OECD publishing

PRODUCTIVITY AND INNOVATION AT THE INDUSTRY LEVEL: WHAT ROLE FOR GLOBAL VALUE CHAIN INTEGRATION?

PETER GAL
WILLIAM WITHERIDGE

OECD PRODUCTIVITY WORKING PAPERS
October 2019 **No. 19**

Global Forum on PRODUCTIVITY

OECD
BETTER POLICIES FOR BETTER LIVES

OECD PRODUCTIVITY WORKING PAPERS

The OECD Productivity Working Papers are associated with the Global Forum on Productivity that provides a forum for mutual exchange of information and fosters international co-operation between public bodies with responsibility for promoting productivity-enhancing policies, including in undertaking joint policy analysis. It offers a platform for exchanging views, experiences and information, institutional and governance arrangements and government structures, with a view towards developing better policies. The Forum extends existing work in the OECD through a well-prioritised and coherent stream of analytical work serving the policy research needs of participants on the drivers of productivity growth.

This paper has been authorised for publication by Luiz de Mello, Director, Policy Studies Branch, Economics Department, Álvaro Santos Pereira, Director, Country Studies Branch, Economics Department, and Andrew Wyckoff, Director, Directorate for Science, Technology and Innovation.

OECD Productivity Working Papers should not be reported as representing the official views of the OECD or of its member countries. The opinions expressed and arguments employed are those of the author(s).

Comments on OECD Productivity Working Papers are welcome and may be sent to: productivity@oecd.org
OECD Productivity Working Papers are published on: oe.cd/productivity
Series: OECD Productivity Working Paper Series
ISSN 2413-9424

Please cite this paper as:

Gal, P. and Witheridge, W., "Productivity and innovation at the industry level: What role for integration in global value chains?", OECD Productivity Working Papers, 2019-19, OECD Publishing, Paris.

ABSTRACT/RÉSUMÉ

Productivity and innovation at the industry level: What role for integration in global value chains?

Productivity growth has declined in most advanced economies in the past two decades and there are signs that the pace of global value chain (GVC) integration has slowed in the post-crisis period. This paper explores the role of GVCs - international trade in intermediate inputs - for multi-factor productivity growth using a range of cross-country industry-level data sources. We find that greater participation in GVCs is associated with faster domestic productivity growth at the industry level. We estimate that if GVCs had continued to grow at their pre-crisis trend, productivity growth would have been around 1 percentage point faster over the subsequent five years in both manufacturing and services. We also find that the productivity-enhancing direction of trade differs between sectors. For manufacturing sectors, greater use of intermediate inputs from foreign sources (backward participation) is linked with faster productivity growth, reflecting the beneficial effects of having access to better quality or cheaper inputs. For services sectors, it is more the sales of intermediates (forward participation) that is associated with productivity gains, in line with the traditional role of services in foreign trade as providing inputs to other activities. Looking by partner country, GVC participation with higher productivity countries is particularly productivity enhancing. We also find that GVC integration spurs greater domestic innovation activity.

JEL classification: F14, D24, O30
Keywords: global value chains, productivity, innovation

****

Productivité et innovation au niveau sectoriel: quel rôle joue l'intégration dans les chaînes de valeur mondiales?

La croissance de la productivité a ralenti dans la plupart des économies avancées au cours des deux dernières décennies et certains signes indiquent que le rythme d'intégration aux chaînes de valeur mondiale (CVM) a ralenti au cours de la période post-crise. Ce document explore le rôle des CVM - le commerce international des intrants intermédiaires - dans la croissance de la productivité multifactorielle à l'aide de plusieurs sources de données au niveau sectoriel couvrant plusieurs pays. Nous constatons qu'une plus grande participation dans les CVM est associée à une croissance plus rapide de la productivité du pays au niveau industrie. Nous estimons que si les CVM avaient poursuivi leur croissance d'avant la crise, la croissance de la productivité aurait été supérieure d'environ 1 point de pourcentage au cours des cinq années suivantes, tant dans le secteur manufacturier que dans celui des services. Nous constatons également que la direction des échanges qui améliore la productivité diffère selon les secteurs. Pour les secteurs manufacturiers, une plus grande utilisation d'intrants intermédiaires de source étrangère (participation en amont) est liée à une croissance plus rapide de la productivité, reflétant les effets bénéfiques de l'accès à des intrants de meilleure qualité ou moins chers. Pour les secteurs de services, ce sont plutôt les ventes d'intermédiaires (participation en aval) qui sont associées à des gains de productivité, conformément au rôle traditionnel des services dans le commerce extérieur en tant qu'intrants pour d'autres activités. En regardant les effets par pays partenaire, la participation aux CVM à travers des liens avec les pays à productivité élevée améliore particulièrement la productivité. Nous constatons également que l'intégration aux CVM stimule une plus grande activité d'innovation dans le pays.

Classification JEL : F14, D24, O30
Mots-clés : mondialisation, productivité, innovation

Table of contents

Tables

Figures

Productivity and innovation at the industry level: What role for integration in global value chains?

By Peter Gal and William Witheridge[1]

1. Introduction and main findings

1. Productivity growth – the main source of rising per-capita incomes over the long run – has been on a downward trend in recent decades in most OECD countries. This slowdown started before the global financial crisis, hence it is likely driven not only by cyclical but also by structural factors (Adalet McGowan et al., 2015[1]; Cette, Fernald and Mojon, 2016[2]; Crafts, 2018[3]), and measurement challenges cannot account for it (Byrne, Fernald and Reinsdorf, 2016[3]; Syverson, 2016[4]). In addition, productivity has taken a further hit since the crisis, and its recovery is proving disappointingly slow, especially in the more trade intensive manufacturing sector (Sorbe, Gal and Millot, 2018[3]). At the same time, there is growing evidence that the expansion of global value chains (GVCs; see Hummels, Ishii and Yi (2001[7]) and Johnson and Noguera (2012[4])) – measured by the intensity of international trade in intermediate goods and services – has slowed substantially since the crisis. The idea has emerged that perhaps this is the "new normal" and GVCs could have reached a plateau due to technological and geographic constraints to further trade integration (Baldwin, 2013[6]; Hoekman, 2015[5]; Haugh et al., 2016[7]).2

2. In addition, recent trade protectionist measures also contribute to weaker global commerce and trade integration. Indeed trade policy started to become more restrictive after the financial crisis, even before more explicit measures, introduced around 2016 (Bown, 2018[1]). This trend was driven by modest increases in import protection through rising subsidies, non-tariff measures, anti-dumping and countervailing duties, which affected intermediate inputs – hence international supply chains – relatively more than final goods. It is still an outstanding question to what extent these measures have led to a structural change in the nature of global trade, moving away from an era when "research and development, design, production of parts, assembly, marketing, and branding […] are increasingly fragmented across firms and countries." (Alfaro et al., 2018[5])

3. Whatever the drivers, less intensive global trade integration can have important consequences on the ability and the incentives of firms to improve their productivity. This paper thus reassesses the link between productivity, innovation and GVC integration at the industry level, using a new cross-country dataset on GVCs and productivity covering the

[1] Corresponding authors are: Peter Gal (Peter.Gal@oecd.org) from the OECD Economics Department and William Witheridge (william.witheridge@nyu.edu) from New York University. The authors would like to thank Jimmy Lopez (Université de Bourgogne) for providing inputs for the industry level productivity measures, and Dan Andrews (Australian Treasury), Shreya Bhattacharya (University of Houston), Sebastian Benz (OECD Trade and Agriculture Directorate), Chiara Criscuolo (OECD Directorate for Science, Technology and Innovation), Giuseppe Nicoletti, Mathilde Pak, Dorothée Rouzet, Stéphane Sorbe (all from OECD Economics Department) and seminar participants at New York University, the Young Economists Symposium at Columbia University and at the OECD for their valuable comments and Sarah Michelson (OECD Economics Department) for providing excellent editorial assistance. The views expressed in this paper are those of the authors and do not necessarily reflect those of the OECD or its member countries.

[2] There is also the possibility, mentioned recently by the BIS that there was an unsustainable GVC-"bubble" in the pre-crisis period linked to manufacturing goods trade and finance (Shin, 2019[13]).

pre- and post-crisis period. It analyses and quantifies the role of lower trade intensity in the productivity slowdown, and also explores the channels through which the two phenomena are related, in particular the role of innovation and the nature of GVC integration. Our analysis confirms a significant positive relationship between GVCs – trade in intermediate goods and services – and subsequent multi-factor productivity (MFP) growth. For the average industry, this link is driven mainly by backward GVC integration (imported foreign intermediates), highlighting the crucial positive role of having access to more variety, better quality or cheaper inputs in production (Bas and Strauss-Kahn, 2015[10]; Halpern, Koren and Szeidl, 2015[11]; Goldberg et al., 2010[12]).[3]

4. Digging deeper, we find that this channel is prevalent among manufacturing industries, while among services activities we detect faster MFP growth when supplying more to producers that export (forward GVC participation). This is consistent with the positive effects found in the literature on the crucial role of services as suppliers of intermediate inputs (Bourlès et al., 2013[15]) and on the beneficial effects of expanded market size, the increased specialization it enables and the more intense competition it brings (Melitz, 2003[17]; Melitz and Ottaviano, 2008[18]; Bernard, Redding and Schott, 2007[19]). We find this channel to be stronger when partner countries in GVCs are more productive, hence offering more possibilities from learning via international production networks (De Loecker, 2013[19]; Coelli, Moxnes and Ulltveit-Moe, 2018[20]). Corroborating the role of knowledge spillovers, we also find evidence for greater information and communication technology (ICT) use and more business spending on R&D when forward GVC participation occurs with high productivity partner countries. These results are also consistent with a mechanism where productivity gains arise through upgrading to meet higher foreign standards – for instance in the case of affiliates of multi-national firms –, by means of innovation.[4]

5. Finally, through counterfactual simulations, we illustrate quantitatively how much higher productivity could have grown if GVC participation had not stalled after the crisis. Our estimates suggests that if the GVC shortfall in manufacturing – about 8.5 percentage points (pp) of value added (and about 1.6 pp for services) – over the 5 years following the crisis could have been avoided, productivity would have been 0.7% (1.1 % for services) higher, which is quite significant compared to the weak observed MFP growth in that period for our sample countries and industries: 2.5% for manufacturing and 3.2% for services, cumulated over 2009-2014.

