Building knowledge from engaging in backward and forward global value chains

Abstract

This study explores the engagement of OECD and non-OECD countries in global value chains (GVCs), and whether the evolution of their forward and backward GVCs' structures, across time, indicate a convergence or divergence in their levels of technological capabilities (as proxied by their level of value added). Our results indicate that the distribution of technological capabilities and the rates of knowledge accumulated are uneven across countries. However, there is an overall trend of OECD and non-OECD countries converging in both their backward and forward GVC structures, and an important role of GVCs' geography, which suggest that many non-OECD countries are catching up with OECD ones, rather than falling behind.

Key words: Backward and forward global value chains, knowledge, globalization, OECD countries, non-OECD countries.

JEL codes: F10, F23, F63, O00

1. Introduction

As the global economy increases in magnitude, so does the extent to which firms and countries can engage in global networks. Engaging in global networks, as highlighted by Hausmann (2016), has important implications for countries' process of knowledge accumulation and innovation as well as their degree of economic complexity. With increasing globalization and global challenges, firms and countries must engage in global networks to remain competitive. This represents an opportunity to tap into different global sources of knowledge (Turkina and Van Assche, 2018), such as FDI (Görg and Greenaway, 2004), global value chains (GVCs) (Guliani et al. 2005; Pietrobelli and Rabellotti, 2011), scientific collaboration (Laursen, 2014), generation of innovations (Archibugi and Michie 1995), and highly skilled human mobility (Artuc et al. 2015).

We can therefore argue that engaging in different types of global networks is an engine for economic growth when they can be used to build knowledge from within countries. A 2007 United Nations Conference on Trade and Development (UNCTAD) report, for example, indicated that engaging in the world economy brings several challenges associated to sustainable growth, especially for developing countries when it comes to successfully catching up with developed countries (UNCTAD, 2007). As highlighted by Hausmann et al. (2014), the accumulation of technological capabilities in various areas of production, triggers further technological development in other interconnected industries. However, countries first need a minimum knowledge threshold to benefit from foreign sources of knowledge to engage in a process of further knowledge accumulation and generation. Hence why cross-country differences in the knowledge base needed for technological capability accumulation also explain the differences in their levels of growth and economic development (see for example Hausmann et al., 2011; Lall, 1992).

Engagement in GVCs as one form of global networks can be an important source of learning and building technological capabilities, in particular for developing and emerging countries to innovate and move up the GVCs. Furthermore, engaging in GVCs brings opportunities for upgrading and engaging in more complex activities within the GVC (Guliani et al., 2005). In fact, empirical evidence (Amendolagine et al. 2017) shows that developing countries have increased their participation in GVCs, both in terms of volume, complexity of the products and the value added that they contribute to GVCs.

Engaging in GVCs has implications for both developed and developing countries. For developed countries, it can potentially bring talent and other key resources from abroad (Chen, 2004; Lewin, Massini, and Peeters, 2009). For developing countries, it can potentially lead to knowledge spillovers fostering learning in their productive industries, thus improving the domestic productive structure and capacity-building from within which then upgrade in the GVC (Guliani et al., 2005). Therefore, through learning-by-engaging in GVCs, developing countries can become more specialized.

As Hausman and Hidalgo (2011), Amendolagine et al. (2017) and OECD (2016, 2017) have pointed out, engaging in global networks can bring positive outcomes for developing and emerging countries, by contributing to learning effects necessary for technological capability development. This reflects the widely shared view that the higher levels and rates of growth enjoyed by some economies are attributable to their greater success in exploiting emerging technological opportunities for upgrading their technological capabilities (Aghion et al. 2009). The United Nations has long emphasized the benefits and challenges of a more interconnected and global economy. It has equally emphasized the importance of learning and innovation for driving economic and social growth. Similarly, innovation studies literature has focused its attention on the importance of learning (Lall, 1992) and technological capability building for latecomer countries (Bell and Figueiredo, 2012; Dutrénit, 2000), for catching up (Lee, 2014; Lee and Lim, 2001) and for innovation in emerging countries. However, due to data limitations in past studies, the level of engagement in different types of global networks across countries remained understudied.

Our exploratory study focuses on the analysis of one type of global networks, namely GVCs (backward and forward), and based on the above premises that engaging in global networks is an engine for economic growth when countries are able to build knowledge from within and when firms are able to tap into foreign sources of knowledge, we propose that (i) countries with more complex technological know-how engage most effectively in GVCs, and (ii) their participation at the backward or forward end of the GVCs depends on their levels of technological capabilities. This study therefore seeks to analyze (i) the network structure of GVCs, (ii) the evolution of this network structure across time, and (iii) if emerging economies have evolved in their technological capabilities as proxied by their participation in GVCs. We do so by examining how value added is shared and distributed amongst OECD and non-OECD countries. This analysis answers our overarching research question: *does the engagement of*

OECD and non-OECD countries in GVCs and their evolution across time indicate a convergence or a divergence in their levels of technological capabilities?

This study uses data form of input-output (I/O) tables (see for example Meng et al., 2012). This data provides rich information in terms of trade, GVCs, and value added across industries, and between OECD and non-OECD countries. We rely on two trade in value added (TiVA) indicators developed by the OECD and the WTO, backward GVCs and forward GVCs.[1] Analysis of both OECD and non-OECD countries was conduced using stochastic neighbour embedding (SNE). SNE is a dimensionality reduction technique where high dimensional data can be viewed in two or three dimensions. By employing SNE, we are able to analyse trends across time and track the evolution of backward and forward GVCs.

The paper is structured as follows. Section two presents a discussion on the engagement in different types of global networks with special focus on GVCs. It also discusses the potential for knowledge and technological capability building from GVCs. Section three presents the methodology. Section four discusses the empirical findings and section five concludes.

2. Engaging in global networks for building knowledge to innovate

In this section, we present an overview of different types of global networks, with particular emphasis on GVCs, and we discuss their potential for contributing to technological capability accumulation needed by firms and countries to innovate.

Engaging in different types of global networks has several effects for firms and countries. Some of the effects include access to foreign knowledge, specialization in advanced products, and diversification of the economy (Hausmann et al. 2014; Ernst & Kim, 2002). However, as discussed by several authors (see for example, Hausmann et al. 2014; Gereffi, et al. 2011; Henderson, 1998; Kaplinsky, 2000; Widodo, 2009), this access to knowledge is not evenly distributed, and can contribute to a further marginalization of less developed countries when they cannot easily access or benefit from foreign sources of knowledge.

From the international business literature, studies have highlighted the different motives, modes and strategies of multinational companies (MNCs) for accessing foreign sources of

[1] https://www.oecd.org/sti/ind/measuring-trade-in-value-added.htm

knowledge (Cano-Kollmann et al. 2016; Cantwell 2009; Cantwell, Dunning & Lundan, 2010). Economic geography studies have discussed how these global networks differ in terms of the geographical location (Martin and Rypestol, 2017). Recently, from the innovation studies literature, contributions have been on how firms and clusters tap into foreign sources of knowledge, and how this impacts innovation (Harirchi and Chaminade, 2014), emphasizing the differences across industries and regions (Chaminade et al. 2016). The intersection of these studies and bodies of literatures is a hot and current topic.

What these studies have in common is the premise that firms and countries need to engage in global networks to tap into foreign sources of knowledge, and generate new knowledge needed to innovate. As emphasized by Cantwell (1989), Galunic & Rodan (1998), Chaminade and De Fuentes (2012), it is necessary to constantly search for useful and new knowledge combinations to innovate, and many of these relevant knowledge sources are globally dispersed. It is on this premise that the literature on technological capabilities (Bell, 1984; Lall, 1992; Dutrénit, 2000; Peerally and Cantwell, 2011 and 2012) contributes to our understanding of how to benefit from different sources of knowledge to build new knowledge, skills and experiences to remain competitive.

2.1. Tapping into foreign sources of knowledge through global networks

The increased globalization of innovation has fostered competition and collaboration both across and within national boundaries (Archibugi, Howells, & Mitchie, 1999), thus supporting the emergence of innovation networks. Archibugi and Michie (1995), and Glucker (2011) argue that the generation, diffusion, and accumulation of technologies is increasingly international in scope, and assume that one of the factors that influence firms in co-operating with foreign firms or investing in a foreign country is the technical expertise that those firms or countries have to offer. In their seminal study, Archibugi and Michie (1995) propose a taxonomy of three main types of global networks. The first is global commercialization, which refers to the innovative products that a country is able to export and to technology licenses. The second refers to the generation of innovations at a global level, more specifically when a subsidiary from a MNC produces abroad, and contributes to the transfer of knowledge from the headquarter to the subsidiary, and from the subsidiary to local organizations (see Girma, 2003 for a more detailed discussion on channels for knowledge spillovers). The third refers to global collaborations, and includes any type of collaboration between organizations to advance applied research and innovation within firms. While for many decades those global innovation networks (GINs) were mainly confined to developed countries, more recent evidence points to the emergence of a new phenomenon where emerging and developing countries are playing an increasingly important role in those GINs, and benefiting from the engagement in different types of global networks.

Barnard and Chaminade (2011) contributed to this discussion and defined GINs in terms of geographical spread (global rather than confined to the Triad), the extent of the networks (both internal and external to the country), and their outcomes (innovation and productivity). Therefore, they define GINs as a “globally organized web of complex interactions between firms and non-firm organizations engaged in knowledge production related to and resulting in innovation”. Other studies contributed to this approach and argue that different types of GINs have a positive effect on the process of technical knowledge and technological capabilities accumulation, and hence, a positive effect on the type of innovation and economic growth (see for example Harirchi and Chaminade, 2014).

At the firm level, firms may engage in GINs either to expand their markets or to access more advanced technologies and knowledge available in other locations, or both. The commercialization in foreign markets and the sourcing of foreign knowledge have a positive impact on the innovative performance of firms (Kuemmerle, 1997). Firms collaborate with foreign organizations to share and build new knowledge. Thus, we can argue that the engagement in GINs is central to firms’ competitiveness, and this contributes to fostering country-level innovation and productivity. Niosi and Godin (1999), for example, found that global R&D during the early 1990s played an important role in fostering Canadian firms’ innovation and productivity, since a great deal of R&D financed by them – especially in product innovation – was performed in host countries such as the US, Europe, Australia, and Japan. They found that in some cases, foreign subsidiaries were the only corporate units performing R&D activities.

