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Global Value Chains and Trade in Value-Added: An Initial Assessment of the Impact on Jobs and Productivity

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Abstract

Global Value Chains and Trade in Value-Added: An Initial Assessment of the Impact on Jobs and Productivity

This paper contributes to a better understanding of the impact of global value chains (GVCs) on jobs and productivity by providing new evidence on employment embodied in value-added trade flows. Linking jobs data to the Trade in Value-Added (TiVA) indicators first highlights that a large share of employment in OECD and key partner countries relies on consumption taking place abroad and for most countries this share has increased between 1995 and 2011. There are differences across industries in the share of jobs embodied in exports but in all industries a majority of these jobs originates in the service sector. In almost all countries, the jobs embodied in exports are shifting towards high-skill and medium-skill occupations. Within GVCs, there is also a shift from employment in core manufacturing activities to employment in service support functions such as R&D, distribution, logistics, marketing, sales and customer services. The impact of GVCs on the number of people engaged in each industry is the combination of several factors but related to specialisation patterns and the evolution of productivity. In this assessment, it is important to look at the whole value chain and not to focus only on industries where GVCs are prevalent. Job creation in sectors less exposed to GVCs is the consequence of productivity gains in sectors the most integrated in GVCs.

Keywords: Global value chains, employment, trade, trade in value-added, business functions, trade in tasks, occupations, productivity.

JEL Codes: F16, F23, J24.

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Table of Contents

Tables

Figures

Executive Summary

This report contributes to a better understanding of the impact of global value chains (GVCs) on jobs and productivity by providing new evidence based on employment data collected within the Trade in Value Added (TiVA) project. Linking jobs data to TiVA indicators first highlights that a large share of employment in OECD and key partner countries relies on consumption taking place abroad and for most countries this share has increased between 1995 and 2011. If for a large country like the United States, 10% of the workforce is involved in production for foreign final consumption, the share goes up to 20% for France, 29% for Germany and 47% for a small open economy like Ireland.

Based on a value-added approach, the calculation includes both the employees of exporting firms and the workers of all the domestic firms providing inputs to exporters. In the People's Republic of China (hereafter "China"), there are more workers 'indirectly' involved in exports (i.e. working in the supplying industries) than in the exporting industries. These figures are however still underestimating the number of persons involved in global value chains as activities of foreign-owned firms producing for domestic consumers are not taken into account.

There are important differences across industries in the share of jobs embodied in exports. Services industries, for example, are generally less export-oriented. In addition, depending on the role of labour as an input in each industry, the same value-added exported can have a lower or higher job content in each industry. But when looking at the industry of origin of jobs embodied in exports, the actual contribution of the service sector is revealed. In the Netherlands or the United Kingdom, more than 70% of jobs embodied in exports originate in the service sector. The figure is close to 70% in France and in the United States.

The jobs embodied in exports are either dependent on imports from the country's partners in the region (e.g. Mexico within NAFTA) or spread more evenly across partners in different regions (e.g. China or the United States). It depends on the position and specialisation of the country in the value chain. The jobs embodied in exports follow the general pattern of trade flows in value-added terms.

In almost all countries, the jobs embodied in exports are shifting towards high-skill and medium-skill jobs. There is also a similar pattern in terms of business functions, with fewer jobs in the core operations of firms (the manufacturing, processing and assembling activities) and more jobs in R&D, design, distribution, logistics, marketing, sales and customer services. The famous 'smile curve' is empirically verified when looking at the change in employment by business function. There are however different patterns of specialisation when it comes to other support business functions such as IT services, administrative support, engineering and related technical services.

The impact of GVCs on the number of people engaged in each industry is the combination of several factors. As a consequence of the fragmentation of production, there is a specialisation of countries and a reallocation of workers not specifically across industries but in different activities in the value chain that can belong to different industries depending on the way firms are organised. In addition, GVCs have an impact on productivity and while some jobs are lost as a consequence of the offshoring of some activities, others are created, either within the same industry (which has become more productive and increased its output) or in other industries (through an income effect). The overall impact of GVCs on employment depends on the relative strength of these factors and there is no simple relationship between the participation in GVCs and the level of employment at the industry level. What

matters at the end is whether income and (total factor) productivity have increased in the whole economy. More evidence is needed on this.

Several reports have already dealt with the relationship between trade and jobs, in particular in the context of the ICITE initiative. There is a consensus that trade can play an important role in creating better jobs, increasing wages and improving working conditions. However, the benefits from trade do not accrue automatically. These reports have also emphasised the complexity of the issues involved and the fact that complementary policies are needed to reap the full benefits on employment and growth.

Against this backdrop and acknowledging the fact that trade policy is only one policy among others that are needed to achieve employment and growth, the preliminary findings suggest that:

- The number of jobs depending on international trade has never been so high. There is a serious threat for employment to be considered for countries introducing new protectionist measures.

- The importance of trade policy for employment is different across countries, based on their openness and the number of jobs used in production for foreign final demand. However, it should be kept in mind that the estimates provided are not (yet) capturing the full scope of activities involving GVCs and that what happens for a relatively small number of jobs in the industries participating in GVCs can have a big impact on the rest of the economy.

- What is missing in the debate on employment and globalisation is to look at the full range of business activities within GVCs. The assessment of the impact of GVCs on jobs cannot be completed if one focuses on the jobs that have disappeared in one segment of the value chain without looking at the jobs created upstream or downstream.

- While in almost all countries, more jobs are in R&D, design, distribution, marketing & sales and customer services, differences are observed across countries for other horizontal support business functions such as IT services, administrative support, engineering and related technical services. These business functions are the ones where some countries have specialised, while others are relying more on offshore services.

- All the above mentioned support business functions are basically services, stressing once again the importance of service reforms and trade policy in the area of services.

- In addition, the assessment of the impact of GVCs on employment is still partial if the productivity gains from GVCs are not taken into account and one does not link job creation in sectors less exposed to GVCs to productivity gains in sectors the most integrated in GVCs.

- There is evidence in the literature that participation in GVCs can increase the productivity of firms. The main channel for productivity growth is a finer division of labour. But there is no overall correlation between the average participation in GVCs and productivity growth at the country level. As trade increases productivity through the gains from specialisation, it is expected that some countries specialise in activities where the fragmentation of production is less prevalent (such as service industries) and they can still improve their productivity and their income.

The objective of this report is to contribute to a better understanding of the impact of GVCs and trade in value added on jobs and productivity. Efforts are on-going at the OECD to collect more information on jobs and skills in the context of the Trade in Value Added (TiVA) project.[1] This report provides an initial assessment based on the first evidence gathered at the country and industry level on the impact of the internationalisation of production on the number of jobs and the composition of tasks, as well as on productivity.

The jobs indicators calculated in this report are based on the 2015 TiVA update that was released in October 2015. Annex A provides more information on their derivation, as well as on the additional data sources used for occupations. The collection of these data is still ongoing and this report covers only the countries for which the data are already available. With respect to productivity, there are also important data limitations at the industry level and more efforts will have to be devoted to develop such data. Annex B gives an overview of the evidence that is currently available.

As an initial assessment, the report is structured around simple questions on GVCs, jobs and productivity and indicates what we can say at this stage and what needs further investigation. Some preliminary conclusions are added in the last section.

How many people work in GVCs?

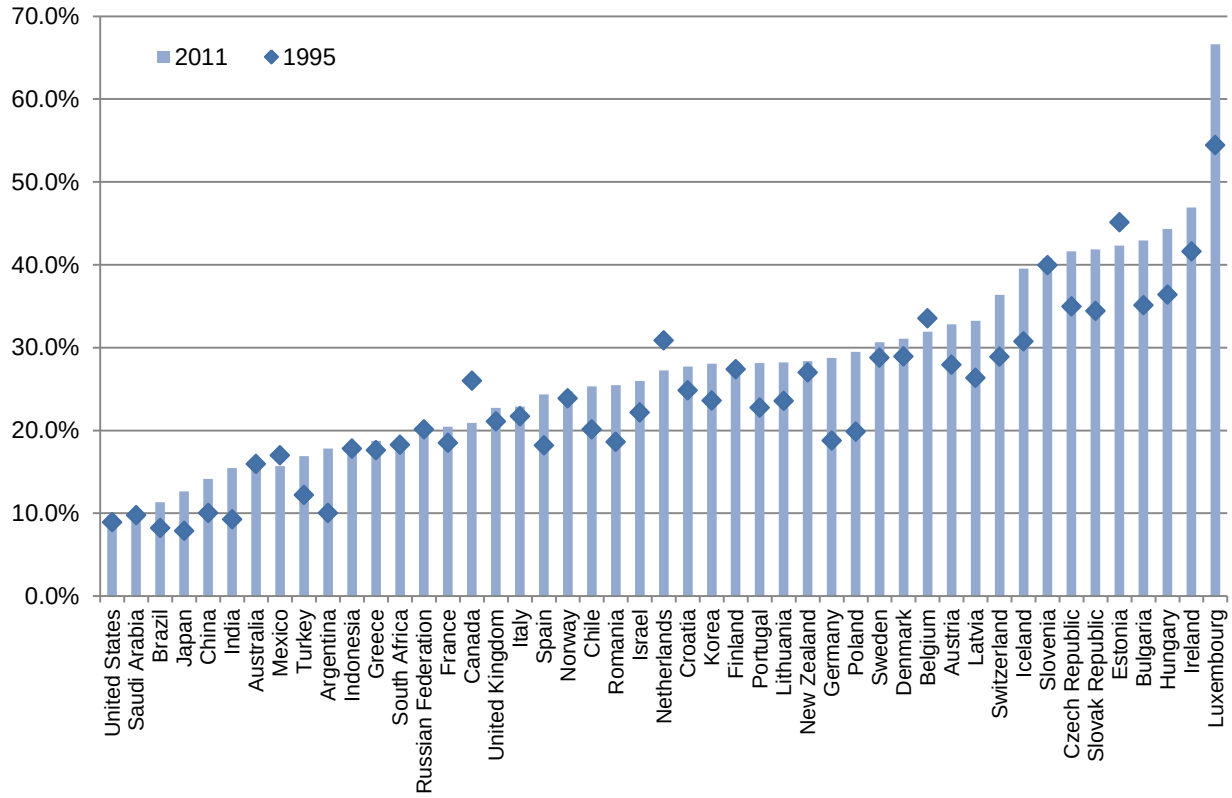
What we describe as "global value chains" is the process through which final goods and services are produced with resources and factors of production coming from a variety of countries and not just the domestic economy. Almost all products include at some level a share of foreign value-added, but this share is more or less significant depending on the industry and the organisation of firms within this industry. A first indicator that can be used to assess the number of jobs relying on GVCs is the share of jobs in each country sustained by foreign final demand. This measure looks at the domestic value-added consumed abroad and the number of embodied jobs (see Annex A for the methodology). There is domestic value added contributing to consumption abroad either when a domestic final good (or service) is exported and consumed in the importing economy or when domestic inputs are used by third countries and embodied in their exports.

Figure 1 highlights that a large share of employment in OECD and key partner countries relies on consumption abroad and for most countries this share has increased between 1995 and 2011. The importance of trade for employment is however influenced by the size of countries, as well as the type of activity they specialise in. The share of jobs sustained by foreign final demand is lower for the United States or Brazil but very high for Ireland or Luxembourg. It should be however noted that a relatively low share in the United States (9.7%) still accounts for a significant number of jobs, about 14 million (Table 1).[2]

1. The report relies on the OECD Trade in Employment indicators, a set of data collected by the Economic Analysis and Statistics division of the Directorate for Science, Technology and Innovation that were made consistent with TiVA. New evidence on jobs, skills and patterns of trade in value-added can also be found in STI Scoreboard 2015 (OECD, 2015).

2. All these figures are estimates as they are derived from employment data that are not always fully comparable with the value added measured in the OECD ICIO and the same labour productivity is assumed among firms producing for foreign and domestic consumers. The objective is to give an estimate of the magnitude of the phenomenon and not an accurate measure.