6. As highlighted above, GVCs, productivity and innovation have already been found to be closely related in the literature through several channels (see a detailed overview in Criscuolo and Timmis (2017[9])). In particular, greater international trade raises productivity growth (Baldwin and Gu, 2004[9]) and provides technological and research and development (R&D) spillovers (Coe and Helpman, 1995[11]; Bloom, Draca and Van Reenen, 2016[10]). GVC integration may encourage the development and adoption of ICTs. More intensive trade links were also found to be linked to more intensive co-innovation

[3] Important firm-level studies on the role of import competition find conflicting effects on productivity an innovation (for Europe, Bloom, Draca and Van Reenen (2016[25]); for the US, Autor, Dorn and Hanson (2016[39])). Our focus is on GVC participation, i.e. trade in intermediates, and not general competition from imports, which also includes the trade of final goods.

[4] There is related evidence from French firm level data that shows that exporting leads to more innovation (measured by patenting activity) for the most productive firms within industries (Aghion et al., 2018[36]).

activities across trading partner countries (De Backer, Destefano and Moussiegt, 2017[27]).[5] Increased trade exposure may necessitate additional innovation efforts in order to remain globally competitive (Akcigit, Ates and Impullitti, 2018[28]).

7. Our paper's industry-level focus complements the vast micro- and macro-level literature on the growth impacts of trade. At the micro level, most studies focus on individual countries, time episodes or specific channels so as to achieve credible identification (De Loecker, 2013[15]; Halpern, Koren and Szeidl, 2015[16]; Kasahara and Rodrigue, 2008[17]). However, this comes at the cost of making it harder to quantify aggregate effects or to generalise results. Moreover, it has been shown that reallocation and selection effects across firms are substantial (Alfaro and Chen, 2018[26]; Melitz, 2003[17]), hence the overall impacts can be more directly assessed by using aggregate data. At the macro level, it is easier to obtain a more global, more general picture using data from a large number of countries and longer time periods (Égert, 2016[31]; Haugh et al., 2016[11]; Ignatenko, Raei and Mircheva, 2019[30]), but empirical identification is more challenging due to many confounding factors such as business cycle effects that are difficult to control for. The macro focus also has limits regarding the understanding of the mechanisms at play.

8. There is little cross-country empirical research on the link between GVCs and productivity at the industry level.[6] One example is Saia, Andrews and Albrizio (2015[15]), who find that greater GVC participation is associated with faster MFP growth by learning from the global frontier using industry-level data, but limited to the pre-crisis period (1984-2007). This paper exploits a more recent industry-level dataset on productivity and GVCs to provide an update and to look at the issue in a more granular way. Besides covering a more up to date sample than Saia et al. (2015[15]), we also take a broader view on the potential impact of GVCs on productivity and innovation by looking at three distinct channels: i) market size expansion (forward participation), ii) access to a broader set of intermediates from abroad (backward participation), iii) and the impact on innovation, measured by business R&D spending or ICT capital intensity.

9. The paper proceeds in Section 2 by describing the various data sources and presenting some key trends on GVCs, productivity and innovation globally and by countries and industries. Section 3 outlines the econometric framework. Section 4 presents the results, explores the mechanisms and discusses the economic significance of our findings. Section 5 concludes.

2. Data and preliminary evidence

2.1. Data description

10. This paper exploits harmonised cross-country industry-level data, sourced from three recently updated databases: the OECD-STructural ANalysis (STAN) database, the OECD-Trade in Value-Added (TiVA) database and the OECD-TiVA Nowcast database.[7] Our

[5] Recent firm-level work in the context of the OECD Global Forum of Productivity (GFP) has also confirmed the role of highly connected GVC hubs and the composition of foreign networks on closing the gap between lagging and frontier firms (Criscuolo and Timmis, 2018[13]).

[6] There is related work at the industry level using import penetration which also shows positive productivity effects (Chen, Imbs and Scott, 2009[37]). However, traditional import penetration measures do not differentiate between intermediate trade (our current focus) and final good trade.

[7] The database – as well as the methodology – builds on previous work of the authors (Andrews, Gal and Witheridge, 2018[41]) that examined the relationship between GVCs and output prices across countries at the detailed industry

dependent variable – i.e. multi-factor productivity – is drawn from STAN, while we exploit the TiVA databases because measuring trade in value-added terms provides a clearer and more nuanced picture of the global integration of production than gross trade flows. Our final database contains productivity measures, GVC and innovation indicators covering 25 OECD countries[8] annually over the period 1995 to 2016 (2014 for GVCs) for 26 industries at the detailed, 2-digit level in ISIC 3.1 (see Table A.1Table A.1). This provides over 9,000 country-industry-year observations that are available, of which we retain about 6,300 observations in the baseline specification due to 5-year differencing our dependent variable. To mitigate the influence of extreme values due to measurement error or rare events (outliers), all variables that enter the regressions are cleaned by removing the observations that are in the top or bottom 1% of their distributions.

2.1.1. GVC indicators

11. Following Johnson and Noguera (2012) and Wang et al. (2017[31]), our primary variables of interest are backward and forward participation in GVCs. We define them as the foreign imported value added content of output (backward participation) and the domestic value added content of exports (forward participation), both as a share of value added, at the country-industry level. Total GVC participation is defined as the sum of backward and forward GVC participation. This is an intensity measure that tends to vary between 0 and 1, capturing the degree of global integration of a particular industry of a particular country.[9]

12. Importantly, our baseline GVC indicator captures the indirect impact of foreign imported content through domestic value chains rather than the direct impact on final demand, differentiating it from standard import intensity measures. To illustrate this with an example, our baseline GVC intensity measure captures the role of value added embodied in the imported components of German cars coming from Eastern Europe but abstracts from German consumers purchasing Japanese cars on the German market (i.e. direct imports of final goods). This measure isolates and focuses on the structural component of the trade integration of domestic industries, while alternative measures – such as the foreign value added embodied in domestic final demand or traditional measures of import penetration – are more likely to be directly affected by cyclical (domestic) demand factors and relative price shifts.

13. Moreover, we take further steps (outlined in more details in Section 3) to abstract from the influence of confounding factors that could affect productivity. First, we always include country-year interacted fixed effects in our regressions to control for country-level cyclical variations or exchange rate shocks. Second, we use a five-year long difference specification

level. The industry level MFP measures are described in Sorbe, Gal and Millot (2018[6]). While a new update of TiVA has become available recently, this paper uses a previous vintage since it includes a longer time period in the past, covering the significant GVC expansion of the 90's and early 2000s. Adding more recent years would not have impacted our estimations given that MFP data stops in 2016 and we use a five-year lag specification (see Section 3 on the econometric framework).

[8] These countries are: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Hungary, Italy, Japan, Korea, Luxembourg, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, United Kingdom, United States. The country coverage is somewhat smaller in the R&D and ICT analysis.

[9] By using an output concept and not exports as the denominator – similarly to (Schwellnus et al., 2018[34]) –, we slightly deviate from the literature with these definitions, with the aim to take into account differences in overall trade intensities across sectors which are more relevant for the channels through which productivity in the sector as a whole can be affected.

to filter out the impact of any short-run (e.g. year-to-year) changes in productivity. Finally, to mitigate the role of large shifts during the crisis and its aftermath, we also estimate our baseline econometric specification using pre-crisis data only.

14. We also exploit the bilateral trade block of the TiVA database to construct GVC indicators that take into account the source country of foreign value added content and destination country of domestic value added content More specifically, we create variables to proxy for GVC integration with both "high-productivity" and "low-productivity" countries based on the level of economic development of the source and destination country.[10]

2.1.2. Productivity and innovation

15. Our main outcome variables of interest are productivity and innovation, both of which can be measured in various ways. The underlying source of the productivity data is the OECD STAN database, also used in recent OECD work by Sorbe, Gal and Millot (2018[6]). Our preferred productivity measure is multi-factor productivity, under the assumption of a Cobb-Douglas constant returns to scale production function for value added (Y_{cst}) as output and the number of employees (L_{cst}) and capital stock (K_{cst}) as inputs:

$$MFP_{cst} = Y_{cst} - \alpha_s K_{cst} - (1 - \alpha_s) L_{cst}.$$

The labour coefficient α_s is based on observed labour shares, calculated as a slow-moving (9-year) average of the cross-country average wage bill over value added ratio, as a compromise to eliminate business cycle changes in the labour share but retain long-run trends in it. The capital stock K_{cst} was constructed by using the perpetual inventory method (PIM):

$$K_{cst} = (1 - \delta) K_{cs,t-1} + I_{cst},$$

assuming an average depreciation rate of δ = 9% [11] and initial values as follows:

$$K_{cst_0} = \overline{I_{cst,t+5}}/(\delta + g),$$

with $\overline{I_{cst,t+5}}$ the average investment for the first 5 years and g the average growth rate of $\overline{I_{cst,t+5}}$ over the first 10 years. As a robustness test to avoid measurement sensitivities of the capital stock and the production function coefficients, we also use a simple labour productivity measure, defined as the ratio of value added to employment.[12]

16. Measuring innovation across a wide range of countries and industries is a challenge and one can use various measures, each with different advantages and drawbacks. We use two particular measures: first, R&D spending by businesses (in logs), sourced from the OECD Main Science and Technology Indicators Database; second, a measure for ICT

[10] The group of "high-productivity countries" is chosen to be those that are part of the EU-15 (EU members prior to 2004) plus Australia, Canada, Japan, New Zealand, Norway, Switzerland and the United States, and "low-wage countries" are all other countries that are part of the TiVA database, including, among others, Asia and Eastern Europe.

[11] This is an implied average depreciation rate using the detailed asset structures from EU KLEMS data and the respective depreciation rates by asset types from Fraumeni (1997[48]).

[12] The increasing fragmentation of production across countries and industries implies that ideally one should move beyond the traditional framework of measuring productivity and encompass all inputs in the value chain (Timmer, 2017[47]). However, such efforts are at an experimental stage and use approximations given the current system of statistical data collection.

capital intensity, defined as the ratio of real ICT to non-ICT capital services (and normalised to 2005 = 100), sourced from the EU KLEMS database (Jäger, 2017[32]). These variables reduce the sample of analysis from our baseline dataset (containing productivity and GVCs). An analysis of patents at the detailed industry level for our sample period would face further data limitations challenges hence we omit it from our innovation measures.

2.1.3. Other variables

17. We also draw on policy variables to test the robustness of our baseline results. These include: *i*) the stringency of employment protection legislation (EPL) of regular contracts, interacted with a sector-specific measure for EPL exposure, taken to be the layoff rate from the United States (Andrews and Cingano, 2014[34]; Bassanini, Nunziata and Venn, 2009[35]); and *ii*) the OECD regulatory burden indicator, which measures the knock-on effects of product market regulations in upstream sectors on downstream sectors via input-output linkages (Égert and Wanner, 2016[34]; Bourlès et al., 2013[16]).