The emergence of GINs is driven by the rapid accumulation of innovation capabilities in some emerging countries (Pilat, De Backer, Basri, Box, & Cervantes, 2009), which has attracted innovation activities from and to diverse geographical locations. This can be related to Hausmann’s et al. (2011) economic complexity index which is a measure indicating countries’ level of economic development. Their index has two main components, the number of products that a country produces and exports (diversity), and the number of countries that produce a specific product (ubiquity). They found that countries with a higher complexity index are indeed more technologically and economically advanced. Furthermore, these countries are more capable of continuously accumulating advanced technical knowledge. The authors also discuss the fact that countries with a low level of economic complexity index are unable to build complex technological capabilities, as they lack the necessary technical knowledge in the first place. Thus, we argue that engaging in GINs can contribute to the rapid development of knowledge and capabilities, and this accumulation has a positive effect on innovation and economic growth for emerging economies. The interaction of these components has, to this date, been understudied mainly due to the lack of comparative data at a global scale, the absence of longitudinal data and the novelty of the phenomenon.

2.2 Effects of global innovation networks

Different bodies of literature have made key contributions regarding the link between country-level economic development and the receipt and absorption of foreign technical knowledge which further contribute to economic growth. However, these contributions are still rather fragmented. The international business literature has historically and extensively examined the role MNCs, the use of different governance structures in their networks and home and host country-level determinants in motivating them to locate either or both production and innovation activities abroad or maintaining them at home or dispersing them globally through internal and/or external modes. At the core, it can be said that the bulk of the international business literature related to innovation specifically, is largely focused on the firm-level strategic issues and implications of balancing the benefits and costs of doing business globally. Innovation studies, on the other hand, have been concerned with the process of creation and accumulation of technical knowledge and capabilities (Bell, 1984, 2009), and have emphasized the importance of catching up processes at the firm and country level (Lee, 2010) for technological development. Innovation scholars who focus on GINs, have emphasized the processes of innovation networks creation and collaboration for innovation (Carlsson, 2006; Chaminade et al. 2016), the effect of local competencies as drivers and enablers of GINs (Chaminade & De Fuentes, 2012), as well as the role of institutions and regions on knowledge sourcing and collaboration (Chaminade et al., 2016). The international development literature has highlighted the importance of knowledge as a key driver of economic growth. Lall and Pietrobelli (2002), for example, emphasized the importance of accumulating technological capabilities for development. Giuliani et al. (2005) emphasize the importance of engaging in GVCs as a key strategy to upgrade technological capabilities. Hausmann et al. (2011) also discuss the importance of technical knowledge as a key determinant for economic growth. These studies offer invaluable insight to the understanding of technological capabilities and its impact on society and economic growth, and have contributed to policy making in the areas of technology and innovation. However, there remains a gap regarding a holistic understanding of the role of different types of GINs in the process of technical knowledge and technological capabilities accumulation, and their combined potential for innovation and economic development.

2.3 GVCs and their potential effects for building technical knowledge

In their seminal work, Archibugi and Michie (1995) identified global commercialization - i.e. the innovative products that a country exports - as one of the three types of GINs. Currently, a high percentage of world exports are in intermediate products, indicating that most exporting countries are part of a GVC. In fact, Suder et al. (2015) argue that the rise of GVCs has been considered one of the most important features of rapid economic globalization in recent decades. Likewise, the OECD (2017) shows that most of global trade is in intermediate products, and are part of a GVC. Suder et al. (2015) found that intra and inter-industry industrial production networks as trade in intermediates is the largest share of total world trade. Indeed, Meng, Yamano, & Fang (2012) show that this trend is growing, providing additional insights into the engagement in GVCs.

The GVC approach focuses on the identification of how different tasks, activities and types of operations positioned in the value-chain are distributed across dispersed geographical locations (Grossman & Rossi-Hansberg, 2008; Mudambi, 2008). However, due to the increasing complexity, sophistication, and rapid evolution in GVCs, coupled with the lack of adequate data, it has been difficult to answer relevant questions associated with the structure of GVCs, and their effects for accumulation of technical knowledge.

Recent studies have contributed to the understanding of GVCs as powerful modes of global networks for building knowledge and innovating. Turkina and Van Assche (2018), for example, identified and characterized four cluster archetypes based on the connection, centrality and embeddedness in the GVC. They found that clusters established knowledge hotspots like Silicon Valley (ICT), Montréal (Aerospace) and San Diego (Biotech) and relied on the global connectedness of their firms to foreign locations to constantly reinforce their local innovation capabilities. While emergent clusters such as Queretaro (Aerospace) and Tallinn

(ICT) increasingly integrate into global knowledge networks by becoming suppliers within GVCs.

Some studies highlight that integration in GVCs can affect FDI spillovers, including those connected to local sourcing (Paus and Gallagher, 2008; Farole and Winkler, 2014). These argue that the country's degree and mode of participation in GVCs can affect the local pattern of production and skills of local firms. On the one hand, as suggested by Amendolagine et al. (2017) higher involvement in GVCs (through both higher imports and exports of intermediate inputs) can improve the capabilities of local firms in developing countries, since it exposes them to stronger competition, more intense information flows and greater production complexity. Moreover, since participation in GVCs requires compliance with international quality standards in order to trade in customized inputs, this implies the entry of high-productivity firms into GVCs (Del Prete et al. 2017). On the other hand, engaging in upstream GVCs can result in low levels of upgrading (Morris and Staritz, 2016). Amendolagine et al. (2017) also mention that the literature on GVCs usually associates a more upstream specialization to lower value added and less structural transformation. However, they show that this pattern of integration in GVCs still offers opportunities for attracting FDI with high local content.

Finally, Suder et al. (2015), and the OECD (2017) argue that countries' final demand for goods may directly induce their partner countries' exports, and further indirectly escalate downstream-induced exports. Suder et al. (2015) also analyse the evolution of GVCs and value added of Asian countries. Their findings indicate that Japan and China present large gain potentials. These countries have fully developed wide-ranging production capacity at home, whereas smaller countries must focus on a selection of specific production processes to maintain some attractiveness in regional value chains.

Therefore, we seek to contribute to the discussion of the structure and evolution of GVCs, and whether the engagement in GVCs contributes to the accumulation of technological capabilities in particular for emerging economies, and if this is an indicator of convergence with more developed economies.

3. Methodology

3.1. Data

The main aim of this paper is to examine the evolution of backward and forward participation in GVCs across OECD and non-OECD countries, and identify their contribution to the development of technological capabilities within countries, in particular of emerging economies. We acknowledge in this paper that some OECD countries might be emerging economies, for example Chile, Mexico, and Turkey, and we also acknowledge that all those in the non-OECD category are emerging economies. Therefore, we put special attention to the effect of GVCs on emerging economies, including a subset of OECD countries.

We use two trade in value added (TiVA) indicators produced jointly by the OECD and the WTO, in particular those associated with backward and forward participation in GVCs. These indicators are calculated annually for 1995 to 2015 inclusive, for 64 countries (see Table 1) and 32 industries. The TiVA indicators are reported in USD million (current prices) or as percentages. The indicators were derived using input-output (I/O) tables. I/O tables provide a rich presentation of data that can help answer many unanswered questions associated with knowledge production, distribution and accumulation. Suder et al. (2015) and Riviera and Suder (2013) propose that conducting future research using novel methodologies and data from I/O datasets, will further inform the study of internationalization of knowledge and its sourcing. Suder et al. (2015), for example, use I/O data to analyse the evolution of GVCs and value added of Asian countries. While Amendolagine et al. (2017) combine data from two surveys on the role of foreign investors in 19 Sub Saharan Africa countries and in Vietnam, with data on internationally comparable I/O tables, to then calculate two indicators of GVC involvement at the country-industry level. They test the increasing involvement of developing countries in GVCs, and analyze if this has a positive effect on demand for locally-produced inputs from enhanced inward FDI spillovers. Their results show that countries and industries with greater participation in GVCs are those where foreign investors generally report higher levels of local sourcing. The contributions help to understand the changing nature of international production (OECD, 2018).

[Table 1]

The indicator for backward participation in GVCs indicates the value added embodied in exports and is presented as a percentage of the total gross exports of the exporting country. As explained by the OECD[2], this indicator is calculated for the total value of source and exporting industries, and it is estimated as the ratio between the value added contents of imports from the source country and the gross exports of the exporting country. It is estimated as:

$$\mathrm{BGVC}cp = \frac{\mathrm{EXGR\_BSCI_{citpit}}}{\mathrm{EXGRp}} \times 100$$

Where $\mathrm{EXGR\_BSCI_{citpit}}$ is the total value added (VA) from country c embodied in the total exports of country p, and $\mathrm{EXGR_p}$ is the total gross exports of country p.

The indicator for forward participation in GVCs indicates the domestic value added embodied in foreign exports, and is presented as a percentage of total gross exports of the source country. This indicator is calculated by the OECD for the total value of source and exporting industries, and it is estimated as being the value added contents of exports originated in the source country, and embodied in the exports of the exporting country, divided by the gross exports of the source country. It is estimated by the OECD as:

$$\mathrm{FGVC}cp = \frac{\mathrm{EXGR\_BSCI_{citpit}}}{\mathrm{EXGRc}} \times 100$$

Where $\mathrm{EXGR\_BSCI_{citpit}}$ is the total VA from country c embodied in the total exports of country p, and $\mathrm{EXGR_c}$ is the total gross exports of country c.

Table 2 and Table 3 provide the descriptive statistics of backward and forward participation in GVC across the 64 countries between 1995-2015.

