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GVC competitiveness regarding business functions

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ABSTRACT

This report updates and extends the findings of Timmer, Los, Stehrer and de Vries (2013 Economic Policy, TLSV) which proposed a concept to measure competitiveness in global value chains. TLSV propose to measure the value that countries contribute to the production of final manufactured goods, referred to as 'Global Value Chain (GVC) income'. By extending the analysis of TLSV to 2018, the report examines the EU's global GVC share, the specialization of EU countries in pre- and post-production business functions, and the number of jobs involved in GVC business functions. The report finds that the EU's GVC share has remained stable since 2012 at about 17%. North-western EU countries have a comparative advantage in functions related to pre- and post-production, while South-eastern EU countries specialize in production. These trends have been accompanied by a slow decline in the number of jobs involved in manufactures' GVCs. The findings of this report suggest that there is a regional division of labour within the EU, with substantial variation between individual countries.

Keywords: Specialization; Business functions; European Union; Global value chains

JEL codes: F14, F60, O14, O19

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1. Introduction

In the current global economy, the typical production process crosses national borders. That is, the various stages for producing final consumer goods are performed by firms in several countries. Consider the example of car production, which involves a large set of firms dispersed across many countries. Demand for cars will in first instance raise the output of the car industry. But production in this industry relies on parts and components that are produced elsewhere, such as engines, braking systems, car bodies, paint, seat upholstery or window screens, but also energy, and various business services such as logistics, transport, marketing and financial services. These intermediate goods and services need to be produced as well, thus raising output in the industries delivering these. In this setting, competition is increasingly about who does what and where, rather than about the products that are produced. From a national perspective, this necessitates alternative approaches to analyse the competitiveness of countries and firms in the global economy.

This report uses the analytical tools introduced by Timmer, Los, Stehrer and de Vries (TLSV) that measure the incomes and jobs being generated by the EU countries in Global Value Chains (GVC) of manufactured goods. Manufactures GVCs are identified by tracing the flow of goods and services across countries as described in a world input-output table. This allows us to trace the incomes from production factors that are directly and indirectly generated in the production of final manufacturing goods.

The main analysis in this report is based on the OECD's Inter-Country Input-Output Database (November 2021 release), the OECD's Trade in Employment database (November 2021 release), and improved and updated occupation data that was introduced by Reijnders and de Vries (2018).

Combining these datasets allows us to examine who does what and where in manufactures GVCs. In particular, the occupations of workers is used to measure the jobs and income from performing business functions. The premise is that knowing a worker is an engineer, machine operator, manager, or a sales worker informs on the business function the worker performs.

This report describes the main trends in the EU's GVC income and GVC jobs by business function for the period until 2018. For various reasons, it is relevant to examine recent trends. In particular, because of shifts in public opinion and policymakers regarding the benefits and costs of ongoing globalization as well as rising geopolitical tensions. The report analyses:

- What are the main trends in the EU27 in GVC jobs and income?

- How competitive are EU countries in manufactures GVCs?
- In which business functions do EU countries specialize when contributing to GVCs?

The remainder of this report is structured as follows. Section 2 outlines the GVC methodology and provides a brief evaluation of the GVC concept. Section 3 discusses the data. In section 4 we examine recent trends in GVC income. In section 5, specialization in business functions is analysed. Finally, section 6 provides concluding remarks and discusses policy implications.

2. Global Value Chains: Conceptual approach

This paper studies the production fragmentation of final products, which are consumed, as opposed to intermediate products that enter production. Consumption is broadly defined as private and public consumption, as well as investment. A global value chain (GVC) of a final product is identified by the country-industry where the last stage of production takes place before delivery to the final user. Examples include the Volkswagen cars from transport equipment manufacturers in Wolfsburg, Germany and Peugeot cars from transport equipment manufacturers in Sochaux, France. Ultimately, the price for a particular product is distributed as income for all country-industries contributing in its GVC.1

The GVC metric offers a macro-economic perspective on the division of functions in international production networks. To model the global production system, we use input-output tables and international trade statistics, following the seminal insight from Leontief (1949). We trace the amount of factor inputs needed to produce a certain amount of final demand. Value is added at various stages of production through the utilization of production factors such as labour and capital.

Consequently, the value of any particular final product is broken down into the value added by all labour and capital that was required in any stage of production. This provides a consistent accounting system of all value added and all global value chains in the world. This is illustrated in Figure 1. The final column in Figure 1 provides the value added by workers and capital employed in a particular industry and country. A row shows the distribution of this value added across all global value chains in which the country*industry participates. The global value chains are represented by the columns. There is one column for each final good or service, produced in each country. The cells in the column show the

[1] The expenditure value is given at the basic price concept. A key distinction in the System of National Accounts is between a value at basic prices and at purchasers' prices. The latter is the price paid by the final consumer and consists of the basic price plus trade and transport margins in the *handling* of the product and any (net) product taxes. The basic price can thus be considered as the price received by the producer of the good.

origin of all value added needed for the production of the final good. The sum across all participating industries makes up the gross output value of the final product, given in the bottom row. Note that these industries are domestic, as well as foreign. As all final products are being consumed somewhere in the world, output values will equal expenditure. Thus, both the columns and the rows add up to world GDP as global final expenditure must be equal to global value added by national accounting convention.

Figure 1. An accounting framework for global value chains

			Final products of a global value chain, identified by country and industry of completion							**Value added**
			Country 1			…	Country M			
			Industry 1	…	Industry N	…	Industry 1	…	Industry N	
Value added from country-industries participating in global value chains	Country 1	Industry 1								
		…								
		Industry N								
	…	…								
	Country M	Industry 1								
		…								
		Industry N								
Total final output value										**World GDP**

Note: Cell values represent the value added generated in the country-industry given in the row, within the global value chain corresponding to the country-industry of completion given by the column. Source: Timmer et al. (2014).

This report subdivides the value added in countries by the type of functions carried out, such as R&D, management, back-office, production, logistics and marketing. The value added of a particular function is proxied by the income of workers that perform the activity. This way the distribution of value added across functions can be determined and specialization patterns of countries analysed.

In order to analyse global production systems, one has to define a set of final products for which the analysis is performed. We focus on the functional specialization patterns in the global production of final manufacturing goods, denoted by the term "manufactures." Production systems of manufactures are highly prone to international fragmentation, as activities have a high degree of international contestability: they can be undertaken in any country with little variation in quality. Note that this includes not only activities in the manufacturing sector, but also activities in all other sectors, such intermediate products from agriculture or marketing and other professional intermediate inputs from business services. On average, 68% of the value added in the manufacturing sector is incorporated into global value chains (GVCs) of manufacturers, according to a median across 27 EU countries in 2011 (Timmer et al. 2013). Similarly, the value added by non-manufacturing

industries to manufacturers' GVCs is nearly as substantial as the value added by manufacturing (with a median ratio of 93% across EU 27).

In contrast to studies of trade in value added, this paper does not trace a country's contribution to its exports, but rather its contribution to the output value of a particular good. This should not be equated to price competitiveness, i.e. competitiveness in manufacturing (as it excludes manufacturing value added for non-manufacturing final products), nor competitiveness in international trade (as it includes final domestic demand and excludes part of non-manufacturing trade). Our aim is to study the competitiveness of European nations in generating jobs and income for domestic labor and capital in the global value chains of manufactured products (Timmer et al. 2013; 2019).

Fragmentation of production can take many forms, such as 'snakes' and 'spiders' (Baldwin and Venables, 2013). 'Snakes' involve a sequence in which intermediate goods are sent from country A to B, incorporated into intermediate goods sent from B to C, and so on until they reach the final stage of production. 'Spiders' involve multiple parts coming together from multiple destinations to a single location for assembly of a new component or final product. Most production processes are complex mixtures of the two, and the GVC approach presented here is a general accounting approach that is not affected by the organization of global production processes. See the technical appendix for a mathematical exposition of the method.

The approach allows measuring the value that is added in various stages of fragmented production processes. The income that a country generates by being active in the production of manufacturing goods is termed GVC income. Below, we briefly assess the key strengths and limitations of this measure of competitiveness.

Strengths include:

1. This approach shifts the focus of competition away from sectors or products, to functions. This is beneficial as activities in global value chains can be carried out by firms not directly classified by the sector or product, such as companies providing business services (e.g. R&D and design). By focusing on functions, the value created is more accurately distributed throughout the economy.
2. This measure computes the revenue from the production of all manufactured goods all over the world. This allows us to gain insight into an economy's strength, both in the global market and in its domestic market. This is significant, since domestic goods may be replaced by foreign goods if domestic companies become less competitive in price or quality.
3. This framework can also be employed to measure GVC jobs. This enables us to assess the income and employment repercussions of being part of global value

chains for different groups of workers, in particular workers classified by their occupation that are mapped into business functions.