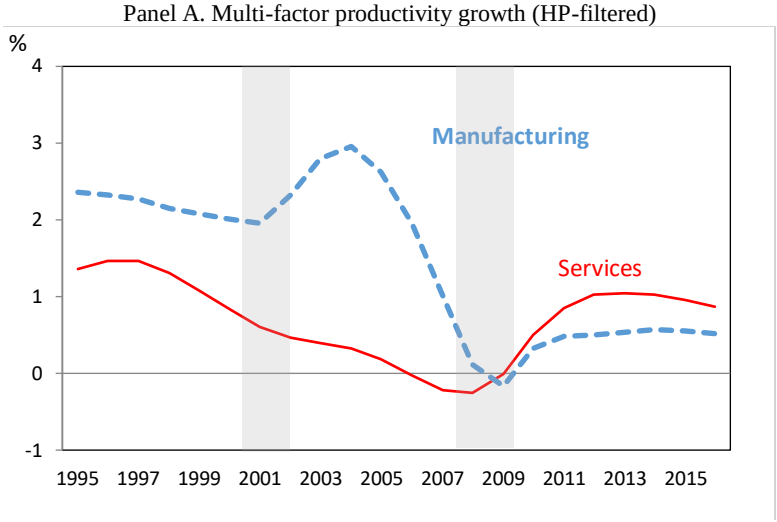
2.2. Descriptive evidence on GVCs, productivity and innovation

18. Figure 1 illustrates the evolution of GVCs, productivity and innovation from the mid-90's up until the latest available years (2014 or 2016, depending on the variables). Panel A shows that MFP growth had been slowing down already before the global financial crisis, but suffered a further setback since then, from which it did not recover yet, especially in the manufacturing sector. A more detailed analysis reveals that the post-crisis manufacturing slowdown was more pronounced in the United States, whereas services slowed down to a similar extent across the two sides of the Atlantic (Sorbe, Gal and Millot, 2018[3]). At the same time, GVC integration expanded significantly from the mid-1990s until the crisis. In the post-crisis period, GVC participation flattened off and remained around the pre-crisis peak. The main summary statistics from our combined database are contained in Table A.2.

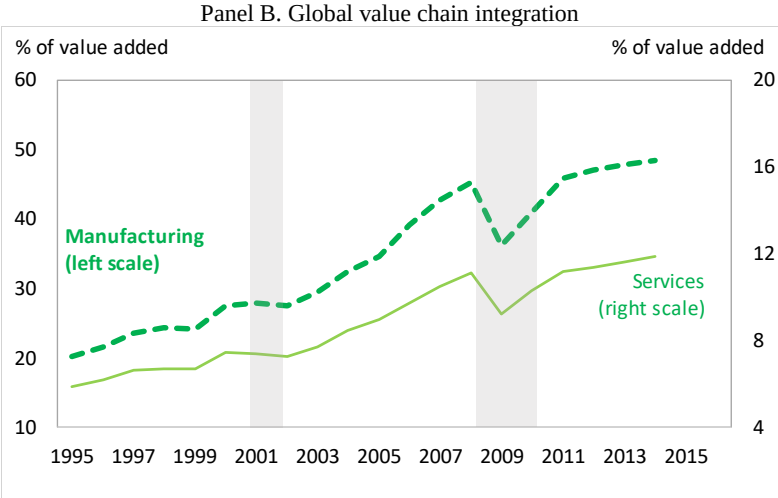
19. An interesting aspect of GVCs which is exploited in the paper is their sectoral characteristics. Table 1 examines this from various angles and reveals that manufacturing is much more integrated than services: for the median country, it has a total GVC participation at 76% of industry value added, while for services the comparable figure is only about 20%. Beyond these large differences in overall intensities, there is a strong distinction along the backward and forward dimension between the two sectors. In particular, manufacturing is much more integrated backwards, that is, it relies on relatively more intermediate imports (57%) than the amount that it supplies to other sectors and countries for further processing (22%). This is the opposite for services activities, where it is the degree of forward participation which is much higher (15%) than backward participation (6.5%). This can be explained by services' traditional role in GVCs as being suppliers of key inputs to manufacturing by providing transport-, accounting-, consulting and further business services. Figure 2 illustrates this pattern for a subset of industries in our sample. The manufacturing sectors (motor vehicles, electronic products and textiles) average much higher levels of backward relative to forward GVC participation, in contrast to services sectors (transport and R&D) or those that produce commodities (mining).

Figure 1. Productivity, value chain integration and innovation

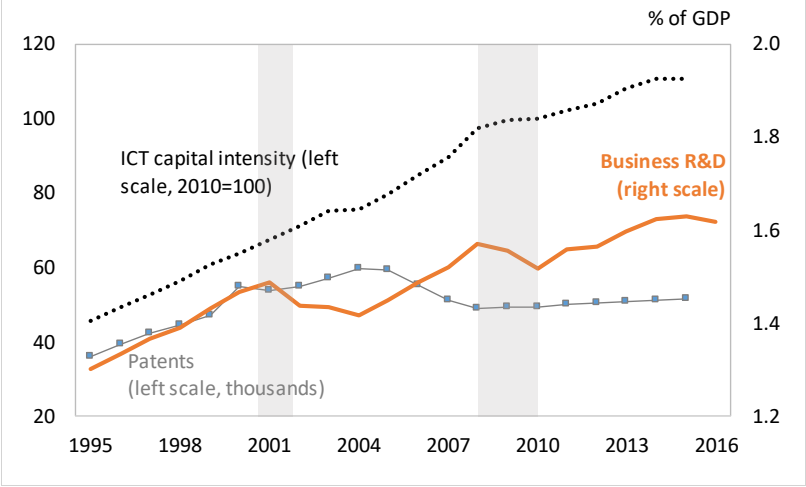
Panel A. Multi-factor productivity growth (HP-filtered)



Panel B. Global value chain integration



Panel C. Innovation measures



Source: OECD STructural ANalysis (STAN) database; OECD Trade in Value-Added (TiVA) database; OECD TiVA Nowcast; Main Science and Technology Indicators; EU KLEMS (Jäger, 2017[33]) and authors' calculations.

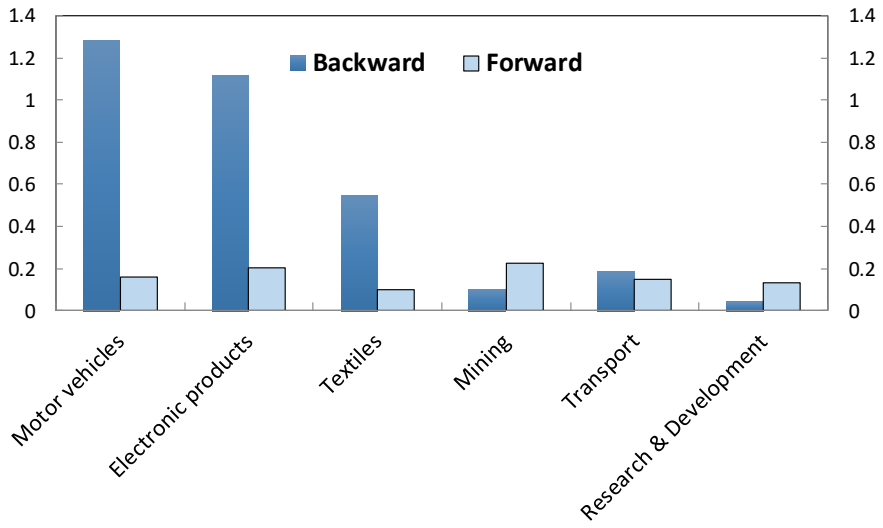
Table 1. Large differences in backward and forward integration across major sectors

	GVC Participation						
	Total	*Backward*			*Forward*		
		All countries	High prod.	Less prod.	All countries	High prod.	Less prod.
Whole economy	35.98	20.06	12.82	6.45	16.40	8.89	5.85
Manufacturing	76.41	57.14	36.59	18.55	21.72	12.90	8.11
Services	19.90	6.46	3.63	2.37	14.83	8.73	5.19

Note: For 2014. All GVC participation measures are expressed as % of industry value added, using the median values across countries. High productivity trading partners are the EU-15 plus AUS, CAN, JPN, CHE, NOR, NZL, USA. Less productive trading partners are all other countries.
Source: OECD Trade in Value-Added (TiVA) database and authors' calculations.

Figure 2. GVC integration by industries: a few examples

GVC trade flows as a ratio to value added



Note: Average GVC participation indicators across countries and over our sample period.
Source: OECD Trade in Value-Added (TiVA) database.