[Table 2]

[Table 3]

3.2. Analysis

Our unit of analysis is at the country-level and includes 64 countries, 37 OECD and 27 non-OECD countries. When comparing OECD with non-OECD countries, we are in effect comparing more technologically advanced and industrialised economies with catching up

[2] https://www.oecd.org/sti/ind/measuring-trade-in-value-added.htm

economies, as mentioned above, we acknowledge that some OECD economies might be emerging economies, therefore, within our analysis we emphasize the evolution within GVC of these particular economies –Chile, Mexico, and Turkey. We start with the premise that higher levels of participation in GVCs, both backward and forward, is an indicator of higher levels of technological capabilities. Similarly, we assume that changes across time in these two indicators suggest that countries are accumulating knowledge across time, due in part to their engagement in GVCs.

The evidence that we present in this paper is therefore key in providing a point of departure for identifying particular patterns of forward and backward GVCs and their main differences across countries. It also provides relevant information for the analysis of production structure in countries, and their evolution indicates that production at time ***t*** in any given country is different from production at time ***t-1***. If the country has been able to build technological capabilities across time, we expect that the goods and services produced at time ***t*** are more complex than products produced at time ***t-1***.

The TiVA dataset for the indicators on backward and forward participation in GVCs includes 109,630 country year observations for each forward and backward participation in GVCs. Due to the magnitude of the data, we first provide an analysis of the evolution of backward and forward participation in GVCs and how has this participation changed across time in terms of the magnitude and the partner countries. We do so by showing in a set of four figures the increase/decrease per country of backward and forward participation in GVCs, and then by analyzing where these changes are taking place. Dimensionality reduction is then applied to the data in order to create a 2D network diagram of the participating OECD and non-OECD countries.

3.2.1. Dimensionality Reduction: t-Distributed Stochastic Neighbor Embedding

We conduct dimensionality reduction by using a algorithm called t-Distributed Stochastic Neighbor Embedding (t-SNE) (Van der Maaten and Hinton, 2008). t-SNE seeks to take input data in a high dimensional space and embed this data in a low dimensional space while preserving the structural relationship between observations. We assume that the input space has dimension, d, and the input sample of data is comprised of m observations. The embedded output space has dimension 2, or 3 (so that it can be easily visualized) and each input observation is mapped to this input space. Equations (1) and (2) describe the input and embedded output spaces respectively.

$$\mathbf{X} \in \mathbb{R}^{m \times d} \qquad (1)$$

$$\mathbf{y} \in \mathbb{R}^{m \times 2} \text{ or } \mathbb{R}^{m \times 3} \qquad (2)$$

It is important to consider a similarity measure when investigating the structure of the input data. Observations that are similar should be relatively close to each other in both the input and output spaces. The conditional probability $p_{j|i}$ is defined as the probability that x_j would be chosen as a neighbor of x_i based on a density estimate between the two observations. A similar conditional probability can be assigned to observations embedded in the output space. Equations (3) and (4).

$$p_{j|i} = \frac{\exp\left(-\frac{\|x_i - x_j\|^2}{2\sigma_i^2}\right)}{\sum_{k \neq i} \exp\left(-\frac{\|x_i - x_j\|^2}{2\sigma_i^2}\right)} \qquad (3)$$

$$q_{i|j} = \frac{\exp(-\|y_i - y_j\|)}{\sum_{k \neq i} \exp(-\|y_i - y_k\|)} \qquad (4)$$

Equation (3) uses a parameter σ_i set the "width" around each input observation such that a point may have few or many neighbors. Van der Maaten and Hinton (2008) use a parameter called perplexity to control the Gaussian width around each data point in the input space that is based on Shannon entropy. The mapping of the high dimensional input space to a low dimensional output space can be viewed as an optimization problem with a cost function described in equation (5). The cost function is based on Kullback-Leibler (KL) divergence across both probability distributions. The KL divergence gives a measure of how well the distribution Q_i models P_i.

$$C = \sum_i KL(P_i \parallel Q_i) = \sum_i \sum_j p_{j|i} \, log \frac{p_{j|i}}{q_{j|i}} \qquad (5)$$

Van der Maaten and Hinton (2008) improved upon the initial work of SNE by introducing t-SNE. One improvement is that they employ a Student-t distribution to compute similarities in the low dimensional output space equation (6). Another improvement is in the use of symmetrical joint probabilities in the high dimensional input space equation (7). These two improvements have the effect of simplifying the gradient calculation of the cost function, and also address the problem of the "crowding" of datapoints in the original SNE algorithm.

$$q_{ij} = \frac{\left(1 + \|y_i - y_j\|^2\right)^{-1}}{\sum_{k \neq i} (1 + \|y_i - y_k\|^2)^{-1}} \qquad (6)$$

$$p_{ij} = \frac{p_{j|i} + p_{i|j}}{2m} \quad (7)$$

The optimization problem is solved by traditional gradient descent on the derivative of the cost function equation (8) with a step-size parameter η and momentum parameter $\alpha(n)$, as illustrated in equation (9).

$$\frac{\partial C}{\partial y_i} = 4\sum_j (p_{ij} - q_{ij})(y_i - y_j)\left(1 + \|y_i - y_j\|^2\right)^{-1} \quad (8)$$

$$\mathbf{y}_n \leftarrow \mathbf{y}_{n-1} + \eta\frac{\partial C}{\partial y_i} + \alpha_n(\mathbf{y}_{n-1} - \mathbf{y}_{n-2}) \quad (9)$$

3.2.2. Data preparation

We used the software Python to run the t-SNE algorithm. The machine learning library Scikit-learn in *Python* (v0.20.2) has a full implementation of the t-SNE algorithm and was used for the analysis of GVCs in this analysis. Data was retrieved from the TiVA dataset for 1995 to 2015 inclusive, accounting for 21 years of data. A total of 63 countries were used as sources - which can be viewed as nodes in a graph - with a total of 63 destination countries per source. Forward value chains can be viewed as flows from sources to destinations, and backward value chains can be viewed as backward flows from destinations to sources.

A data matrix X was formed by concatenating each destination country's export (or import value) along each row, and row represented a specific year. There is one row per country per year, therefore X has 1323 rows and 63 columns. In terms of using the t-SNE algorithm, X contains 1323 observations each with an input dimensionality of 63. The t-SNE algorithm was then used using the following parameters: perplexity = 30, output dimension = 2, $n\_iter = 2000$, $\eta = 200$, early_exaggeration = 15.

4. Forward and backward GVCs and their evolution between 1995 and 2015

In this section, we provide a snapshot of the evolution of backward and forward GVCs for OECD and non-OECD countries. Our premise is that an increase in value adding across time is an indicator of upgraded firm-level technological capabilities within the countries examined, while the opposite also holds true.

First, we generate and present a set of figures that compares the position of the 63 countries and the evolution of their backward and forward GVCs across two points in time - 1995 and 2015. Hence, we analyze the backward and forward participation in GVC across countries and the evolution of these backward and forward linkages.

4.1. Forward participation in GVCs

Forward participation in GVCs indicates

Regarding forward participation in GVCs specifically, a group of OECD countries (shown in Figure 1) have increased their engagement in GVCs above 6% for the period analyzed. This includes, for example, Australia (6.91), Canada (7.73), Chile (9.13), Iceland (5.58), and Norway (7.76). This suggests that these countries were able to increase production for different combinations of intermediate goods that are required further down in the GVCs. On the other hand, some countries have decreased their participation in forward GVCs, such as Luxemburg (-0.36).

[Figure 1]

A similar pattern can be observed for forward participation in GVCs across non-OECD countries (Figure 2). Overall, this group of countries has also increased its participation in GVCs. Those that have increased their participation above 6% for the period analyzed include, for example, Brazil (7.18), Brunei Darussalam (10.13), Colombia (10.88), Peru (11.6), Philippines (8.86), and Saudi Arabia (7.39). However, as seen in Figure 2, a group of countries has also experienced decreased participation in GVCs, for example, Argentina (-2.5), Croatia (-1.93) and Vietnam (-3.5). The engagement in forward GVCs can bring key opportunities for non-OECD countries to tap into foreign knowledge networks. However, the knowledge that is shared in this network is in part determined by the type of products that are exported by the non-OECD countries.

[Figure 2]

Figure 3 indicates the mean and Table 4 indicates the standard deviation for the forward participation in GVC across countries for all the observed years. The *Y* axe indicates the country of source of exports and the *X* axe indicates the country of destination. We observe that in terms of participation of forward GVC, countries like U.S. Germany and China, present higher levels of VA, in addition, we observe that geographic location matters, for example linkages between U.S. and Canada, Korea and Japan, China and Taiwan, amongst others.

Table 4 on the other hand, shows the standard deviation across time, between 1995 and 2015. We observe also interesting linkages, for example the countries that have changed the most in their forward GVC with other countries. For example Canada and Peru, the country that shows the highest number of changes is China with Austria, Canada, Philippines and Taiwan for example.

[Figure 3]

[Figure 4]

As we show in Figure 5, using the modularity function, we obtain 90 clusters for forward GVCs [For example, Austria (1-2), Greece (13-64), Korea (21-20), Spain (33-34), Sweden (35-36), Turkey (38-39), Brazil (43-44), Bulgaria (46-47), Indonesia (55-56), Malta (66-60), Singapore (67-68), Taiwan 70-21), Vietnam (73-74)]. The countries that observe a larger difference across years for forward GVCs - particularly for 2011 - are Greece, Indonesia and Korea. This represents a shift in their GVCs' arrangement which can be attributed to internal (for example economic policies) and external forces (inward foreign direct investment, participation in trade agreements, etc.).

[Figure 5]

4.2. Backward participation in GVCs

Backward participation in GVC indicates the value added embodied in exports of the exporting country. We suggest that higher levels of value added and broader engagement in backward GVC suggest that the exporting country has achieved a higher level of technological capabilities. This allows the country to contribute to higher levels of value added. In addition, it is important to identify the countries of destination, as recipient countries can be due to geographical reasons, or to the level of specialization of the exporting country.

