Fragmentation, incomes and jobs: an analysis of European competitiveness

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1. INTRODUCTION

The competitiveness of nations is a topic that frequently returns in mass media, governmental reports and discussions of economic policy. While specific definitions of national competitiveness are much debated, most economists would agree that the

We are grateful for the comments and suggestions received from many colleagues over the years at seminars at the World Bank, ECB, OECD, EU Directorates General for Trade and for Economic and Financial Affairs, Harvard, MERIT Maastricht, University of Groningen, Trinity College, Korea Productivity Centre, Dutch Ministry of Economic Affairs, Upjohn Institute, and at various WIOD meetings, the final conference of INDICSER in Budapest, the WIOD launch meeting in Brussels and the EP panel meeting in Dublin. Particular thanks to Richard Baldwin for encouragement and advice. Reitze Gouma, Abdul Azeez Erumban and Neil Foster provided excellent research assistance. Comments from the Panel discussants Josep Pijoan-Mas and Alexander Michaelides, four anonymous referees and an editor are also gratefully acknowledged. This paper is part of the World Input–Output Database (WIOD) project that was funded during the period from 2009 to 2012 by the European Commission, Research Directorate General as part of the 7th Framework Programme, Theme 8: Socio-Economic Sciences and Humanities, grant Agreement no: 225 281. More information on the WIOD-project can be found at www.wiod.org.

The Managing Editor in charge of this paper was Nicola Fuchs-Schündeln.

Economic Policy October 2013 pp. 613–661 Printed in Great Britain

concept refers to a country's ability to realize income and employment growth without running into long-run balance of payments difficulties. The ability of advanced nations to maintain 'good jobs' in the face of rising global competition is a long-standing concern. The unleashing of the market economy in China and India added to global competitive pressures, casually linked to dwindling manufacturing employment in traditional strongholds in Western Europe, Japan and the US and curtailing development opportunities for other emerging economies such as in Eastern Europe. Slow recovery after the global financial crisis in 2008, fuelled demands for more active industrial policies to restore competitiveness around the world. Rebuilding the competitive strengths of Europe, and in particular curbing the divergence between Northern and Mediterranean countries, is therefore high on the European policy agenda.

To track developments in competitiveness, shares in world export markets are traditionally used as the main indicator. However, this measure is increasingly doubted in a world with increasing fragmentation of production across borders. Fostered by rapidly falling communication and coordination costs, the various stages of production need not be performed near to each other anymore. Increased possibilities for fragmentation mean in essence that more parts of the production process become open to international competition. In the past competitiveness of countries was determined by domestic clusters of firms, mainly competing 'sector to sector' with other countries, based on the price and quality of their final products. But globalization has entered a new phase in which international competition increasingly plays out at the level of activities within industries, rather than at the level of whole industries, dubbed the 'second unbundling' by Baldwin (2006) (see also Feenstra, 1998, 2010). To reflect this change in the nature of competition, a new measure of competitiveness is needed that is based on the value added in production by a country, rather than the gross output value of its exports. Or as put by Grossman and Rossi-Hansberg (2006, pp. 66–7): '[But] such measures are inadequate to the task of measuring the extent of a country's international integration in a world with global supply chains … we would like to know the sources of the value added embodied in goods and the uses to which the goods are eventually put.' In this paper we present a framework which is developed to do just this. We propose a new measure of the competitiveness of a country based on value added and jobs involved in global production chains, and show how it can be derived empirically from a world input–output table.