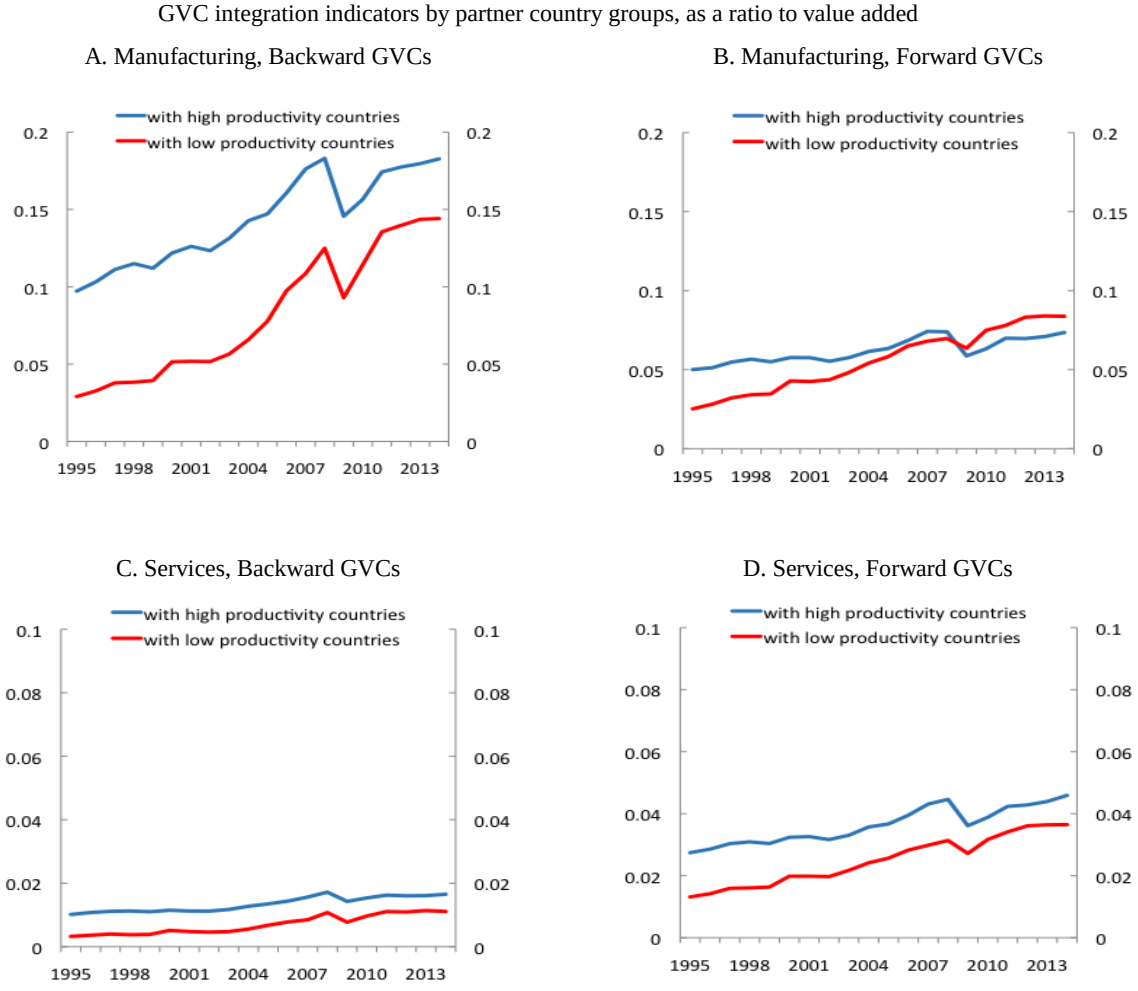
20. Another key dimension of the TiVA data that we exploit is the partner country where intermediates are sourced from or supplied to in GVCs. Being connected to more productive destinations or suppliers could bring more productivity benefits through learning, knowledge spillovers embedded in services and products and by being exposed to more demanding technical requirements. When grouped into roughly equal sized high- and low productivity groups (corresponding to more and less advanced countries; see Section 2.1 and the note below Table 1), we find that GVC integration with high productivity countries is deeper than with low productivity countries. This is true for backward and forward integration alike, in manufacturing as well as in services.

21. There were, however, changes over time in the composition of GVCs: low-productivity countries – who also tend to have low wages – have become increasingly integrated into global supply chains since the mid-1990s, more so than high-productivity – and high wage – countries (Figure 2). This is especially true for manufacturing, both

regarding backward links (Panel A) and forward links (Panel B). Services have substantially lower GVC participation, with important increases in particular for forward links (Panels C and D). Looking at individual countries, most of them present a general pattern of rising integration looking at a long period between 1995 and 2014, especially in the forward direction (Figure 3). There are also important cross-country differences remaining in the more recent period: for example, large economies with significant internal markets, such as the United States, are characterised by lower GVC integration, whereas smaller European economies generally have the largest share of foreign value added in their own exports. Still, within the natural limits determined by geographic constraints, these large differences indicate more scope for further integration. However, when looking at the global picture (Figure 2 and see OECD (2018[38]) for 2015-16), there are signs of plateauing in each of the GVC measures, and further integration is at risk given rising protectionism in the global economy.

Figure 3. Countries with lower productivity have been contributing more to GVC expansion

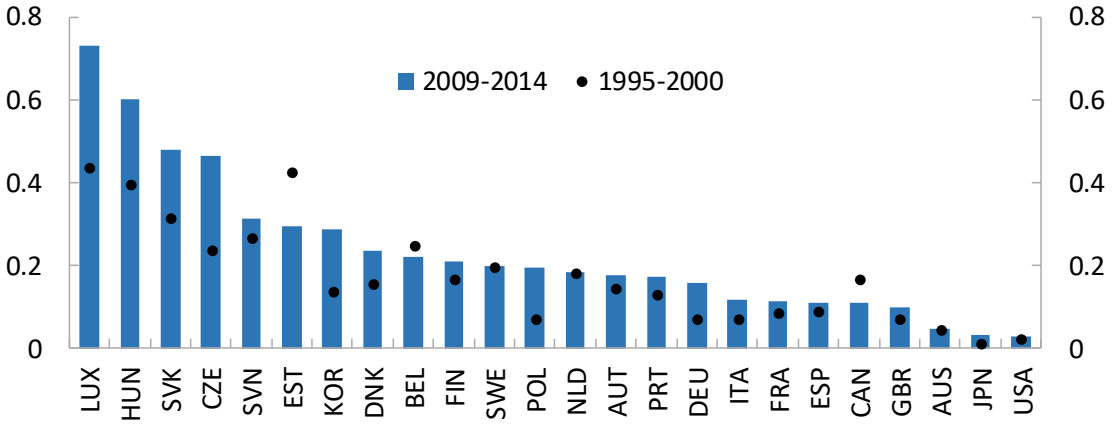
GVC integration indicators by partner country groups, as a ratio to value added



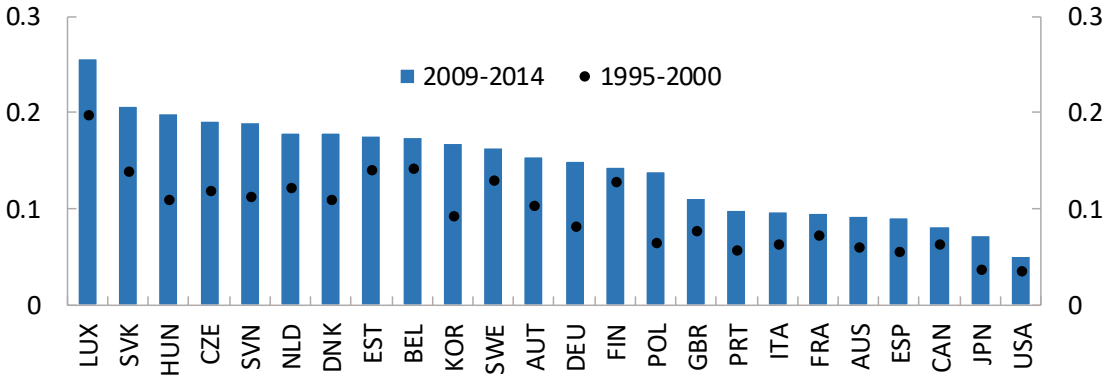
Note: "High-productivity countries" are the more developed segment of our sample, defined as those countries that are part of the EU-15 (EU members prior to 2004) plus Australia, Canada, Japan, New Zealand, Norway, Switzerland and the United States; "Low-productivity countries" are all other countries in the TiVA database. Unweighted average across all country-industry cells where data are available.
Source: OECD Trade in Value-Added (TiVA) database and authors' calculations.

Figure 4. GVC integration differs significantly by country

A. Backward GVC participation, as a ratio to value added



B. Forward GVC participation, as a ratio to value added



Note: Weighted averages by value added across industries.
Source: OECD Trade in Value-Added (TiVA) database and authors' calculations.

3. Econometric framework

22. To explore the link between productivity and GVC integration, we estimate the following long difference specification:

$$\Delta Y_{cst} = \beta_1 GVC_{cs,t-5} + \sum_j \gamma_j X^j_{cs,t-5} + \delta_{ct} + \delta_{st} + \varepsilon_{cst} \quad (1)$$

where: Δ denotes the long difference operator, corresponding to five years in the baseline specification; Y_{cst} denotes the log of multi-factor productivity (MFP) in the baseline estimation and log business R&D spending or ICT capital intensity when exploring the innovation channel; and $GVC_{c,s,t}$ denote the GVC Total, Backward or Forward Participation indicator. We also include control variables (contained in the vector $X^j_{c,s,t}$) such as ICT intensity and product and labour market regulations. We rely on five-year long differences (e.g. 2014-2009, 2013-2008, etc.) in MFP to reduce the influence of short-term

fluctuations since we are interested in the medium-term trends in productivity. Given that we Clustered robust standard errors at the country-industry pair level, using overlapping periods is innocuous (Bloom, Draca and Van Reenen, 2016[25]).

23. The baseline model includes interacted country-year fixed effects (δ_{ct}) to control for omitted time-varying country-specific shocks (e.g. macroeconomic shocks, exchange rate fluctuations, macroeconomic and structural policy changes) and industry-year fixed effects (δ_{st}) to control for time-varying global industry factors (e.g. general technological or market structure changes). This choice of fixed effects structure implies that we are identifying from industry level variation in GVC participation once we have purged the data of time-varying aggregate shocks.

24. Our main parameter of interest is β_1 and we expect it to be positive and significant, implying that stronger GVC integration, conditional on the set of controls and fixed effects, is associated with faster productivity growth or higher investments in innovation over the medium term (defined here as over 5 years). The rich set of fixed effects and the fact that we relate lagged GVC participation to subsequent medium term productivity growth reduces the risk of endogeneity stemming from reverse causality (that GVC integration is enabled by stronger productivity, i.e. a form of "self-selection"). This concern is even less relevant in the case of backward participation (importing intermediates), which is our main baseline result. However, there could still be unobserved common factors driving GVC integration and medium-term MFP growth. To mitigate their potential impact, we also include variables that control for innovation activity (R&D spending and ICT capital intensity) and public policies (regulations of product and labour markets), and we carry out a number of further robustness checks.[13]

4. Empirical results

4.1. Baseline results for the total market sector

25. Table 2 shows the baseline estimates for the five-year long difference specification ((1) for industry level MFP growth and lagged GVC participation intensity. Regardless of the fixed effects structure – which becomes more burdensome from column 1 to columns 2 and 3 – medium-term MFP growth is positively related to the degree of lagged GVC integration and the coefficient is statistically significant at the 1% level. Including backward and forward GVC participation as separate variables (column 3) also reveals that the dominant channel is backward participation – the amount of imported intermediates that enter exports, pointing to the importance of potentially cheaper, better quality or larger variety of imports in affecting productivity growth.

[13] In particular, we also include country-sector interacted fixed effects; we difference GVC integration; we include the lagged dependent variable (lagged MFP) among the explanatory variables to control for potential mean-reversion effects, as in an error correction model (ECM).