In this section, we will discuss our findings in three stages, first, as indicated by Figures 4 and 5, we will focus on the change of Backward participation per country emphasizing three different periods. Then we show the presence and engagement of backward linkages per exporting country and country of destination. Then we show the results from our dimension reductionality analysis, and show the evolution of countries and some interesting patterns we observe. These three pieces of analysis will be extremely helpful to discuss patterns of engagement and changes across time, with special focus on non-OECD economies and those OECD economies that can be characterized as developing countries.

Regarding backward participation in GVCs, the data indicates how much of the countries' products exports' are being sourced from abroad. This is a key indicator of engagement in GVCs and provides additional information on the countries' technological intensity. As suggested by Amendolagine et al. (2017), the position of a country in the GVCs matters, i.e. where the specialization occurs - upstream or downstream –is a key indicator of the technological capabilities of the firms within those countries.

Our initial empirical analysis, from Figure 6, indicates that most of the OECD countries have increased the amount of foreign value added embodied in their exports for the periods analyzed, with the exception of Estonia, Canada, and Norway. A deeper examination of the potential causes of this effect involves analyzing the source of imports and the type of products associated to these imports, and is therefore beyond the scope of this study. From a theoretical perspective, we surmise that this points towards an increased process of industrialization in the countries that decreased their backward participation in GVCs, or alternatively it could also suggest a fall in the number or type of exports from these countries.

[Figure 6]

Regarding backward participation in GVCs for non-OECD countries, as shown in Figure 7, the data indicates an increased participation. These include, for example, Taipei, Malaysia, Bulgaria, Thailand, Cambodia, Vietnam, Tunisia, India, South Africa, and Argentina. Exports from this group of countries have a higher percentage of foreign value added. On the other hand, some countries - such as Malta and Philippines - have decreased their backward participation in GVCs during the periods analyzed. This finding suggests a process of further engagement in more complex activities within GVCs.

Finally, there is a group of countries that have remained quite unchanged during the period under analysis, such as Singapore, Russia, and Indonesia. As these countries are structurally different \the possible causes of these variations are also very different, and we require to provide further elaboration.

[Figure 7]

Tables 8 and 9 show the mean and standard deviation of backward participation in GVC for all countries between 1995 and 2015. Similar to the forward participation in GVC, Germany, and U.S. show the highest engagement with different countries. In terms of changes, as we see on tables 8 and 9, geographic location matters.

[Figure 8]

[Figure 9]

Using dimension rotationality, we obtain 46 clusters of countries as depicted in Figure 10, and which highlights the three largest clusters namely clusters A, B and C.

[Figure 10]

We observe three main clusters. Cluster A is formed by several countries, including Greece, Israel, Turkey, India and South Africa. Greece exhibits the largest changes in terms of its structure of backward participation in GVCs. For the year 2006 and 2008, it observes high similitudes in the GVC structures of those of South Africa 2011. In other words, the nature of its GVC activities and components are highly aligned for these reported years. While its GVC structures for 2014 are more like those of India 2014. South Africa also observes interesting changes, where in early 2005-2011, the backward linkages structures remained more similar to Israel 2014, and later, in 2008-2015 they are more similitude to Greece 2007.

Cluster B includes Chile, USA, Argentina, Brazil, Colombia and Peru. This cluster highlights the strength of regionalization for the Americas and suggests that the USA has similar backward linkages as other major economic players in this cluster. This is further explained by the number of free trade agreements in place between these countries. We also observe several changes happening in this group, where Chile, Colombia, Brazil and Peru, for example, are evolving and becoming more similar to USA’s structure. This may suggest a higher level of integration in their economy, including trade activities as well.

Cluster C includes Korea, Hong Kong, Taiwan and Thailand. In this cluster, Taiwan, Philippines and Thailand’s GVC structures show a clear convergence with that of Korea 2015, once again suggesting a higher level of integration in their economy including trade activities, driven by trade agreements and similar policies. On the other hand, Hong Kong's GVC structure seems to diverge from the other main players in the region. This suggests that it is evolving a different structural patterns of backward GVC, or deepening it's level of deindustrialization.

One of the findings that is also on line with the literature of geography of exports is that geographically closer countries look alike in terms of their backward and forward GVCs. This might be a result of regional proximity, and also the trade agreements that contribute to shape GVCs.

5. Discussion and preliminary conclusions

With this exploratory study we aimed to answer the research question: *does the engagement of OECD and non-OECD countries in GVCs and their evolution across time indicate a convergence or a divergence in their levels of technological capabilities?* To do so, we undertook an initial examination of the evolution of forward and backward GVCs across OECD and non-OECD countries using the use of TiVA indicators and I/O tables. We use the VA at forward and backward integration in the GVCs as a proxy for their firm-level technological capabilities.

International business, economic geography and innovation studies literatures have long examined whether economies are technologically and thus, economically converging or diverging. Some have extensively discussed this through the lenses of foreign direct investment and MNCs [starting for example with the work of Narula and Dunning (1999)]. Others have done so through the lenses of actors and agents within innovation systems [for example Lall (1992) and Lall and Pietrobelli (2002)]. While some have focused on micro-economic firm-level lenses [for example Lee (2014) and Lee and Lim (2015)], and others on employing new empirical approaches (Verspagen, 1991). We begin to address whether economies are technologically converging or diverging, or whether some are catching-up and other falling behind, through the lenses of their engagement and participation with GVCs. Thus, our research contributes to the international business literature on the geography of knowledge sourcing, but also on the dynamics of backward and forward linkages, as an important source of technical knowledge. Our results firstly indicate that the distribution of technical knowledge - in this case equated to the evolution of backward or forward GVCs - is uneven across countries, and that there are also differences in the rates of knowledge accumulated and used [which are in line with are in line with those of Hausmann et al. (2014), Gereffi, et al. (201), Henderson (1998), Kaplinsky (2000) and Widodo (2009)]. However, and secondly, our findings also suggest that there is an overall trend of OECD and non-OECD countries experiencing convergence in both their backward and forward GVC structures. This suggests that non-OECD countries are catching up rather than falling behind. However, we acknowledge that the historically known falling-behind countries of sub-Saharan Africa, for example, are not included in our databases. There are also some outlier countries, which are experiencing deep changes in their forward (e.g. Greece) or backward GVC structures (e.g. Hong Kong) where convergence may not necessarily equate to catching-up, and divergence to falling behind. Hence, further examination is required to carefully analyze the nature of these differences.

We acknowledge that this study is limited by the empirical methodology, as we are using the t-SNE dimensionality results as a compass to identify the evolution in backward and forward GVCs across OECD and non-OECD countries; however, the methodology used was appropriate for generating the initial findings which provide clear guidance on the research needed for a further and more comprehensive analysis of the evolution of type of products and industries that play a role to shape GVCs. As the complexity of products is also a key indicator of the technological capabilities associated with firms and countries alike, as suggested by Haussman and Hidalgo (2013).

This study sets the groundwork to further examine the nature of the countries that engage in backward and forward GVCs and build more advanced knowledge from this type of networks, in contrast to other countries that are not capable to build significant knowledge even though they are part of backward or forward GVCs. Both outcomes – as we have unveiled here with different group of countries that are catching up or falling behind in terms of knowledge building – not only provide researchers with a clear list of countries that should be investigated at the micro-level, but will also prove fruitful in terms of isolating the countries which need aid in designing appropriate policies for either further advancing catching up or closing the gap for those that are falling behind.

Finally, recent international business studies have argued that discontinuities at the border ensure that international knowledge-based linkages are more selective and valuable than regional linkages (Beugelsdijk & Mudambi, 2013; Scalera et al., 2017). Therefore, another area for further study involves investigating the nature and dynamics of the complex interdependence amongst various types of global networks.

Finally, one of the main limitations of this paper is that in this paper we do not account for the type of products involved in these backward participation, we recognize that a further analysis will require to identify the products involved. the and is presented as a percentage of the total gross exports of the exporting country

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Table 1. OECD-WTO's list of countries with TiVA indicators

OECD Countries		Non-OECD countries	
AUS-Australia	KOR-Korea	ARG-Argentina	MLT-Malta
AUT-Austria	LTU-Lithuania	BRA-Brazil	MAR-Morocco
BEL-Belgium	LVA-Latvia	BRN-Brunei Darussalam	PER-Peru
CAN-Canada	LUX-Luxembourg	BGR-Bulgaria	PHL-Philippines
CHL-Chile	MEX-Mexico	KHM-Cambodia	ROU-Romania
CZE-Czech Republic	NLD-Netherlands	CHN-China (People's Republic of)	RUS-Russian Federation
DNK-Denmark	NZL-New Zealand		SAU-Saudi Arabia
EST-Estonia	NOR-Norway	COL-Colombia	SGP-Singapore
FIN-Finland	POL-Poland	CRI-Costa Rica	ZAF-South Africa
FRA-France	PRT-Portugal	HRV-Croatia	TWN-Chinese Taipei
DEU-Germany	SVK-Slovak Republic	CYP-Cyprus	THA-Thailand
GRC-Greece	SVN-Slovenia	HKG-Hong Kong, China	TUN-Tunisia
HUN-Hungary	ESP-Spain	IND-India	VNM-Viet Nam
ISL-Iceland	SWE-Sweden	IDN-Indonesia	
IRL-Ireland	CHE-Switzerland	KAZ- Kazakhstan	
ISR-Israel	TUR-Turkey	MYS-Malaysia	
ITA-Italy	GBR-United Kingdom		
JPN-Japan	USA-United States		