Figure 1. Share of domestic employment used in production for foreign final demand, 2011

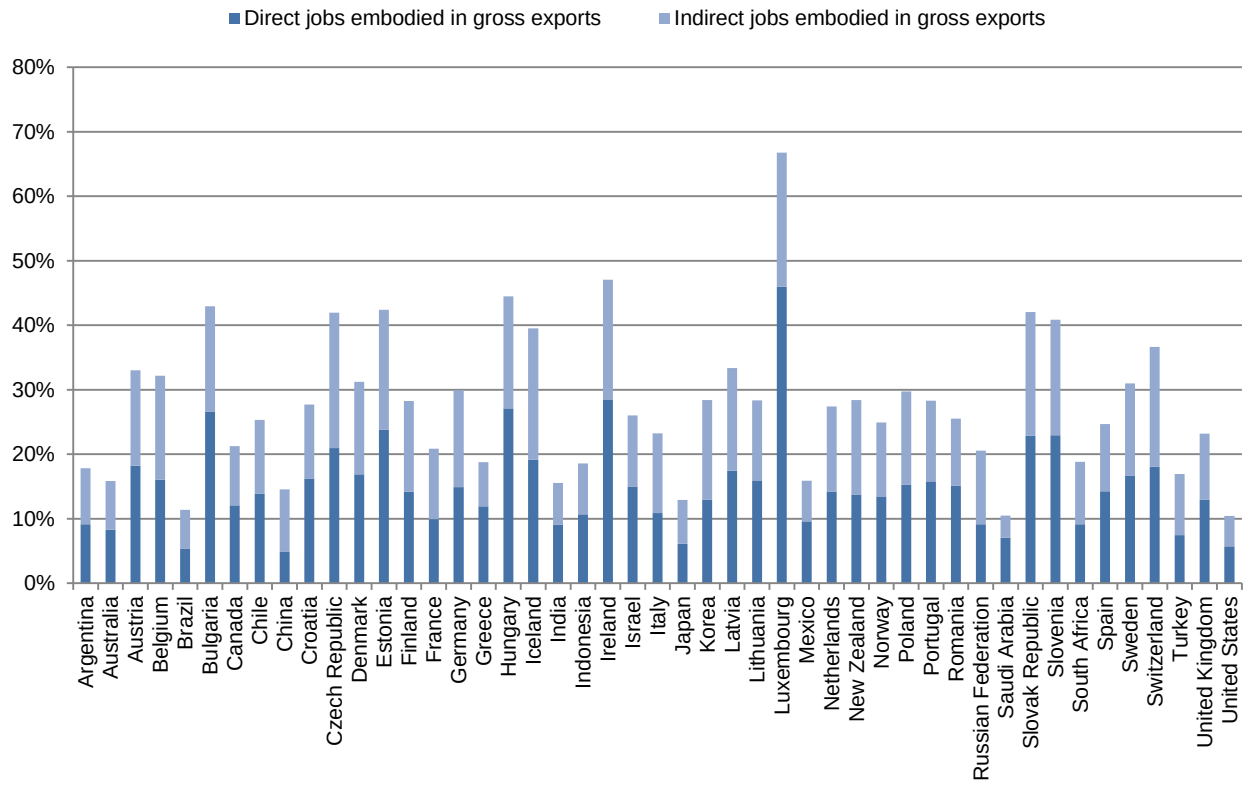


Source: OECD Trade in Employment indicators.

The economies where jobs sustained by foreign final demand have increased the most between 1995 and 2011 are found in the European Union. The share has increased by more than 8 percentage points in Luxembourg, Poland but also Germany. There are a few countries where the share has decreased. For example, a significant reduction in the number of jobs sustained by foreign final demand is observed in Canada, the Netherlands and Estonia. It does not mean that there is an issue with employment in these economies. Producing more for domestic consumers is often associated with an increase in domestic income. Figure 1 does not provide any information on the relative performance of countries, but rather some implications in terms of how important trade policy is for employment. By definition, trade policy matters more for small open economies when it comes to the impact on jobs.

However, with a value-added measure of trade, we can learn more about the contribution of trade to domestic employment. The people working in GVCs are either directly involved in the production of exports or employed by companies that provide inputs to domestic exporters. Figure 2 shows the share of jobs embodied in gross exports and distinguishes between these two categories of GVC workers. This figure illustrates how useful TiVA statistics are to understand the real contribution of domestic employment to exports. In all countries, the share of employment involved in export activities is significantly higher when taking into account the "indirect" jobs. Some countries, such as China, even have more trade-related jobs in the industries supplying inputs to export industries than in the exporting industries themselves. It confirms that the gains from trade trickle down to other industries less exposed to international trade.

Figure 2. Jobs embodied in gross exports (as a share of domestic employment), 2011



Source: Author's calculation based on the OECD ICIO and OECD Trade in Employment indicators.

The estimates from Figure 1 would be slightly higher by focusing on the business sector, as it was done in STI Scoreboard (OECD, 2015).[3] The average percentages include industries that are part of what is regarded as the "non-tradable" sector. There are still workers involved in export activities in this sector, in particular because of the "indirect" contribution that is captured in value-added measures. But by definition, the share of employment used in gross exports is lower in industries where products are non-tradable. The overall estimates from Figure 1 are therefore lower than what is expected in the business sector.

Moreover, the evidence in Table 1 is limited to cross-border trade and does not include all the people who work for foreign-owned companies in the domestic economy. When foreign affiliates export, their value added is regarded as 'domestic' and the embodied jobs are captured in the above indicators. But some affiliates are established in order to supply the domestic economy (horizontal FDI). Workers of foreign-owned firms also contribute to global value chains and should be taken into account if one wants to estimate the overall number of GVC jobs. In the future, with the development of data linking activities of multinational enterprises (AMNE statistics), FDI and TiVA statistics, it should be possible to provide estimates on the number of jobs involved in investment-related activities of firms.

3. Agriculture is excluded from STI Scoreboard estimates because employment is more difficult to measure in this sector (due to the presence of seasonal workers and farm workers having also a manufacturing job). In addition, employment in public administration, education, health and other social services is not taken into account. In this report, we keep all sectors to estimate an overall share.

Table 1. Number of domestic jobs used in production for foreign final demand, million, 2011

Country	1995	2011	Country	1995	2011
Argentina	1.2	3.1	Japan	5.3	8.1
Australia	1.3	1.8	Korea	4.8	6.8
Austria	1.0	1.4	Latvia	0.3	0.3
Belgium	1.3	1.5	Lithuania	0.3	0.4
Brazil	5.7	11.3	Luxembourg	0.1	0.2
Bulgaria	1.2	1.5	Mexico	5.5	7.4
Canada	3.5	3.7	Netherlands	2.2	2.4
Chile	1.0	1.8	New Zealand	0.4	0.6
China	68.2	108.2	Norway	0.5	0.6
Croatia	0.4	0.4	Poland	2.8	4.6
Czech Republic	1.8	2.1	Portugal	1.0	1.3
Denmark	0.8	0.9	Romania	2.2	2.3
Estonia	0.3	0.2	Russian Federation	12.5	14.4
Finland	0.6	0.7	Saudi Arabia	0.5	1.0
France	4.4	5.5	Slovak Republic	0.7	0.9
Germany	7.1	12.0	Slovenia	0.4	0.4
Greece	0.7	0.8	South Africa	2.0	2.5
Hungary	1.5	1.8	Spain	2.5	4.7
Iceland	0.0	0.1	Sweden	1.2	1.4
India	35.2	72.0	Switzerland	1.2	1.7
Indonesia	15.0	20.4	Turkey	2.6	4.1
Ireland	0.5	0.9	United Kingdom	5.4	6.7
Israel	0.5	0.9	United States	11.4	13.9
Italy	4.8	5.7			

Source: Trade in Employment indicators.

What are the industries where jobs are the most dependent on GVCs?

There are important differences across industries in the share of GVC jobs (Figure 3). One reason is that the fragmentation of production is more or less pronounced across sectors. For example, services industries have generally a lower foreign content. In addition, depending on the role of labour as an input in each industry, the same value-added exported can have a lower or higher job content in each industry. This can be understood by looking at the average ratio of employment per unit of value added in each industry (Figure 4). The most labour intensive industries are agriculture, hotels & restaurants and textiles and apparel. On the other hand, utilities, financial services and mining are capital-intensive and fewer jobs are embodied in exports of value-added for such industries.

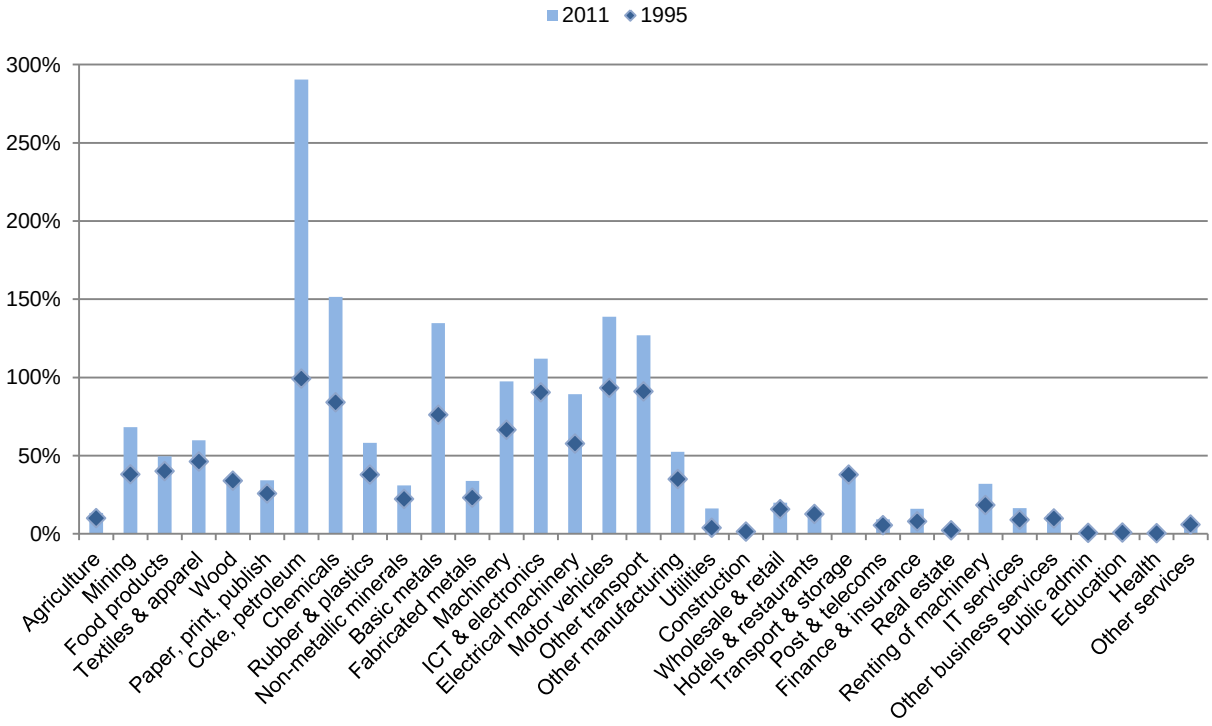
Because value-added trade flows include the value-added by other industries supplying inputs to the exporting industry, some percentages in Figure 3 are above 100%. In the case of coke and petroleum but also chemicals, basic metals, motor vehicles and other transport equipment, many jobs are found upstream in the supplying industries (including many services inputs). Therefore there are more jobs embodied in exports than the total employment in these industries. The opposite is observed in the case of services. A very small share of employment for example is found embodied in exports of business services, but business services are inputs used in the production of exports of manufacturing goods and these service jobs contribute to the high percentages observed in transport equipment or chemicals on Figure 3.

What one can also see in Figure 3 is the important increase in the number of jobs embodied in gross exports for some industries. In the case of coke and petroleum, the employment to value-added ratios

are affected by the fluctuations in prices and one limitation in the input-output analysis is the difficulty to account for price changes. But leaving aside this specific case, many industries show an upward trend in the jobs embodied in exports, which is a very interesting stylised fact about the relationship between GVCs and jobs.

When industries offshore the sourcing of inputs and when this offshoring leads to productivity gains, less jobs are expected. The intuition is often (from the point of view of developed economies) that the fragmentation of production is about losing jobs. But Figure 3 illustrates that what is happening is that industries that are particularly involved in GVCs, such as electronics or transport equipment, are industries where the number of jobs embodied in gross exports has increased between 1995 and 2011.

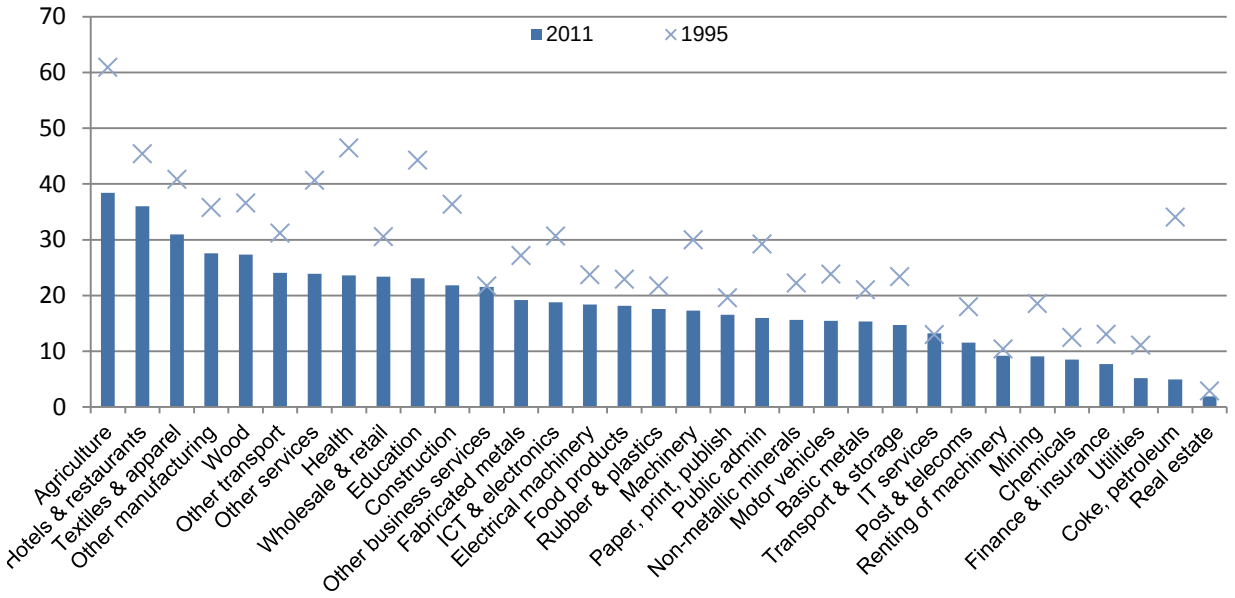
Figure 3. Jobs embodied in gross exports as a percentage of domestic industry employment, average among OECD countries, 2011 and 1995



Source: Author's calculation based on the OECD ICIO and OECD Trade in Employment indicators.