Table 2. Integration to GVCs and MFP growth

Baseline results, dependent variable: log MFP differenced over 5 years

GVC participation (5 year lagged)	(1)	(2)	(3)
Total	0.0872***	0.0995***	
	(0.0183)	(0.0188)	
Backward			0.105***
			(0.0213)
Forward			0.0601
			(0.130)
Controls			
Observations	6,306	6,306	6,254
Adj. R-squared	0.289	0.326	0.334
country, ind., year FE	YES	YES	YES
country X year FE	YES	YES	YES
ind. X year FE	NO	YES	YES

Note: Clustered robust standard errors (at the country-industry level) in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. The time period is 1995-2016.

26. This positive relationship is robust to a number of variations in the sample, the productivity measure, the econometric specification and the set of control variables in the regressions.

- First, we use alternative specifications that rely on purely within country-sector identification. This helps mitigate endogeneity issues and allows for a more causal interpretation, which is GVC integration causing higher productivity growth (Table 3). Note also that our main finding is related to backward GVC participation (imports of intermediates) where it is less obvious to find a mechanism that could lead to reverse causality as in the case of exporting.

Table 3. Integration to GVCs and MFP growth: alternative specifications

Dependent variable: log MFP differenced over 5 years

GVC participation (5 year lagged)	(1)	(2)	(3)
Backward	0.0816*	0.0889***	0.0380*
	(0.0421)	(0.0332)	(0.0218)
Forward	0.0374	0.378***	0.176
	(0.217)	(0.143)	(0.133)
Controls			Lagged MFP
Observations	6,237	5,806	6,155
Adj. R-squared	0.572	0.325	0.456
GVCs included in	levels	changes	levels
country, ind., year FE	YES	YES	YES
country X year FE	YES	YES	YES
ind. X year FE	YES	YES	YES
country X ind. FE	YES	NO	NO

Note: Clustered robust standard errors (at the country-industry level) in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. The first column contains fully saturated fixed effects, i.e. adding country-industry interacted ones to the baseline set of fixed effects. In the second column, GVC participation is measured in first differenced form in t-5, to provide an alternative strategy for eliminating country-industry specific differences in GVC participation levels. The third column includes lagged MFP as a control and uses the baseline fixed effects specification, to allow for catching-up effects in MFP and also controls for potential mean reversion in MFP. The time period is in principle 1995-2016. See more details in the text.

- Second, we control for within-country industry-level variation in product market regulations (more precisely, their impact on downstream sectors using the output of regulated sectors, in the spirit of Bourlès et al., (2013[17]), employment protection legislation (interacted with sectoral exposure based on layoff rates, following Bassanini, Nunziata and Venn (2009[36])), the ICT capital share and business R&D spending to address the concern that our baseline estimates are simply picking up omitted reforms of regulations, the role of innovation activity or technology adoption, which could positively affect both productivity and GVC integration (Table 4).
- Third, we use labour productivity as our dependent variable, a simpler but cruder measure of productivity than MFP, which does not rely on the assumptions behind building capital stock estimates and the production function (Table B.1 in Annex B).
- Fourth, for our explanatory variable of interest, we use the log-level instead of the level of GVC indicators, in this way allowing for a non-linear effect on productivity (Table B.2). More specifically, it allows us to see whether results are robust to assuming that the productivity impacts of an absolute percentage point increase diminish at higher levels of GVC integration, a sort of "decreasing returns" to GVC integration. We find support for this: the estimated coefficients of GVC integration remain positive and significant.
- Finally, we re-estimate the model on pre-crisis data only to control for the impact of large shocks and confirm the relationship between productivity and GVCs, which is found to be even stronger than on the whole period (Table B.3). This result

indicates that it is not primarily the crisis period that drives identification, which alleviates concerns about a demand-driven spurious correlation between productivity and GVCs.

Table 4. Integration to GVCs and MFP growth: robustness to including controls

Dependent variable: log MFP differenced over 5 years

GVC participation (5 year lagged)	(1)	(2)	(3)	(4)	(5)
Backward	0.175***	0.111***	0.0922***	0.119***	0.327***
	(0.0489)	(0.0307)	(0.0245)	(0.0400)	(0.110)
Forward	-0.179	0.117	0.240	0.217	-0.682
	(0.252)	(0.175)	(0.148)	(0.201)	(1.059)
Controls	ICT	R&D	PMR, EPL	PMR, EPL, R&D	ICT, R&D, PMR, EPL
Observations	1,730	2,679	4,674	1,928	572
Adj. R-squared	0.317	0.291	0.365	0.310	0.319
country, ind., year FE	YES	YES	YES	YES	YES
country X year FE	YES	YES	YES	YES	YES
ind. X year FE	YES	YES	YES	YES	YES

Note: Clustered robust standard errors (at the country-industry level) in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. . Business R&D spending is measured in logs, and ICT capital intensity is the ratio of ICT capital services to total capital services. PMR and EPL measures use sectoral exposures either through input-output links or natural layoff rates (see details in Section 2.1).The time period is in principle 1995-2016.

4.2. The dominant channels are very different across sectors

27. One of the key advantages of using industry level data is that it allows us to better explore the mechanisms and heterogeneous effects across different activities. Testing our baseline specification by the group of manufacturing and services industries reveals some intuitive differences (Table 5). In manufacturing, it is the backward participation channel that yields significant positive coefficient estimates. This result is in line with existing results from the – mostly microeconomic – literature that explains it by broader, cheaper or better quality input choices that are available through foreign suppliers in GVCs rather than relying only on domestic ones (Bas and Strauss-Kahn, 2015[10]; Halpern, Koren and Szeidl, 2015[11]; Goldberg et al., 2010[12]). On the other hand, services activities show quite different mechanisms: it is the forward participation channel (selling intermediates to exporters) that is found to be significant. This is consistent with the important role of services as suppliers to other sectors that sell abroad (Bourlès et al., 2013[35]), and that they tend to import less themselves (see Table 1 and Figure 2).

Table 5. Integration to GVCs and MFP growth: differences across sectors

Dependent variable: log MFP differenced over 5 years

GVC participation	Manufacturing		Services	
(5 year lagged)	(1)	(2)	(3)	(4)
Backward	0.0844***	0.0844***	0.104	0.0833
	(0.0223)	(0.0231)	(0.0990)	(0.103)
Forward	0.145	0.192	0.724**	0.698**
	(0.149)	(0.159)	(0.300)	(0.293)
Observations	3,614	3,614	1,480	1,480
Adj. R-squared	0.316	0.341	0.290	0.314
country, ind., year FE	YES	YES	YES	YES
country X year FE	YES	YES	YES	YES
ind. X year FE	NO	YES	NO	YES

Note: Clustered robust standard errors (at the country-industry level) in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. The time period is in principle 1995-2016. See more details in the text.

28. Splitting GVC integration by partner country groups reveals that the beneficial productivity effects arise from being connected to high-productivity countries (Table 6). In both manufacturing and services, backward GVC linkages are significant when they connect with highly productive suppliers, meaning purchasing intermediates from productive sources. The role of partner countries are similar for forward linkages: these are productivity enhancing only when they supply to productive destinations. However, this relationship is significant only for services.[14]

[14] Note that we find a negative coefficient estimate for backward integration with low productivity countries in services, but there is very little actual trade along that margin (2.4% of value added, the lowest among all the GVC indicators in Table 1). This can make these results more sensitive to measurement error or idiosyncratic changes, hence one should not over-interpret them.

Table 6. Integration to GVCs and MFP growth: trading partners matter

Dependent variable: log MFP differenced over 5 years

GVC participation (5-year lagged)	Manufacturing (1)	(2)	Services (3)	(4)
Backward				
from **highly productive** countries	0.180*** (0.0498)	0.188*** (0.0544)	0.741*** (0.199)	0.718*** (0.201)
from **less productive** countries	-0.160 (0.145)	-0.173 (0.163)	-1.380** (0.562)	-1.418** (0.597)
Forward				
to **highly productive** countries	0.120 (0.181)	0.103 (0.183)	0.980** (0.421)	0.942** (0.462)
to **less productive** countries	0.216 (0.386)	0.471 (0.438)	0.473 (1.095)	0.477 (1.062)
Observations	3,556	3,556	1,480	1,480
Adj. R-squared	0.316	0.347	0.309	0.334
country, ind., year FE	YES	YES	YES	YES
country X year FE	YES	YES	YES	YES
ind. X year FE	NO	YES	NO	YES

Note: Clustered robust standard errors (at the country-industry level) in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. The time period is in principle 1995-2016. High productivity trading partners are the EU-15 plus AUS, CAN, JPN, CHE, NOR, NZL, USA. See more details in the text.

29. To investigate how innovation intensity is affected by GVCs, Table 7 shows regression results where the dependent variable (MFP growth) is replaced by two different measures for innovation: spending on R&D or ICT capital intensity (in long-differences, similarly as for MFP). The estimation results indicate that when participating in GVCs, there is a significant increase in innovation efforts. This relationship is driven primarily by forward participation in manufacturing industries, in particular through supplying to more productive destinations. This could suggest that the requirements to meet the standards of technologically advanced buyers lead firms to implement quality upgrades, consistent with previous findings in the literature on the role of quality improvements while exporting (De Loecker, 2013[21]). Quality improvements and the important role of high quality inputs in productivity could also explain why we find that the productivity benefits (Table 5) show up at those industries that use inputs (backward participation) rather than at those who supply those inputs to others (forward participation).[15] Taken together, these findings are consistent with the idea that importing high-quality inputs – which may embody the suppliers' R&D – serves as a substitute for doing R&D in-house.

[15] Indeed, innovation efforts could have positive payoffs that can be more thought of as quality upgrades rather than increases in traditional productivity measures – a conjecture that outside the scope of our current analysis but could be explored in future work. The concept of "GVC productivity" – recently introduced by Timmer (2017[37]) – could also be useful in this respect since it takes into account all inputs along the entirety of the value chain and relates their use to the final outputs.