Source: OECD-WTO, TiVA indicators

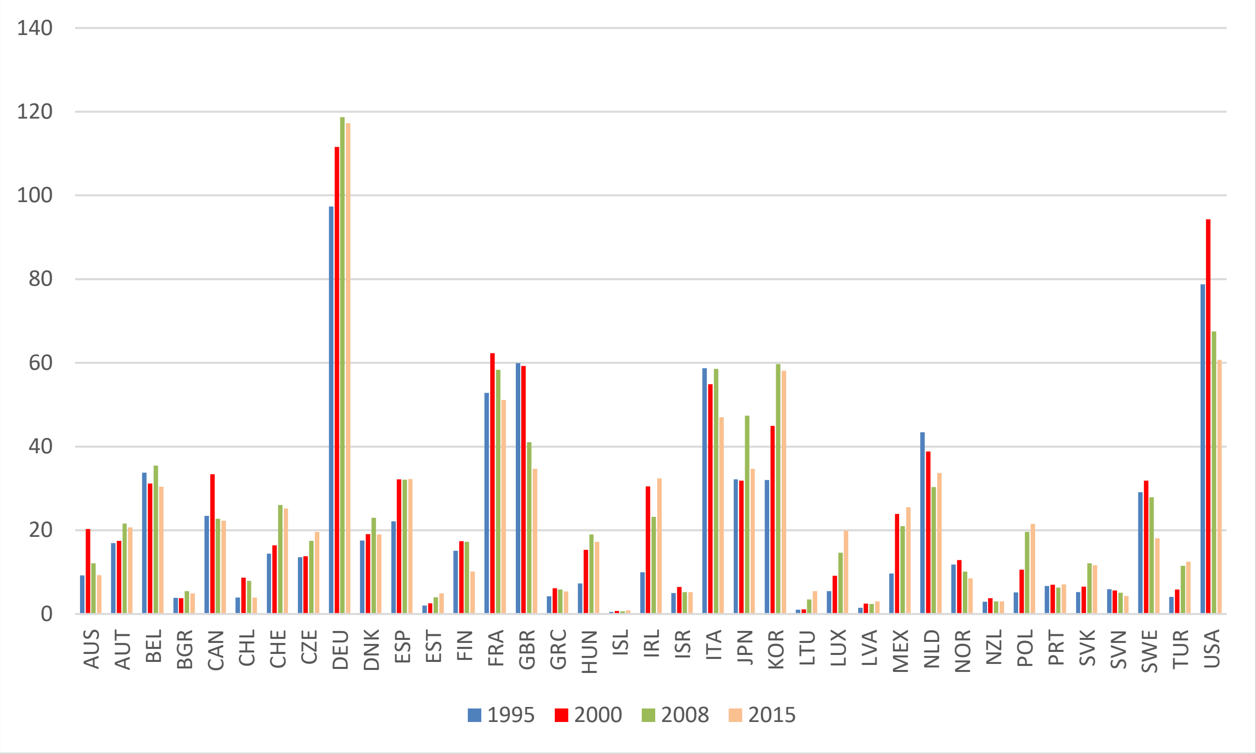
Table 2. Descriptive statistics. OECD countries 1995-2015

OECD	Backward					Forward				
	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
AUS	1,702	0.8983	2.0104	0	15.69	1,355	0.1973	0.4820	0	5.43
AUT	1,702	2.2370	5.3388	0	29.86	1,355	0.3151	0.3996	0	3.87
BEL	1,702	2.8373	6.7760	0	37.01	1,355	0.4835	0.4922	0	4.01
BGR	1,702	2.7717	6.3808	0	40.74	1,355	0.0658	0.1299	0	1.43
CAN	1,702	1.6062	4.3071	0	26.94	1,355	0.4160	0.6586	0	7.57
CHL	1,702	1.1454	2.6905	0	22.48	1,355	0.1030	0.4014	0	5.15
CHE	1,702	2.1114	5.0946	0	27.51	1,355	0.3275	0.3095	0	2.89
CZE	1,702	3.1593	7.3668	0	41.36	1,355	0.2519	0.4653	0	6.2
DEU	1,702	1.5861	3.6362	0	23.19	1,355	1.7455	1.2637	0	6.15
DNK	1,702	2.2021	5.1927	0	31.49	1,355	0.2961	0.4144	0	3.34
ESP	1,702	1.8859	4.3251	0	25.74	1,355	0.4843	0.4473	0	3.31
EST	1,702	3.0164	7.0416	0	44.54	1,355	0.0576	0.2016	0	2.16
FIN	1,702	2.2638	5.3240	0	32.08	1,355	0.2318	0.4801	0	4.45
FRA	1,702	1.7400	3.9980	0	23.38	1,355	0.8930	0.7335	0	4.41
GBR	1,702	1.3764	3.1170	0	18.8	1,355	0.7550	0.6744	0	7.11
GRC	1,702	1.6000	3.7420	0	29.84	1,355	0.0829	0.1478	0	1.32
HUN	1,702	3.8391	8.8491	0	51.5	1,355	0.2367	0.3182	0	2.17
ISL	1,702	1.8379	4.4261	0	28.03	1,355	0.0109	0.0222	0	0.19
IRL	1,702	3.1984	7.5629	0	44.67	1,355	0.3630	0.3990	0	2.84
ISR	1,702	1.6784	3.7565	0	26.82	1,355	0.0859	0.0789	0	0.79
ITA	1,702	1.6678	3.8036	0	25.47	1,355	0.8429	0.6814	0	4.37
JPN	1,702	0.7542	1.8385	0	15.81	1,355	0.5484	0.8041	0	6.53
KOR	1,702	2.3608	5.6264	0	42.42	1,355	0.7997	1.1670	0	9.83
LTU	1,702	2.1305	5.5728	0	35.48	1,355	0.0406	0.1542	0	1.85
LUX	1,702	4.7766	11.9873	0	68.84	1,355	0.1784	0.3243	0	2.57
LVA	1,702	1.9048	4.4870	0	27.08	1,355	0.0392	0.1628	0	1.38
MEX	1,702	2.4418	6.4006	0	36.1	1,355	0.3340	0.4183	0	3.6
NLD	1,702	2.0569	4.7258	0	30.18	1,355	0.5236	0.4327	0	3.62
NOR	1,702	1.2211	2.9881	0	21.73	1,355	0.1702	0.2281	0	1.56
NZL	1,702	1.2065	2.8234	0	22.22	1,355	0.0540	0.1628	0	2.41
POL	1,702	2.1021	4.9300	0	28.42	1,355	0.2260	0.2686	0	1.79
PRT	1,702	2.4376	5.8065	0	30.36	1,355	0.1026	0.1542	0	1.29
SVK	1,702	3.5974	8.3116	0	48.31	1,355	0.1398	0.2762	0	2.12
SVN	1,702	3.0181	7.1446	0	38.14	1,355	0.0768	0.2182	0	2.7
SWE	1,702	2.1428	5.1781	0	29.81	1,355	0.4236	0.6454	0	4.65
TUR	1,702	1.2013	2.7742	0	21.13	1,355	0.1429	0.1872	0	1.72
USA	1,702	0.8470	1.9117	0	12.9	1,355	1.1340	1.1925	0	7.99

Table 3. Descriptive statistics. Non-OECD countries 1995-2015

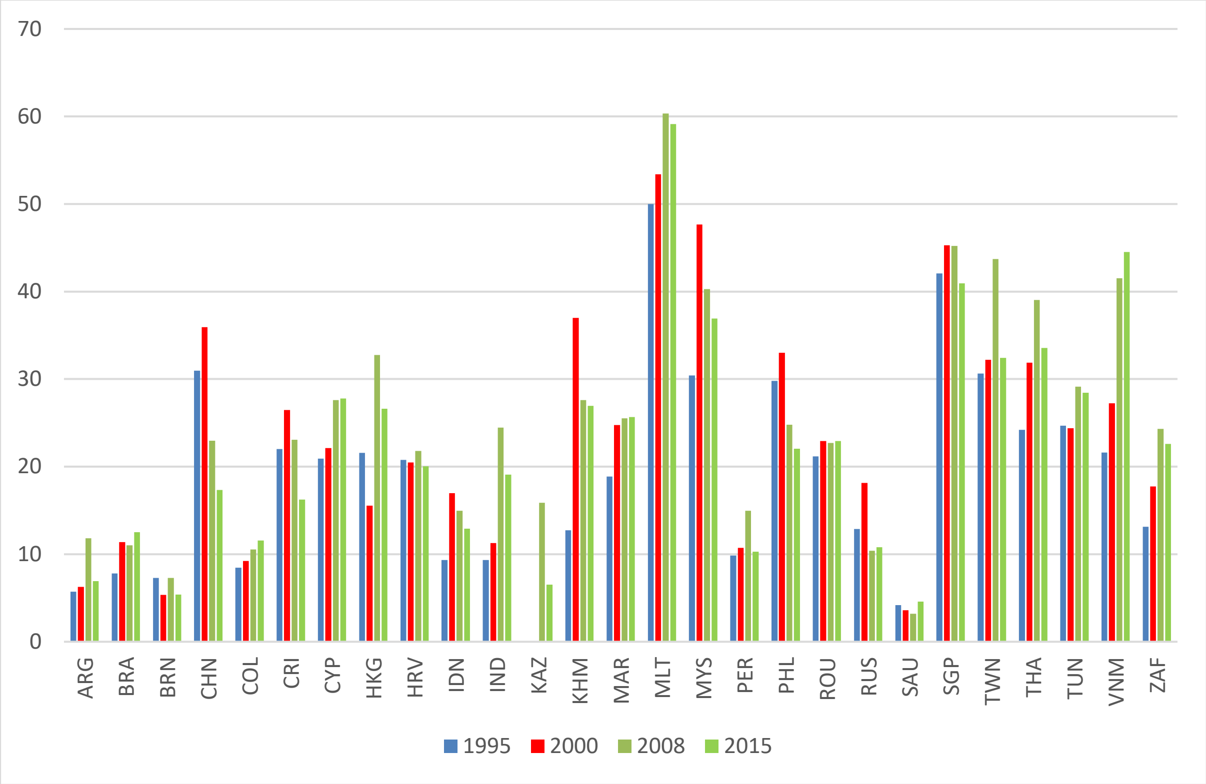
Non OECD	Backward					Forward				
	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
ARG	1,702	0.6406	1.5226	0	12.32	1,355	0.0354	0.1036	0	1.18
BRA	1,702	0.7675	1.7372	0	13.55	1,355	0.1216	0.2288	0	1.97
BRN	1,702	0.5390	1.2504	0	12.46	1,355	0.0021	0.0061	0	0.07
CHN	1,702	2.0530	4.9367	0	38.7	1,355	1.4908	1.8057	0	10.73
COL	1,702	0.6721	1.6133	0	11.58	1,355	0.0181	0.0404	0	0.48
CRI	1,702	1.5824	3.9766	0	29.84	1,355	0.0133	0.0291	0	0.37
CYP	1,702	1.9168	4.3994	0	27.78	1,355	0.0210	0.0538	0	0.62
HKG	1,702	1.8409	4.4375	0	32.74	1,355	0.1261	0.1459	0	1.37
HRV	1,702	1.7014	3.9885	0	22.71	1,355	0.0327	0.1121	0	1.1
IDN	1,702	1.0304	2.3899	0	18.36	1,355	0.1534	0.5141	0	9.24
IND	1,702	1.1549	2.9858	0	25.1	1,355	0.2303	0.4046	0	3.2
KAZ	902	0.9853	2.6320	0	20.26	715	0.0331	0.0920	0	1.09
KHM	1,702	2.2130	5.8471	0	41.41	1,355	0.0075	0.0215	0	0.18
MAR	1,702	1.8621	4.2449	0	28.46	1,355	0.0335	0.0445	0	0.31
MLT	1,702	4.6610	11.2301	0	67.9	1,355	0.0290	0.0561	0	0.76
MYS	1,702	3.0573	7.1281	0	47.67	1,355	0.4505	0.5383	0	3.84
PER	1,702	0.7920	1.8511	0	14.96	1,355	0.0243	0.0758	0	0.87
PHL	1,702	2.1457	5.2572	0	40.47	1,355	0.0853	0.1209	0	1.19
ROU	1,702	1.9442	4.5084	0	27.56	1,355	0.0673	0.1286	0	1.29
RUS	1,702	0.9443	2.1626	0	18.15	1,355	0.3169	0.5344	0	4.93
SAU	1,702	0.2857	0.6537	0	5.33	1,355	0.0477	0.0711	0	1.74
SGP	1,702	2.9862	6.8258	0	45.29	1,355	0.4898	0.5733	0	4.24
TWN	1,702	2.5570	6.1983	0	43.71	1,355	0.4799	0.6754	0	7.03
THA	1,702	2.3952	5.6694	0	39.03	1,355	0.3404	0.5242	0	9.24
TUN	1,702	2.3136	5.4642	0	30.58	1,355	0.0230	0.0280	0	0.16
VNM	1,702	2.5552	6.3648	0	44.52	1,355	0.1450	0.4357	0	5.44
ZAF	1,702	1.4103	3.1990	0	24.35	1,355	0.0733	0.0886	0	0.99