Concerns about the increasing disconnect between growth in gross exports and the generation of incomes and jobs for workers have been expressed before. In his analysis of Germany's 'pathological export boom', Sinn (2006) showed that the increasing imports of intermediates, mainly from Eastern Europe, led to a decline in the German value added per unit of exports, while export-earned value added as a share of GDP was maintained due to increased specialization and over-proportional growth of exports as such. He, in fact, argued that due to high and rigid wages for unskilled workers there was an over-specialization on the skill- and capital-intensive segments of the production chain. In a revealed comparative advantage (RCA) analysis based on

gross exports, Di Mauro and Forster (2008) find that the specialization pattern of the euro countries has not changed much during the 1990s and 2000s. They also relate this surprising finding to the inability of gross exports statistics to capture the value added in internationally fragmented production. More recently, Koopman *et al.* (2012) studied production in the export sector of China, which consists for a large part of assembly activities based on imported intermediates. They empirically showed that value added in these activities was much lower than suggested by the gross export values, but grew at a faster pace. Johnson and Noguera (2012) confirmed the existence of a similar gap for a larger set of countries in a multi-country setting.

However, none of the studies so far have come up with a new value-added based measure of competitiveness. In this paper we propose such a measure and define competitiveness of a country as 'the ability to perform activities that meet the test of international competition and generate increasing income and employment'. We focus on activities that are directly and indirectly involved in production of final manufacturing goods and measure their value added. These activities are particularly prone to fragmentation and have a high degree of international contestability. The income and jobs related to these activities are called 'manufactures global value chain (GVC) income' and 'GVC jobs'. We address the links between fragmentation and the creation of income and jobs based on a new input–output model of the world economy using industry-level data. This is not a new methodology but extends the approach used in Johnson and Noguera (2012) and Bems *et al.* (2011), which in turn revived an older literature on input–output accounting with multiple regions going back to Isard (1951) and in particular work by Miller (1966). We will extend this by further decomposing value added into the contribution by various factor inputs. This is related, but not identical, to the work on the factor content of trade (e.g. Trefler and Zhu, 2010), who focus only on production for foreign final demand, ignoring domestic demand. The main novelty of the study is thus in the empirical application and in particular the interpretation of the results in the context of analysing competitiveness.

The accuracy of the empirical implementation will obviously depend on the quality of the data. We use a new public database (the World Input–Output Database) developed specifically for use in detailed multi-sector models. It is the first to provide a time-series of input–output tables that are benchmarked on national account series of industry-level output and value added. It does not rely on the so-called proportionality assumption in the allocation of imported goods and services to end-use category. Instead, it allows for different import shares for intermediate, final consumption and investment use. It also provides additional industry-level data on the number of workers, their levels of educational attainment and wages (see Timmer, 2012). This allows for a novel analysis of both the value added and jobs created in GVC production.

In this paper the focus is in particular on the European region as it has undergone a strong process of integration in the past two decades both within and outside the European Union. Our main findings are as follows. We confirm a strong process of international fragmentation of manufacturing production across Europe. This has led

to an increasing disconnect between gross exports and GVC incomes. Growth in manufactures GVC income during 1995–2008 is much lower than growth in gross manufacturing exports for all European countries, in particular for Austria, Greece, Spain and Eastern European countries. Also the 'super-competitiveness' of the German economy (Marin, 2010) is in large part derived from increasing use of imported intermediates. In addition, we find strong changes in revealed comparative advantages of the EU when based on our new measures rather than gross exports. European GVC income is increasing fastest in activities carried out in the production of non-electrical machinery and transport equipment, while declining in activities related to the production of non-durables. These findings seem to be more in line with expectations than the suggestion of stagnant patterns of comparative advantage based on gross export data.

In contrast to popular fear, we do not find that international fragmentation necessarily leads to destruction of jobs in advanced countries. Indeed, we do find a declining number of manufactures GVC jobs located in the manufacturing sector, a phenomenon that is often highlighted in the popular press. But in most countries this was more than counteracted by a steady increase in the number of GVC jobs in the services sector. In fact, in 2008 almost half of the manufactures GVC jobs were in non-manufacturing sectors. A myopic approach to policies focusing on the manufacturing sector only is missing out on this important trend.