Table 7. A positive link between forward GVCs with productive countries and innovation

Dependent variable: Business R&D and ICT capital intensity, differenced over 5 years

	Business R&D spending			ICT capital intensity	
	All sectors	Manufacturing		Manufacturing	
GVC participation					
Backward	-0.0202	-0.00331		-0.198	
	(0.0709)	(0.0693)		(0.131)	
from **highly productive** countries			-0.0955		-0.269
			(0.129)		(0.242)
from **less productive** countries			0.286		-0.0391
			(0.409)		(0.480)
Forward	0.774**	0.763**		1.780***	
	(0.356)	(0.378)		(0.609)	
to **highly productive** countries			1.081*		2.443***
			(0.587)		(0.779)
to **less productive** countries			0.504		-0.268
			(0.826)		(1.866)
Observations	4,413	3,283	3,188	774	771
R-squared	0.349	0.370	0.371	0.491	0.501
country, industry, year FE	YES	YES	YES	YES	YES
country X year FE	YES	YES	YES	YES	YES
industry X year FE	YES	YES	YES	YES	YES

Note: Clustered robust standard errors (at the country-industry level) in parentheses. Business R&D spending is measured in logs, and ICT capital intensity is the ratio of ICT capital services to total capital services. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. High productivity trading partners are the EU-15 plus AUS, CAN, JPN, CHE, NOR, NZL, USA. The time period is in principle 1995-2014. See more details in the text.

4.3. Assessing economic significance

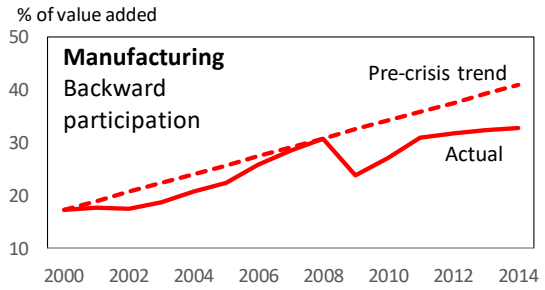
30. To illustrate the economic significance of the relationship between productivity and GVCs, we carry out two types of thought experiments: first, a time-series experiment, assessing the counterfactual gains from a continued expansion of GVCs after the crisis; second, capturing cross-sectional differences in GVC integration across particular countries.

31. First, Figure 5 Panels A and B visualise the actual path and the hypothetical trend of deepening GVC integration for manufacturing and services, respectively. Panels C and D multiply the shortfall with the estimated coefficients of Table 5. This shows the actual MFP increase of 2.5% in manufacturing over the five years following the crisis (2009-2014), is estimated to have been 3.2% if GVCs continued at their pre-crisis trend. As for services, the actual MFP growth was 4.5% over the same period, instead of 5.7% in the case of continued GVC expansion. These calculations imply that a significant portion (about 40% for manufacturing and about 20% for services) of the weak post-crisis productivity growth could be attributed to falling GVC integration. Considering that GVCs have not recovered

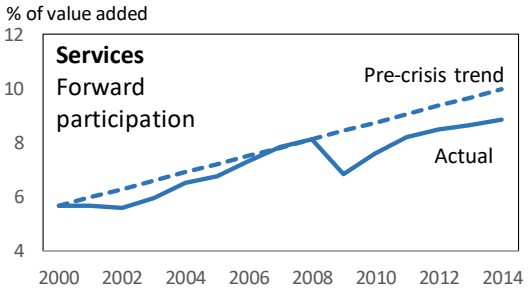
to their pre-crisis trend, and that more recent aggregate GVC numbers even indicate a plateauing, there is a continued lost potential in terms of subpar MFP growth, in particular in the more tradable segment of the economy. These links between MFP and GVCs highlight the important costs of restrictive trade policy for potential productivity growth.

Figure 5. Quantifying the gains on MFP from stronger post-crisis GVC integration

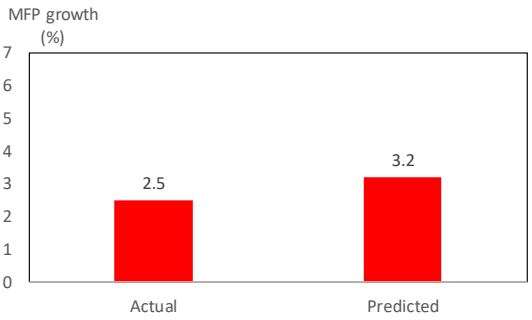
Panel A. GVC participation trends in manufacturing



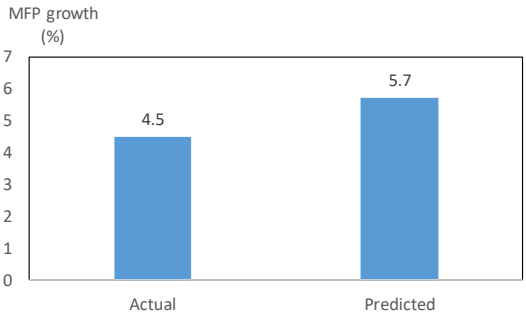
Panel B. GVC participation trends in services



Panel C. Actual and counterfactual MFP growth in manufacturing, cumulated between 2009 and 2014



Panel D. Actual and counterfactual MFP growth in services, cumulated between 2009 and 2014

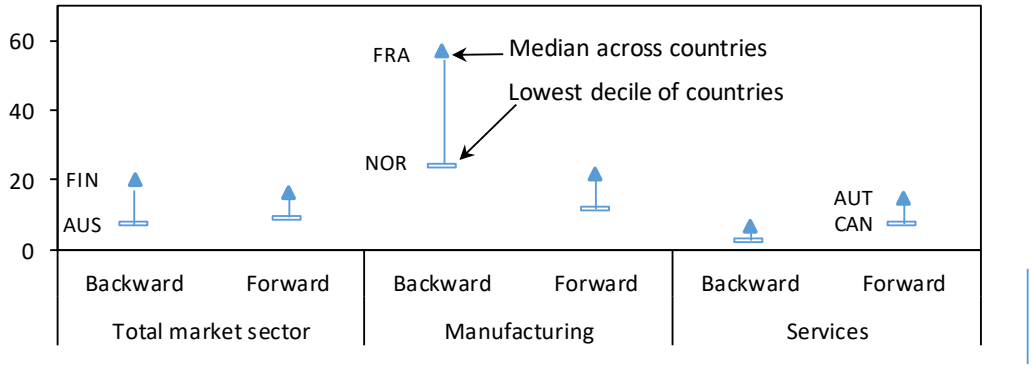


Note: Panels A and B fit a linear trend on the pre-crisis period that is shown on the figures (2000-2007) and prolong it for the post-crisis period. Panels C and D use the difference between the actual and the hypothetical paths, multiplied by the estimated coefficients from Table 5 (columns 2 and 4).
Source: Calculations using the estimation results in Table 5, the OECD TiVA database and the OECD STAN database.

32. Our second type of thought experiment involves cross-sectional comparisons, and shows the productivity growth gains associated with having GVC integration at "low" vs at "typical" levels: i.e. comparing the bottom 10% of countries to the median GVC intensity across countries for the sake of illustrations (Figure 6). For the total market sector and backward integration – the channel that has a significant productivity benefit –, this represents comparing Australia (around 7% of value added) to Finland (20%); for manufacturing, this means comparing Norway (24%) to France (almost 60%); while for services, this corresponds to a comparison of Canada (7%) with Austria (15%) in terms of forward participation (the relevant channel for productivity according to our results).

Figure 6. Comparing "low" and "typical" GVC intensities

Increasing GVC integration: illustrative scenarios

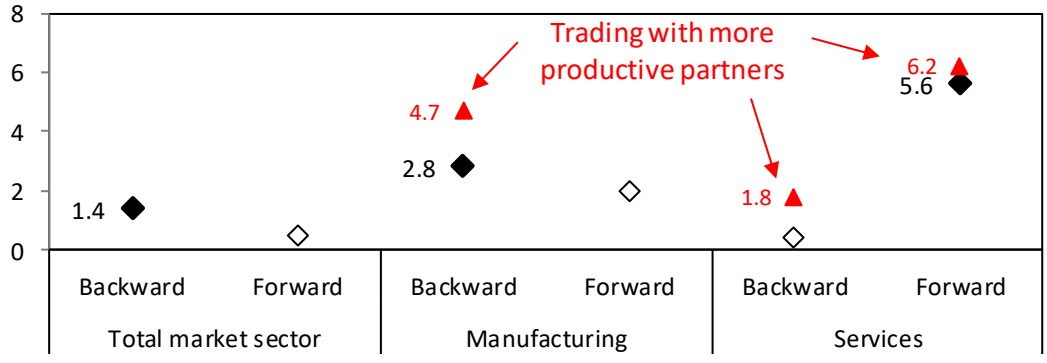


Note: Typical GVC intensity is captured by the median value across countries, separately for the total market sector, manufacturing and services. Low GVC intensity is captured by the bottom 10% value across countries.
Source: Calculations using the OECD Trade in Value-Added (TiVA) database.

33. Then these differences are multiplied by the corresponding estimated coefficients from Table 2 (column 3), Table 5 (columns 2 and 4) and Table 6 (columns 2 and 4) to obtain the implied positive gains for productivity from deepening GVC integration. Figure 7 illustrates the results: over 5-years, the increase in total market sector MFP is 1.4% that is linked to higher backward participation. In manufacturing it is twice as big, 2.8%, and it is even larger, 4.7%, when the additional GVC integration occurs only with highly productive suppliers. The forward participation channel is significant only for services and its expansion is associated with a 5.6% MFP increase (6.2% with highly productive partners). Given a mean value of 3.7% 5-year MFP growth (Table A.2), these increases are substantial and economically significant – although the associated hypothetical differences in the degree of GVC integration are large and not easily actionable by policy measures.

Figure 7. Quantifying the MFP gains from higher GVC integration

Estimated MFP gains from increasing GVC integration from "low" to "typical" levels (over 5 years, in %)



Note: Typical GVC intensity is the median across countries, separately for the total market sector, manufacturing and services. Filled marks indicate significant values, unfilled ones are not significant.
Source: Calculations using the estimation results in Table 2 (column 3), Table 5 (columns 2 and 4), Table 6 (columns 2 and 4) and the thought experiments of moving from "low" (bottom 10%) to "typical" (median) GVC intensity across countries (see Figure 6).

5. Conclusion and future research

34. This paper has explored the relationship between global value chain integration and productivity growth at the detailed sectoral level, highlighting several channels and mechanisms. Using a rich cross-country industry level database, it finds substantial economic gains from GVC integration, with important differences across sectors and the types of integration. In particular, importing intermediate inputs – backward integration – was found to be productivity enhancing in manufacturing sectors, in line with results from the literature on the importance of the quality, variety and the cost of inputs in production for productivity. On the other hand, supplying to other countries and sectors that export – forward participation – is primarily beneficial for services activities, consistent with their traditional role of being more "upstream" (i.e. suppliers) in the value chain. The productivity level of partner countries matters too: it is the connections with more technologically advanced industries and countries that bring stronger economic gains, which finding is in line with theoretical and empirical work that emphasise knowledge spillovers in production chains and learning from trading partners.