Figure 1. Forward participation in GVCs: Domestic value added embodied in foreign exports, as a % share of total gross exports of the source country, OECD countries



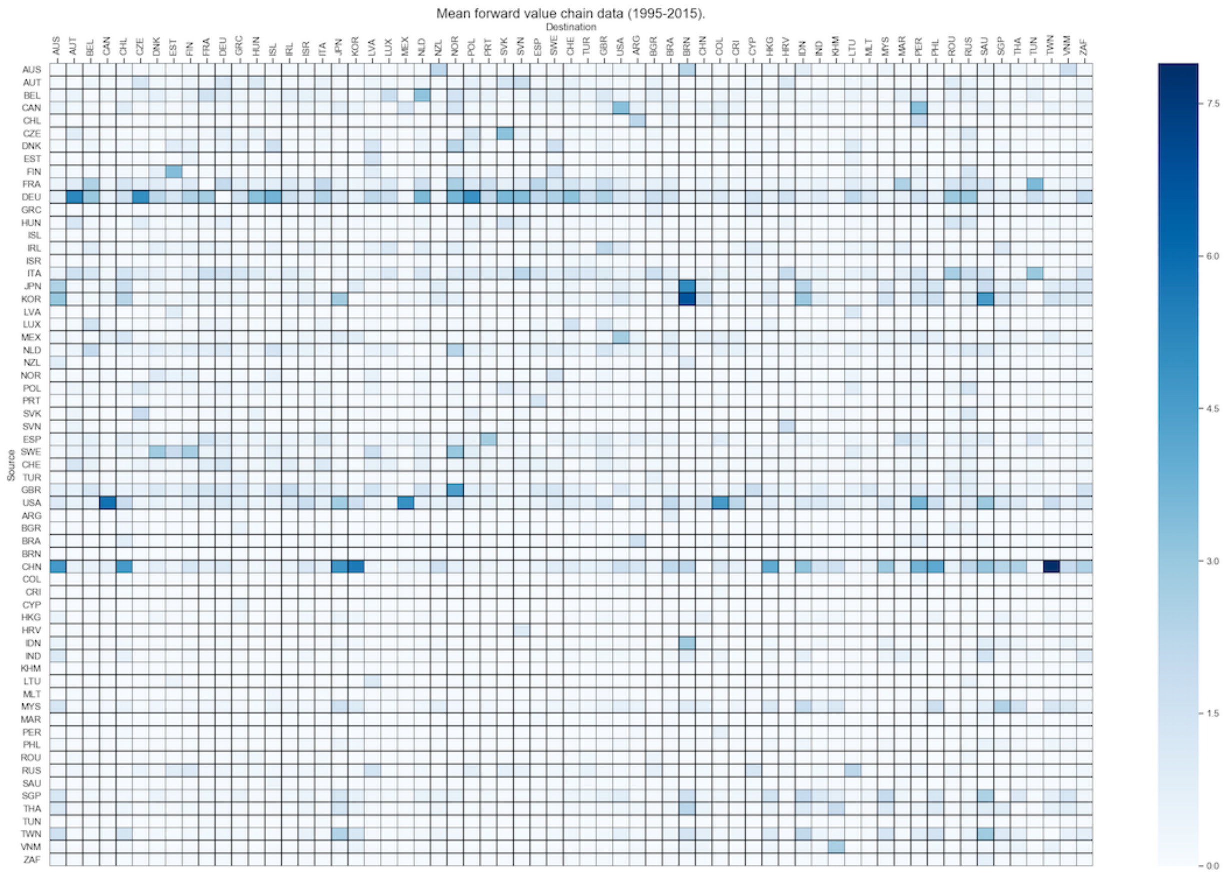
Source: Authors' own based on OECD-WTO, TiVA indicators

Figure 2. Forward participation in GVCs: Domestic value added embodied in foreign exports, as a % share of total gross exports of the source country, non-OECD countries



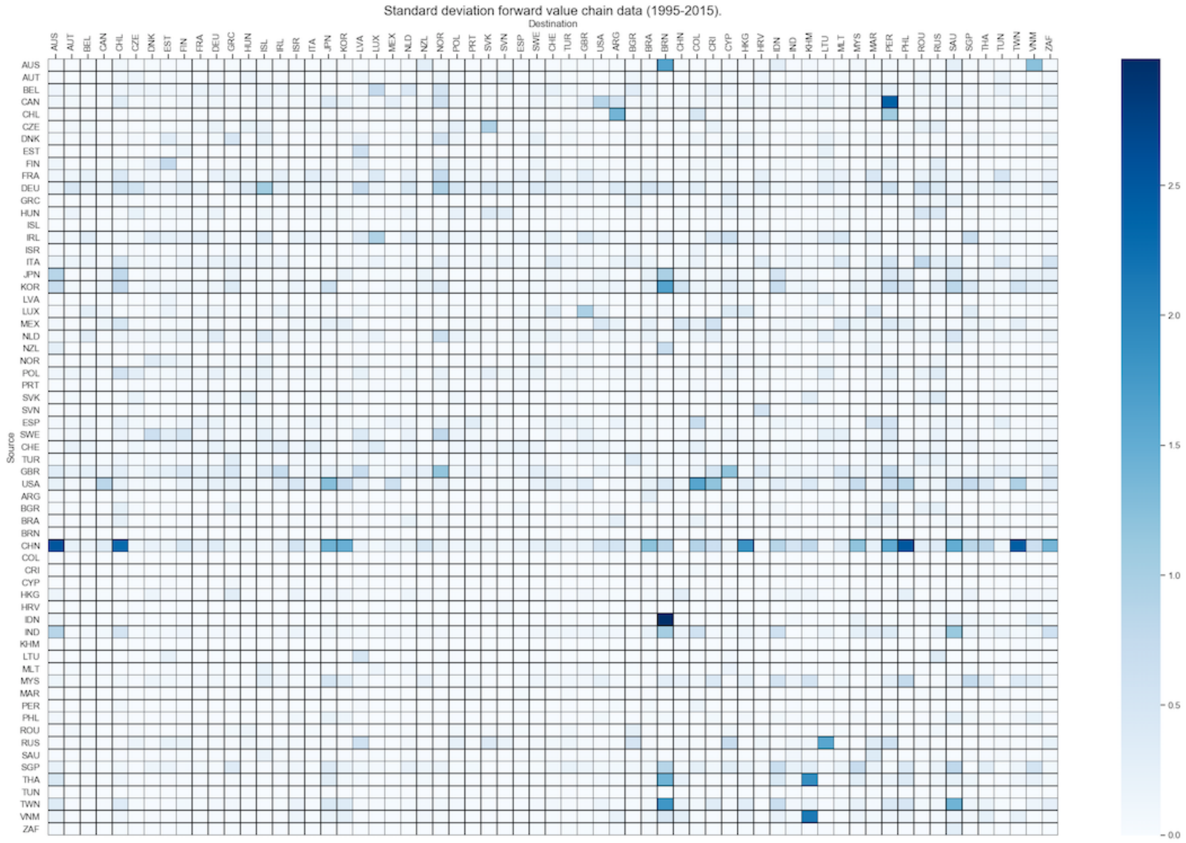
Source: Authors' own based on OECD-WTO, TiVA indicators

Figure 3. Forward participation in GVC, mean all periods 1995-2015.



Source: Authors' own based on OECD-WTO, TiVA indicators

Figure 4. Forward participation in GVC, standard deviation all periods 1995-2015.

