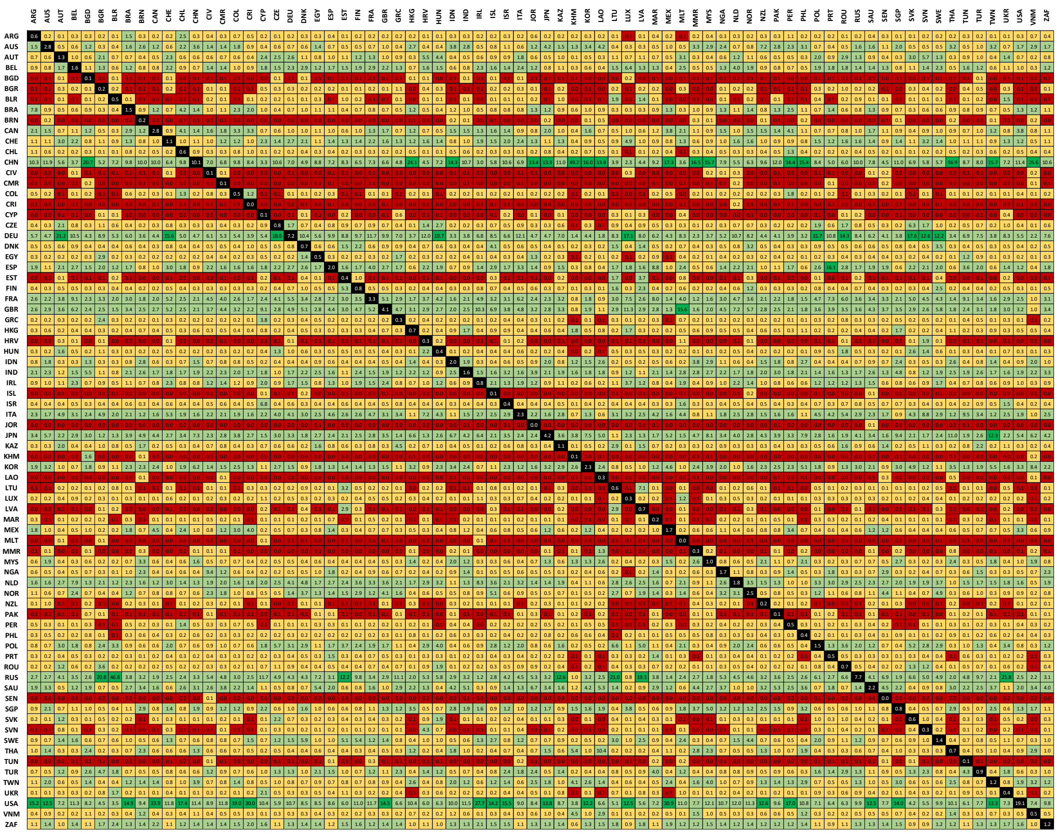


Source: own elaboration on OECD and World Bank data

Table 1: Inter-Country Input-Output table

		Intermediate Use				Final Demand		Total Output
		s1	s2	r1	r2	s	R	
Intermediate Inputs	s1	Z_{s1s1}	Z_{s1s2}	Z_{s1r1}	Z_{s1r2}	Y_{s1s}	Y_{s1r}	X_{s1}
	s2	Z_{s2s1}	Z_{s2s2}	Z_{s2r1}	Z_{s2r2}	Y_{s2s}	Y_{s2r}	X_{s2}
	r1	Z_{r1s1}	Z_{r1s2}	Z_{r1r1}	Z_{r1r2}	Y_{r1s}	Y_{r1r}	X_{r1}
	r2	Z_{r2s1}	Z_{r2s2}	Z_{r2s1}	Z_{r2s2}	Y_{r2s}	Y_{r2r}	X_{r2}
Value-Added		VA_{s1}	VA_{s2}	VA_{r1}	VA_{r2}			
Total Input		X'_{s1}	X'_{s2}	X'_{r1}	X'_{r2}			

Table 2. Heatmap of supply partner shares of total imports of intermediates (% by country, 2019)



Source: own elaboration on OECD data

Note: values are grouped into four classes based on their distribution. Black diagonal boxes represent the VA re-imported by the country of origin. The first class is delimited by the 25th percentile. The second class collects observations beyond the 25th percentile up to the 75th. The third class is delimited by the 99th percentile. Values of observations above the 99th percentile belong to the fourth class.