Limitations or reservations include:

1. When assessing jobs and income from business functions in GVCs, we take into account the value added by labour and allocate the value added by capital proportionally. As a consequence of data limitations, it is currently not possible to allocate capital income to specific business functions. Currently, only data on investments in physical assets and a limited set of intangibles (e.g. software) can be found in the national accounts. A large proportion of profits are obtained from the use and generation of intangibles such as knowledge, technology, design, and branding, which are still not accurately reflected in official statistics.
2. GVC income in the inter-country input-output tables is expressed in US dollars using current exchange rates. Exchange rates have varied throughout the time period taken into account. The selection of the US dollar as the base currency has no effect on the GVC income measure of a country in comparison to other countries. Expressing GVC income shares, for instance, in Euros will produce the same results. However, it will affect the absolute levels of GVC incomes and hence comparisons over time within a country.
3. The location where the value is being added is not necessarily the same as where the produced income will eventually go to. Global value chains are created not only through arms-length trade in intermediate inputs, but also through significant flows of investment. Part of the value added in foreign countries will be documented as income for multinational companies located in other countries through capital ownership. To analyse capital income at a national level, data on foreign ownership is required. This type of information is notoriously hard to get, not least because of the notional relocation of profits for tax accounting purposes. This issue mainly applies to GVC income as the discrepancy between GVC jobs recorded on a domestic or national basis is likely smaller.
4. Ideally, to measure competitiveness one would like to include the value added in all activities that are internationally contestable, and not only those in the production of manufactured goods. An increasing portion of world trade is in services, and only intermediate services associated with manufacturing production are incorporated in GVCs of manufactures. GVCs of services cannot be evaluated, however, as the level of observation for services in the data is not detailed enough to focus on those services that are highly traded, such as consultancy services. The recent FIGARO tables from Eurostat do offer additional detail for services. These

FIGARO tables are available from 2010 onwards, and therefore not used as this report takes a long-term comparative perspective.2

5. This methodology is basically an ex-post accounting framework rather than a fully specified economic model. It begins with exogenously given final demand and traces the value added without explicitly modelling the interaction of prices and quantities that are fundamental in a full-fledged Computable General Equilibrium model (see, for instance, Levchenko and Zhang, 2012). Even though CGE models are richer in the modelling of behavioural relationships, there is the need for additional econometric estimation of several key parameters of production and demand functions. As we do not intend to separate price and quantity effects, we can rely on a reduced form model in which only input cost shares are known. We use annual IO tables so that cost shares in production change over time. Therefore, the analysis does not rely on Leontief or Cobb-Douglas types of production functions where cost shares remain constant. The changing shares are consistent with a translog production function which offers a second-order approximation to any functional form. This feature of the model makes it particularly suitable for our ex-post analysis.

3. Inter-Country Input-Output Tables and Occupation Data

To measure GVCs of manufacturing goods, we briefly describe the Inter-Country Input-Output Tables (ICIOTs) in section 3.1. Section 3.2 then describes the country-industry occupation dataset to proxy business functions.

3.1. Inter-Country Input-Output Tables

The November 2021 release of the OECD ICIO databases covers 66 countries (plus Rest of the World), 45 unique industries and all years for the period 1995 to 2018 (see country and industry lists in Appendix Tables 1 and 2).

The principle elements of the Inter-Country Input-Output Tables (ICIOTs) are a matrix of domestic and international industry-to-industry monetary flows of intermediate inputs; a matrix of output meeting final demand; vectors of total output by country and industry; and a vector of the value added generated in production by country and industry. Taxes less subsidies on intermediate and final products are separated to ensure that the estimates of intermediate and final demand are measured at basic prices. The ICIO tables are benchmarked to countries' latest time series of SNA main aggregates (GDP, final demand, exports and imports) and output and value added by industry.

[2] The FIGARO tables contribute to the compilation of the OECD global inter-country input-output tables by providing the data for the EU and its member states.

The OECD ICIO tables are constructed using similar multi-stage trade balancing techniques as those developed for earlier work on global input-output databases (Wang et al., 2010; Ahmad et al., 2013; Dietzenbacher et al. 2013). However, the methodology used goes further by introducing additional steps for balancing both cross-border trade and direct purchases by non-residents abroad within a National Accounts framework. This is necessary because reported bilateral trade in goods and services statistics are not balanced at a global level and, reported national SUTs and IOTs are not necessarily harmonized with a country's latest National Accounts framework.

The OECD ICIO tables are based on the 2008 System of National Accounts (2008 SNA). Compared to the previous standard (1993 SNA), expenditures on Research and Development (R&D) are recorded as gross fixed capital formation rather than intermediate consumption, and economic activities are reported according to Revision 4 of the International Standard Industrial Classification (ISIC Rev.4, see Yamano et al. 2022 for further details).

We combine the ICIO tables with occupation and wage data to derive job and incomes shares by business functions in GVCs, described next.

3.2. Occupation Dataset

We describe the main sources and methods for occupation by industry data. For European countries, yearly occupational data by detailed industry are from the European Labor Force Survey (EU LFS). This large household survey provides information on labour force participation of persons aged 15 and over, and is conducted by the national statistical institutes across Europe and centrally processed by Eurostat. The EU LFS classifies occupations according to the International Standard Classification of Occupations (ISCO) 1988 for years before 2011, and ISCO 2008 for 2011 onwards. Similarly, industries are classified in NACE 2 from 2008 onwards, and NACE 1 before 2008, with an overlapping year. To create the final time series, the series are linked, resulting in a time series in ISIC rev. 4 and ISCO 2008. To derive shares in labour compensation, we also need wages, which the EU LFS does not provide by occupation, except by deciles in recent years. Therefore, we built up relative wage data by occupation from the micro data provided in the Structure of Earnings Surveys (SES). The Structure and Earnings Surveys (SES) provide harmonized data on earnings in European countries. We compute relative wages by 2-digit occupation for each European country. These relative wages are interpolated between the survey years.

For the United States we use the same data sources as in Autor (2015), namely the 2000 Current Population Census and the annual American Community Surveys, containing industry-level information on around 800 occupations. To match the industries

distinguished in the Inter-Country Input-Output Tables, all industry codes are converted into the ISIC rev. 4 classification, using conversion tables from the Bureau of the Census. The National Crosswalk Service Center provides a crosswalk of the SOC occupation codes to ISCO 2008.

For Japan, we use detailed five-yearly occupational employment data by industry from the Japan Population Censuses, and derive relative wage data from the wage structure surveys by occupation for the same years. The industries distinguished in the Population Censuses are matched to the ICIOTs, and the occupations in the wage structure surveys are mapped to the occupations distinguished in the Population Census. For South Korea, we use the annual Korea Labor and Income Panel Study (KLIPS). For China, we obtain occupational employment by industry from the 2000 and 2010 population census. Wages by occupation are from the 2010 IZA wage indicator survey, which appears to be the only source that provides information on wages by occupation in China.

For each country, occupations by industry are matched to business functions, as shown in Appendix Table 3. This mapping of occupations is exhaustive, and the employment shares sum to one. We use persons employed as the measure of employment and not hours worked due to data availability. By combining employment data with relative wages, we also create an exhaustive split of the labour share in value added. We proportionally allocate capital income.

4. GVC income and jobs: an update of Timmer et al. (2013)

This section summarizes some of the main trends in the distribution of income in manufactures global value chains. It updates the key trends documented by Timmer et al. (2013). TLSV focused on the period from 1995 to 2008, which is the period up to the global financial crisis. The analysis presented here is up to 2018, which allows us to study trends before and after the financial crisis. We focus in particular on the position of the European Union as a whole and on developments in each of the 27 nation states that are members of the EU.

4.1. GVC income

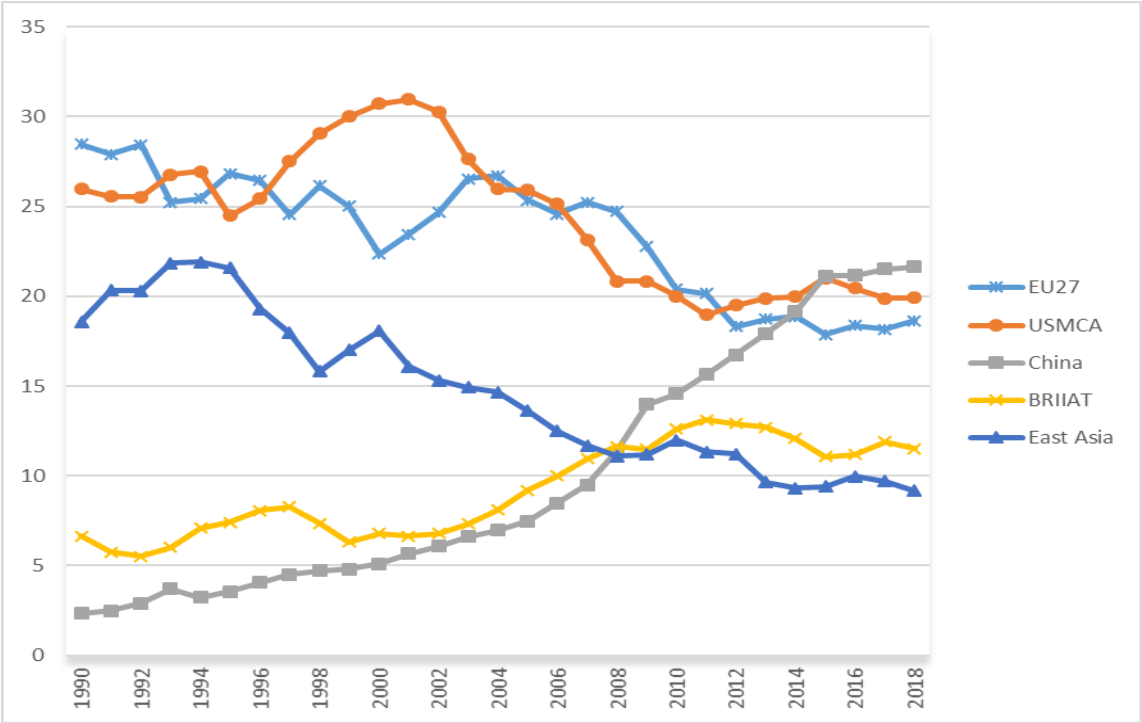
Figure 1 provide shares of regions in world GVC income in the production of manufactures. TLSV observed that the share of the EU was holding up until the global financial crisis.[3] The global financial crisis hit Europe in particular and its share dropped. From 2012 onwards, the share has been stable at about 18%. The share of the USMCA countries (comprising Canada, Mexico and the US) increased during the ICT bubble years, up to

[3] The EU 27 share in Figure 1 is about 5 percentage points lower compared to Timmer et al. (2013), which is largely due to the UK not being part of EU 27 anymore.

31%, when its share was higher than the EU. But it rapidly declined afterwards to 19% in 2011. Thereafter, the share hovered between 19 and 21%. GVC shares of East Asia (comprising Japan, South Korea and Taiwan) were on a long decline since 1995, falling from 22% in 1995 to 10% in 2013 and stable thereafter, still 9% in 2018. The share of China has been rapidly increasing. It rose from about 2% in 1990 to 11% by 2008 and its share continued to increase to 22% by 2018. The share of other emerging markets was also rapidly rising since 1995, but their share peaked at 11% in 2011 and then gradually fell to 9% by 2018.