From Figure 4, it is clear that labour productivity (in levels) has increased in all industries in OECD countries.[4] To produce the same value-added, a smaller number of jobs is needed in 2011 as compared to 1995. But while labour productivity has increased in these industries, exports have also increased and the loss in jobs from productivity gains is more than compensated by the increase in the volume of exports. This is why in most countries there is more employment in exports today than 15 years ago.[5]

Figure 4. Employment to value-added ratios (jobs per USD million of VA), average by industry, OECD countries, 2011 and 1995



Source: Author's calculation based on the OECD ICIO and OECD Trade in Employment indicators. Value-added data have been converted to constant USD using deflators from the OECD Annual National Accounts database, base year 2010.

What is the contribution of jobs in the service sector to exports?

Another interesting decomposition allowed by the use of TiVA is to look at the industry of origin of the jobs embodied in gross exports. Figure 5 highlights that when accounting for the "indirect" jobs, there is a strong contribution from the service sector to exports. For countries such as Belgium, Denmark, Ireland, Luxembourg, the Netherlands, Norway or the United Kingdom, more than 70% of jobs embodied in gross exports are found in services industries. The figure is close to 70% in France, Switzerland and in the United States.

Having in mind the employment to value-added ratios from Figure 4, this result should not be attributed to a lower labour productivity in services industries. Business services or financial services, for example, are rather capital-intensive and have a low content in jobs for a given value-added. The services that account for a large number of jobs in exports generally are the ones supporting manufacturing activities, such as transport and telecoms, distribution, finance and other business services. But these services are increasingly exported as services and not just embodied in goods. The category "other services" also includes jobs in sectors such as health, education, environment or

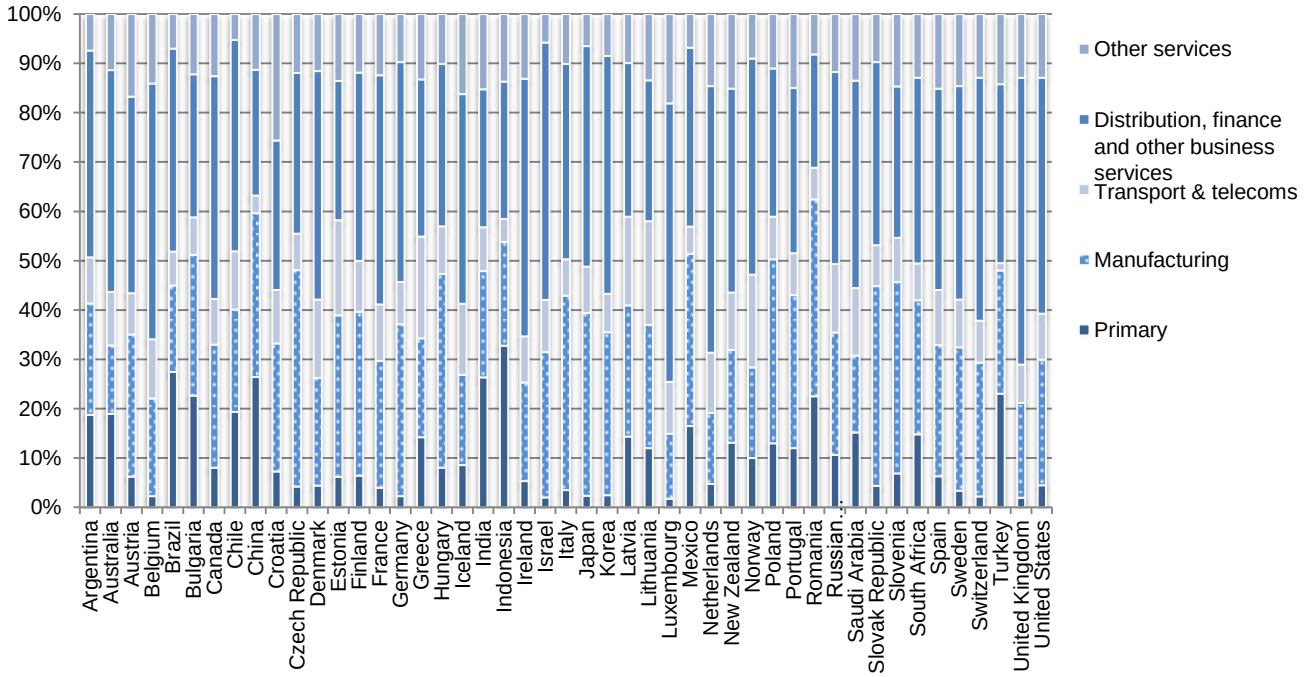
4. The employment to value-added ratio is the inverse of the labour productivity, which is the value-added per employee.

5. As explained in Annex A, a limitation in the current data is that labour productivity is assumed to be the same for exporting and non-exporting firms. Further analysis would be needed to assess the bias resulting from this assumption.

entertainment where some countries have developed significant exports. The bulk of employment in this category is however related to tourism.

Not all countries have a majority of jobs embodied in exports originating in the service sector. For countries such as Bulgaria, China, Indonesia, Mexico or Romania, more than 50% of embodied jobs come from the primary and manufacturing sectors. But this share has decreased as compared to 1995.

Figure 5. Jobs embodied in gross exports, by industry of origin, 2011



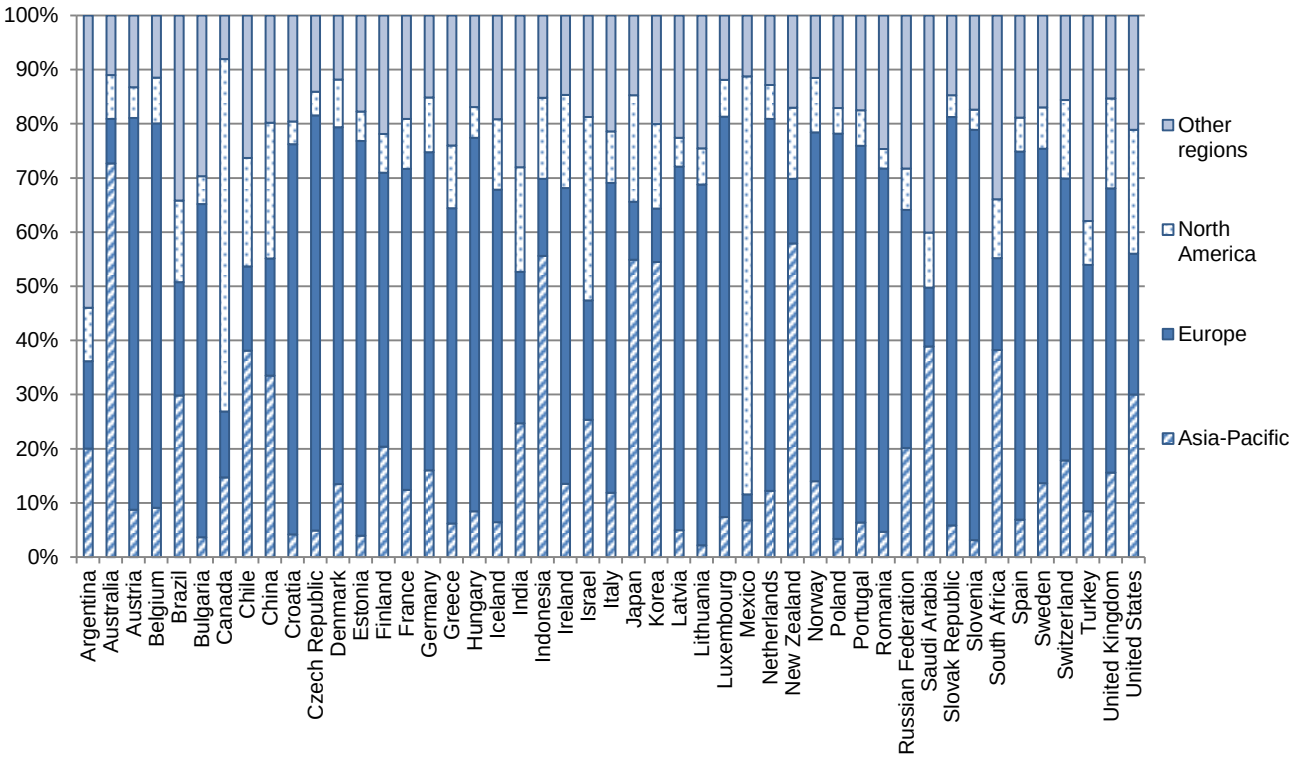
Source: Author's calculation based on the OECD ICIO and OECD Trade in Employment indicators.

Who are the partners importing the exports where jobs are embodied?

It is also useful to decompose the jobs embodied in gross exports according to the partner economy where these embodied jobs are "exported" (Figure 6). Such decomposition does not provide any surprise as the number of jobs follows closely the share of the different partners in gross exports.

Figure 6 highlights the regional dimension of GVCs with European economies having most of embodied jobs in exports to other EU countries. But one can also see the specialisation of countries and their position in the value chain. For example, Mexico provides many inputs to the US economy (and has therefore a high share of employment in its exports to the United States), while the US export final goods and services to a broader set of countries with shares of embodied jobs more evenly spread across regions.

Figure 6. Jobs embodied in gross exports, by export destination, 2011



Source: Author's calculation based on the OECD ICIO and OECD Trade in Employment indicators.

The same heterogeneity can be observed within Asia. Economies such as Indonesia, Japan and Korea, have more than 50% of their jobs embodied in gross exports to other Asian economies. It is different for China, where only one third of the jobs embodied in gross exports are sustained by intra-regional trade. Almost half of the jobs embodied in Chinese exports depend on imports from Europe and North America.

In South-America too, Argentina has jobs mostly embodied in regional exports while the pattern is different for Brazil and Chile. The employment data does not cover other Latin American economies included in the TiVA database but on the basis of exports of value-added, most of the jobs embodied in gross exports of Colombia or Costa Rica would also depend on extra-regional exports.

What types of tasks are more prevalent in exports of value-added?

So far, the evidence presented has just translated in a number of jobs what was already known on the distribution and generation of value-added across countries through the TiVA indicators. More specific analysis and new policy implications require to go a step further and to try to characterise the type of jobs embodied in gross exports.