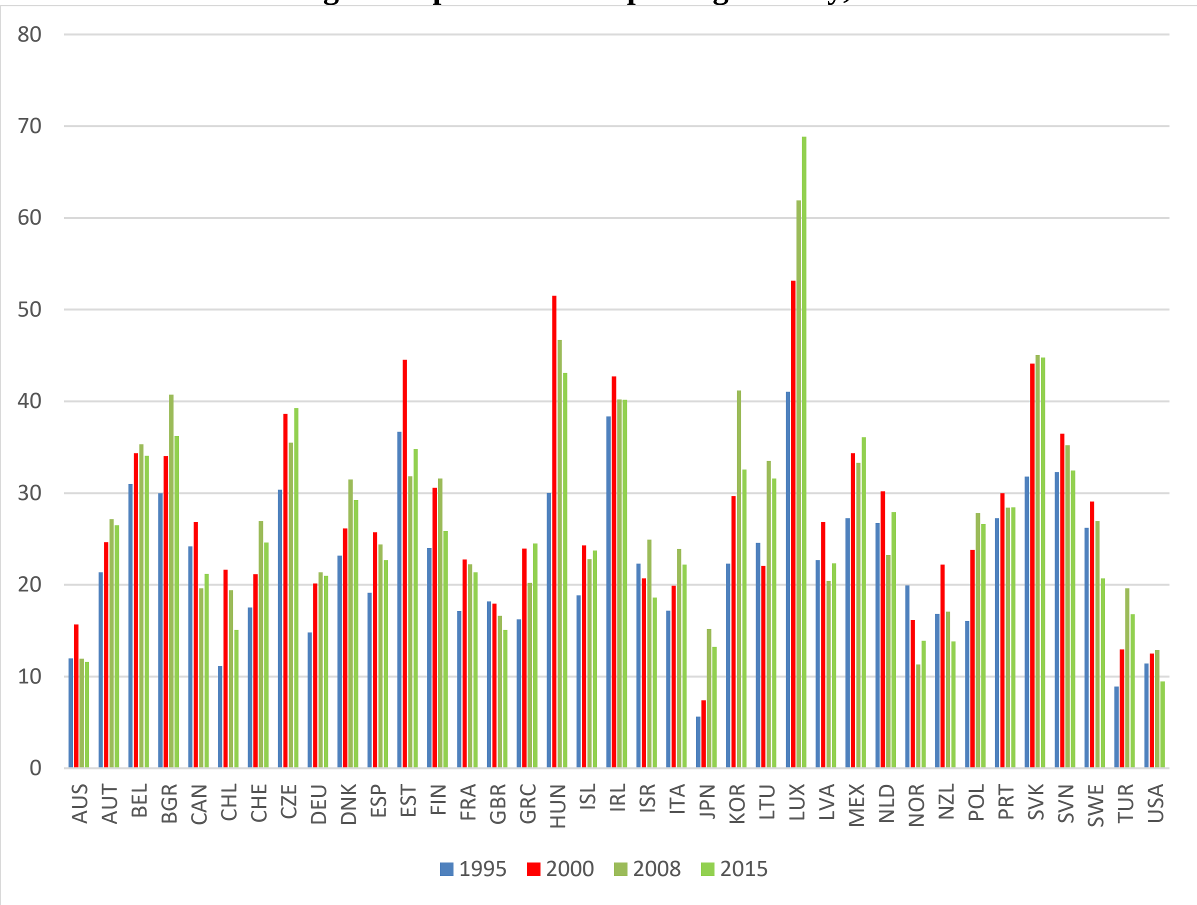


Source: Authors' own based on OECD-WTO, TiVA indicators

Figure 5. Dimension rotationality, forward participation in GVCs. All countries

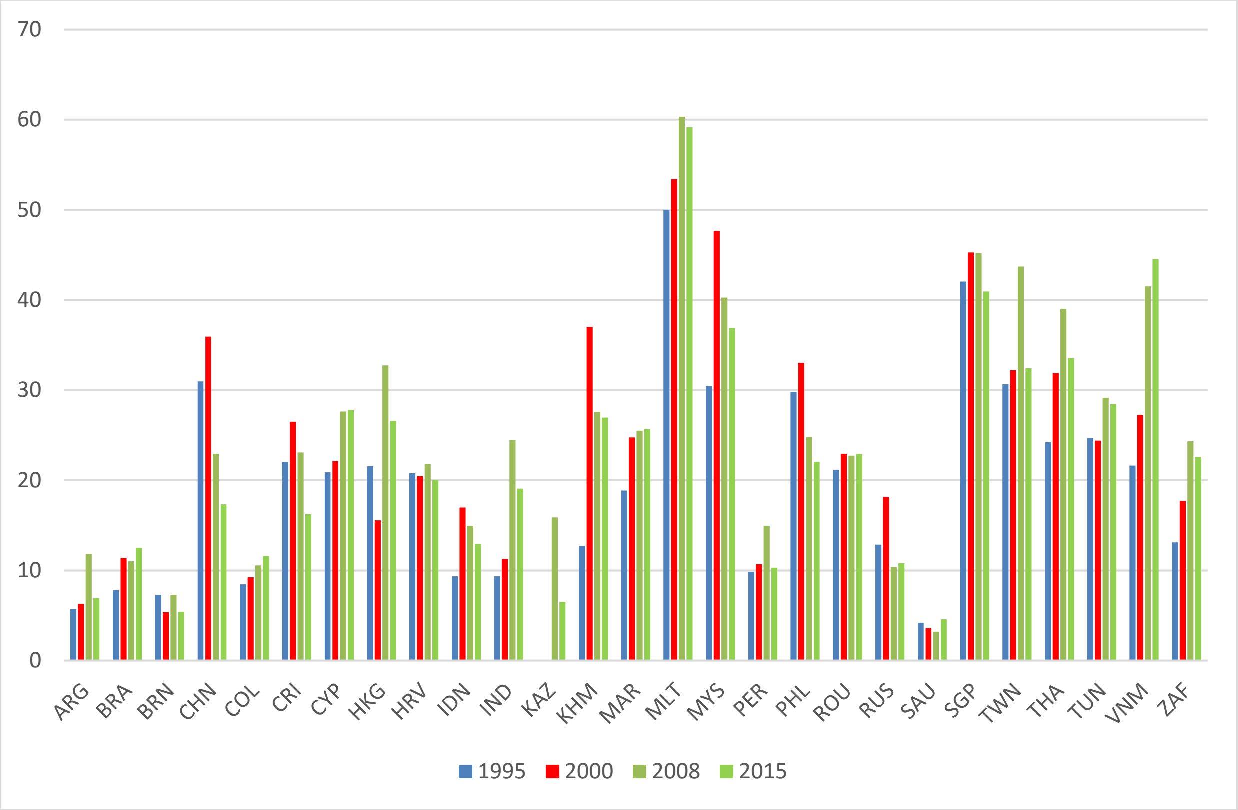
Source: Authors' own based on OECD-WTO, TiVA indicators

Figure 6. Backward participation in GVCs: Foreign value added embodied in exports, as a % of total gross exports of the exporting country, OECD countries



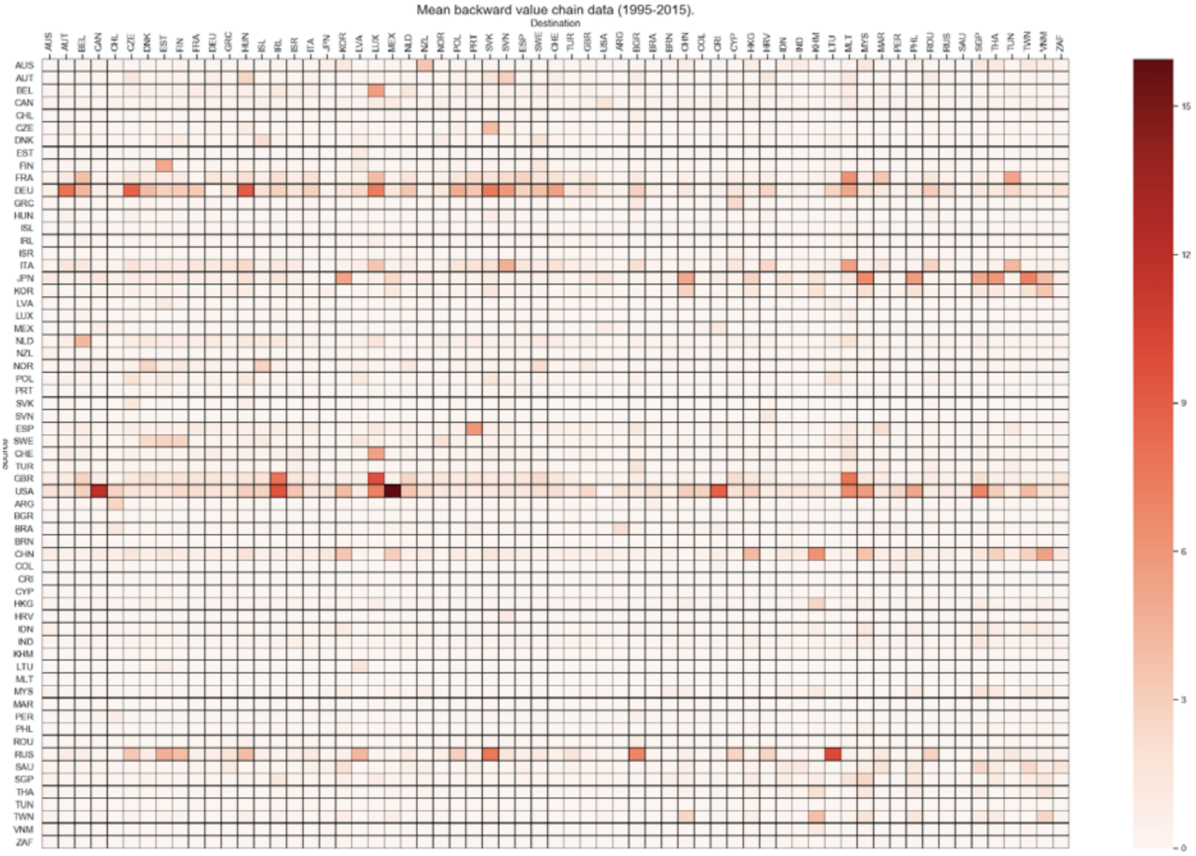
Source: Authors' own based on OECD-WTO, TiVA indicators