How should we interpret the stable shares in GVC income for the EU27 countries from 2012 onwards? With rising income in the EU, it is expected that domestic demand shifts increasingly towards services. Hence, one would expect a gradual decline in GVC income from manufactured goods. Yet, domestic demand for manufactures does not always directly correlate with production value added due to international trade. The extent to which domestic demand for manufactures is geared towards goods with high levels of domestic value added depends on the home production bias, which is uncertain due to the high tradability of manufacturing goods and intermediates. Demand for manufactures in emerging markets could be met either through imports or domestic production; even if there is a preference for domestic production, advanced countries can still capture a significant share of their value through the supply of intermediate inputs and services.
This suggests that the stable shares in GVC income for the EU27 countries during the past decade, can be interpreted as that it is holding up its competitive position. Note, however, that in real terms GVC income for the EU27 as a whole decreased by 18% between 2008 and 2018 (see Table 1). The stable share yet absolute decline in GVC income is suggestive of maintaining a competitive position while expenditure by advanced nations and China shifts towards services due to non-homothetic tastes.

Figure 1. Regional shares in world GVC income for all manufactures (%)



Notes: Value added by regions in the production of final manufacturing goods. East Asia includes Japan, South Korea, and Taiwan. BRIIAT includes Brazil, Russia, India, Indonesia, Australia, and Turkey. EU27 includes all European countries that are part of the European Union as of January 2022. USMCA includes Canada, Mexico, and the US. Shares do not add up to 100% as the remainder is the share of all other countries in the world. Source: Author's calculations based on the OECD Inter-Country Input-Output Tables, release November 2021 for the period 1995-2018; extrapolated to 1990 using the trend in GVC income by region based on the long-run WIOD, release March 2022 (Woltjer et al. 2021).

Aggregate EU27 performance hides substantial variation within the European Union. In Table 1 we present the change in GVC income for individual EU countries. The first two columns in Table 1 confirm TLSV, which indicate that real GVC income has increased in all EU countries between 1995 and 2008.4 There was a major expansion in the European production capacity in Eastern Europe. After 2011, real GVC income decreased in all EU countries, with the exception of Poland, Bulgaria, Lithuania, Estonia, Romania, Luxembourg, and Ireland.5 The main industrial economy of Europe is Germany, contributing more than a quarter to EU27 GVC income since 1995 (31.3% of total EU27 GVC income in 2018). The share in Poland has been steadily rising from 1.9% in 1995 to 4.2% in 2018.

By splitting the final demand vector, we can analyse the importance of domestic versus foreign final demand in the generation of GVC income in a country and observe trends in

[4] We deflate GVC income by the US CPI rather than domestic CPIs, because manufactured products are mainly traded in US dollars on the world market and manufactures products prices are best reflected by an international world price.

[5] Ireland revised its GDP upwards in 2015. It is primarily due to the relocation of assets to Ireland by a limited number of large multinationals.

the dependence on external demand. The GVC income due to foreign demand is equal to the measure termed 'domestic value added embodied in foreign final demand' in the OECD TiVA indicators (Johnson and Noguera, 2012). TLSV concluded that all EU countries became increasing dependent on foreign demand to generate manufactures GVC income during the period from 1995 to 2008. The update shown in the final column of Table 1, suggests that this dependence grew further for almost all EU countries. Taken together, the results are indicative of continued specialization in individual EU countries in particular tasks and products.

Table 1. Real GVC income in EU 27 countries, all manufactures.

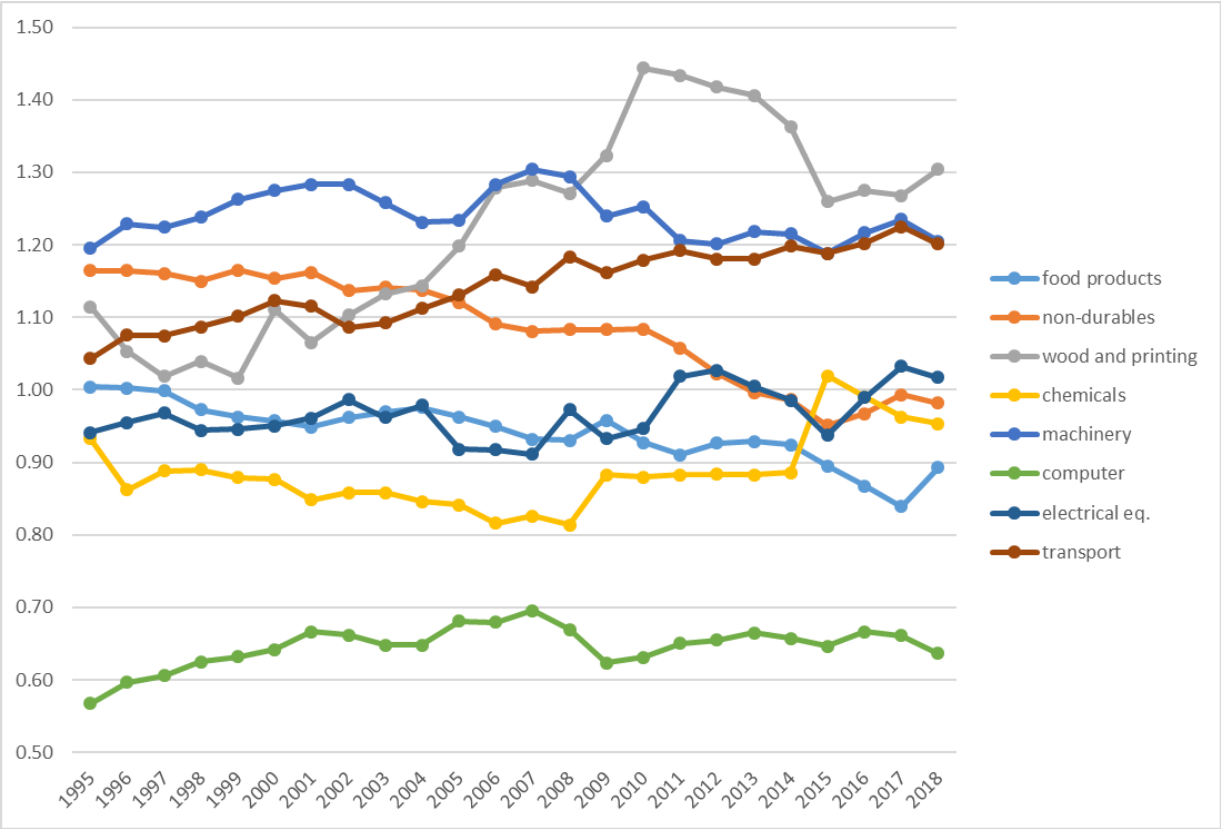
	Real GVC income (in constant $m)				Share in EU27 GVC income		Real GVC income due to foreign demand (%)	
	1995	2008	2011	2018	1995	2018	2008	2018
Germany	623,580	677,914	648,872	593,680	34.0	31.3	53.5	60.0
France	302,105	317,848	304,231	233,334	16.5	12.3	53.2	60.8
Italy	287,630	362,586	347,052	261,766	15.7	13.8	45.1	52.5
Spain	124,911	174,043	166,587	138,038	6.8	7.3	47.2	57.5
Netherlands	94,718	121,980	116,754	99,835	5.2	5.3	71.1	82.5
Belgium	66,846	70,690	67,662	58,372	3.6	3.1	70.8	76.1
Sweden	56,567	70,076	67,074	53,062	3.1	2.8	69.8	71.7
Austria	50,395	64,265	61,512	57,472	2.7	3.0	63.9	71.0
Denmark	35,149	39,307	37,623	33,446	1.9	1.8	71.7	76.4
Poland	34,287	78,995	75,611	80,379	1.9	4.2	53.8	64.8
Finland	28,835	41,419	39,645	25,839	1.6	1.4	66.7	63.4
Portugal	23,650	27,363	26,191	22,472	1.3	1.2	48.7	63.3
Greece	20,997	26,445	25,312	15,365	1.1	0.8	45.7	55.9
Ireland	18,181	39,323	37,639	71,056	1.0	3.7	84.6	93.2
Czech Republic	14,902	43,284	41,430	40,148	0.8	2.1	67.9	77.1
Romania	12,605	34,557	33,077	34,508	0.7	1.8	35.1	49.6
Hungary	10,761	25,549	24,455	21,498	0.6	1.1	75.2	80.3
Slovenia	4,898	8,242	7,889	7,247	0.3	0.4	79.0	82.1
Croatia	4,733	8,212	7,860	5,625	0.3	0.3	38.5	47.7
Slovak Republic	4,356	16,855	16,133	15,665	0.2	0.8	74.2	82.6
Luxembourg	3,990	6,065	5,805	6,263	0.2	0.3	101.2	90.3
Bulgaria	3,635	6,750	6,461	7,899	0.2	0.4	54.2	71.5
Cyprus	1,492	2,037	1,949	1,396	0.1	0.1	54.0	63.2
Lithuania	1,468	7,046	6,744	7,188	0.1	0.4	55.7	67.0
Latvia	1,076	3,470	3,322	2,880	0.1	0.2	54.7	72.6
Malta	972	1,020	976	964	0.1	0.1	71.0	81.6
Estonia	818	2,903	2,778	2,974	0.0	0.2	73.0	76.5
All EU 27	1,833,558	2,278,246	2,180,644	1,898,373	100	100		

Notes: Real GVC income for all manufactures and in constant 1995 prices using US CPI as deflator. US CPI is 1.41 in 2008, 1.48 in 2011, and 1.65 in 2018. Source: Author's calculations based on the OECD Inter-Country Input-Output Tables, release November 2021.