35. The paper has carried out a large number of robustness tests to mitigate endogeneity concerns. Still, future work could go further by constructing global supply- and demand driven instruments, or looking at major trade liberalisation episodes to strengthen the causal interpretation of the results. Further analysis on the innovation channel of GVCs can also be undertaken, possibly relying on alternative productivity measures based on the totality of inputs throughout the whole value chain. Finally, a better understanding of the role of goods and services in value chains should ideally move beyond the standard industrial classification and take into account the increasingly blurred boundary between services and manufacturing activities within individual sectors.

References

Adalet McGowan, M. et al. (2015), *The Future of Productivity*, OECD, Paris, https://www.oecd.org/eco/OECD-2015-The-future-of-productivity-book.pdf. [1]

Aghion, P. et al. (2018), "The Impact of Exports on Innovation: Theory and Evidence", *NBER Working Papers*, No. 24600, National Bureau of Economic Research, http://dx.doi.org/10.2139/ssrn.3171084. [47]

Akcigit, U., S. Ates and G. Impullitti (2018), "Innovation and Trade Policy in a Globalized World", *SSRN*, http://dx.doi.org/10.17016/IFDP.2018.1230. [28]

Alfaro, L. et al. (2018), "Internalizing Global Value Chains: A Firm-Level Analysis", *Journal of Political Economy*, http://dx.doi.org/10.1086/700935. [13]

Alfaro, L. and M. Chen (2018), "Selection and market reallocation: Productivity gains from multinational production", *American Economic Journal: Economic Policy*, http://dx.doi.org/10.1257/pol.20150437. [30]

Andrews, D. and F. Cingano (2014), "Public policy and resource allocation: evidence from firms in OECD countries", *Economic Policy*, Vol. 29, pp. 253-296. [36]

Andrews, D., P. Gal and W. Witheridge (2018), "A genie in a bottle? Globalisation, competition and inflation", *OECD Economics Department Working Papers*, No. 1462, OECD. [50]

Autor, D., D. Dorn and G. Hanson (2016), "The China Shock: Learning from Labor-Market Adjustment to Large Changes in Trade", *SSRN*, http://dx.doi.org/10.1146/annurev-economics-080315-015041. [49]

Baldwin, J. and W. Gu (2004), "Trade liberalization: Export-market participation, productivity growth, and innovation", *Oxford Review of Economic Policy*, http://dx.doi.org/10.1093/oxrep/grh022. [24]

Baldwin, R. (2013), "The Great Trade Collapse : Causes, Consequences and Prospects", *VoxEU Report*, http://dx.doi.org/10.1146/annurev-economics-082912-110201. [9]

Bas, M. and V. Strauss-Kahn (2015), "Input-trade liberalization, export prices and quality upgrading", *Journal of International Economics*, http://dx.doi.org/10.1016/j.jinteco.2014.12.005. [14]

Bassanini, A., L. Nunziata and D. Venn (2009), "Job protection legislation and productivity growth in OECD countries", *Economic Policy*, Vol. 24/58, pp. 349–402, https://academic.oup.com/economicpolicy/article-abstract/24/58/349/2926026. [37]

Bernard, A., S. Redding and P. Schott (2007), "Comparative advantage and heterogeneous firms", *Review of Economic Studies*, http://dx.doi.org/10.1111/j.1467-937X.2007.00413.x. [20]

Bloom, N., M. Draca and J. Van Reenen (2016), "Trade Induced Technical Change? The Impact of Chinese Imports on Innovation, IT and Productivity", *The Review of Economic Studies*, Vol. 83/1, pp. 87-117, http://dx.doi.org/10.1093/restud/rdv039. [26]

Bloom, N., R. Sadun and J. Van Reenen (2012), *Americans do IT better: US multinationals and the productivity miracle*, http://dx.doi.org/10.1257/aer.102.1.167. [51]

Bourlès, R. et al. (2013), "Do product market regulations in upstream sectors curb productivity growth? Panel data evidence for OECD countries", *The Review of Economics and Statistics*, Vol. 95/5, pp. 1750–1768, http://dx.doi.org/10.1162/REST_a_00338. [40]

Bourlès, R. et al. (2013), "Do Product Market Regulations In Upstream Sectors Curb Productivity Growth? Panel Data Evidence For Oecd Countries", *Review of Economics and Statistics*, http://dx.doi.org/10.1162/REST_a_00338. [17]

Bown, C. (2018), "Trade Policy Toward Supply Chains After the Great Recession", *IMF Economic Review*, http://dx.doi.org/10.1057/s41308-018-0061-9. [12]

Byrne, D., J. Fernald and M. Reinsdorf (2016), "Does the United States Have a Productivity Slowdown or a Measurement Problem", *SSRN*, http://dx.doi.org/10.17016/FEDS.2016.017. [4]

Cette, G., J. Fernald and B. Mojon (2016), "The pre-Great Recession slowdown in productivity", *European Economic Review*, http://dx.doi.org/10.1016/j.euroecorev.2016.03.012. [2]

Chen, N., J. Imbs and A. Scott (2009), "The dynamics of trade and competition", *Journal of International Economics*, http://dx.doi.org/10.1016/j.jinteco.2008.10.003. [48]

Coe, D. and E. Helpman (1995), "International R&D spillovers", *European Economic Review*, http://dx.doi.org/10.1016/0014-2921(94)00100-E. [25]

Coelli, F., A. Moxnes and K. Ulltveit-Moe (2018), *Better, Faster, Stronger: Global Innovation and Trade Liberalization*. [22]

Crafts, N. (2018), "The productivity slowdown: Is it the 'new normal'?", *Oxford Review of Economic Policy*, http://dx.doi.org/10.1093/oxrep/gry001. [3]

Criscuolo, C. and J. Timmis (2018), "The Changing Structure of Global Value Chains: Are Central Hubs Key for Productivity?", *International Productivity Monitor*. [46]

Criscuolo, C. and J. Timmis (2017), "The Relationship Between Global Value Chains and Productivity", *International Productivity Monitor*. [23]

De Backer, K., T. Destefano and L. Moussiegt (2017), "The links between global value chains and global innovation networks", *OECD Science, Technology and Innovation Policy Papers*, No. 37, OECD, https://www.oecd-ilibrary.org/docserver/76d78fbb-en.pdf?expires=1556387906&id=id&accname=ocid84004878&checksum=4AD405A6B641B13AA79159E27B48A845. [27]

De Loecker, J. (2013), "Detecting learning by exporting", *American Economic Journal: Microeconomics*, http://dx.doi.org/10.1257/mic.5.3.1. [21]

Égert, B. (2016), "Regulation, Institutions, and Productivity: New Macroeconomic Evidence from OECD Countries", *American Economic Review*, Vol. 106/5, pp. 109-113, http://dx.doi.org/10.1257/aer.p20161026. [31]

Égert, B. and I. Wanner (2016), "Regulations in services sectors and their impact on downstream industries: The OECD 2013 Regimpact Indicator", *OECD Economics Department Working* [38]

Papers, No. 1303, OECD Publishing, Paris, https://dx.doi.org/10.1787/5jlwz7kz39q8-en.

Fraumeni, B. (1997), *The Measurement of Depreciation in the U.S. National Income and Product Accounts*, Survey of Current Business, Government Printing Office. [53]

Goldberg, P. et al. (2010), "Imported intermediate inputs and domestic product growth: Evidence from India", *Quarterly Journal of Economics*, http://dx.doi.org/10.1162/qjec.2010.125.4.1727. [16]

Halpern, L., M. Koren and A. Szeidl (2015), "Imported inputs and productivity", *American Economic Review*, Vol. 105/12, http://dx.doi.org/10.1257/aer.20150443. [15]

Haugh, D. et al. (2016), *Cardiac Arrest or Dizzy Spell: Why is World Trade So Weak and What can Policy Do About It? With contributions from*, OECD Economic Policy Paper No. 18. [11]

Hoekman, B. (2015), *The Global Trade Slowdown: A New Normal?*, Centre for Economic Policy Research, https://voxeu.org/content/global-trade-slowdown-new-normal. [10]

Hummels, D., J. Ishii and K. Yi (2001), "The nature and growth of vertical specialization in world trade", *Journal of International Economics*, Vol. 54/1, pp. 75-96, https://econpapers.repec.org/article/eeeinecon/v_3a54_3ay_3a2001_3ai_3a1_3ap_3a75-96.htm (accessed on 30 April 2019). [7]

Ignatenko, A., F. Raei and B. Mircheva (2019), "Global Value Chains: What are the Benefits and Why Do Countries Participate?", *IMF Working Paper*, No. WP/19/18, International Monetary Fund. [32]

Jäger, K. (2017), "EU KLEMS Growth and Productivity Accounts. 2017 Release, Statistical Module. Description of methodology and country notes for Germany", *The Conference Board*. [35]

Johnson, R. and G. Noguera (2017), "A Portrait of Trade in Value Added over Four Decades", http://dx.doi.org/10.1162/REST_a_00665. [43]

Johnson, R. and G. Noguera (2012), "Proximity and Production Fragmentation", *American Economic Review*, Vol. 102/3, pp. 407-411, http://dx.doi.org/10.1257/aer.102.3.407. [8]

Johnson, R. and G. Noguera (n.d.), "Proximity and Production Fragmentation", http://dx.doi.org/10.1257/aer.102.3.407. [44]

Jorgenson, D. and M. Timmer (2011), "Structural Change in Advanced Nations: A New Set of Stylised Facts", *Scandinavian Journal of Economics*, Vol. 113/1, pp. 1-29, http://dx.doi.org/10.1111/j.1467-9442.2010.01637.x. [42]

Kasahara, H. and J. Rodrigue (2008), "Does the use of imported intermediates increase productivity? Plant-level evidence", *Journal of Development Economics*, http://dx.doi.org/10.1016/j.jdeveco.2007.12.008. [29]

Melitz, M. (2003), "The impact of trade on intra-industry reallocations and aggregate industry productivity", *Econometrica*, http://dx.doi.org/10.1111/1468-0262.00467. [18]

Melitz, M. and G. Ottaviano (2008), "Market size, trade, and productivity", *Review of Economic Studies*, http://dx.doi.org/10.1111/j.1467-937X.2007.00463.x. [19]

Nickell, S. (1981), "Biases in Dynamic Models with Fixed Effects", *Econometrica*, Vol. 49/6, [41]

p. 1417, http://dx.doi.org/10.2307/1911408.