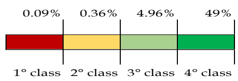
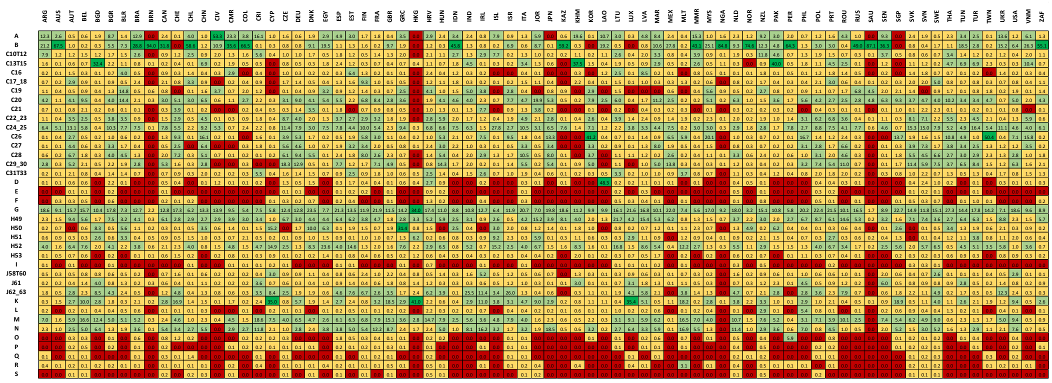


Table 3: Heatmap of country-industry involvement in countries GVC (% share by country, 2019).



Source: own elaboration on OECD data

Note: values are grouped into four classes based on their distribution. The first class is delimited by the 25th percentile. The second class collects observations beyond the 25th percentile up to the 75th. The third class is delimited by the 99th percentile. Values of observations above the 99th percentile belong to the fourth class.

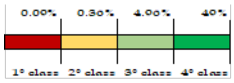


Table 4: Backward and forward participation indicators, average by country (2013-19)

Country	Forward linkages AVG (2013-2019)	Backward Linkages AVG (2013-2019)	Country	Forward linkages AVG (2013-2019)	Backward Linkages AVG (2013-2019)
West Europe and Balkan	*19%*	*18%*	*East Europe and Russia*	*18%*	*19%*
AUT	18%	16%	BGR	19%	21%
BEL	21%	22%	BLR	25%	20%
CHE	18%	14%	CYP	18%	20%
DEU	15%	12%	CZE	19%	25%
DNK	16%	17%	GRC	8%	13%
ESP	10%	12%	HRV	10%	17%
EST	23%	20%	HUN	22%	27%
FIN	14%	16%	POL	16%	17%
FRA	10%	13%	ROU	17%	15%
GBR	11%	11%	RUS	18%	9%
IRL	36%	30%	SVK	21%	23%
ISL	20%	15%	SVN	22%	19%
ITA	9%	12%	UKR	20%	20%
LTU	22%	18%	*Africa*	*11%*	*14%*
LUX	41%	43%	CIV	13%	10%
LVA	18%	15%	CMR	12%	10%
MLT	24%	39%	EGY	6%	7%
NLD	20%	19%	JOR	10%	27%
NOR	23%	13%	MAR	12%	21%
PRT	11%	16%	NGA	12%	17%
SWE	15%	13%	SEN	7%	3%
East Asian and Pacific	*17%*	*17%*	TUN	13%	13%
AUS	14%	8%	ZAF	14%	17%
BGD	3%	9%	*West and Central Asia*	*16%*	*12%*
BRN	33%	19%	IND	10%	11%
CHN	8%	10%	ISR	12%	11%
HKG	18%	26%	KAZ	23%	15%
IDN	14%	10%	PAK	4%	8%
JPN	10%	8%	SAU	37%	12%
KHM	16%	18%	TUR	8%	12%
KOR	16%	18%	*South and Central America*	*11%*	*9%*
LAO	21%	14%	ARG	7%	6%
MMR	11%	11%	BRA	6%	7%
MYS	23%	21%	CHL	17%	11%
NZL	10%	10%	COL	10%	9%
PHL	13%	14%	CRI	11%	11%
SGP	35%	31%	MEX	14%	10%
THA	22%	23%	PER	14%	10%
VNM	25%	33%			
North America	*10%*	*10%*			
CAN	14%	13%			
USA	5%	7%			