A decomposition often found in the literature deals with the skills of workers and whether they are part of high-skill, medium-skill or low-skill activities. The WIOD database includes some information on the level of skills and can be used to look at the change in employment in exports by skill type between 1995 and 2009 (Figure 7). There is, in all countries, a shift towards higher skills. Interestingly, there is only one country (Denmark) showing some "job polarisation", i.e. an increase in the share of both low-skill and high-skill workers to the detriment of medium-skill workers.[6] This job polarisation

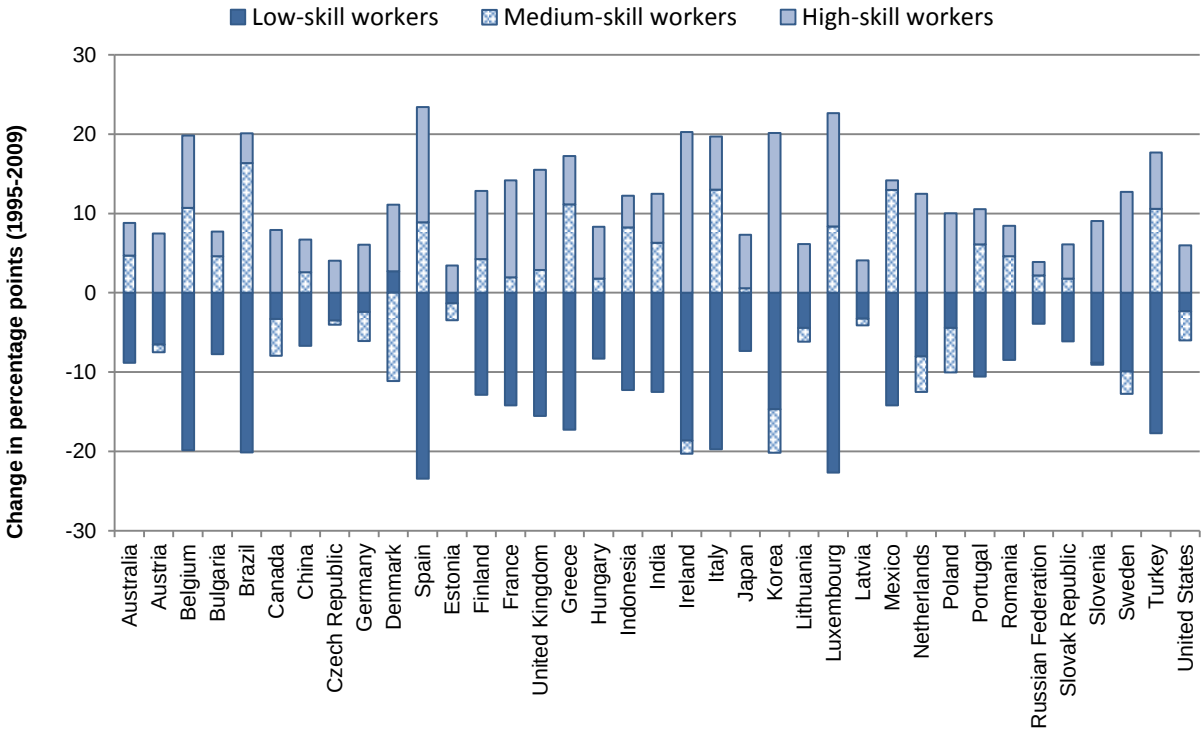
6. On the job polarisation, see Autor et al. (2006) and Goos et al. (2009, 2014).

may be observed in overall employment in some countries (such as the United States) but is not found in the job content of exports. Jobs embodied in exports are clearly moving towards higher skills, and often as well, medium skills. The pattern is the same in Brazil, China, India or Indonesia; there is no evidence suggesting a specialisation of emerging economies in a particular type of skills.

There are of course limitations in the data, and one should be cautious in interpreting Figure 7. First, the skill shares in the WIOD database are based on educational attainment. The results might look different with a measure of skills based on the actual activity of workers rather than their diploma. Some workers can be hired to perform tasks that are below their level of education. They could appear as medium-skill or high-skill workers on Figure 7 while still being involved in low-skill occupations. Second, the methodology used to derive the export content of jobs assumes similar shares of employment and related skills for export activities and the production for the domestic market. It was mentioned before that exporting firms are generally more productive. They could also have a different profile in terms of the distribution of skills.

Despite these limitations, it is fair to say that we cannot learn too much from the distribution of skills, since all countries are more or less moving in the same direction. If one is interested in the specialisation of countries in specific activities in the value chain, another decomposition is needed, focusing more on the tasks and activities within industries. Figure 8 proposes to look at the share of employment in exports, based on business functions rather than on skills.

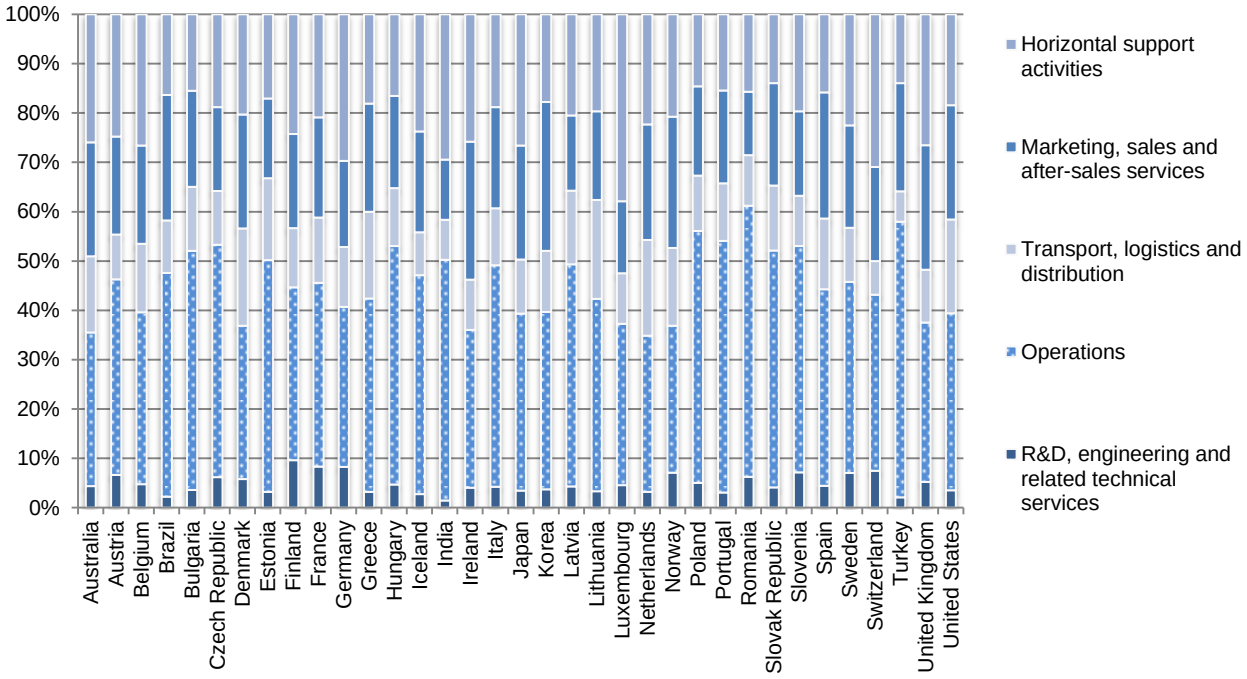
Figure 7. Change in employment embodied in gross exports (1995-2009), by skill type



Source: Author's calculation based on the OECD ICIO and OECD Trade in Employment indicators.

The business functions are taken from the literature on GVCs (Nielsen, 2008; Sturgeon and Gereffi, 2009; Nielsen and Sturgeon, 2014) and are identified by looking at occupations at a disaggregated level in labour force surveys and census statistics.[7] At the beginning of the value chain are activities related to R&D, engineering and design, then followed by the primary activity of the firm, generally the production of a good or a service to be sold on a market. Once production has taken place, there are transport, logistics and distribution functions to deliver the goods or services. The products are then marketed and sold and some customer services are provided. This is the end of the sequential value chain but all these activities could not happen without some horizontal support activities (horizontal in the sense that they support R&D, design, operations, logistics, sales etc.). These support activities include: IT service, software support, management, administration, back-office services, and repair and maintenance activities.

Figure 8. Jobs embodied in gross exports, by business function (2011)



Source: OECD ICIO and occupational data described in Table C.1 in Annex C.

From Figure 8, one can already see some differences across countries, but it is when looking at the change in employment shares in the different business functions that some patterns of specialisation appear. The detailed results for each country are in Figure 9. These charts are an empirical representation of the famous "smile curve" mentioned in the GVC literature (Baldwin, 2012). There is a "smile" when the occupations embodied in exports have moved from operations (the middle of the curve and of the value chain) to R&D, engineering and related technical services upstream (on the left of the chart) and to transport, logistics, distribution, marketing, sales and after-sales services downstream (on the right). Support activities are represented as a straight line on these charts since they contribute to all production stages along the value chain.

7. The data sources are detailed in Table C.1 (Annex C). A description of the 7 business functions used in the analysis can be found in Table C.2 in the same annex.

A "smile" is observed in almost all countries. The number of jobs embodied in exports and corresponding to the core operations of firms has generally decreased between 2000 and 2011. It means that there are fewer workers in charge of processing, manufacturing and assembling the goods that are exported. The jobs lost in operations are replaced by jobs either upstream (pre-production) or downstream (post-production) in the value chain.

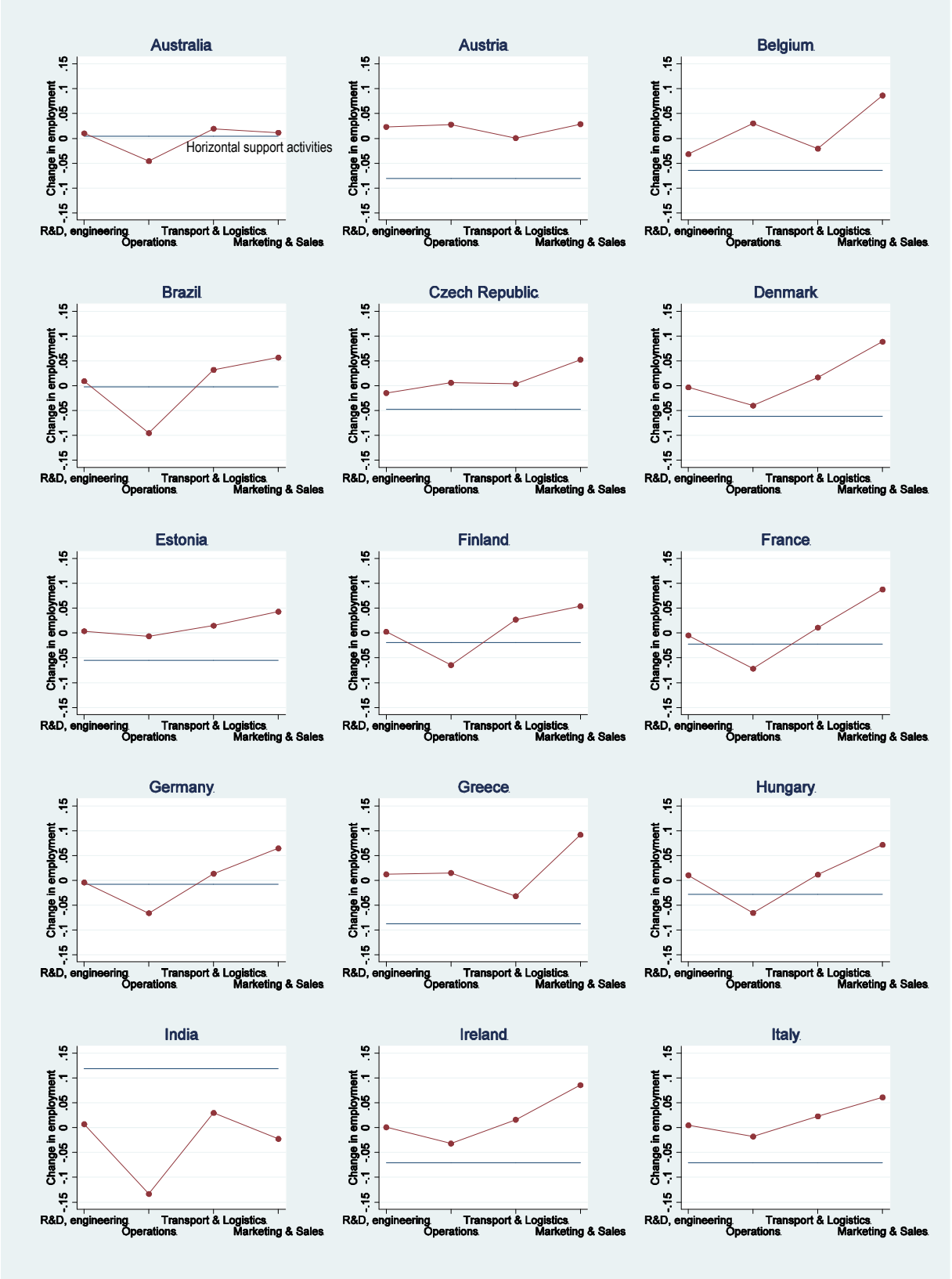
Upstream are the "R&D, engineering and related technical services" activities. This business function has only slightly increased. The number of occupations related to R&D and engineering has increased by less than 3 percentage points in all the countries included in Figure 9. There is even a slight decrease in several EU countries. The activities where the number of jobs embodied in exports has increased are rather the ones located downstream (post-production). Relatively high positive percentage changes are observed for 'transport and logistics' and for most countries the values are even higher for 'marketing and sales' (a business function including customer services).