Figure 7. Backward participation in GVCs: Foreign value added embodied in exports, as a % of total gross exports of the exporting country, non-OECD countries



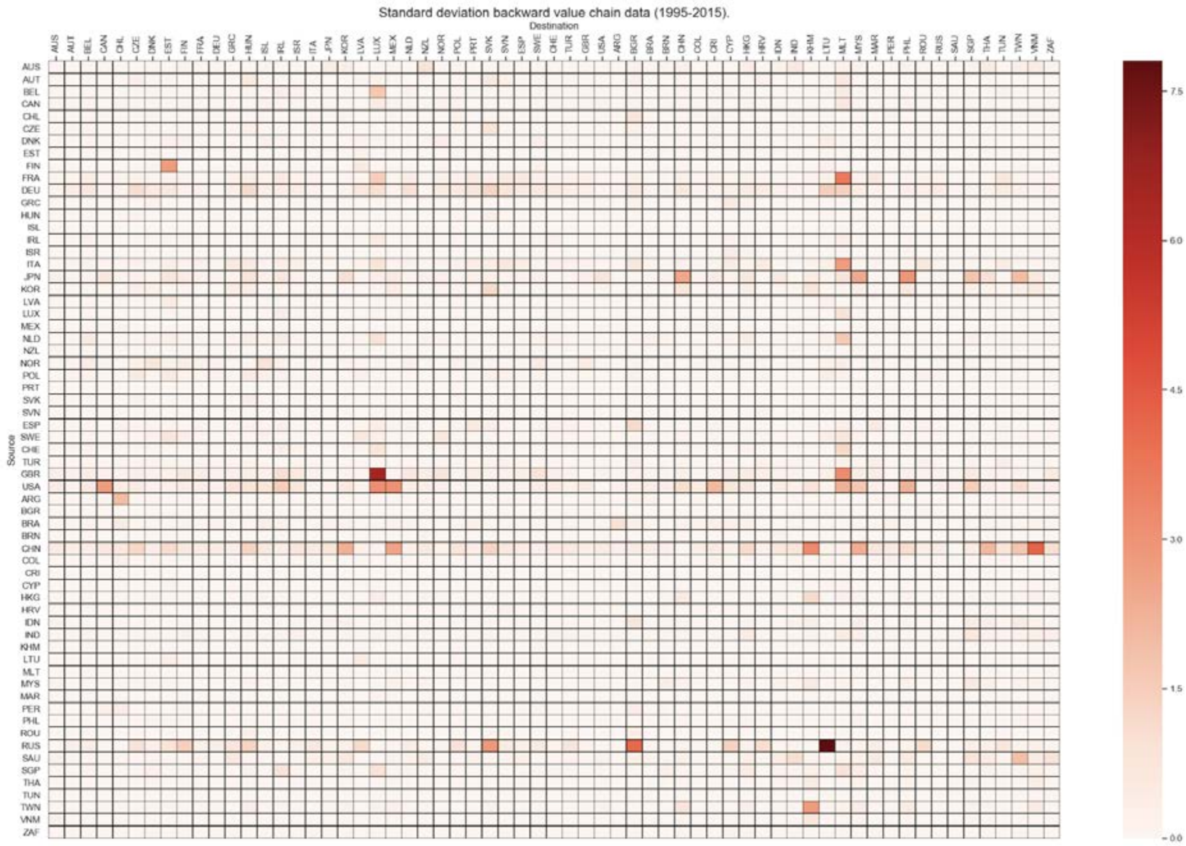
Source: Authors' own based on OECD-WTO, TiVA indicators

Figure 8. Backward participation in GVC, standard deviation all periods 1995-2015.



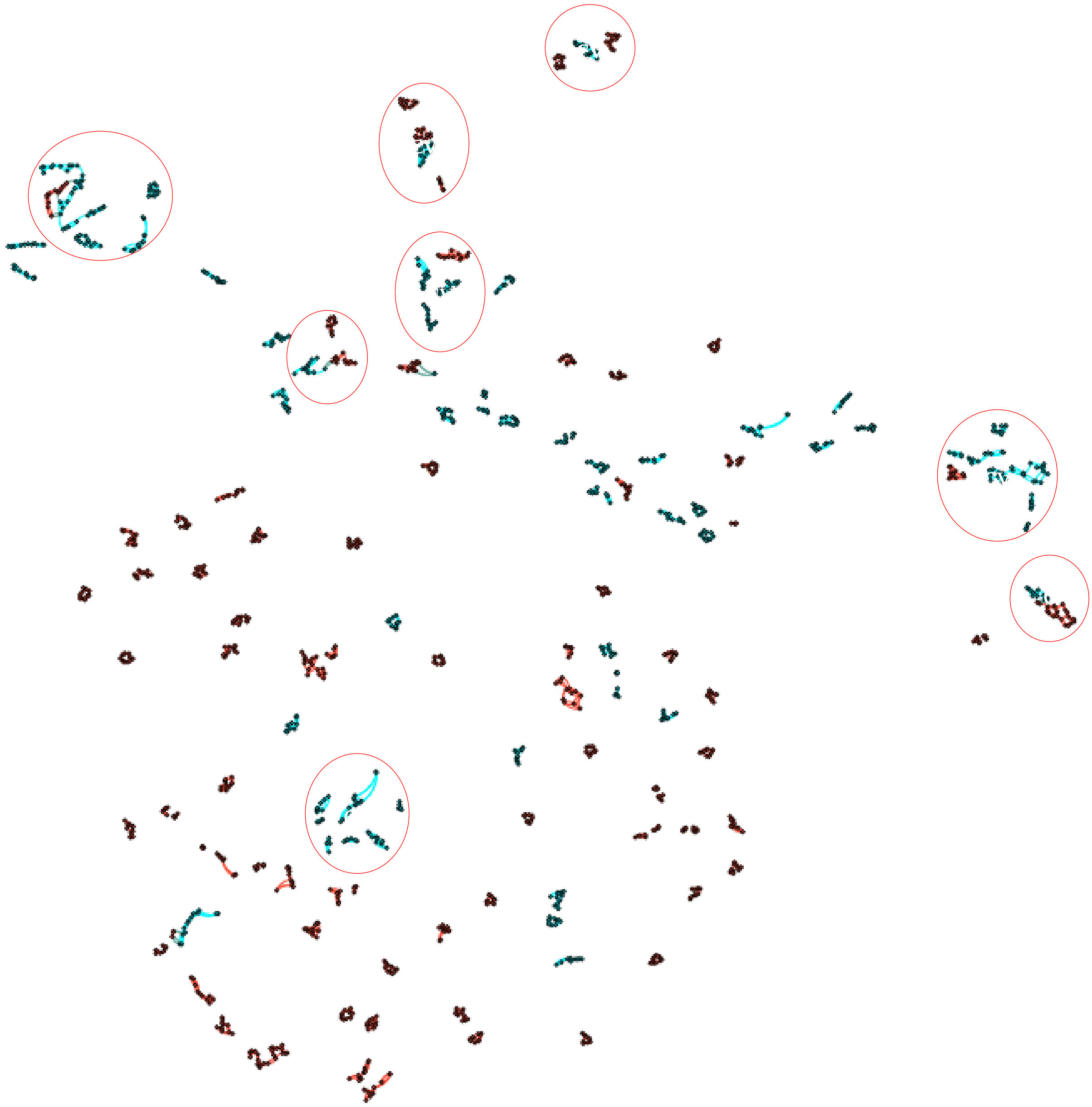
Source: Authors' own based on OECD-WTO, TiVA indicators

Figure 9. Backward participation in GVC, standard deviation all periods 1995-2015.



Source: Authors' own based on OECD-WTO, TiVA indicators

Figure 10. Dimension rotationality, backward participation in GVCs. All countries



Source: Authors' own based on OECD-WTO, TiVA indicators

Appendix

Table A.1. Trade in Value Added (TiVA) - List of industries

Manufacturing	
High-tech manufacturing	**Low-tech manufacturing**
24 Manufacture of chemicals and chemical products 29 Manufacture of machinery and equipment n.e.c. 30 Manufacture of office, accounting and computing machinery 31 Manufacture of electrical machinery and apparatus n.e.c. 32 Manufacture of radio, television and communication equipment and apparatus 33 Manufacture of medical, precision and optical instruments, watches and clocks 34 Manufacture of motor vehicles, trailers and semi-trailers 35 Manufacture of other transport equipment	15 Manufacture of food products and beverages 16 Manufacture of tobacco products 17 Manufacture of textiles 18 Manufacture of wearing apparel; dressing and dyeing of fur 19 Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear 20 Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials 21 Manufacture of paper and paper products 22 Publishing, printing and reproduction of recorded media 23 Manufacture of coke, refined petroleum products and nuclear fuel 25 Manufacture of rubber and plastics products 26 Manufacture of other non-metallic mineral products 27 Manufacture of basic metals 28 Manufacture of fabricated metal products, except machinery and equipment 36 Manufacture of furniture; manufacturing n.e.c. 37 Recycling
Services	
Knowledge intensive business services	**Traditional services**
72 Computer and related activities 73 Research and development 74 Other business activities	45 Construction 50 Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel 51 Wholesale trade and commission trade, except of motor vehicles and motorcycles 52 Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods 55 Hotels and restaurants 60 Land transport; transport via pipelines 61 Water transport 62 Air transport 63 Supporting and auxiliary transport activities; activities of travel agencies 64 Post and telecommunications 65 Financial intermediation, except insurance and pension funding 66 Insurance and pension funding, except compulsory social security 67 Activities auxiliary to financial intermediation 70 Real estate activities 71 Renting of machinery and equipment without operator and of personal and household goods

Source: OECD-WTO, TiVA indicators