Source: own elaboration on OECD data

Table 5. Labour productivity by country (thousands USD, 2017)

Country	LP (2007)	LP (2019)	Δ%(2007-2019) per year	Country	LP (2007)	LP (2019)	Δ%(2007-2019) per year
West Europe and Balkan	*80*	*86*	*0.7*	*East Europe and Russia*	*24*	*27*	*0.7*
AUT	80	85	0.5	BGR	11	17	4.6
BEL	85	90	0.5	BLR	8	10	2.3
CHE	107	139	2.5	CYP	36	34	-0.5
DEU	71	79	0.9	CZE	32	40	2.0
DNK	90	101	1.0	GRC	56	38	-2.7
ESP	58	54	-0.5	HRV	26	28	0.6
EST	27	36	2.6	HUN	27	28	0.1
FIN	81	84	0.3	POL	21	27	2.5
FRA	79	79	0.0	ROU	16	24	4.0
GBR	87	74	-1.3	RUS	16	19	1.8
IRL	99	150	4.3	SVK	25	33	2.7
ISL	97	106	0.7	SVN	39	44	0.9
ITA	79	70	-1.0	UKR	6	5	-1.0
LTU	23	32	3.2	*Africa*	*7*	*9*	*2.4*
LUX	198	198	0.0	CIV	3	7	11.3
LVA	24	29	1.8	CMR	3	3	2.5
MLT	40	52	2.5	EGY	5	9	5.7
NLD	84	85	0.0	JOR	10	14	3.4
NOR	137	135	-0.1	MAR	6	9	3.2
PRT	37	39	0.5	NGA	5	7	2.4
SWE	87	88	0.1	SEN	4	5	2.9
East Asian and Pacific	*27*	*36*	*2.6*	TUN	10	9	-0.7
AUS	75	98	2.7	ZAF	15	16	0.5
BGD	1	4	14.1	*West and Central Asia*	*23*	*30*	*2.8*
BRN	72	60	-1.4	IND	2	5	9.9
CHN	4	16	24.8	ISR	48	82	5.8
HKG	52	82	4.7	KAZ	12	17	3.7
IDN	4	7	7.3	PAK	3	4	3.3
JPN	63	67	0.5	SAU	45	53	1.6
KHM	1	2	10.9	TUR	26	20	-1.7
KOR	41	54	2.4	*South and Central America*	*14*	*19*	*3.3*
LAO	1	4	17.9	ARG	13	21	5.0
MMR	1	3	20.9	BRA	13	16	1.9
MYS	16	21	2.8	CHL	20	29	3.5
NZL	55	69	2.1	COL	9	12	1.8
PHL	4	7	6.4	CRI	12	24	8.8
SGP	62	96	4.6	MEX	22	21	-0.6
THA	6	11	7.4	PER	6	11	7.6
VNM	1	4	13.3				
North America	*81*	*98*	*1.8*				
CAN	73	78	0.5				
USA	89	119	2.9				

Source: own elaboration on OECD and World Bank data

Table 6. Aggregate productivity and trade participation (76 countries, 1995-2019)