Finally, delving more deeply into the skill-intensity of the jobs involved, we do find large distributional shifts. Fragmentation seems to be related to a magnification of comparative advantages as European countries increasingly specialize in activities that require more skilled workers. GVC income shares of high-skilled workers increase much faster than those of medium- and low-skilled workers. Surprisingly, we find this pattern for both the old and new EU members, reminiscent of the findings for Mexico–US integration in the 1990s (Feenstra, 1998, 2010).

How do our measures compare to more conventional indicators of competitiveness? It is important to note that a country's manufactures GVC income indicates its competitive strength in a particular set of activities, namely those directly and indirectly related to the production of final manufactures. This includes activities in the manufacturing sector itself but also in supporting industries such as business, transport and communication and finance services through the delivery of intermediate inputs needed in the production of manufacturing goods. These indirect contributions from non-manufacturing sectors will be explicitly accounted for through the modelling of input–output linkages across sectors.[1] Manufactures GVC income is thus not synonymous with manufacturing competitiveness as it excludes those activities in manufacturing involved in the production of intermediates for non-manufacturing final goods and services (e.g. cement used in house construction). It is also not the same as overall

[1] Herrendorf *et al.* (2011) provide a related discussion of what they call the 'consumption value added' and the 'final consumption expenditure' perspectives. Our approach follows the former.

competitiveness in international trade of a country as it does not cover all international trade flows (e.g. exports of final non-manufacturing goods and services), as will be discussed in more detail below. In addition, GVC income measures competitiveness of the domestic, not the national, economy as it is based on activities carried out on the domestic territory of a country disregarding the ownership of the production factors. This difference is typically small for employment, as labour migration is still limited. But this is not necessarily true for value added by capital. For countries with large net positive positions of foreign investments, the capital income derived in GVCs at the domestic territory will be lower than the national capital income. Summarizing, the manufactures GVC income of a country measures the income derived from activities on the domestic territory related to the production of final manufacturing goods.

The rest of the paper is organized as follows. In Section 2 we describe our input output model and the derivation of our GVC income measure. This is done both in an intuitive and a more technical fashion. In Section 3 we outline the data sources used to measure GVC incomes and jobs and discuss issues that are important for assessing the validity of the empirical results. In Section 4 we summarize the main trends in the manufactures GVC incomes of the EU as a whole and for individual member states and carry out a revealed comparative advantage analysis. A comparison with indicators based on gross exports is made. The structure of employment is central in Section 5, discussing the shift in manufactures GVC jobs from manufacturing to services, and from low- to high-skilled workers. Section 6 provides concluding remarks.

2. ANALYTICAL FRAMEWORK FOR GVC DECOMPOSITION

In this section we introduce our method to account for the value added by countries in GVC production. We start with outlining our general approach and clarify some of the terminology used in Section 2.1. In Section 2.2 we provide a technical exposition of the GVC decomposition that contains some matrix algebra. This section might be skipped without losing flow of thought and main messages of the paper as we provide the intuition of the method in Section 2.1. The method is illustrated by a decomposition of the GVC of German car manufacturing in Section 2.3 which is recommended reading for a better understanding of the type of results that follow in Section 4.

2.1. General approach and terminology

In this subsection we introduce our new indicator, called *global value chain (GVC) income*. To measure this we rely on a standard methodology that allows for a decomposition of the value of a final product into the value added by each country that is involved in its production process. This value added accrues as income to production factors labour and capital that reside in the country. GVC incomes are thus always related to

a particular final product and computed on a domestic basis. In this section we provide a non-technical and intuitive discussion, while a full technical exposition is deferred to Section 2.2.