We follow TLSV and investigate to what extent Europe is specializing in business functions within specific product GVCs. The Revealed Comparative Advantage (RCA) analysis is used to measure specialization. When a country's RCA is more than one, it indicates that the country has a greater share of its overall GVC income from its involvement in production of that product, in comparison to other countries. This signifies that the country is specialized in the business functions of GVC production for the said product, however it does not always mean that it is a major exporter of the product, as it may be involved in tasks upstream in the production process, or it may serve a large domestic market.

Figure 2 provides the results of an RCA analysis for the EU27 based on GVC incomes in six groups of final manufacturing products. RCA is calculated as the EU27 share in world GVC income for a product group divided by the EU27 share in world GVC income for all product groups. TLSV found that the EU27 had a strong and increasing RCA in tasks related to the production of machinery and transport equipment. The update confirms the continuation of this trend for transport, which continued throughout. But not for machinery equipment, where we observe a decline in the RCA. The RCA in non-durables is on a declining trend throughout. The declining trend in RCA for chemical products before 2008 is reversed thereafter, suggesting a rebounding since the financial crisis. The EU27's aggregate participation in the production of computer equipment is low.

Figure 2. Revealed comparative advantage of EU27, by group of final manufactures (%)



Notes: Revealed comparative advantage calculated as EU 27 share in world GVC income for a group of manufactures divided by same ratio for all manufactures. Food manufacturing products (Food: produced in ISIC rev. 4 industries 10 to 12), Other non-durable products (Tex: 13 to 15, 31 to 33), Chemical products (Chem: 19 to 24), Machinery and metal products (Mach: 25 and 28), Computer equipment (Comp: 26), Electrical machinery products (Elec: 27) and Transport equipment (Tra: 29, 30). Source: Author's calculations based on the OECD Inter-Country Input-Output Tables, release November 2021.

Aggregate EU27 specialization patterns hide substantial variation within the European Union. In Table 2 we present the RCA for member states, calculated as above, to track particular specialization patterns and compare with China, Japan, South Korea, and the United States. Major Eastern European countries, such as Poland, the Czech Republic, Romania, Hungary, and the Slovak Republic, all continued to improve or stabilize their positions in GVCs of transport equipment. Germany specialized further in activities in the production of transport equipment after 2008. Its specialization in non-electrical machinery reversed after 2008. The Netherlands, Belgium, and Ireland specialize in chemicals. Austria and Sweden in non-electrical machinery. Finland specialized in computer equipment and electrical machinery between 1995 and 2008, but its specialization in computer equipment rapidly eroded thereafter. Italy's specialization in non-durables such as textiles, wearing apparel, and footwear might be expected. But it tends to be relatively low-skill intensive and affected by the rise of exports from Asia. However, this could possibly imply that Italy transitioned in the non-durable value chains away from low-skill assembly and production activities towards higher-skill activities such as branding and design, which will be discussed in more detail in the following section.

Table 2. Revealed comparative advantage based on GVC incomes by product, selected countries

	Chemicals			Computer equipment			Electrical equipment			Food products			Non-elec. machinery and metal			Non-durables			Transport equipment		
	1995	2008	2018	1995	2008	2018	1995	2008	2018	1995	2008	2018	1995	2008	2018	1995	2008	2018	1995	2008	2018
Germany	0.99	0.74	0.80	0.59	0.73	0.73	1.28	1.25	1.27	0.74	0.66	0.60	1.52	1.61	1.50	0.87	0.78	0.71	1.35	1.58	1.65
France	0.89	0.86	0.95	0.64	0.62	0.62	0.72	0.73	0.73	1.21	1.15	1.17	0.87	0.87	0.77	1.18	1.11	1.04	1.07	1.25	1.19
Italy	0.75	0.64	0.76	0.38	0.42	0.41	0.84	0.83	0.95	0.85	0.86	0.86	1.36	1.55	1.49	1.88	1.81	1.65	0.80	0.91	0.89
Spain	0.86	0.80	0.89	0.40	0.32	0.24	0.58	0.90	0.85	1.31	1.29	1.29	0.66	0.86	0.78	1.29	1.17	1.08	1.17	1.17	1.18
Netherlands	1.14	1.17	1.12	0.55	0.99	0.99	0.82	0.61	0.67	1.48	1.17	1.25	0.92	1.02	1.11	0.88	0.82	0.73	0.59	0.76	0.73
Belgium	1.26	1.36	1.80	0.48	0.54	0.48	0.86	0.81	0.71	1.03	0.97	1.02	1.00	1.15	1.02	0.98	0.83	0.71	1.12	0.95	0.74
Sweden	0.89	0.88	0.85	1.16	0.99	0.55	0.91	0.96	0.97	0.75	0.62	0.63	1.39	1.63	1.56	0.62	0.68	0.57	1.26	1.30	1.57
Austria	0.94	0.68	0.84	0.73	0.67	0.78	1.11	1.71	1.68	0.87	0.73	0.74	1.39	1.65	1.59	1.17	1.01	0.88	0.74	1.10	0.99
Denmark	0.94	1.24	1.73	0.60	0.79	0.72	0.76	0.78	0.66	1.41	1.03	0.95	1.29	1.55	1.39	0.99	0.84	0.92	0.50	0.55	0.40
Poland	0.94	0.73	0.83	0.38	0.47	0.42	0.50	0.91	1.15	1.36	1.24	1.16	0.78	1.00	0.95	1.45	1.15	1.10	0.72	1.09	1.07
Finland	0.69	0.61	0.94	1.17	2.26	1.15	0.87	1.15	1.27	1.06	0.70	0.82	1.21	1.63	1.57	0.81	0.67	0.67	0.61	0.60	0.65
Portugal	0.65	0.63	0.67	0.39	0.47	0.41	0.49	0.64	0.73	1.20	1.28	1.20	0.49	0.72	0.69	2.36	2.02	1.95	0.65	0.73	0.84
Greece	1.03	1.15	1.21	0.14	0.27	0.32	0.35	0.59	0.75	1.93	1.69	1.91	0.44	0.71	0.62	1.44	1.17	0.78	0.23	0.37	0.35
Ireland	1.48	1.69	2.60	1.50	1.39	1.17	0.46	0.44	0.35	1.34	1.08	0.70	0.48	0.54	0.49	0.84	1.07	1.17	0.41	0.39	0.31
Czech Republic	0.84	0.56	0.55	0.31	0.78	0.86	1.11	1.11	1.32	1.08	0.74	0.66	1.43	1.41	1.24	1.12	0.95	0.77	0.97	1.66	1.85
Romania	0.83	0.50	0.68	0.38	0.48	0.40	0.43	0.62	1.09	1.61	1.64	1.36	0.89	0.66	0.66	1.32	1.33	1.09	0.58	1.01	1.20
Hungary	0.97	0.93	0.92	0.40	1.15	0.90	0.81	1.29	1.09	1.60	0.96	0.91	0.78	0.80	0.93	0.99	0.67	0.67	0.74	1.40	1.49
Slovenia	0.95	0.98	1.17	0.55	0.56	0.50	1.29	1.78	2.14	0.85	0.63	0.60	0.93	1.41	1.31	1.67	1.14	0.94	0.83	1.10	1.09
Croatia	1.31	0.97	1.20	0.23	0.46	0.40	0.95	1.19	1.20	1.61	1.49	1.31	0.53	0.72	0.95	1.16	1.02	1.18	0.29	0.51	0.43
Slovak Republic	0.90	0.57	0.59	0.28	0.99	0.61	0.97	1.11	1.24	1.15	0.67	0.59	1.27	1.66	1.25	1.19	0.88	0.80	0.80	1.39	1.92
Luxembourg	1.06	0.82	1.20	0.48	0.96	0.75	0.83	0.90	0.88	0.81	0.82	0.84	1.86	1.54	1.41	1.13	1.07	0.99	0.87	1.04	0.90
Bulgaria	1.09	0.68	0.78	0.23	0.32	0.46	0.80	1.06	1.40	1.49	1.40	1.28	1.01	1.22	1.17	1.34	1.57	1.26	0.41	0.48	0.67
Lithuania	0.87	1.23	1.01	0.23	0.45	0.50	0.32	0.45	0.54	1.83	1.68	2.02	0.47	0.89	0.68	1.64	0.72	0.67	0.22	0.40	0.35
Cyprus	0.84	1.43	0.99	0.39	0.29	0.42	0.47	0.40	0.60	1.76	1.50	1.40	0.35	0.44	0.66	1.69	1.35	1.73	0.31	0.40	0.47
Latvia	0.40	0.72	0.67	0.19	0.39	0.55	0.30	0.52	0.86	1.92	1.63	1.49	0.45	0.69	0.68	1.72	1.21	1.24	0.29	0.47	0.51
Malta	1.07	1.26	0.89	0.98	1.55	1.62	0.48	0.65	0.77	1.23	0.80	0.98	0.43	0.50	0.65	1.78	1.69	1.35	0.37	0.56	0.82
Estonia	0.60	0.68	0.71	0.28	0.73	0.68	0.49	0.95	1.32	1.81	1.23	1.10	0.51	0.99	0.93	1.63	1.49	1.54	0.38	0.58	0.61
China	0.66	0.38	0.51	0.87	1.34	1.29	1.04	1.75	1.46	1.22	0.95	0.84	1.20	1.26	1.36	1.25	1.39	1.27	0.70	0.91	1.01
Japan	0.78	0.65	0.83	1.68	1.77	1.37	1.64	1.69	1.33	0.78	0.71	0.85	1.24	1.24	1.22	0.77	0.58	0.66	1.00	1.36	1.25
South Korea	0.52	0.47	0.45	1.86	2.40	2.88	0.87	1.04	1.40	0.74	0.49	0.42	1.08	1.20	1.35	1.09	0.84	0.67	1.23	1.56	1.30
United States	0.97	1.19	1.35	1.28	1.32	1.12	0.75	0.64	0.60	0.87	0.93	0.91	0.89	0.87	0.82	0.92	0.77	0.65	1.25	1.07	1.18

Notes: Revealed comparative advantage calculated as country share in world GVC income for a group of manufactures divided by same ratio for all manufactures. Food manufacturing products (Food: produced in ISIC rev. 4 industries 10 to 12), Other non-durable products (Tex: 13 to 15, 31 to 33), Chemical products (Chem: 19 to 24), Machinery and metal products (Mach: 25 and 28), Computer products (Comp: 26), Electrical machinery products (Elec: 27) and Transport equipment (Tra: 29, 30). Source: Author's calculations based on the OECD Inter-Country Input-Output Tables, release November 2021.