Dependent variable: labour productivity, levels

	(1)	(2)	(3)	(4)	(5)	(6)
Method:	OLS-FE	OLS-FE	OLS-FE	OLS-FE	OLS-FE	OLS-FE
Sample:	All	All	1995-2007	2009-2019	Developing	Developed
Forward linkages	-0.138*	-0.0994	-0.285**	-0.143**	-0.249***	0.071
	(0.079)	(0.077)	(0.127)	(0.0711)	(0.086)	(0.087)
Backward linkages	-0.184	0.092	0.125	0.089	0.195**	0.030
	(0.123)	(0.098)	(0.141)	(0.080)	(0.094)	(0.124)
Capital labour ratio	0.236**	0.488***	0.546***	0.241***	0.320***	1.022***
	(0.095)	(0.091)	(0.146)	(0.058)	(0.066)	(0.093)
Overall-R2	0.61	0.310	0.137	0.132	0.407	0.604
N. observations	1,790	1,790	899	816	909	881
Country FE	YES	YES	YES	YES	YES	YES
Year FE	YES	NO	NO	NO	NO	NO
Dummy 2008, 2009	NO	YES	NO	NO	YES	YES

Note: all models include a constant. All variables are measured in logs and monetary variables are in constant prices (2017). Trade determinants are lagged by one period. Robust and clustered standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Table 7. Sectoral productivity and trade participation: 28 countries, 1995-2019.

Dependent variable: sectoral labour productivity, levels

	(1)	(2)	(3)
Method:	OLS-FE	OLS-FE	OLS-FE
Sample:	All	1995-2007	2009-2019
Forward linkages	0.120***	0.173***	0.160***
	(0.031)	(0.054)	(0.040)
Backward linkages	0.113***	0.095**	0.063
	(0.036)	(0.041)	(0.042)
Capital labour ratio	0.949***	0.970***	0.623***
	(0.011)	(0.011)	(0.039)
Overall-R2	0.831	0.833	0.595
N. observations	12,752	6,187	5,987
Country FE	YES	YES	YES
Industry FE	YES	YES	YES
Dummy 2008, 2009	YES	NO	NO

Note: all models include a constant. All variables are measured in logs and monetary variables are in constant prices (2017). Trade determinants are lagged by one period. Robust and clustered standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Table 8. Aggregate productivity and trade participation: 76 countries, 1995-2019

Dependent variable: labour productivity, annual growth

	(1)	(2)	(3)	(4)	(5)
Method:	OLS-FE	OLS-FE	OLS-FE	OLS-FE	OLS-FE
Sample:	All	1995-2007	2010-2019	Developing	Developed
Forward linkages	0.016	0.023	0.014	-0.136***	0.131***
	(0.030)	(0.035)	(0.041)	(0.040)	(0.047)
Backward linkages	0.114***	0.140***	0.087***	0.206***	0.129***
	(0.019)	(0.025)	(0.026)	(0.022)	(0.030)
Capital labour ratio	0.654***	0.479**	0.749***	0.332	0.641***
	(0.166)	(0.232)	(0.187)	(0.235)	(0.220)
Initial productivity level	-0.036***	-0.025***	-0.046***	-0.042***	-0.274***
	(0.005)	(0.007)	(0.005)	(0.014)	(0.029)
Overall-R2	0.150	0.269	0.221	0.255	0.096
N. observations	1,789	905	884	898	741
Country FE	YES	YES	YES	YES	YES
Dummy for 2008-2009	YES	NO	NO	YES	YES

Note: all models include a constant. All variables are measured in logs and monetary variables are in constant prices (2017). Robust and clustered standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Table 9. Sectoral productivity and trade participation: 28 countries, 1995-2019

Dependent variable: sectoral labour productivity, annual growth

	(1)	(2)	(3)
Method:	OLS-FE	OLS-FE	OLS-FE
Sample:	All	1995-2007	2010-2019
Forward linkages	0.067***	0.069**	0.003
	(0.023)	(0.030)	(0.049)
Backward linkages	0.040***	0.147***	0.053
	(0.015)	(0.037)	(0.035)
Capital labour ratio	0.819***	0.842***	0.920***
	(0.021)	(0.023)	(0.011)
Initial productivity level	-0.803***	-0.835***	-0.977***
	(0.021)	(0.021)	(0.011)
Overall-R2	0.652	0.625	0.643
N. observations	12,737	6,750	5,416
Country FE	YES	YES	YES
Industry FE	YES	YES	YES
Dummy for 2008-2009	YES	NO	NO