Our decomposition method is rooted in the analysis introduced by Leontief (1936) in which the modelling of input–output (IO) structures of industries is central. The IO structure of an industry indicates the amount and type of intermediate inputs needed in the production of one unit of output. Based on a modelling of the linkages across industries and countries, one can trace the gross output in all stages of production that is needed to produce one unit of final demand. To see this, take the example of car production in Germany. Demand for German cars will in the first instance raise the output of the German car industry. But production in this industry relies on car 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, say the German business services industry, the Czech braking systems industry and the Indian textile industry. In turn, this will raise output in industries delivering intermediates to these industries and so on. When we know the gross output flows associated with a particular level of final demand, we can derive the value added by multiplying these flows with the value-added to gross-output ratio for each industry. By construction the sum of value added across all industries involved in production will be equal to the value of the final demand. Following the same logic, one can also trace the number of workers that is directly and indirectly involved in GVC production. We will use this variant to analyse the changing job distribution in GVC production, in terms of geography, sector and skill level, in Section 5.

It is important at this stage to clarify our approach and terminology. We refer to the global value chain of a product as the collection of all activities needed to produce it. Baldwin and Venables (2010) introduced the concepts of 'snakes' and 'spiders' as two archetype configurations of production systems. The snake refers to a production chain organized as a sequence of production stages, whereas the spider refers to an assembly-type process on the basis of delivered components and parts. Of course, actual production systems are comprised of a combination of various types. Our method measures the value added in each activity in the process, irrespective of its position in the network. Also, concepts like 'global supply chains' or 'international production chains' typically refer only to the physical production stages, whereas the value chain refers to a broader set of activities both in the pre- and post-production phases including research and development, software, design, branding, finance, logistics, after-sales services and system integration activities. The GVC income measure will take account of the value added in all these stages of production (see Timmer *et al.*, 2013 for more on this). Recent case studies of electronic products such as the Nokia smartphone (Ali-Yrkkö *et al.*, 2011) and the iPod and laptops (Dedrick *et al.*,

2010) suggest that it is especially in these activities that most value is added. This was already stressed more generally in the international business literature, popularized by Porter (1985).

GVC incomes are measured by decomposing the value of a particular set of final products. Throughout the paper we will focus on GVC income in the production of final manufacturing goods. We denote these goods 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. It is important to note that GVCs of manufactures do not coincide with all activities in the manufacturing sector, and neither with all activities that are internationally contestable. Some activities in the manufacturing sector are geared towards production of intermediates for final non-manufacturing products and are not part of manufactures GVCs. On average, 68% of the value added in the manufacturing sector ends up in GVCs of manufactures (median across 27 EU countries in 2011). On the other hand, GVCs of manufactures also includes value added outside the manufacturing sector, such as business services, transport and communication and finance, and in raw materials production. These indirect contributions will be explicitly accounted for through the modelling of input–output linkages across sectors. The value added by non-manufacturing industries in manufactures GVC was almost as large as the value added by manufacturing (median of this ratio is 93% across EU 27), a finding we return to later.

Ideally, to measure competitiveness one would like to cover value added in all activities that are internationally contestable, and not only those in the production of manufactures.[2] GVCs of manufactures cover about 59% of gross export flows of all products (primary, industrial and services) in 1995 and 55% in 2008 (median across EU 27). An increasing part of world trade is in services, and only intermediate services related to manufacturing production are included in GVCs of manufactures. GVCs of services cannot be analysed, however, as the level of observation for services in our data is not fine enough to zoom in on those services that are heavily traded, such as consultancy services. The lowest level of detail in the World Input–Output Database (WIOD) is 'business services', which for the major part contains activities that are not internationally traded, and hence are much less interesting to analyse from a GVC perspective. Only 5% of final output of these services is added outside the domestic economy (EU 27 average in 2008), while this is 29% in manufacturing as shown later. This is all the more true for other services, such as personal or retail services. They require a physical interaction between the buyer and provider of the service and a major part of the value added in these chains is effectively not internationally

[2] In the limit, GVC income is equal to gross domestic product when final demand for all goods and services in the world economy are taken into account. Hence for a meaningful analysis, one has to limit the group of products and we focus on those products for which production processes are most fragmented and which can be analysed with the data at hand.

contestable. More detailed data on trade in, and production of, services is needed before meaningful GVC analyses of final services can be made.