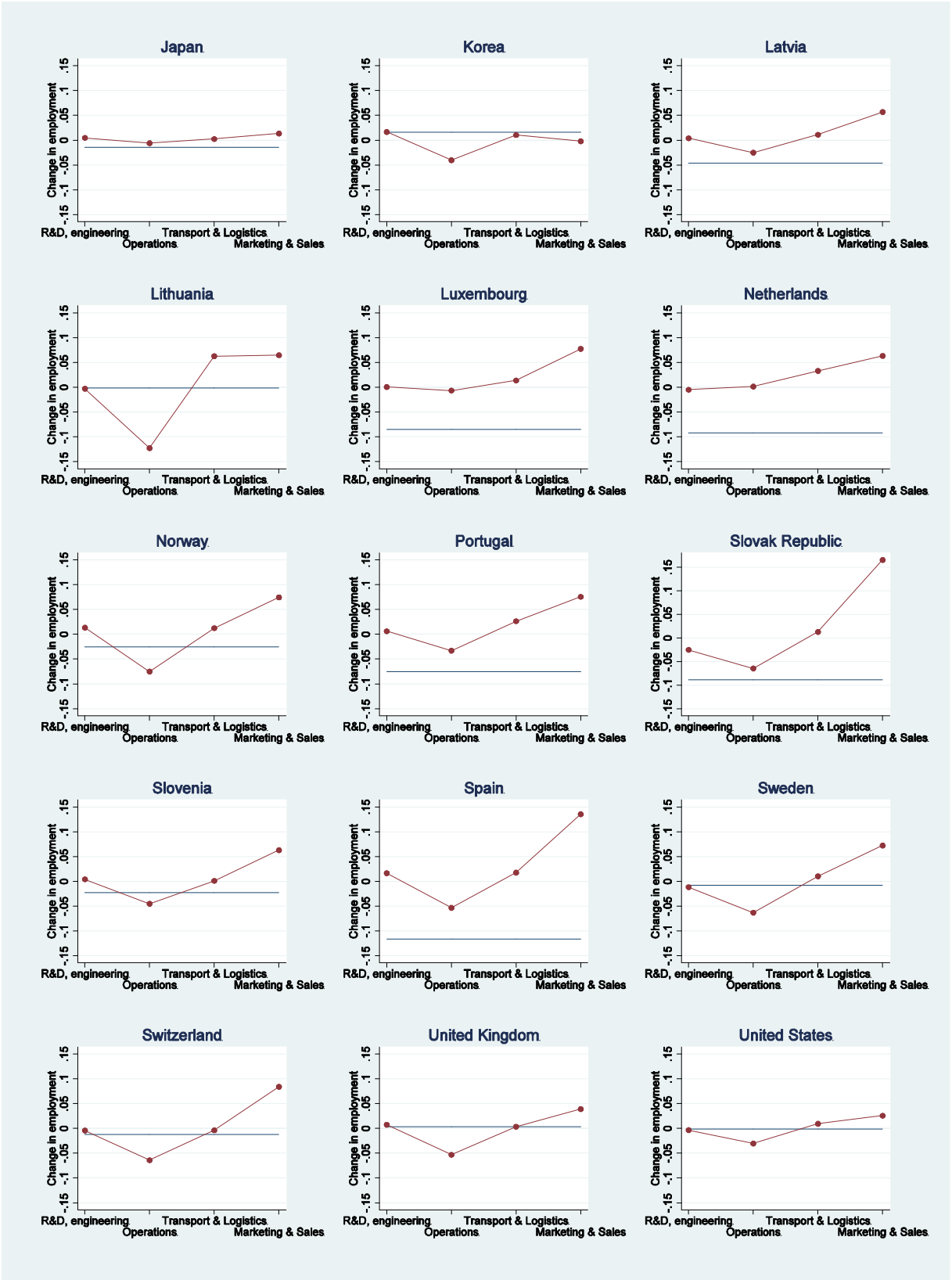
Among the 30 countries of Figure 9, 20 follow this pattern of a "full smile". In Australia, Finland, India, and the Netherlands, 'marketing and sales' has increased less than 'transport and logistics', while there is the same increase in both business functions in the case of Austria, Lithuania and Italy. Belgium, the Czech Republic and Greece are the only economies with a different pattern with respect to 'operations'. More jobs are found in this business function, while less people work in 'R&D, engineering' (Belgium and the Czech Republic) or in 'transport and logistics' (Greece). But jobs in 'marketing and sales' have increased in all three countries, thus preserving part of the 'smile'.

The smile curve is therefore empirically verified when looking at occupations within industries.[8] In addition, Figure 9 offers an interesting finding with respect to "horizontal support activities" (the straight line in each chart). While there tends to be a common pattern across countries, for R&D, engineering, operations, transport, logistics, marketing and sales, the results are very different for the support activities (IT services, back-office services, and repair and maintenance activities). Some countries, such as India or Korea, seem to have specialised in such business functions, with an increase in the share of support activities in exports. On the contrary, countries such as Austria, Italy, the Netherlands or Spain seem to have outsourced abroad these business functions. This result is in line with the literature on offshore services (Gereffi and Fernandez-Stark, 2010) highlighting that such horizontal business services are increasingly traded. It also offers interesting avenues to look at the role of the routine content of occupations in explaining the offshorability of services (Marcolin et al., 2016). An overall trend in companies might also be to reduce the number of people working in management and administration. In order to increase efficiency and market responsiveness, many firms have for example flattened their hierarchies and removed some layers of management (Rajan and Wulf, 2006). It could also explain the shift in employment from horizontal support functions to marketing and sales.

8. The smile curve has often been elusive in the empirical literature because when relying on data by industry, only activities that are outsourced to other industries can be included in the analysis. R&D activities on Figure 9 correspond to workers that are identified as 'researchers', 'engineers', etc. independently of the industry for which they work. They can belong to the "other business services" industry (where R&D firms are) or to a specific manufacturing industry (for example as employees of a car manufacturer).

Figure 9. Change in employment embodied in exports, by business function (2000-2011)





Source: OECD ICIO and occupational data described in Table C.1 in Annex C. The horizontal bar indicates the change in employment in horizontal support activities (IT services, management, back-office, repair and maintenance services).

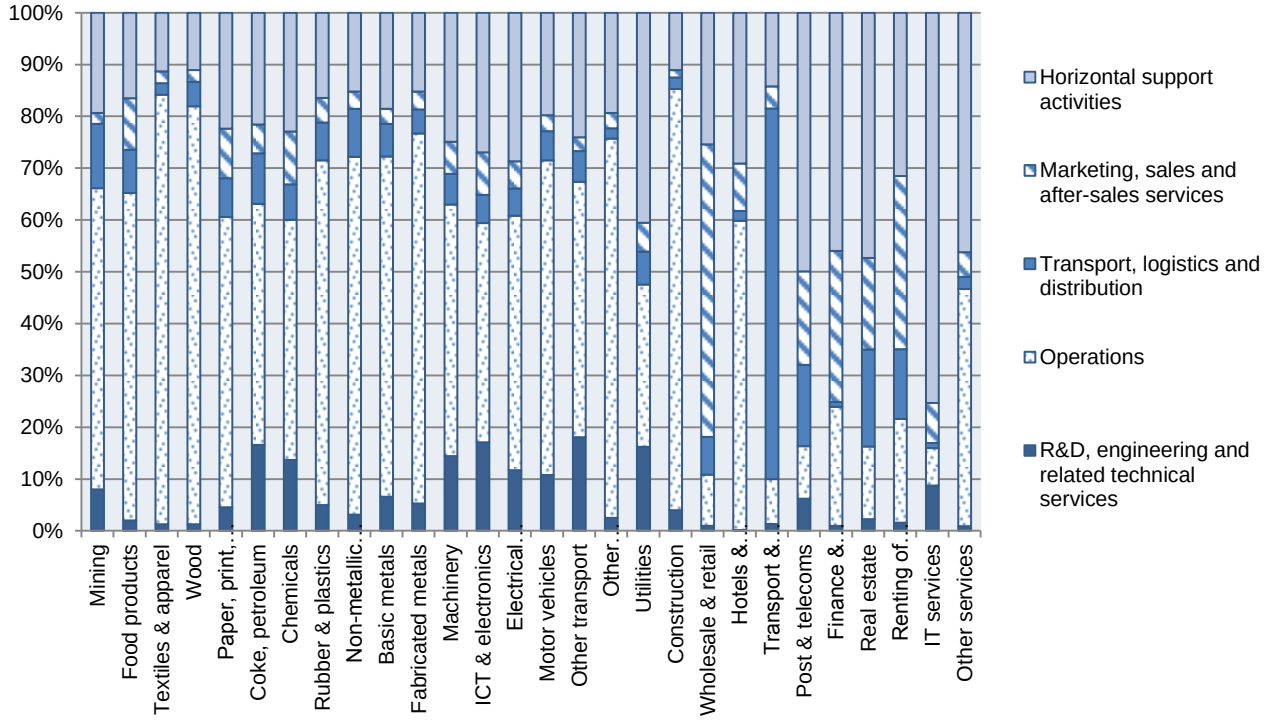
Even more interesting patterns are likely to emerge at the industry level. Figure 10 provides sample averages for the domestic jobs embodied in foreign final demand based on the industry of the final product. It is a full decomposition of the value chain (while the data on Figure 9 is based on the gross exports of each country).

Services industries have been included in Figure 10 but the results need to be interpreted in a different way. In the case of manufacturing industries, the operations of firms are the core manufacturing activities and the support business functions are services. For services industries, the core activity of the firm is also a service. Not surprisingly, in the 'transport & storage' industry there are many workers part of the 'transport, logistics and distribution' business function and in the 'wholesale & retail trade' industry most workers are in the 'marketing and sales' business function. The typology and the analysis will have to be adjusted to deal with services value chains.

Figure 10 is interesting to highlight differences across industries in terms of the respective weight of different business functions. For example, R&D activities play a more important role in 'coke and petroleum' and 'electronics' as opposed to 'food products' or 'textiles and apparel'. In labour-intensive industries, such as 'textiles and apparel', the highest number of jobs is found in the operations of firms while in 'electronics', the role of R&D, engineering, marketing, sales and after-sales services is more important. Once calculated for specific countries, these data can then tell us more about the specialisation of countries in specific segments of the value chain.

Lastly, what is clear on Figure 10 is that, in most industries, the bulk of employment remains in operations. The "smile curve" is only verified for the change in employment (or the change in value-added). In terms of levels, there is still an inverse U-shaped curve with pre- and post-production support activities accounting for a lower share of employment or value-added as compared to operations. This result holds for all manufacturing industries (as previously emphasised, the distribution of business functions is different in the case of services).

Figure 10. Jobs embodied in foreign final demand, by business function, average across countries (2011)

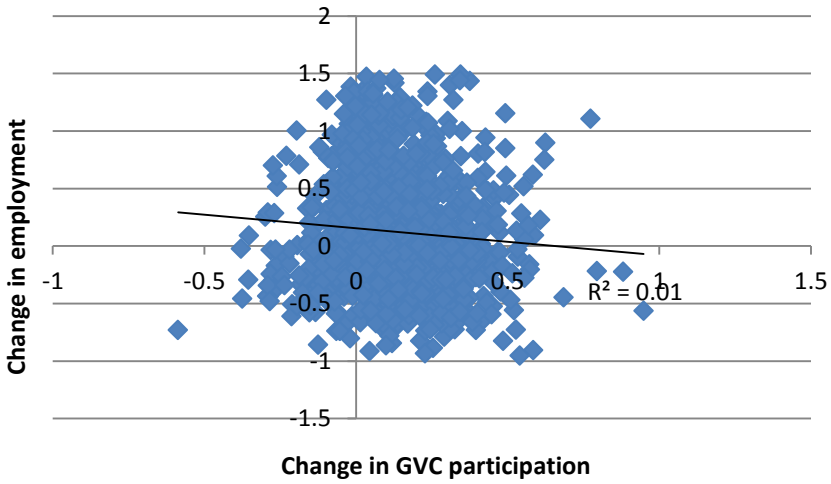


Source: OECD ICIO and occupational data described in Table C.1 in Annex C.

Have GVCs a negative impact on employment in industries exposed to trade?

The impact of GVCs on the number of people engaged in each industry is the combination of several factors. As a consequence of the fragmentation of production, there is a specialisation of countries and a reallocation of workers. The literature on GVCs emphasises that this reallocation takes place at a more granular level and not at the level of industries (Baldwin, 2012). If countries specialise in specific production stages or business functions within the same industry, the impact on the total number of jobs in each industry should be neutral. But if these production stages correspond to different industries, one should observe an increase in employment in some industries and a decrease in others. The analysis is also further complicated by the fact that activities within the boundaries of the firm and outside are not classified in a consistent way. In the business functions statistics presented in the previous section, R&D and engineering occupations for example could either be found in the "other business services" industry (where R&D activities and engineering services are) or within manufacturing firms employing the researchers and engineers. Any outsourcing of R&D or engineering activities would reduce the number of employees in such industries. Therefore, the reallocation of labour within GVCs should lead in any case to changes in the level of industry employment.

Figure 11. Change in GVC participation and in employment (1995-2011) [9]



Source: Author's calculation based on the OECD ICIO and OECD Trade in Employment indicators.