4.2. GVC jobs

Many policy concerns surrounding globalization issues are ultimately about jobs – good jobs in particular. It is thus useful to look at the global division of labour in global value chains and analyse the changes in the characteristics of workers directly and indirectly involved in the production of manufacturing goods, in short manufactures GVC jobs.6 For each country, we will measure the number of workers involved on the domestic territory. We follow TLSV and characterize GVC jobs by sector of employment.

Table 3 below illustrates the developments in the 27 EU countries, China, Japan, South Korea, and the United States from 2008 to 2018. The first two columns display the share of manufacturing GVC workers as a percentage of the overall workforce. The following columns indicate the sectoral structure of employment for these workers, which include agriculture, manufacturing, and services (including mining, construction, and utilities). The first set of columns reflects the number of GVC workers by sector in 2018, and the subsequent four columns show the changes over the 2008-2018 period.

TLSV found that only about half of the workers in manufactures GVCs are actually employed in the manufacturing sector. The other half is employed in non-manufacturing industries delivering intermediates, and this share was growing. Indeed, in most countries, manufactures GVC job increases in services were higher than job losses in manufacturing. These trends continued during the period from 2008 to 2018. However, the trend was less pronounced. TLSV found that in 1995, manufactures GVC workers made up 26% of the total employed labor force in the EU27 and this declined to 22% in 2008. Table 3 indicates that it declined further to 21.2% by 2018.
Notable declines in the shares for Greece, Portugal, and Spain between 1995 and 2008 (cf. Table 5 in TLSV) are not observed or even reversed for the period from 2008 to 2018. Indeed, the final column suggests substantial variation in GVC workers across EU member states. Among others, it increases in Germany, the Netherlands, Austria, Poland, and the Czech Republic. It declines in France, Italy, Spain and Eastern European nations such as Estonia, Latvia, and Lithuania. In some countries, GVC workers in manufacturing are increasing (such as Germany and Poland), but mostly the differently trend in GVC workers across EU countries appears due to changes in GVC workers in services.
These trends suggest that part of the EU, including Austria, Germany and Poland, maintained a competitive position in manufactures GVCs such that manufacturing jobs were growing, whereas other parts of the EU, such as France and Belgium, did not.
In comparison to other major economies, the overall trend in the EU is similar to that observed in China, Japan and the United States. The trend for South Korea, in particular

[6] The data is in number of workers. Ideally, one would prefer to measure the number of hours worked rather than the number of workers employed. This cannot be done due to lack of data.

the expansion of manufacturing jobs in manufactures GVCs, shares similarities with Austria, Germany, and Poland.

Sectoral differences in productivity growth affect the results. In particular, job loss in agriculture reflects rapid improvements in labour productivity and technologies in this sector. It could be contended that a decrease in the proportion of GVC jobs within the overall economy is merely a reflection of the higher productivity growth observed in the manufacturing sector compared to non-traded services, which aligns with Baumol's cost disease hypothesis. When considering a closed economy with a rising per capita income, the final demand for manufactured goods tends to diminish relative to domestic services due to a lower income elasticity, resulting in a reduced workforce requirement. However, for open economies, foreign demand for manufactured goods can counterbalance this trend. Notably, the table illustrates substantial variations among countries in their capacity to capitalize on the expanding demand for manufactured goods in emerging markets.

5. GVC income and jobs by business function

In a world with international production fragmentation, the broad Heckscher–Ohlin predictions will still hold: countries will carry out activities using local value added that is relatively intensive in their relatively abundant factors. Increased opportunities for international production fragmentation may have the tendency to increase specialization of countries as suggested by Baldwin and Evenett (2012).

We examine the number of workers by business function in manufactures GVCs. Table 4 shows the growth rates of manufactures workers by function: engineering, production, support, management and other.7 We find that during 2011-2018 in most EU countries the growth in engineering and support workers was higher than the growth in production workers. In some countries, such as Austria, Poland, Portugal, and Sweden growth in engineering jobs was highest. In other countries such as Germany, Luxembourg, and Romania, support jobs expanded most rapidly. While in Ireland and the Czech Republic management jobs expanded most. Clearly, the EU has been specializing in pre- and post-production jobs. A similar specialization pattern is also observed in China, Japan, and South Korea. In China, production accounts for the majority of manufactures GVC jobs, about 69 percent in 2018. Interestingly, in the US the number of production jobs in manufactures GVCs increased between 2011 and 2018. This expansion of production jobs is also observed in many Eastern European countries.

[7] We examine the period from 2011 to 2018 in this section, because it is the period after the 2008 great financial crises and to avoid breaks in the series due to the methodological changes in the international standard classification, which changed from ISCO1988 to ISCO2008 in the EU LFS.

Overall, Table 4 suggests employment expansion in business functions that are relatively well paid. This happens within the setting of a highly competitive international environment for manufactured goods.

Table 3. Manufactures GVC workers, 2008 and 2018, by sector

	Manufactures GVC workers as (%) share of all workers in the economy		Manufactures GVC workers in 2018 by sector				Change in manufactures GVC workers between 2008 and 2018 (in %)			
	2008	2018	Agriculture (% of total)	Manufacturing (% of total)	Services (% of total)	Total (in thousands)	Agriculture	Manufacturing	Services	Total
Germany	25.1	23.7	2.2	52.9	44.9	10,633	-21.6	2.6	6.6	3.6
France	16.6	14.8	5.6	40.8	53.6	4,159	-16.0	-15.7	1.0	-7.5
Italy	24.3	22.3	5.1	49.6	45.3	5,662	-17.9	-12.5	-1.1	-8.0
Spain	16.4	16.9	9.6	39.5	50.9	3,344	11.6	-15.1	4.5	-3.7
Netherlands	17.7	18.0	5.0	30.2	64.8	1,689	-7.3	-4.5	15.0	7.1
Belgium	20.2	18.2	3.0	37.9	59.1	877	-4.8	-16.0	8.2	-2.8
Sweden	18.8	14.9	3.4	50.0	46.6	761	-1.9	-12.8	-9.5	-11.0
Austria	21.9	21.2	5.9	48.7	45.4	950	-22.7	4.0	14.5	6.3
Denmark	16.3	14.6	5.3	43.7	51.0	434	-17.1	-15.9	-3.1	-9.9
Poland	27.1	27.5	14.0	53.1	32.9	4,504	-20.5	9.6	14.7	5.5
Finland	19.8	16.1	6.7	47.2	46.1	423	-18.7	-21.3	-12.0	-17.1
Portugal	21.8	21.6	15.6	51.8	32.6	1,062	-26.7	-2.3	9.3	-4.0
Greece	13.8	13.8	19.8	35.6	44.6	622	-1.4	-24.6	9.8	-7.3
Ireland	19.9	18.1	10.3	37.8	51.9	401	-26.3	-13.8	8.6	-5.3
Czech Republic	30.1	30.8	4.1	61.3	34.6	1,671	0.0	4.5	11.4	6.6
Romania	28.1	29.2	28.7	45.7	25.6	2,521	-21.5	-7.2	38.3	-4.2
Hungary	26.8	24.6	6.4	55.9	37.7	1,149	4.4	2.8	10.5	5.7
Slovenia	25.6	25.1	6.3	57.5	36.3	256	-15.9	-5.4	14.5	0.1
Croatia	22.5	20.4	8.7	58.8	32.6	340	-51.3	-14.7	5.0	-15.0
Slovak Republic	28.6	27.8	3.7	57.8	38.5	672	10.8	1.2	9.6	4.6
Luxembourg	19.1	18.0	1.4	32.3	66.3	81	-9.6	0.7	35.3	21.0
Bulgaria	26.9	27.4	20.8	47.1	32.2	964	0.2	-17.9	13.0	-6.1
Lithuania	23.1	22.1	10.1	51.4	38.5	305	-32.1	-7.0	0.9	-7.7
Cyprus	14.6	12.0	10.0	43.5	46.5	51	-10.9	-15.7	-12.9	-14.0
Latvia	18.4	17.6	12.3	48.2	39.5	158	-25.1	-21.5	-11.8	-18.4
Malta	18.5	13.4	1.6	43.6	54.8	32	-26.6	-12.6	30.9	6.4
Estonia	21.1	19.7	5.8	57.1	37.0	128	-21.4	-6.2	8.7	-2.4
All EU 27	22.1	21.2	8.0	48.4	43.7	43,846	-16.0	-5.1	6.4	-1.5
China	35.3	29.7	34.2	35.2	30.5	225,283	-38.8	-7.1	24.2	-15.6
Japan	21.6	18.7	7.9	53.8	38.3	12,743	-18.7	-4.7	-17.4	-11.1
South Korea	23.1	22.3	7.0	47.5	45.5	5,985	-25.2	7.3	19.5	9.1
United States	12.4	11.4	5.5	45.4	49.1	18,755	-0.1	-5.0	1.8	-1.5

Notes: Manufactures GVC workers are workers directly and indirectly involved in the production of final manufacturing goods. The first two columns indicate the share of GVC workers in the total number of workers in the economy. Next four columns indicate the total number of GVC workers by sector in 2018. And the last four columns indicate the change in the number of GVC workers by sector between 2008 and 2018. Source: Author's calculations based on the OECD Inter-Country Input-Output Tables, release November 2021 and OECD TiM, release 2021.