Note also that the GVC income measure includes value added in the production for both domestic and foreign final demand, which is particularly important for analysing the competitive strength of countries with a large domestic market. To see this, assume that final demand for cars by German consumers is completely fulfilled by cars produced in Germany with all value added in domestic industries. In this case, the value of consumption accrues completely as income to German production factors. If German car producers start to offshore part of the activities, however, GVC income might decline. Offshoring of intermediates production might lead to lower prices and higher demand for the final product and this would generally be considered as an improvement of competitiveness. However, if the price elasticity of demand for cars is not particularly high, the total increase in the value of car production might not be enough to compensate the declining share of domestic value added. The net effect of offshoring on domestic GVC income might thus be negative. Similarly, if German consumers shift demand to cars from Japan, GVC income in Germany will also decline. Measures based on foreign demand and exports will not pick up this trend.

It is also important to note that GVC incomes are measured on a domestic, rather than a national basis. It includes the value added on the domestic territory and hence measures competitiveness in terms of generating GDP, not national income. Much of the offshoring is done by multinational firms that maintain capital ownership and hence GVC income in the outsourcing country is underestimated and income in the receiving country is overestimated. Data on foreign ownership and returns on capital is needed to allow for an income analysis on a national rather than a domestic basis, which is left for future research (Baldwin and Kimura, 1998). For individual countries with large net FDI positions, this domestic-territory basis of the GVC income concept needs to be kept in mind when interpreting the results in Section 4. Given modest international labour migration, this distinction is much less important for our analysis of GVC jobs in Section 5.

2.2. Technical exposition

This section gives a mathematical exposition of our GVC analysis. It is aimed to give a deeper insight into the measurement of GVC incomes and jobs, but can be skipped without loss of the main thread of the paper. To measure GVC incomes we follow the approach outlined in Johnson and Noguera (2012), which in turn revived an older literature on input–output accounting with multiple regions going back to Isard (1951) and in particular work by Miller (1966).[3] By tracing the value added at the various stages of production in an international input–output model, we are able to provide an *ex-post* accounting of the value of final demand. We introduce our accounting

[3] See Miller and Blair (2009) for an introduction into input–output analysis.

framework drawing on the exposition in Johnson and Noguera (2012) and then generalize their approach to analyse the value added by specific production factors.

We assume that there are S sectors, F production factors and N countries. Although we will apply annual data in our empirical analysis, time subscripts are left out in the following discussion for ease of exposition. Each country-sector produces one good, such that there are SN products. We use the term country-sector to denote a sector in a country, such as the French chemicals sector or the German transport equipment sector. Output in each country-sector is produced using domestic production factors and intermediate inputs, which may be sourced domestically or from foreign suppliers. Output may be used to satisfy final demand (either at home or abroad) or used as intermediate input in production (either at home or abroad as well). Final demand consists of household and government consumption and investment. To track the shipments of intermediate and final goods within and across countries, it is necessary to define source and destination country-sectors. For a particular product, we define i as the source country, j as the destination country, s as the source sector and t as the destination sector. By definition, the quantity of a product produced in a particular country-sector must equal the quantities of this product used domestically and abroad, since product market clearing is assumed (changes in inventories are considered as part of investment demand). The product market clearing condition can be written as

$$y_i(s) = \sum_j f_{ij}(s) + \sum_j \sum_t m_{ij}(s,t) \tag{1}$$

where $y_i(s)$ is the value of output in sector s of country i, $f_{ij}(s)$ the value of goods shipped from this sector for final use in any country j, and $m_{ij}(s, t)$ the value of goods shipped from this sector for intermediate use by sector t in country j.[4] Note that the use of goods can be at home (in case $i = j$) or abroad ($i \neq j$).