Note: all models include a constant. All variables are measured in logs and monetary variables are in constant prices (2017). Robust and clustered standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

APPENDIX

Table A.1. List of countries, ISO3 classification

ISO3	*Country*	*ISO3*	*Country*
ARG	Argentina	**JPN**	**Japan**
AUS	Australia	KAZ	Kazakhstan
AUT	**Austria**	KHM	Cambodia
BEL	**Belgium**	KOR	South Korea
BGD	Bangladesh	LAO	Lao
BGR	**Bulgaria**	**LTU**	**Lithuania**
BLR	Belarus	**LUX**	**Luxembourg**
BRA	Brazil	**LVA**	**Latvia**
BRN	Brunei Darussalam	MAR	Morocco
CAN	Canada	MEX	Mexico
CHE	Switzerland	**MLT**	**Malta**
CHL	Chile	MMR	Myanmar
CHN	China	MYS	Malaysia
CIV	Côte d'Ivoire	NGA	Nigeria
CMR	Cameroon	**NLD**	**Netherlands**
COL	Colombia	NOR	Norway
CRI	Costa Rica	NZL	New Zealand
CYP	Cyprus	PAK	Pakistan
CZE	**Czech Republic**	PER	Peru
DEU	**Germany**	PHL	Philippines
DNK	**Denmark**	**POL**	**Poland**
EGY	Egypt	**PRT**	**Portugal**
ESP	**Spain**	**ROU**	**Romania**
EST	**Estonia**	RUS	Russian Federation
FIN	**Finland**	SAU	Saudi Arabia
FRA	**France**	SEN	Senegal
GBR	**United Kingdom**	SGP	Singapore
GRC	**Greece**	**SVK**	**Slovak Republic**
HKG	Hong Kong, China	**SVN**	**Slovenia**
HRV	Croatia	**SWE**	**Sweden**
HUN	**Hungary**	THA	Thailand
IDN	Indonesia	TUN	Tunisia
IND	India	TUR	Türkiye
IRL	**Ireland**	TWN	Chinese Taipei
ISL	Iceland	UKR	Ukraine
ISR	Israel	**USA**	**United States**
ITA	**Italy**	VNM	Viet Nam
JOR	Jordan	ZAF	South Africa

Note: 28 countries included in the tri-dimensional panel dataset in bold.

Table A.2. List of industries, NACE Rev.2 classification

Industry	NACE Rev.2
Agriculture, hunting, forestry, fishing, and aquaculture	A
Mining and quarrying	B
Food products, beverages and tobacco	C10T12
Textiles, textile products, leather and footwear	C13T15
Wood and products of wood and cork	C16
Paper products and printing	C17_18
Coke and refined petroleum products	C19
Chemical and chemical products	C20
Pharmaceuticals, medicinal chemical and botanical products	C21
Rubber, plastics and other non-metallic mineral products	C22-23
Basic metals and fabricated metal products	C24-25
Computer, electronic and optical equipment	C26
Electrical equipment	C27
Machinery and equipment, nec	C28
Motor vehicles, trailers and semi-trailers and other transport equipment	C29-30
Manufacturing nec; repair and installation of machinery and equipment	C31T33
Electricity, gas, steam and air conditioning supply	D
Water supply; sewerage, waste management and remediation activities	E
Construction	F
Wholesale and retail trade; repair of motor vehicles	G
Land transport and transport via pipelines	H49
Water transport	H50
Air transport	H51
Warehousing and support activities for transportation	H52
Postal and courier activities	H53
Accommodation and food service activities	I
Publishing, audiovisual and broadcasting activities	J58T60
Telecommunications	J61
IT and other information services	J62_63
Financial and insurance activities	K
Real estate activities	L
Professional, scientific and technical activities	M
Administrative and support services	N
Public administration and defence; compulsory social security	O
Education	P
Human health and social work activities	Q
Arts, entertainment and recreation	R
Other service activities	S

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