Table 4. Growth in manufactures GVC workers by business function, 2011 and 2018

	Engineering			Production			Support			Management			Other		
	2011	2018	change	2011	2018	change	2011	2018	change	2011	2018	change	2011	2018	change
Germany	1,337	1,311	-1.9	3,906	3,889	-0.4	3447.6	3886.0	12.7	571.5	551.6	-3.5	926.1	994.2	7.4
France	616	523	-15.0	1,521	1,495	-1.7	1256.9	1256.5	0.0	337.3	347.8	3.1	471.1	536.2	13.8
Italy	436	550	26.1	2,544	2,345	-7.8	1916.9	1949.4	1.7	213.3	191.9	-10.0	469.4	625.7	33.3
Spain	210	246	16.9	1,496	1,544	3.2	898.9	934.1	3.9	175.6	158.9	-9.5	384.9	460.7	19.7
Netherlands	132	133	1.2	504	502	-0.4	611.6	676.5	10.6	113.4	95.0	-16.2	240.7	282.0	17.2
Belgium	100	85	-15.2	285	289	1.4	300.9	299.1	-0.6	70.1	80.5	14.8	101.1	123.0	21.7
Sweden	85	121	42.0	327	258	-21.0	226.4	255.1	12.7	45.6	54.5	19.7	75.1	71.3	-5.1
Austria	87	110	27.2	387	379	-2.1	280.7	316.3	12.7	46.7	44.8	-4.1	85.6	99.6	16.3
Denmark	42	59	40.3	156	160	2.1	154.4	149.4	-3.2	10.7	7.2	-33.1	54.4	58.9	8.2
Poland	245	447	82.6	2,469	2,469	0.0	880.6	1063.6	20.8	228.5	248.7	8.8	249.8	275.3	10.2
Finland	59	60	2.1	198	170	-13.9	125.2	132.2	5.6	29.3	14.3	-51.2	47.0	45.6	-3.0
Portugal	49	74	49.0	639	610	-4.5	176.6	218.2	23.6	58.5	54.5	-6.9	96.7	105.8	9.4
Greece	36	31	-14.2	391	321	-17.9	182.0	212.1	16.5	21.5	18.6	-13.3	33.3	39.0	17.2
Ireland	20	29	44.7	154	172	12.3	103.6	117.9	13.8	25.6	39.4	54.0	29.3	42.0	43.5
Czech Republic	144	173	20.5	794	869	9.5	397.6	438.3	10.2	62.1	75.9	22.2	101.7	114.6	12.7
Romania	119	132	10.4	1,919	1,819	-5.2	294.8	360.0	22.1	38.8	32.5	-16.3	161.0	177.9	10.5
Hungary	69	82	19.2	557	636	14.1	248.9	292.6	17.6	50.4	42.9	-14.9	91.7	95.6	4.3
Slovenia	21	24	14.9	110	121	10.0	58.5	68.7	17.4	19.1	20.7	8.6	17.7	21.1	19.0
Croatia	28	33	19.0	213	180	-15.5	82.7	86.3	4.3	14.8	14.8	0.2	25.4	25.6	0.9
Slovak Republic	49	54	11.3	321	349	8.7	166.7	180.9	8.6	31.3	29.1	-7.1	45.4	59.4	30.6
Luxembourg	7	6	-10.7	24	24	-0.6	27.8	37.2	33.7	3.4	2.8	-17.6	8.3	10.6	27.2
Bulgaria	41	49	19.6	607	577	-4.9	182.9	205.7	12.5	51.3	54.8	6.8	95.9	77.1	-19.6
Lithuania	16	18	16.6	161	167	3.6	71.6	69.6	-2.8	23.5	24.3	3.6	22.3	25.2	13.1
Cyprus	2	3	38.8	22	23	4.8	18.8	17.6	-6.6	2.7	2.4	-10.7	6.4	5.2	-18.3
Latvia	10	10	2.8	87	83	-4.7	38.0	38.5	1.2	15.9	14.1	-11.4	13.1	12.3	-6.1
Malta	2	3	19.7	11	12	4.8	6.3	9.8	57.0	2.1	3.0	42.2	3.6	4.2	13.9
Estonia	9	10	15.9	66	63	-3.6	27.6	29.4	6.6	10.2	15.2	48.4	9.6	9.4	-1.4
All EU 27	3,969	4,377	10.3	19,868	19,530	-1.7	12,185	13,301	9.2	2,273	2,240	-1.4	3,867	4,398	13.7
China	6,734	9,293	38.0	197,829	156,188	-21.0	41,087	45,355	10.4	5,062	4,897	-3.3	9,599	9,550	-0.5
Japan	1,119	1,198	7.0	6,585	6,215	-5.6	4,245	4,019	-5.3	485	457	-5.8	843	855	1.4
South Korea	444	394	-11.1	2,814	2,523	-10.4	2,178	2,174	-0.2	95	87	-8.5	630	808	28.3
United States	1,331	1,951	46.6	6,613	6,976	5.5	5,581	5,323	-4.6	1,949	1,510	-22.5	2,486	2,995	20.5

Notes: Manufactures GVC workers are workers directly and indirectly involved in the production of final manufacturing goods. Change is the (log) growth rate between 2011 and 2018. Sources: Author's calculations based on the OECD Inter-Country Input-Output Tables, release November 2021, OECD TiM, release 2021, and the Occupation Database.

In Table 5, we observe that about two thirds of EU income in manufactures' GVCs originates from workers involved in pre- and post-production functions in 2018. This increased during the period from 2011 to 2018. In particular, the share of support tasks (such as marketing and after sales services) increased by 1.8 percentage points. In contrast, production declined by 0.6 percentage points. This suggests a clear but gradual specialization pattern away from production and towards the upstream and downstream end of global value chains. Still almost one third of income in GVC is earned by performing production tasks.

In Table 5 we trace the sectoral origins of changes in business functions for the EU as a whole. We focus on the major sectors. The top panel of table 5 splits up the total shares of

functions in 2018. As discussed, the GVC approach measures direct and indirectly embodied functions in final products. This is borne out by Table 5 where a substantial part of income shares across functions originates from services sectors, in particular business services for pre- and post-production functions.

The bottom part of Table 5 shows the contribution from sectors to the changes in shares between 2011 and 2018. The share of production declined, and the results suggest this mainly originated from a decline in agriculture and mining. In contrast, production tasks in chemicals and transport manufacturing expanded. Much of the increase in pre- and post-production functions originates in industry. About 1.3 (0.5) percentage points of the 1.8 (0.2) percentage points change in support (engineering) activities originates in industry. Support activities also expanded in services, in particular in business services, rising by 0.5 percentage points. These business services are a heterogeneous grouping, consisting of architecture, research, consulting, and various other services. Some of these business services are closely related to pre- and post-production functions (e.g. R&D and design) and have expanded considerably during the past decades. Overall, it suggests the aggregate pattern of specialization in pre- and post-production functions is broad based.
What explains the decreasing income share from production? The production stage's costs are reduced by offshoring, leading to a decline in value added. According to Baldwin (2012), there are three primary drivers of this decline in low-skilled production: specialization according to comparative advantage, multinational firms combining capital and technologies with low wages, and standardized production tasks with high competition keeping wages low. On the other hand, tasks not offshored tend to be those with more market power, such as design, branding, or product differentiation.

Table 5. EU Income in manufactures' GVCs by sector and business function

	Engineering	Production	Support	Management	Other	Total
2018 shares						
Industry, of which	**11.4**	**23.8**	**12.4**	**6.2**	**1.3**	**55.1**
Food	0.7	3.8	1.9	0.7	0.3	7.3
Chemical	3.0	4.4	3.0	1.6	0.5	12.4
Machinery and metal	2.4	5.1	2.3	1.3	0.1	11.3
Transport	2.6	4.1	1.9	0.8	0.1	9.5
Other industry	2.6	6.5	3.4	1.7	0.4	14.6
Services, of which	**3.8**	**7.1**	**21.0**	**5.2**	**4.2**	**41.4**
Trade and construction	0.6	2.9	6.9	1.9	0.7	13.0
Business services	2.1	1.1	10.7	2.2	2.1	18.0
Non-market services	1.1	3.2	3.4	1.1	1.5	10.3
Agriculture and mining	**0.2**	**2.7**	**0.3**	**0.2**	**0.2**	**3.6**
Total	***15.3***	***33.7***	***33.7***	***11.6***	***5.7***	***100***
Change in shares over 2011-2018						
Industry, of which	**0.5**	**-0.1**	**1.3**	**0.5**	**-0.4**	**1.8**
Food	0.0	-0.1	0.1	-0.1	-0.1	-0.1
Chemical	0.2	0.1	0.3	0.3	-0.1	0.8
Machinery and metal	0.0	0.0	0.2	0.1	0.0	0.2
Transport	0.4	0.3	0.5	0.1	0.0	1.3
Other industry	-0.1	-0.3	0.1	0.1	-0.1	-0.4
Services, of which	**-0.2**	**0.1**	**0.7**	**-0.5**	**-0.9**	**-0.8**
Trade and construction	0.1	0.2	0.1	-0.1	-0.6	-0.3
Business services	0.0	0.1	0.5	-0.3	-0.2	0.1
Non-market services	-0.2	-0.2	0.0	-0.1	-0.1	-0.6
Agriculture and mining	**-0.2**	**-0.6**	**-0.1**	**0.0**	**0.0**	**-1.0**
Total	***0.2***	***-0.6***	***1.8***	***-0.1***	***-1.3***	***0***

Notes: Manufactures GVC income directly and indirectly involved in the production of final manufacturing goods.
Sources: Author's calculations based on the OECD Inter-Country Input-Output Tables, release November 2021, and the Occupation Database.

What does this imply for functional specialization in GVCs? Table 6, provides a specialization index, which compares a country's share in GVCs of a particular function to its overall share.8 If the index is above one, the country is said to be specialized in that function.