Using matrix algebra, the market clearing conditions for each of the SN goods can be combined to form a compact global input–output system. Let $\mathbf{y}$ be the vector of production of dimension ($SN \times 1$), which is obtained by stacking output levels in each country-sector. Define $\mathbf{f}$ as the vector of dimension ($SN \times 1$) that is constructed by stacking world final demand for output from each country-sector $f_i(s)$. World final demand is the summation of demand from any country, such that $f_i(s) = \sum_j f_{ij}(s)$. We further define a global intermediate input coefficients matrix $\mathbf{A}$ of dimension ($SN \times SN$). The elements $a_{ij}(s, t) = m_{ij}(s, t)/y_j(t)$ describe the output from sector s in country i used as intermediate input by sector t in country j as a share of output in the latter sector. The matrix $\mathbf{A}$ describes how the products of each country-sector are produced using a combination of various intermediate products, both domestic and foreign. Using this we can rewrite the stacked SN market clearing conditions from (1) in com-

[4] It should be noted that we assume a given price for a product irrespective of its use. Therefore, in our empirical application we use the IO-tables at the basic price concept in which margins and net taxes are separately recorded.

pact form as $\mathbf{y} = \mathbf{Ay} + \mathbf{f}$. Rearranging, we arrive at the fundamental input–output identity

$$\mathbf{y} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{f} \tag{2}$$

where $\mathbf{I}$ is an $(SN \times SN)$ identity matrix with ones on the diagonal and zeros elsewhere. $(\mathbf{I} - \mathbf{A})^{-1}$ is famously known as the Leontief inverse (Leontief, 1936). The element in row m and column n of this matrix gives the total production value of sector m needed for production of one unit of final output of product n. To see this, let $\mathbf{z}_n$ be a column vector with the nth element representing a euro of global consumption of goods from country-sector n, while all the remaining elements are zero. The production of $\mathbf{z}_n$ requires intermediate inputs given by $\mathbf{Az}_n$. In turn, the production of these intermediates requires the use of other intermediates given by $\mathbf{A}^2\mathbf{z}_n$, and so on. As a result the increase in output in each sector is given by the sum of all direct and indirect effects $\sum_{k=0}^{\infty} \mathbf{A}^k\mathbf{z}_n$. This geometric series converges to $(\mathbf{I} - \mathbf{A})^{-1}\mathbf{z}_n$.

Our aim is to attribute the value of final demand for a specific product to value added in country-sectors that directly and indirectly participate in the production process of the final good. Value added is defined in the standard way as gross output value (at basic prices) minus the cost of intermediate goods and services (at purchasers' prices). We define $p_i(s)$ as the value added per unit of gross output produced in sector s in country i and create the stacked SN-vector $\mathbf{p}$ containing these 'direct' value added coefficients. To take 'indirect' contributions into account, we derive the SN-vector of value added levels $\mathbf{v}$ as generated to produce a final demand vector $\mathbf{f}$ by pre-multiplying the gross outputs needed for production of this final demand by $\mathbf{p}$:

$$\mathbf{v} = \hat{\mathbf{p}}(\mathbf{I} - \mathbf{A})^{-1}\mathbf{f} \tag{3}$$

in which a hat symbol indicates a diagonal matrix with the elements of $\mathbf{p}$ on the diagonal.[5] We can now post-multiply $\hat{\mathbf{p}}(\mathbf{I} - \mathbf{A})^{-1}$ with any vector of final demand levels to find out what value added levels should be attributed to this particular set of final demand levels. We could, for example, consider the value added by all SN country-sectors that produce for global final demand for transport equipment products of