Moreover, the impact of GVCs on employment cannot be properly dealt with without taking into account productivity change. The literature on the impact of offshoring, for example, highlights that at the industry level, there is a negative impact of offshoring on employment (the substitution effect where domestic employment is replaced with foreign employment) but generally compensated by a productivity effect (where firms that have offshored the sourcing of their inputs become more productive and produce more, thus increasing their demand for labour).[10]

Since there is a reallocation of labour across industries and it is not clear whether the substitution effect or the productivity effect is stronger when companies offshore part of their production, we do not

9. GVC participation is measured differently as compared to previous OECD reports. It is calculated as the share of domestic value-added used in production for foreign final demand (forward participation) plus the share of foreign value-added in domestic final demand (backward participation). This measure based on final demand is more comprehensive than the one based on the foreign value-added in gross exports and domestic value-added in exports of third-countries.

10. Hijzen and Swaim (2007), Foster-McGregor et al. (2013).

expect a significant relationship between the change in GVC participation and the change in employment at the industry level. And this lack of one-way relationship is empirically observed on Figure 11 where no significant correlation emerges when pooling all industries and countries and looking at the change in GVC participation and employment between 1995 and 2011. It would require more rigorous econometric analysis to confirm that there is no significant correlation between the two variables but at this stage it suffices to say that the TiVA data are in line with what we could expect based on the existing literature.

What is clear is that there is no reason for employment in the same industry to always decrease when participation in GVCs increases. Even if some offshoring takes place, an outcome can be more output and more employment. Figures 3 and 4 in Section 2 had already alluded to this by showing that the job content of exports has increased in industries where labour productivity has also augmented.

Have GVCs increased productivity in the overall economy?

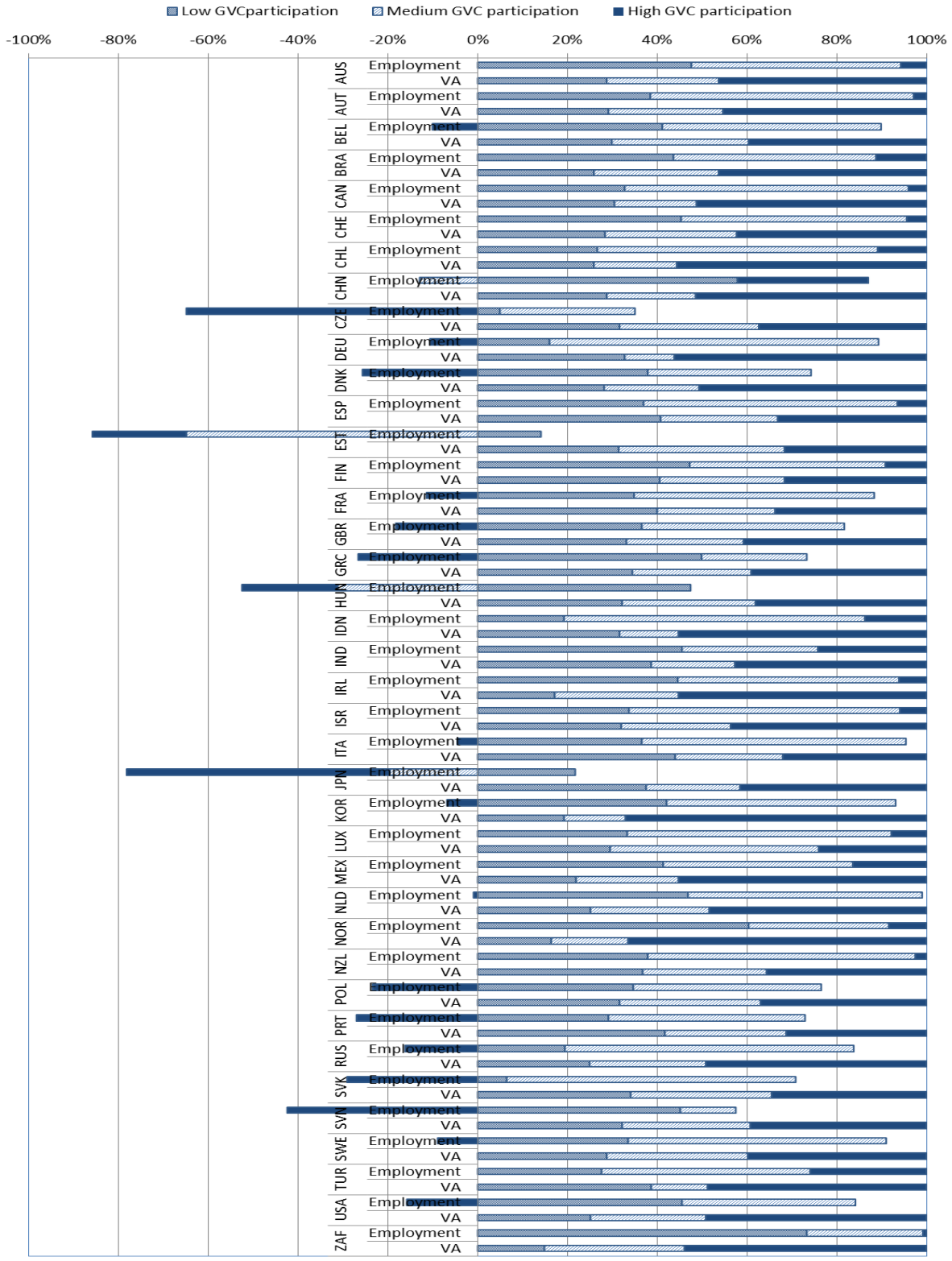
As previously mentioned, it is beyond the scope of this report to fully answer this question, in particular because it would require productivity data at the industry level that are difficult to come by.[11] But the question is still important for the analysis of employment because, if we cannot always observe a positive increase in the number of jobs in the industries exposed to trade, there is still a potentially positive impact of GVCs on employment through the additional income that results from productivity gains in the tradable sector. In the United States, for example, it was observed that most of the job creation in the last 20 years took place in the non-tradable sector while value-added per employee has increased mainly in the tradable sector (Spence and Hlatshwayo, 2011). Using the GVC participation index to distinguish between three types of industries according to their integration in GVCs, Figure 12 illustrates that there is often a discrepancy between the industries where jobs were created between 1995 and 2011 and those where value-added has increased, highlighting the importance of productivity change and the fact that productivity gains in an industry can create jobs in others.

By looking at value added per employee across industries, the TiVA database can to some extent explain these evolutions. But a full analysis of productivity gains would need additional information on total or multi-factor productivity and cannot rely on apparent labour productivity only. Figure 13 provides a simple scatter plot based on the TFP industry-level data described in Annex B. There is a positive relationship but again no significant coefficient emerges from these data. Without controlling for other productivity determinants and the specificities of countries and industries, this result is expected.

A positive and significant relationship between GVCs and productivity (TFP) has been found in the literature. Using firm-level data, Baldwin and Yan (2014) point out that the integration of Canadian manufacturing firms into GVCs has improved their productivity. They control for the self-selection effect (i.e. the fact that only the most productive firms join GVCs in the first place) and find that firms' productivity increases both immediately and over time. An earlier literature had already identified a link between the access to cheaper (and higher quality) inputs and TFP growth (Bas and Strauss-Khan, 2012). Trade is also expected to have an impact on the organisation of firms and this is another channel linking GVCs to productivity, as suggested by Caliendo and Rossi-Hansberg (2012).

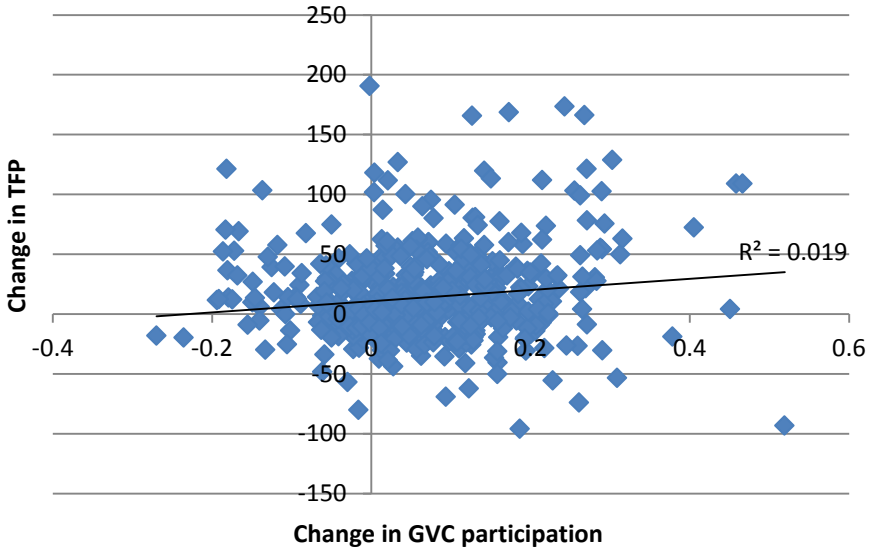
11. See Annex B.

Figure 12. Change in employment and in value-added (1995-2011) according to participation in GVCs



Source: Author's calculation based on the OECD ICIO and OECD Trade in Employment indicators. Decomposition of the change across the three types of industries.

Figure 13. Change in GVC participation and TFP growth (1995-2005)



Source: OECD ICIO 2015 and KLEMS (see Annex B).

It would be interesting to confirm such results at the industry level on the basis of the TiVA database. But the literature on GVCs also suggests that when production is fragmented, it is not clear whether GDP-based productivity remains the best approach and whether industry-level analysis makes sense (Dietzenbacher and Los, 2012).

First, GDP includes both investment and exports as part of output, while the welfare of inhabitants only depends on consumption at the end. Of course, investment is about future consumption and countries need to export in order to import and increase their overall consumption through trade. But the fact that countries consume a different share of their GDP suggests that looking at the contribution of productivity to consumption growth can complement the traditional GDP growth analysis.

Second, GVCs have important implications for the analysis of productivity at the industry level. In international production networks, specialisation tends to occur at a finer level. Countries specialise in tasks rather than in specific industries, as illustrated in Section 6. It implies that the value added in the same industry in two countries can correspond to very different types of activities. For example, one country can be specialised in the manufacturing of very high tech electronic products while another one only performs the assembly of electronic components at the end of the value chain. Comparing the productivity of the electronics industry in these two countries does not make sense if one cannot account for differences in the type of activity (hence the importance of developing data on business functions).

In this example, a higher labour productivity in both countries (and therefore a higher income) comes from their GVC specialisation and not from some capital intensification or increase in multi-factor productivity. And it would be misleading to encourage the country specialised in the assembly activities to try to reach the same industry productivity levels as the one specialised in high tech products or to move to high tech goods. In the long term, investment in skills and know-how may lead the first country to specialise in high tech goods as well, but in the short term higher consumption levels are reached by the division of labour in GVCs.

Concluding remarks

Some preliminary results have been presented in this report and further analysis is required to confirm these results. In particular, the general evidence gathered at the country and industry level from TiVA needs to be complemented by case studies and deeper analysis capturing more of the nuances across GVCs.

Several reports have already dealt with the relationship between trade and jobs, in particular in the context of the International Collaborative Initiative on Trade and Employment (ICITE) (OECD, 2012). There is a consensus that trade can play an important role in creating better jobs, increasing wages and improving working conditions. Further work from the OECD Trade and Agriculture Directorate has also stressed the positive role of GVCs in upgrading and helping developing countries to achieve higher income levels (Shepherd, 2013; Kowalski et al., 2015) as well as reducing wage inequality (Lopez-Gonzalez et al., 2015).

However, the benefits from trade do not accrue automatically. These reports have also emphasised the complexity of the issues involved and the fact that complementary policies are needed to reap the full benefits on employment and growth. Particularly when it comes to employment, the outcome depends on well-functioning labour markets and appropriate labour market policies. Trade is about specialisation and the re-allocation of resources from low-productivity industries to high-productivity industries. The impact on workers is not trivial and policies are needed to facilitate adjustments but also to deal with the new risks associated with the fragmentation of production.

In these adjustments, technological progress (including innovations of firms in the way they organise their production and manage workers) is often a more important driving force than trade. The literature on trade and jobs has often difficulties in separating the outcome of trade and the outcome of technological progress or firm strategies. The two are intertwined with the consequence that it is difficult to assess what trade policy can do.

Against this backdrop and acknowledging the fact that trade policy is only one policy among others that are needed to achieve employment and growth, the preliminary findings suggest that:

- The number of jobs depending on international trade has never been so high. There is a serious threat for employment to be considered for countries introducing new protectionist measures. For some countries, exports of value-added are already concentrated at the aggregate level, involving a limited number of partner countries. This concentration could even be higher for specific products. The volatility and risk discussed with respect to the disruption of GVCs also has implications for employment.
- The importance of trade policy for employment is different across countries, based on their openness and the number of jobs used in production for foreign final demand. However, it should be kept in mind that the estimates provided are not (yet) capturing the full scope of activities involving GVCs. Moreover, what happens for a relatively small number of jobs in the industries participating in GVCs can have a big impact on the rest of the economy (whether positively such as in the case of productivity spillovers, or negatively, if there is a negative impact on wages for example).
- What is missing in the debate on employment and globalisation is to look at the full range of business activities within GVCs. The assessment of the impact of GVCs on jobs cannot be completed if one focuses on the jobs that have disappeared in one segment of the value chain without looking at the jobs created upstream or downstream. The evidence suggests that in all countries, less jobs are devoted to the core operations of firms (the manufacturing, processing and assembly part of the value chain) and more jobs involved in business functions upstream (R&D, engineering) and downstream (transport, logistics, distribution, marketing, sales, after-sales services).