The allocation of countries to a particular group is based on the highest functional specialization index of the country in 2018. This maximum can only be for one function such that the groups are mutually exclusive. Interestingly, we find that EU countries, even those at similar levels of income, have rather different specialization patterns. For example, we observe strong specialization in engineering in Finland, Germany and Sweden, in management in France and Belgium, in support activities in Italy and Luxembourg. In general, western EU countries tend to specialize in pre- and post-production functions whereas south and eastern EU countries specialization in production although this effect does not come out strongly due to the specialization of China in production. The

8 Note the difference to the specialization measure presented in Table 2. In Table 2, income shares for a particular industry are compared to the overall income share for each country. In Table 6, income shares by activity of a country are compared to the overall income share for the EU, China, Japan, South Korea, and the United States.

specialization indices are suggestive of a regional division of labor within the EU with typically western EU countries orchestrating production networks that reach deep into the region.

The findings indicate that a country's specialization pattern is determined by a variety of factors. Western EU countries have well-functioning legal systems, high-quality infrastructure, and high levels of human capital. Hence, the differences in specialization must be attributed to other factors such as size, geographical characteristics, and historical built up of capabilities and networks. These characteristics are likely to develop and diminish gradually. Tellingly, the majority of countries had the same highest functional specialization index in 2018 compared to 2011. This indicates that specialization patterns evolve slowly.

This period is relatively brief and thus further research is needed to measure stability over a longer timeframe. Additionally, it is important to note that the specialization index is a relative measure based on the comparison of value added in various functions of a country, and does not provide information about the overall functions in the country. Therefore, it should be interpreted in combination with information on the volume of business functions, presented above.

6. Concluding remarks and policy discussion

This report employed a global value chain approach that accounted for the significance of global production networks and the growing connection between output, consumer demand, and remuneration to production factors across borders. The global value chain approach poses a new angle to examine the competitive strength of firms and nations in the global economy. The GVC perspective aims to advance policy debates on how to measure and interpret competitiveness.

Specialization in business functions is a slow moving process. Specialization in sectors is likely driven by developments in countries' endowments such as the built up of human capital or the business environment. But it also points to the possibility of spill overs and complementarities due to for example the need for specific job skills, shared infrastructure or need for specialized inputs and services. In addition, it may also be related to less tangible spill overs in knowledge and soft technologies associated with the entrepreneurial discovery process. These considerations make it likely that attracting backshoring will be related to the historical build-up of knowledge and a supporting infrastructure by countries in specific sectors.

The gradual shift away from production and towards pre- and post-production functions likely implies that backshoring of production tasks will be limited, although new investments such as for solar panels and electric panels relate to demand for workers performing production and engineering tasks. Given the supply of workers and high wages, it is likely that new investments will go hand in hand with the adoption of highly automated capital-intensive production technologies.

Table 6. Functional specialization in GVCs, 2011 and 2018

	Engineering	Production	Support	Management	Other	Engineering	Production	Support	Management	Other
	2018	2018	2018	2018	2018	2011	2011	2011	2011	2011
Specialized in engineering										
Germany	**1.34**	0.73	**1.22**	**1.12**	0.92	**1.62**	0.75	**1.14**	0.95	0.97
Sweden	**1.60**	0.71	**1.12**	**1.14**	0.94	**1.30**	0.92	**1.04**	0.81	**1.17**
Austria	**1.30**	0.80	**1.11**	**1.03**	**1.17**	**1.24**	0.83	**1.12**	0.99	**1.20**
Denmark	**1.67**	0.71	**1.22**	0.31	**1.56**	**1.39**	0.76	**1.27**	0.41	**1.73**
Finland	**1.46**	0.82	**1.10**	0.72	**1.19**	**1.50**	0.83	0.94	**1.15**	**1.20**
Ireland	**1.53**	0.76	0.92	**1.48**	**1.14**	**1.22**	0.88	**1.06**	0.95	**1.27**
Specialized in management										
France	**1.35**	0.68	**1.02**	**1.61**	**1.39**	**1.76**	0.67	0.99	**1.27**	**1.34**
Belgium	0.99	0.61	**1.17**	**1.93**	**1.37**	**1.29**	0.62	**1.21**	**1.37**	**1.37**
Portugal	0.97	0.91	0.89	**1.58**	**1.25**	0.88	0.89	0.88	**1.63**	**1.33**
Slovenia	1.00	0.90	0.99	**1.54**	0.93	**1.15**	0.84	0.99	**1.46**	**1.01**
Malta	0.89	0.76	**1.13**	**1.51**	**1.42**	**1.13**	0.92	0.88	**1.14**	**1.61**
Estonia	0.73	0.94	0.90	**1.96**	0.88	0.82	**1.03**	0.92	**1.30**	0.98
Bulgaria	0.78	0.99	0.98	**1.43**	0.96	0.76	**1.07**	0.90	**1.12**	**1.22**
Lithuania	0.70	**1.09**	0.87	**1.48**	0.92	0.84	**1.03**	0.92	**1.28**	0.90
Latvia	0.70	**1.03**	0.92	**1.59**	0.88	0.73	**1.04**	0.90	**1.38**	**1.03**
Poland	**1.01**	0.96	**1.04**	**1.14**	0.84	0.81	**1.06**	0.98	**1.08**	0.87
Specialized in support										
Italy	0.95	0.81	**1.25**	**1.06**	**1.17**	0.86	0.85	**1.30**	0.90	**1.08**
Luxembourg	0.69	0.44	**2.01**	0.74	**1.09**	0.92	0.43	**1.88**	0.91	**1.10**
Cyprus	0.71	0.68	**1.43**	**1.42**	**1.09**	0.56	0.59	**1.54**	**1.41**	**1.36**
Greece	0.57	0.99	**1.32**	0.75	0.81	0.77	**1.11**	**1.13**	0.59	0.81
Croatia	**1.07**	0.93	**1.14**	0.77	**1.05**	**1.16**	0.92	**1.12**	0.76	**1.12**
Specialized in other										
Netherlands	**1.02**	0.58	**1.44**	**1.06**	**1.58**	**1.25**	0.60	**1.40**	**1.01**	**1.41**
Spain	0.93	0.97	0.94	**1.08**	**1.48**	0.93	0.96	0.94	**1.15**	**1.38**
Specialized in production										
Czech Republic	**1.04**	**1.09**	0.95	0.87	0.75	**1.12**	**1.10**	0.97	0.69	0.80
Romania	0.97	**1.26**	0.82	0.38	**1.08**	**1.17**	**1.40**	0.62	0.42	0.80
Only specialized in production										
Hungary	0.86	**1.20**	0.89	0.64	0.97	**1.02**	**1.11**	0.89	0.83	**1.06**
Slovak Republic	0.87	**1.15**	0.91	0.83	0.97	0.97	**1.08**	0.99	0.84	0.88
Specialization in other major economies										
China	0.52	**1.41**	0.86	0.40	0.82	0.44	**1.49**	0.80	0.37	0.81
Japan	**1.10**	**1.13**	**1.04**	0.40	0.65	**1.10**	**1.14**	**1.08**	0.36	0.70
South Korea	**1.30**	0.84	**1.10**	0.75	**1.40**	**1.22**	0.84	**1.13**	0.72	**1.59**
United States	**1.33**	0.69	0.99	**1.84**	**1.14**	**1.07**	0.69	0.99	**2.03**	**1.08**

Notes: GVC income share by business function of a country relative to GVC income share of business function in EU 27, China, Japan, South Korea, and the United States. Entries bigger than one in bold. Allocation of countries to a particular group are based on the highest functional specialization index of the country in 2018. *Sources*: Author's calculations based on the OECD Inter-Country Input-Output Tables, release November 2021, and the Occupation Database.

The validity of the findings in this report is heavily dependent on the quality of the databases that are used. To maximize the use of the available data on national input-output tables, international trade statistics, and production factor incomes, the data was constructed with great care. However, inconsistencies are unavoidable, and compromises had to be made. It

is evident that current statistical systems are lagging behind the rapid changes of today's world, particularly in terms of trade in services and intangibles such as royalties and licenses. Future development of international trade statistics should prioritize the inclusion of these factors.

This study provides indicative trends in macro-economic trends, and further micro-studies are necessary to gain a deeper understanding of the dynamics of global value chains. It is important to investigate the factors that lead to fragmentation, such as the so-called 'viscidity' that keeps activities locally clustered (Baldwin and Evenett, 2015). Micro-case studies on industrial clusters, such as those surveyed by Frenken, Cefis and Stam (2015), will offer insights into the spill overs between activities. Additionally, it is critical to comprehend the clustering and fragmentation of tasks across individual workers.

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Technical appendix.
Measuring business functions in global value chains

We follow the approach outlined in Timmer et al. (2013) which is an extension of a standard input-output decomposition technique introduced by Leontief (1949) towards a multi-country setting. Leontief's seminal insight is rather straightforward and intuitive: to produce output one needs labor, capital and intermediate inputs. These intermediates need to be produced themselves, involving again production factors and intermediates, and so on, until all intermediates are accounted for. Leontief provided a mathematical model which allows one to trace the factor inputs needed in all the stages of production a particular final good. By tracing the value added at all stages of production, it provides an ex-post accounting of the value of final products. This allows one to measure the importance of foreign demand relative to domestic demand for home-country value added growth, in a consistent framework.[9]

We start by assuming that there are N countries, S industries in each country.[10] Output in each industry of each country is produced using domestic production factors (capital and labor) and intermediate inputs, which may be sourced domestically or from foreign suppliers. Output may be used to satisfy final demand or be used as an intermediate input in production, at home or abroad. Final demand consists of household and government consumption and investment.[11] To track the shipments of intermediate and final goods within and across countries, it is necessary to define source and destination countries, as well as source and destination industries.