[5] If $\mathbf{v}$ is indeed to give the distribution of the value of final output as attributed to sectors in the value chain of product n, the elements of $\mathbf{v}$ should add up to the elements of $\mathbf{f}$. Intuitively, this should be true, since the Leontief inverse takes an infinite number of production rounds into account, as a consequence of which we model the production of a final good from scratch. The entire unit value of final demand must thus be attributed to country-sectors. We can show also mathematically that this is true. Let $\mathbf{e}$ an SN summation vector containing ones, and a prime denotes transposition, then using Equation (3) the summation of all value added related to a unit final demand $(\mathbf{e}'\mathbf{v}_n)$ can be rewritten as $\mathbf{e}'\mathbf{v}_n = \mathbf{e}'\hat{\mathbf{p}}(\mathbf{I} - \mathbf{A})^{-1}\mathbf{z}_n = \mathbf{p}'(\mathbf{I} - \mathbf{A})^{-1}z_n$. By definition, value added is production costs minus expenditures for intermediate inputs such that $\mathbf{p}' = \mathbf{e}'(\mathbf{I} - \mathbf{A})$. Substituting gives $\mathbf{e}'\mathbf{v}_n = \mathbf{e}'\mathbf{z}_n$. The value of final demand is thus attributed to value added generation in any of the SN country-sectors that could possibly play a role in the global value chain for product n.

which the last stage of production (that is, before delivery to the user) takes place in Germany, as done in the next section.

These value added levels will depend on the structure of the global production process as described by the global intermediate inputs coefficients matrix **A,** and the vector of value-added coefficients in each country-sector **p**. For example, both **p** and **A** will change when outsourcing takes place and value added generating activities which were originally performed within the sector are now embodied in intermediate inputs sourced from other country-sectors. **A** will change when, for example, an industry shifts sourcing its intermediates from one country to another.

The decomposition of the value of final demand outlined above can be generalized to analyse the value and quantities used of specific production factors (labour or capital) in the production of a particular final good. In our empirical application we will study the changes in distribution of jobs in global production, both across countries and across different types of labour. To do so, we now define $p^{L}_{i}(s)$ as the direct labour input per unit of gross output produced in sector s in country i, for example the hours of low-skilled labour used in the Hungarian electronics sector to produce one euro of output. Analogous to the analysis of value added, the elements in $\mathbf{p}^{\mathrm{L}}$ do not account for labour embodied in intermediate inputs used. Using Equation (3), we can derive all direct and indirect labour inputs needed for the production of a specific final product.

We would like to stress that the decomposition methodology outlined above is basically an *ex-post* accounting framework rather than a fully specified economic model. It starts from exogenously given final demand and traces the value added without explicitly modelling the interaction of prices and quantities that are central in a full-fledged Computable General Equilibrium model (see, for example, Levchenko and Zhang, 2012). While CGE models are richer in the modelling of behavioural relationships, there is the additional need for econometric estimation of various key parameters of production and demand functions. As we do not aim to disentangle 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 such that cost shares in production change over time. Thus the analysis does not rely on Leontief or Cobb-Douglas types of production functions where cost shares are fixed. The changing shares are consistent with a translog production function which provides a second-order approximation to any functional form. In these production models, shifting cost shares summarise the combined effects of changes in relative input prices, in cross-elasticities and input-biased technical change (Christensen *et al.*, 1971). This characteristic of the model makes it particularly well suited for our *ex-post* analysis.

2.3. Illustrative example: GVC income and jobs for German transport equipment

In this section, we illustrate our methodology by decomposing final output from the German transport equipment industry. Developments in the German car

industry reflect global trends in the automotive industry which has witnessed some strong changes in its organizational and geographical structures in the past two decades (Sturgeon *et al.*, 2008). A distinctive feature is that final vehicle assembly has largely been kept close to end markets mainly because of political sensitivities. This tendency for automakers to 'build where they sell' has encouraged the dispersion of assembly activities which now take place in many more countries than in the past. At the same time strong regional-scale patterns of integration in the production of parts and components have been developed. This is nicely illustrated by a case study of the fragmented production process of a typical German luxury car (the Porsche Cayenne) by Dudenhöffer (2005). In 2005, the last stage of production of a Porsche Cayenne before being sold to German consumers took place in Leipzig. But the activity involved was the placement of an engine in a near-finished car assembled in Bratislava, Slovakia. Slovakian workers assembled a wide variety of components such as car body parts, interior and exterior components, some of which were (partly) made in Germany itself, but others were sourced from around the world. All in all, Dudenhöffer (2005) estimated that the domestic value added content of this German car was only about one-third, while two-thirds was added abroad.