OECD (2018), *The changing nature of international production: Insights from Trade in Value Added and related indicators*, https://www.oecd.org/industry/ind/tiva-2018-flyer.pdf (accessed on 26 September 2019). [39]

Saia, A., D. Andrews and S. Albrizio (2015), "Productivity Spillovers from the Global Frontier and Public Policy: Industry-Level Evidence", *OECD Economics Department Working Papers*, No. 1238, OECD, https://www.oecd-ilibrary.org/economics/spillovers-from-the-global-productivity-frontier-and-public-policy_5js03hkvxhmr-en (accessed on 27 April 2019). [33]

Schwellnus, C. et al. (2018), "Labour share developments over the past two decades The role of technological progress, globalisation and "winner-takes-most" dynamics", *OECD Economics Department Working Papers*, No. 1503, OECD, Paris, https://www.oecd-ilibrary.org/economics/labour-share-developments-over-the-past-two-decades_3eb9f9ed-en (accessed on 26 September 2019). [55]

Shin, H. (2019), *What is behind the recent slowdown?*, https://www.bis.org/speeches/sp190514.htm. [54]

Sorbe, S., P. Gal and V. Millot (2018), "Can productivity still grow in services based economies? A literature overview and preliminary evidence from OECD countries", *Economics Department Working Papers*, No. forthcoming, OECD. [6]

Syverson, C. (2016), "Challenges To Mismeasurement Explanations for the U.S. Productivity Slowdown", *Journal of Chemical Information and Modeling*, Vol. 53/9, http://dx.doi.org/10.1017/CBO9781107415324.004. [5]

Timmer, M. (2017), "Productivity Measurement in Global Value Chains", *International Productivity Monitor*, Vol. 33, pp. 182-193, https://econpapers.repec.org/article/slsipmsls/v_3a33_3ay_3a2017_3a9.htm (accessed on 29 April 2019). [52]

Wang, Z. et al. (2017), "Measures of Participation in Global Value Chains and Global Business Cycles", *NBER Working Papers*, No. 23222, National Bureau of Economic Research, http://dx.doi.org/10.3386/w23222. [34]

Westmore, B. (2014), "Policy incentives for private innovation and maximising the returns", *OECD Journal: Economic Studies*, Vol. 2013/1, https://dx.doi.org/10.1787/eco_studies-2013-5k3trmjlhxzq. [45]

Annex A. Further data details

36. We confronted two main hurdles when constructing our combined analytical database, which came at considerable computational cost. First, in order to exploit the timeliest indicators of GVCs, we appended the TiVA Nowcast database (covering 2012-2014) to the industry-level GVC indicators that span 1995-2011 in the historical TiVA database. Second, we needed to address the industry classification mismatch between the TiVA data – which is measured with international classification system ISIC Rev.3 at the 2-digit level – and the 2017 release of the STAN database, which conforms to the ISIC Rev.4 classification. To this end, STAN data were converted to the equivalent ISIC Rev.3 industries using the generic concordance presented in Table A.1 in order to ensure alignment with the TiVA data.[16]

[16.] Where multiple 2-digit industries in ISIC Rev.4 are combined in this process of conversion to ISIC Rev.3, aggregated production in volume terms or the price indices are calculated by applying the real growth rate for individual industries based on their time-varying nominal weights.

Table A.1. ISIC Rev.4 to ISIC Rev.3 industry concordance table

Industry	ISIC Rev.3	ISIC Rev.4
Mining and quarrying	10t14	05t09
Food products, beverages and tobacco	15t16	10t12
Textiles, textile products, leather and footwear	17t19	13t15
Wood and products of wood and cork	20	16
Pulp, paper, paper products, printing and publishing	21t22	17, 18, 58
Chemicals and chemical products	24	20t21
Rubber and plastics products	25	22
Other non-metallic mineral products	26	23
Basic metals	27	24
Fabricated metal products except machinery and equipment	28	25
Machinery and equipment n.e.c	29	28
Computer, electronic and optical products	30, 32, 33	26
Electrical machinery and apparatus n.e.c	31	27
Motor vehicles, trailers and semi-trailers	34	29
Other transport equipment	35	30
Manufacturing n.e.c; recycling	36t37	31t33
Electricity, gas and water supply	40t41	35, 36
Construction	45	41t43
Wholesale and retail trade; repairs	50t52	45t47, 95
Hotels and restaurants	55	55t56
Transport and storage	60t63	49, 50, 51, 52, 79
Post and telecommunications	64	53, 61
Renting of machinery and equipment	71	77
Computer and related activities	72	62t63
Research and development; Other Business Activities	73t74	69t75, 78, 80t82
Public admin. and defense; compulsory social security	75	84
Education	80	85
Other community, social and personal services	90t93	37t39, 59t60, 90t93, 94, 96

Source: OECD.

37. The TiVA Nowcast data use a slightly different process to the TiVA database. Rather than using a new inter-country input-output (ICIO) table as for a regular TiVA update, the Nowcast projections are based on the latest 2011 OECD ICIO table and use more recent national input-output industry tables, national accounts and bilateral trade data (OECD, 2017). Importantly, the Nowcast annual projections are made in volumes terms (to account for differential price movements and changes in exchange rates) which are then iteratively reflated and balanced using official volume and current price activity and trade data to ensure comparability. However, given the underlying ICIO tables are not fully updated, we

cannot rule out that there may have been greater shifts in structure of the international production process which are not fully reflected in the TiVA Nowcast data.

Table A.2. Descriptive statistics

	$MFP_{c,i,t}$	$\Delta^5 MFP_{c,i,t}$	$GVC_{c,i,t}$ Total	$GVC_{c,i,t}$ Backward	$GVC_{c,i,t}$ Forward
Mean	2.034	0.037	0.475	0.337	0.138
Median	2.167	0.024	0.274	0.142	0.117
P10	1.067	-0.180	0.052	0.012	0.015
P90	2.738	0.273	1.134	0.874	0.277
St. dev.	0.704	0.190	0.579	0.512	0.112
N	9315	6688	9475	9475	9475

Source: OECD TiVA and OECD STAN.

Annex B. Further results

Table B.1. Integration to GVCs and productivity growth

Robustness test: Labour productivity growth as dependent variable (5 year differencing)

GVC participation (5 year lagged)	(1)	(2)	(3)
Total	0.0800**	0.0864**	
	(0.0362)	(0.0394)	
Backward			0.0629*
			(0.0328)
Forward			0.238
			(0.152)
Observations	7,881	7,881	7,791
Adj. R-squared	0.310	0.326	0.336
country, ind., year FE	YES	YES	YES
country X year FE	YES	YES	YES
ind. X year FE	NO	YES	YES

Note: Clustered robust standard errors (at the country-industry level) in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. The time period is in principle 1995-2014. See more details in the text.

Table B.2. Integration to GVCs and MFP growth

Robustness test: Assuming lower gains of integration from already high levels

GVC participation (5 year lagged)	(1)	(2)
Total	0.0410***	
	(0.0122)	
Backward		0.0230**
		(0.0102)
Forward		-0.00588
		(0.0216)
Observations	6,298	5,850
Adj. R-squared	0.315	0.324
GVCs included in	logs	logs
country, ind., year FE	YES	YES
country X year FE	YES	YES
ind. X year FE	YES	YES

Note: Clustered robust standard errors (at the country-industry level) in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. GVC participation is measured in logs to allow for a smaller impact of the same absolute rise in the GVC to value added ratios. The time period is in principle 1995-2014. See more details in the text.

Table B.3. Integration to GVCs and MFP growth

Robustness test: Pre-crisis period

GVC participation (5 year lagged)	(1)	(2)	(3)
Total	0.180***	0.181***	
	(0.0397)	(0.0406)	
Backward			0.214***
			(0.0445)
Forward			-0.121
			(0.205)
Observations	1,731	1,731	1,736
Adj. R-squared	0.295	0.276	0.274
country, ind., year FE	YES	YES	YES
country X year FE	YES	YES	YES
ind. X year FE	NO	YES	YES

Note: Clustered robust standard errors (at the country-industry level) in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. The time period is in principle 1995-2007. See more details in the text.

OECD PRODUCTIVITY WORKING PAPERS

OECD Productivity Working Papers are published on oe.cd/GFP

05. *The Best versus the Rest: The Global Productivity Slowdown, Divergence across Firms and the Role of Public Policy*
(November 2016) by Dan Andrews, Chiara Criscuolo and Peter N. Gal

06. *What makes cities more productive? Agglomeration economies and the role of urban governance: Evidence from 5 OECD countries*
(February 2017) by Rudiger Ahrend, Emily Farchy, Ioannis Kaplanis and Alexander C. Lembcke

07. *Pro-Productivity Institutions: Learning From National Experience*
(April 2017) by Andrea Renda and Sean Dougherty

08. *The impact of structural reforms on productivity: The role of the distance to the technological frontier*
(May 2017) by Gustavo Monteiro, Ana Fountoura Gouveia and Sílvia Santos

09. *Product markets' deregulation: A more productive, more efficient and more resilient economy?*
(September 2017) by Gustavo Monteiro, Ana Fountoura Gouveia and Sílvia Santos

10. *Achieving New Zealand's productivity potential*
(October 2017) by Paul Conway

11. *The Contribution of Multinational Enterprises to Labor Productivity: The Case of Israel*
(February 2018) by Tatiana Slobodnitsky, Lev Drucker and Assaf Geva

12. *GVCs and centrality: mapping key hubs, spokes and the periphery*
(February 2018) by Chiara Criscuolo and Jonathan Timmis

13. Fear the walking dead: zombie firms, spillovers and exit barriers
(June 2018) by Ana Fontoura Gouveia and Christian Osterhold

14. *GVC centrality and productivity: Are hubs key to firm performance?*
(June 2018) by Chiara Criscuolo and Jonathan Timmis

15. *Patterns of firm level productivity in Ireland*
(September 2018) by Javier Papa, Luke Rehill and Brendan O'Connor

16. *Productivity spillovers from multinational activity to local firms in Ireland*
(November 2018) Mattia Di Ubaldo, Martina Lawless and Iulia Siedschlag

17. *Unconventional monetary policy and productivity*
(January 2019) Silvia Albrizio, Marina Conesa, Dennis Dlugosch and Christina Timiliotis

18. *Industry concentration in Europe and North America*
(January 2019) Matej Bajgar, Giuseppe Berlingieri, Sara Calligaris, Chiara Criscuolo and Jonathan Timmis

BETTER POLICIES FOR BETTER LIVES