Let **y** be the output vector of dimension (SNx1), the elements of which represent output levels in each country-industry. We further define a global input-output matrix **A** of dimension (SNxSN) with elements $a_{ij}(s,t) = m_{ij}(s,t)/y_j(t)$, which are intermediate input coefficients. These give the cost shares of output from industry *s* in country *i* used by industry *t* in country *j*. They are defined as the value of intermediate inputs as a share of gross output by the using sector. The matrix **A** can be written as

[9] See Miller and Blair (2009) for an elementary introduction into input-output analysis.
[10] We use the term country-industry to denote an industry in a country, such as the Chinese chemicals industry and the German transport equipment industry.
[11] In the input-output tables these final demand categories are separately modelled, but they are taken together for the empirical analysis.

$$\mathbf{A} \equiv \begin{bmatrix} \mathbf{A}_{11} & \mathbf{A}_{12} & \cdots & \mathbf{A}_{1N} \\ \mathbf{A}_{21} & \mathbf{A}_{22} & \cdots & \mathbf{A}_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{A}_{N1} & \mathbf{A}_{N2} & \cdots & \mathbf{A}_{NN} \end{bmatrix}, \quad (1)$$

where $\mathbf{A}_{ij}$ is an SxS matrix with typical element $a_{ij}(s,t)$. The sub-matrices on the main diagonal contain the cost shares of domestically produced intermediate inputs, while the off-diagonal sub-matrices contain the cost shares of foreign intermediate inputs. The matrix **A** thus summarizes the input requirements of all intermediate goods across industries and countries. We can use it to rewrite the stacked SN market clearing conditions as

$$\begin{bmatrix} \mathbf{y}_1 \\ \mathbf{y}_2 \\ \vdots \\ \mathbf{y}_N \end{bmatrix} \equiv \begin{bmatrix} \mathbf{A}_{11} & \mathbf{A}_{12} & \cdots & \mathbf{A}_{1N} \\ \mathbf{A}_{21} & \mathbf{A}_{22} & \cdots & \mathbf{A}_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{A}_{N1} & \mathbf{A}_{N2} & \cdots & \mathbf{A}_{NN} \end{bmatrix} \begin{bmatrix} \mathbf{y}_1 \\ \mathbf{y}_2 \\ \vdots \\ \mathbf{y}_N \end{bmatrix} + \begin{bmatrix} \sum_j \mathbf{f}_{1j} \\ \sum_j \mathbf{f}_{2j} \\ \vdots \\ \sum_j \mathbf{f}_{Nj} \end{bmatrix} \quad (2)$$

In this expression, $\mathbf{y}_i$ represents the S-vector with production levels in country *i*, and $\mathbf{f}_{ij}$ indicates the S-vector of final demands in country *j* for the products of country *i*. In compact form, this system can be expressed as:

$$\mathbf{y} = \mathbf{A}\mathbf{y} + \mathbf{f} \quad (3)$$

Rearranging (3), we arrive at the fundamental input-output identity:

$$\mathbf{y} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{f} \quad (4)$$

I is an (SNxSN) identity matrix with ones on the diagonal and zeros elsewhere. $(\mathbf{I} - \mathbf{A})^{-1}$ is famously known as the Leontief inverse. It represents the gross output values in all stages of production that are generated in the production process of one unit of final output. To see this, let **z** be a column vector with the first element representing the global consumption of products from the first country-industry, while all the remaining elements are zero. The production of final output **z** requires intermediate inputs given by **Az**. In turn, the production of these intermediates requires the use of other intermediates given by **A(Az)**, and so on. As a result, the increase in gross output in all industries is given by the sum of all direct and indirect effects $\sum_{k=0}^{\infty} \mathbf{A}^k \mathbf{z}$. This geometric series can be rewritten as $(\mathbf{I} - \mathbf{A})^{-1}\mathbf{z}$. This represents the gross output levels in each of the SN industries that are induced by global final demand for the products of the first country-industry.

To measure the value added of activities in the production chain of a particular product, we need to model the production process more explicitly. Let the quantity of output in an industry be a standard function of the quantities of labor, capital and intermediate inputs used. By the usual accounting definition, the value of output of the industry is then equal to the value of all inputs used, and is expressed in dollars in our data. Let $y_i(s)$ be the value of output in industry *s* of country *i*, then we can define $l_i^u(s)$ as the value added by workers in activity *u* (as measured by their labor income plus capital income proportionally allocated) in industry *s* in country *i* per dollar output in the industry, and create the column vector $\mathbf{l}^u$ with dimension SNx1 for activity *u*. Importantly, the elements in this vector are country- and industry-specific. This vector indicates the value added in one particular activity. We define a new matrix $\mathbf{L}^u$ that indicates the value in activity *u* in each country-sector that

is added in all stages of production of a final product. We derive this for a particular product by pre-multiplying the gross outputs needed for production of this product as derived in (4):

$$\boldsymbol{L^u = \widehat{l^u}(\mathbf{I} - \mathbf{A})^{-1}\mathbf{f}} \qquad (5)$$

where a hat indicates a diagonal matrix with the elements of a vector on the diagonal. If the final demand vector **f** is chosen to represent say worldwide final demand for the products sold by the German transport equipment industry, $\mathbf{L^u}$ represents the value added in activity *u* in each country-industry in the world that contributes to production. Elements in this matrix can be added across industries in a country to arrive at the activity contribution of countries in a particular value chain. By repeating the same decomposition for final demand for all manufacturing products in the world (the SN elements) and for each activity, and then summing across industries within a country provides the distribution of activity value added of a country in manufactures production. The latter is central to the analyses in this report.

Data appendix.

Appendix Table 1: Country list Inter-Country Input-Output Tables, 2021 edition

	Code	Countries		Code	Countries
1	AUS	Australia	40	ARG	Argentina
2	AUT	Austria	41	BRN	Brunei Darussalam
3	BEL	Belgium	42	BGR	Bulgaria
4	CAN	Canada	43	KHM	Cambodia
5	CHL	Chile	44	CHN	China (People's Republic of)
6	COL	Colombia	45	HRV	Croatia
7	CRI	Costa Rica	46	CYP	Cyprus
8	CZE	Czech Republic - Czechia	47	HKG	Hong Kong, China
9	DNK	Denmark	48	IND	India
10	EST	Estonia	49	IDN	Indonesia
11	FIN	Finland	50	KAZ	Kazakhstan
12	FRA	France	51	LAO	Lao (People's Democratic Republic)
13	DEU	Germany	52	MYS	Malaysia
14	GRC	Greece	53	MLT	Malta
15	HUN	Hungary	54	MAR	Morocco
16	ISL	Iceland	55	MMR	Myanmar
17	IRL	Ireland	56	PER	Peru
18	ISR	Israel	57	PHL	Philippines
19	ITA	Italy	58	ROU	Romania
20	JPN	Japan	59	RUS	Russian Federation
21	KOR	Korea	60	SAU	Saudi Arabia
22	LVA	Latvia	61	SGP	Singapore
23	LTU	Lithuania	62	ZAF	South Africa
24	LUX	Luxembourg	63	TWN	Chinese Taipei
25	MEX	Mexico	64	THA	Thailand
26	NLD	Netherlands	65	TUN	Tunisia
27	NZL	New Zealand	66	VNM	Viet Nam
28	NOR	Norway	67	ROW	Rest of the World
29	POL	Poland			
30	PRT	Portugal			
31	SVK	Slovak Republic			
32	SVN	Slovenia			
33	ESP	Spain			
34	SWE	Sweden			
35	CHE	Switzerland			
36	TUR	Türkiye			
37	GBR	United Kingdom			
38	USA	United States			
39	BRA	Brazil			

Notes: data are presented for 66 countries (i.e. 38 OECD countries and 28 non-OECD economies), and the Rest of the World.

Appendix Table 2: 45 industries in ICIO tables, 2021 edition

Code	Industry	ISIC Rev.4
A01_02	Agriculture, hunting, forestry	01, 02
A03	Fishing and aquaculture	03
B05_06	Mining and quarrying, energy producing products	05, 06
B07_08	Mining and quarrying, non-energy producing products	07, 08
B09	Mining support service activities	09

C10T12	Food products, beverages and tobacco	10, 11, 12
C13T15	Textiles, textile products, leather and footwear	13, 14, 15
C16	Wood and products of wood and cork	16
C17_18	Paper products and printing	17, 18
C19	Coke and refined petroleum products	19
C20	Chemical and chemical products	20
C21	Pharmaceuticals, medicinal chemical and botanical products	21
C22	Rubber and plastics products	22
C23	Other non-metallic mineral products	23
C24	Basic metals	24
C25	Fabricated metal products	25
C26	Computer, electronic and optical equipment	26
C27	Electrical equipment	27
C28	Machinery and equipment, nec	28
C29	Motor vehicles, trailers and semi-trailers	29
C30	Other transport equipment	30
C31T33	Manufacturing nec; repair and installation of machinery and equipment	31, 32, 33
D	Electricity, gas, steam and air conditioning supply	35
E	Water supply; sewerage, waste management and remediation activities	36, 37, 38, 39
F	Construction	41, 42, 43
G	Wholesale and retail trade; repair of motor vehicles	45, 46, 47
H49	Land transport and transport via pipelines	49
H50	Water transport	50
H51	Air transport	51
H52	Warehousing and support activities for transportation	52
H53	Postal and courier activities	53
I	Accommodation and food service activities	55, 56
J58T60	Publishing, audiovisual and broadcasting activities	58, 59, 60
J61	Telecommunications	61
J62_63	IT and other information services	62, 63
K	Financial and insurance activities	64, 65, 66
L	Real estate activities	68
M	Professional, scientific and technical activities	69 to 75
N	Administrative and support services	77 to 82
O	Public administration and defence; compulsory social security	84
P	Education	85
Q	Human health and social work activities	86, 87, 88
R	Arts, entertainment and recreation	90, 91, 92, 93
S	Other service activities	94,95, 96
T	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	97, 98

Appendix table 3: Classification of occupational groupings into business functions

Occupational grouping	Description	Business function
1	Legislators	Management
2	Managers	Management
3	Engineering professionals	Engineering
4	Health professionals	Other
5	Teaching professionals	Other
6	Other professionals	Support
7	Clerical support workers	Support

8	Personal service workers	Other
9	Sales workers	Support
10	Craft workers and machine operators	Production
11	Agricultural workers	Production
12	Other, including armed forces	Other
13	Drivers	Production

***Notes*: occupational grouping based on Reijnders and de Vries (2018)**