- Differences are observed across countries mainly for other horizontal support business functions such as IT services, administrative support, maintenance and repair. These business functions are the ones where some countries have specialised, while others are relying more on offshore services.
- All the above mentioned support business functions (not only the horizontal support activities but also transport, logistics, distribution, marketing, sales and after-sales services) are basically services. The services value-added measured so far in TiVA (the value-added from services industries embodied in exports) is somehow the tip of the iceberg. Within all manufacturing industries, there are more and more occupations corresponding to business functions that are services and measured as manufacturing value-added in the context of TiVA. Trade policy in the area of services matters even more than previously thought.

In addition, the assessment of the impact of GVCs on employment is still partial if the productivity gains from GVCs are not taken into account and one does not link job creation in sectors less exposed to GVCs to productivity gains in sectors the most integrated in GVCs. Due to data limitations, it was not possible to go very far in this report in the analysis of productivity change. Nonetheless, the following preliminary conclusions are suggested:

- There is evidence in the literature that participation in GVCs can increase productivity. The main channel for productivity growth is a finer division of labour. GVCs enhance the gains from specialisation.
- But the involvement of countries in GVCs also depends on their specialisation. It is expected that some countries specialise in activities where the fragmentation of production is less prevalent (in particular services) and productivity growth can also be achieved this way.

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Annex A.

Employment Data and TiVA-related Indicators

In order to assess the impact of GVCs on jobs, this report calculates indicators that have been developed in the context of the Trade in Value Added (TiVA) project. The list of industries covered is the same as in TiVA with 34 industries defined as an aggregation of the ISIC Rev. 3.1 classification, accounting for the whole economy, from agriculture to services (Table A.1).

Table A.1. List of industries

Number	ISIC equivalent	Name	Description
1	C01T05	Agriculture	Agriculture, hunting, forestry and fishing
2	C10T14	Mining	Mining and quarrying
3	C15T16	Food products	Food products, beverages and tobacco
4	C17T19	Textiles & apparel	Textiles, textile products, leather and footwear
5	C20	Wood	Wood and products of wood and cork
6	C21T22	Paper, print, publish	Pulp, paper, paper products, printing and publishing
7	C23	Coke, petroleum	Coke, refined petroleum products and nuclear fuel
8	C24	Chemicals	Chemicals and chemical products
9	C25	Rubber & plastics	Rubber and plastics products
10	C26	Non-metallic minerals	Other non-metallic mineral products
11	C27T28	Metals	Basic metals and fabricated metal products
12	C28	Fabricated metals	Fabricated metal products
13	C29	Machinery	Machinery and equipment, nec
14	C30.32.33	ICT & electronics	Computer, Electronic and optical equipment
15	C31	Electrical machinery	Electrical machinery and apparatus, nec
16	C34	Motor vehicles	Motor vehicles, trailers and semi-trailers
17	C35	Other transport	Other transport equipment
18	C36T37	Other manufacturing	Manufacturing nec; recycling
19	C40T41	Utilities	Electricity, gas and water supply
20	C45	Construction	Construction
21	C50T52	Wholesale & retail	Wholesale and retail trade; repairs
22	C55	Hotels & restaurants	Hotels and restaurants
23	C60T63	Transport & storage	Transport and storage
24	C64	Post & telecoms	Post and telecommunications
25	C65T67	Finance & insurance	Financial intermediation
26	C70	Real estate	Real estate activities
27	C71	Renting of machinery	Renting of machinery and equipment
28	C72	IT services	Computer and related activities
29	C73T74	Other business services	R&D and other business activities
30	C75	Public admin	Public admin. and defence; compulsory social security
31	C80	Education	Education
32	C85	Health	Health and social work
33	C90T93	Other services	Other community, social and personal services
34	C95	Private households	Private households with employed persons

The OECD STAN database[1] includes information on the number of persons engaged, the total number of hours worked per person engaged, and the compensation of employees broken down by industries. Building on STAN, employment data consistent with TiVA industries have been constructed by the OECD Directorate for Science, Technology and Innovation (STI). These data are now available for 48 TiVA countries (including some non-OECD members): Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Chile, China, Croatia, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Mexico, New Zealand, the Netherlands, Norway, Poland, Portugal, Romania, Russia, Saudi Arabia, the Slovak Republic, Slovenia, South Africa, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States.

The dataset covers the same years for which the TiVA indicators are provided: 1995, 2000, 2005, 2008, 2009, 2010 and 2011. The TiVA ICIO 2015 is used for all the calculations. It includes heterogeneous data for China and Mexico (i.e. different input-output coefficients for firms exporting or being part of processing trade as opposed to domestic firms). The heterogeneous tables are used in order to provide more accurate estimates for these economies where processing trade is important.

Calculation of employment used in production for foreign final demand

The calculation is similar to the one used in the TiVA database to produce estimates of the domestic value added in foreign final demand. An employment vector by country and by industry is built using the number of persons employed. This vector is multiplied by the Leontief inverse from the Inter-Country Input-Output table and by a matrix of final demand (by country). Final demand refers to the sum of final consumption expenditure by households, government and non-profit institutions serving households (NPISH) and gross fixed capital expenditures, as defined in the 1993 System of National Accounts. In the resulting matrix, elements corresponding to the foreign final demand are summed up in order to obtain a vector by country and by industry of the domestic jobs used in production for foreign final demand. The formula is:

$$eBF = e(I - A)^{-1}F$$

where e is the vector of employment (country/industry), A the input-output coefficients matrix (country/industry*country/industry) and F the matrix of final demand (country/industry*country). The diagonal elements from the resulting eBF matrix are set to zero and the off-diagonal elements summed up in order to obtain a vector by country and by industry of the employment used in production for foreign final demand.

It should be noted that an underlying assumption in this calculation is that the labour productivity of domestic and exporting firms is the same. As the literature points out, exporting firms generally have a higher productivity[2] and as a consequence the jobs estimates may be biased upwards. Even if in the case of Mexico and China, the tables are split according to the exporting status of firms, we do not have employment data for each category of exporters and the bias is thus not fully avoided.[3]

Another limitation in the analysis is the lack of harmonisation across countries in the definition of full-time equivalents for the number of persons engaged. The data may not be fully comparable because of differences in the way the total number of persons engaged is derived.

1. For a detailed description of OECD STAN employment and compensation data country by country see www.oecd.org/sti/ind/47513935.pdf. For a country, industry and time coverage of the OECD STAN ISIC Rev. 3 version see: www.oecd.org/sti/industryandglobalisation/46671527.XLS.

2. See for example, Bernard et al. (2007).

3. The employment vector is split according to these categories in our calculations but based on a proportional allocation that does not reflect differences in productivity.

Calculation of domestic jobs embodied in gross exports

Instead of using a matrix or vector of final demand, the employment vector and the Leontief inverse can be multiplied by a vector of gross exports. This calculation allows the identification of the domestic employment embodied in gross exports. The formula is:

$$eBX = e(I - A)^{-1}X$$

where X is a vector of gross exports (by country and by industry). An element-by-element multiplication (instead of a matrix multiplication) is used to identify both the source and destination country/industry of the jobs embodied in gross exports. However, as we do not have the employment data for all countries (and industries) in the ICIO, the matrix has blocks of zeroes and we cannot fully assess at this stage the full foreign employment content of exports. In addition, since labour productivity differs across countries, a foreign job content of exports is difficult to interpret and comparing the domestic and foreign content in terms of a given number of jobs would be misleading.

Calculation of embodied skills and business functions

To identify skills and business functions embodied in final demand or gross exports, the formulas used are the same as before, except that instead of an employment vector *e* we use a matrix of employment by skill type or by business function. We have to assume that the matrix is the same for domestic production and exports. In particular, we cannot recreate for China and Mexico different shares in the case of processing exports. The data used for skills come from the World Input-Output Database (WIOD) described in Timmer et al. (2015a). Annex C describes the occupational data for which business functions are derived.

Annex B.

Productivity Data

The OECD compiles harmonised productivity statistics at the total economy level, industry and firm level. At the total economy level, labour productivity and total factor productivity (TFP) measures are periodically published by the OECD Economics Department as part of the Economic Outlook and by the OECD Statistics Directorate in the OECD Productivity Database.[1]

At the industry level, the OECD Directorate for Science, Technology and Innovation compiles the OECD Structural Analysis (STAN) database providing, amongst a wide range of indicators, labour productivity measures. In addition, the Statistics Directorate maintains the OECD Productivity Database by Industry (PDBi), offering internationally consistent measures of TFP growth by industry for 20 OECD economies.[2] At the firm level, the OECD ORBIS database provides the basis to create comparable cross-country firm level data for structural analysis that facilitates more detailed analyses such as the evaluation of the contribution of public policies to cross-country differences in productivity (see Andrews et al., 2014; Andrews and Criscuolo, 2013; Andrews and Cingano, 2012). Recent work from the Economics Department (see Gal, 2013) has extended the data coverage of the ORBIS database with imputations allowing for the calculation of TFP measures at the firm level.

This report focuses on the relationships between productivity at the industry level, employment and GVCs, and so concentrates on productivity measures at the industry level. The most recent version of the OECD PDBi reports industry-level data according to the International Standard Industrial Classification of all economic activities, Revision 4 (ISIC Rev. 4). However, as the system of Inter-Country-Input-Output (ICIO) tables used to derive TiVA is based on ISIC Rev. 3.1, an earlier version of PDBi, based also on ISIC Rev. 3.1, is considered for the analysis. Despite being discontinued in 2011, this version of PDBi covers 20 OECD countries and 14 industries from 1990 to 2009, although the time coverage varies across countries and industries.[3]

However, to have a larger set of countries, industries and years, additional data have been sourced from EU-KLEMS and WORLD-KLEMS. The EU-KLEMS database relies on growth and productivity accounts by industry for EU Member states and additional non-EU countries with a breakdown into contributions from capital (K), labour (L), energy (E), materials (M) and service

1. The coverage of the Productivity database varies by productivity measure. All OECD countries and The Russian Federation are included for labour productivity measures but only 20 countries are included for multifactor productivity measures, reflecting national data availability.

2. The OECD PDBi is the result of a joint project between the OECD Directorate for Science, Technology and Innovation and the OECD Statistics Directorate launched in 2008 and aiming at developing TFP measures at the industry level. Measures of output and labour inputs, as well as other variables, have been sourced directly from the OECD STAN database, hence ensuring full comparability between the two databases (see OECD, 2001 for methodological details).

3. The countries covered are: Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Iceland, Ireland, Italy, Korea, the Netherlands, Norway, Poland, Spain, Sweden, the United Kingdom, and the United States. The 14 industries covered in the PDBi are classified according to the ISIC Rev.3.1 but with varying levels of aggregation. In some instances, industry groups, resulting from the aggregation of two or more 2-digit industries in ISIC Rev. 3.1 are created to ensure a minimum level of industry detail for which comparisons can be made across all countries. Real estate activities (ISIC code 70) are excluded from the Business services aggregate as their value-added includes the imputation made for the dwelling services provided and consumed by home-owners (for more details see Arnaud et al., 2001).

inputs (S), from 1970 onwards (see O'Mahony and Timmer, 2009). Within the WORLD-KLEMS initiative, a set of harmonised KLEMS-type data sets and projects have also been developed in collaboration with regional networks (in particular ASIA-KLEMS) and the national statistical offices of countries like Argentina, China, Korea and Russia, to increase comparability across a larger set of countries.[4] The latest release of EU-KLEMS with an industry breakdown following ISIC Rev. 3.1 covers 27 European countries, as well as a number of non-European countries, such as Australia, Canada, Japan, Korea and the United States. It includes data for a detailed list of 32 industries and various aggregations, and covers the period 1970-2007. The additional countries covered in the WORLD-KLEMS initiative, including some already present in EU-KLEMS, have the same list of industries but more recent data.

Despite both sources following the same underlying conceptual framework, i.e. the growth accounts methodology, in deriving their TFP estimates, the EU-KLEMS approach relies on a larger set of inputs, including in addition to labour and capital, intermediate inputs broken down into energy, materials and services. Moreover, unlike the OECD PDBi, EU-KLEMS adjusts labour and capital inputs for quality differences over time and across countries (see Arnaud et al., 2011, for more details on the derivation of estimates of capital input within the PDBi). Furthermore, in the OECD PDBi inputs are combined with weights that reflect the cost shares of each input in total costs, while in EU-KLEMS revenue shares are used as weights to combine the different inputs. Lastly, the level of industry detail also varies between the two data sources, with EU-KLEMS having the most disaggregated level of industry aggregation, with data up to 3-digit level of ISIC Rev. 3.1 for certain industries.

Table B.1. Labour productivity in manufacturing and services industries, average annual growth, 1990*-2007

	AUT	BEL	CAN	CZE	DEU	DNK	ESP	FIN	FRA	GBR	GRC	IRL	ITA	KOR	NLD	POL	SWE	USA
Manufacturing (C15T37)																		
KLEMS	4.90	3.08	2.77	6.31	3.09	1.83	0.90	6.12	3.58	3.66	2.32	8.07	1.42	9.71	3.27	9.08	5.62	4.47
PDBi	3.78	3.01	2.58	6.52	3.45	2.32	1.14	6.27	3.48	3.64	1.03	7.33	1.53	9.45	3.44	8.93	5.93	4.89
correlation	0.87	0.91	0.87	0.99	0.98	0.99	0.87	0.94	0.94	0.87	0.49	0.84	0.99	0.67	0.95	0.66	0.97	0.86
Business services (C50T74x) **																		
KLEMS	0.73	1.94	2.32	4.89	1.30	1.84	2.55	2.00	1.42	3.50	4.51	1.79	1.18	3.13	2.92	7.12	2.35	2.43
PDBi	1.60	1.98	2.04	3.75	2.49	2.49	1.17	2.06	1.44	4.48	4.13	-	1.69	4.98	2.53	4.72	2.86	2.43
Correlation	0.49	0.74	0.56	0.82	0.48	0.59	0.87	0.80	0.81	0.57	0.57	-	0.82	0.91	0.96	0.65	0.92	0.76

Notes: * The starting year is 1990 or the earliest year available. Note also that Norway and Iceland are not covered in EU/WORLD-KLEMS. ** Business services industry excludes Real estate activities (C70).

Source: OECD PDBi and EU/WORLD-KLEMS.

4. At the moment, additional countries (e.g. India, Mexico, Indonesia, Malaysia, etc.) and regions (Latin America) are collaborating with research teams from the WORLD-KLEMS initiative in order to expand the coverage of the growth and productivity accounts data at the industry level. See www.worldklems.net/data.htm.

Table B.2. TFP in manufacturing and services industries, average annual growth, 1990*-2007

	AUT	BEL	CAN	CZE	DEU	DNK	ESP	FIN	FRA	GBR	IRL	ITA	NLD	SWE	USA
Manufacturing (C15T37)															
KLEMS	3.88	1.00	1.98	5.11	2.10	1.00	-0.42	4.42	2.01	3.18	0.62	0.41	2.02	4.30	2.73
PDBi	3.35	2.24	2.24	6.47	2.81	2.13	0.68	5.62	2.76	4.05	5.31	0.76	3.08	5.88	4.02
correlation	0.93	0.86	0.89	0.97	0.97	0.97	0.75	0.95	0.93	0.43	0.92	0.97	0.98	0.97	0.84
Business services (C50T74x) **															
KLEMS	-0.04		1.67	2.52	0.60	0.61	1.28	1.12	0.23	1.63	1.15	0.49	2.17	0.80	0.79
PDBi	1.15		1.33	3.83	1.38	1.40	0.39	1.83	0.89	3.71	-	-	2.05	2.58	1.54
correlation	0.48		-	0.76	0.53	0.73	0.94	0.88	0.84	0.60	-	-	0.97	0.93	0.57

Notes: * The starting year is 1990 or the earliest year available. Note also that Norway and Iceland are not covered in EU/WORLD-KLEMS. ** Business services industry excludes Real estate activities (C70).

Source: OECD PDBi and EU/WORLD-KLEMS.

Even accounting for the differences in the methodologies, growth measures of labour productivity and TFP in both datasets are very similar – see Tables B.1 and B.2 for a comparison of labour productivity growth and TFP growth in aggregated manufacturing and services industries for a comparable set of countries and years.

Overall, the average annual changes of both measures in the two databases are relatively close and characterised by very high correlation coefficients, revealing a reasonable level of comparability between the two data sources. As such, the analysis in this report is based on EU-WORLD/KLEMS estimates for labour productivity and TFP growth estimates in order to preserve a broader level of industry disaggregation while covering a large set of countries and years.

The industry-level estimates of labour productivity and TFP from EU-KLEMS and the related WORLD-KLEMS initiative have been aggregated, when necessary, using industry value added as weights, to match as closely as possible the aggregation scheme used in the OECD TiVA dataset. The final dataset is composed of 28 industries, 12 of which are services industries.

Annex C.

Identifying Business Functions at the Industry Level Through Data on Occupations

The *business function* is a new statistical unit of analysis proposed in the GVC literature to capture trends that are difficult to analyse with current statistics (Sturgeon et al., 2013). The starting point is the analysis of the value chain by Michael Porter (1985) and the distinction between the primary or core activity of the firm (its operations) and a number of intangible support functions such as R&D, sales, marketing or IT services. These functions are the ones that tend to be outsourced or offshored and that are behind the fragmentation of production. The analysis of production through these business functions also highlights the role of services in the creation of value.

Statistics on business functions have started to be collected at the firm-level in the context of national surveys such as the 2010 National Organizations Survey in the US (Brown et al., 2014) or EUROSTAT *ad hoc* survey on the international sourcing of business functions by enterprises (Nielsen, 2008). These surveys have confirmed that outsourcing and offshoring take place at the level of business functions rather than individual tasks. One can hope that in the future this type of information will be more systematically collected by statistical agencies. In the meantime, another approach has been suggested to identify business functions (Timmer et al., 2015b) by relying on occupational data from labour force surveys. This approach is the one followed in this report, but at a more disaggregated level than previously proposed.

The database will be further developed and is at a preliminary stage. It includes occupations data for 38 countries over the period 1995-2011 (but the year coverage varies across countries). The sources and the classifications are reported in Table C.1.

Table C.1. Sources for occupational data by industry

Country	Source	Year coverage	Data
Australia	Labour Force, Australia	1997-2011	ANZSIC 2006, 3-digit ANZSCO 2006, 2-digit
Brazil	Pesquisa Nacional por Amostra de Domicílios (PNAD)	1995, 2001-2009, 2011	ISIC Rev.3/Rev.4, 2-digit National classification of occupations, 3-digit
EU countries (28), Iceland, Norway, Switzerland and Turkey	Eurostat Labour Force Survey (EU LFS)	1995-2011*	NACE Rev. 1/Rev. 2, 2-digit ISCO 88/08, 3-digit
Japan	Population Census	1995, 2000, 2005, 2010	ISIC Rev.3/Rev.4, 2-digit National classification of occupations, 3-digit
Korea	Korean Labour & Income Panel Study	1998-2011	KSIC, 2-digit KSOC, 3-digit
India	National Sample Survey (NSS)	2000, 2006, 2008, 2010	NIC 1998/2004/2008, 2-digit NCO 1968/2004, 3-digit
United States	Occupational Employment Statistics (OES) Survey	1999-2011	SIC/NAICS, 3-digit SOC 2000/2010, 6-digit

* The year coverage varies across countries.

With the exception of the OES survey in the United States, all these labour force surveys rely on an industry classification derived from ISIC (Rev. 3 or Rev. 4). The conversion to the list of 34 industries from Table A.1 is straightforward. In the case of the United States, the data are first converted to ISIC using the concordance tables provided by the Census Bureau. When it comes to occupations, the classifications are too different across countries to use a single classification. Instead, the Secretariat has built specific concordance tables between each classification and a typology of business functions. This approach should improve the comparability of data across countries. For example, managers are classified in a very different way in the US SOC classification and the international ISCO classification. It may be difficult to assess the number of US managers for each ISCO category (and vice-versa) but all managers belong to the same business function ("management, administration and back office"). Differences in classifications of occupations do not generally affect the type of business function.

The typology of business functions used in the report is detailed in Table C.2.[1] The first business function corresponds to the core or primary activity of the firm in relation to its industry code. Typically, it includes occupations directly related to the production process in this industry. For example, "food processing workers"[2] are part of the core activity of firms involved in food processing. It would be interesting to identify assembly activities and to distinguish them from "operations" as it is done in some typologies of business functions. But there are very few occupation codes (at the 3-digit level) related to assembly (such as "assemblers"). Some workers involved in assembly activities are likely to be classified in more generic industry-specific activities. The choice is therefore to keep "operations" and "assembly" merged in a single primary business function. Some managers are also kept within the primary business function when their work is really part of the production process. Examples include: 'production managers in agriculture, forestry and fisheries', 'professional services managers' and 'hotel and restaurant managers'.

All the other business functions are support activities (or secondary business functions). Their role is to support the core activity of the firm. Some essential support functions are "transport, logistics and distribution", the activities related to procurement (the sourcing of inputs) and the delivery of goods and services to customers, as well as "marketing, sales and after-sales service", a business function including all the activities related to market research, marketing, advertising and selling. Managers that are specifically identified as distribution and logistics managers, or marketing and sales managers, are included in these support functions. Customer services are also included in this business function (under the heading "after-sales service"). These activities are also easily identified in the list of occupations.

The only difficulty when using the occupational data is to distinguish between the pre-production and post-production activities related to logistics. Ideally we would like to distinguish the procurement of inputs from the distribution and logistics activities that are post-production. But the workers moving the goods or in charge of organising these activities tend to be in similar occupations. Therefore, they are all included in the "transport, logistics and distribution" business function.

There is then a group of more horizontal support activities, including 'IT services and software support functions', 'management, administration and back-office support functions' (from the secretaries to the top managers, but excluding managers dedicated to more specific business functions), 'R&D, engineering and related technical services' (in particular certification and technical testing). The distinction between engineers and workers involved in R&D and design is not always straightforward and therefore the two are grouped. Researchers are more involved in science, mathematics, architecture and design (with no reference to a specific industry), while engineers have an occupation more related to specific industries and specific technical tasks.

1. This classification builds on earlier work done by Gaaitzen de Vries from the University of Groningen. The business functions are derived from Nielsen and Sturgeon (2014).

2. All the examples of occupations in this section are based on the ISCO 2008 classification. But as previously indicated, the database relies on a variety of classifications and a concordance was created for each of them to identify the same business functions across different occupational classifications.

Table C.2. Typology of business functions

No.	Business function	Definition	Examples of occupations (ISCO 2008)
1	Operations/Core business functions	The core/primary business function of the firm. Generally the production of goods or services intended for the market or third-parties.	Food processing and related trades workers; Wood processing and papermaking plant operators; Assemblers; Garment and related trades workers.
2	Transport, logistics and distribution support functions	A support function that includes activities related to procurement, transportation, warehousing and the delivery of goods and services to customers.	Material-recording and transport clerks; Heavy truck and bus drivers; Transport and storage labourers.
3	Marketing, sales, after sales service support function	A support function focusing on market analysis, advertising, selling, retail management, as well as customer services (including help desks and call centres).	Sales, marketing and development managers; Sales, marketing and public relations professionals; Cashiers and ticket clerks; Client information workers.
4	IT services and software support functions	Activities related to data processing, software development and the provision of ICT services.	Software and applications developers and analysts; Database and network professionals; Information and communications technology technicians.
5	Management, administration, and back-office support functions	Activities associated with the administration of the firm, including legal, finance, accounting and human resources management.	Managing directors and chief executives; General office clerks; Administrative and specialised secretaries.
6	R&D, engineering and related technical services and R&D support functions	This support function includes activities related to experimental development, research, design, engineering and related technical consultancy, technical testing, analysis and certification.	Mathematicians, actuaries and statisticians; Architects, planners, surveyors and designers; Engineering professionals; Life science technicians and related associate professionals; Ship and aircraft controllers and technicians.
7	Other business functions	Activities related to maintenance and repair, security, as well as other activities not belonging to specific firm-level business functions. Also includes education and training.	Domestic, hotel and office cleaners and helpers; Protective services workers; Machinery mechanics and repairers; Armed forces officers; legislators and senior officials; religious professionals; Secondary education teachers.

Source: Based on Nielsen and Sturgeon (2014).

It is important to understand that these business functions are part of the "value chain" defined at the level of the firm, as in the seminal work by Porter (1985). When we talk about GVCs, the "value chain" is describing a global production process where many firms are involved and each firm participating in the GVC may have its own "local" value chain where the business functions described in Table C.2 are relevant. The concepts are similar and the "macro" and "micro" value chains overlap (in particular when a single firm owns the whole global value chain) but one should keep in mind that a firm producing an input upstream (from a GVC perspective) has R&D, logistics, marketing and support activities the same way as a firm downstream (producing final goods for example). The "mix" of business functions is however likely to be different. Firms involved in final production will have more staff in charge of after-sale services and marketing as opposed to firms involved mostly in R&D and design activities. But since we aggregate occupations across industries (and lose the perspective of the firm), the business functions inferred from occupations can still tell us something about GVCs.