Using our database and methodology, we can provide a comparable decomposition for the output of the German car industry as a whole. We decompose the value of output of all final products delivered by the German transport equipment industry (NACE rev. 1 industries 34 and 35). This includes the value added in the last stage of production, which will take place in Germany by definition, but also the value added by all other activities in the chain which take place anywhere in the world as illustrated above. The upper panel of Figure 1 shows the percentage distribution of value added in Germany and abroad. The foreign value added share increased rapidly from 21% in 1995 to 34% in 2008. The German share includes value added in the domestic transport equipment industry itself (GER TR), but also in other German industries that deliver along the production chain both in manufacturing (GER OMA) and in non-manufacturing industries (GER REST). Interestingly, the importance of non-manufacturing activities has increased and in 2008 added almost half of the German value.

The lower panel of Figure 1 gives insight in the number of workers directly and indirectly related to German car production, using workers per unit of output in Equation (3). Off-shoring has had a major impact on the geographical distribution of jobs involved. The share of foreign GVC jobs was 50% in 1995 increasing to 62% in 2008. This share in jobs is much higher than the share in GVC income due to the much lower unit labour costs of foreign workers. Cheap medium-skilled technical workers were one of the main attractions for German firms to offshore to Eastern Europe (Marin, 2006) and allowed them to keep costs down. Conversely, the share of domestic GVC workers dropped to 38% in 2008. However, due to rapidly increasing demand for German cars, the number of German jobs has not declined but increased

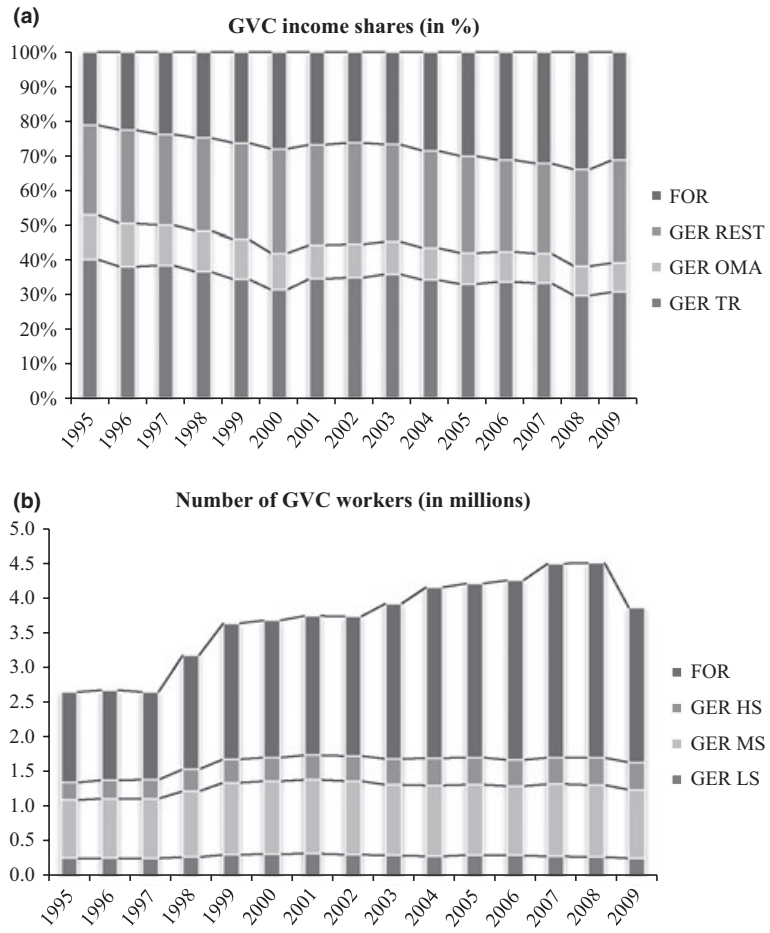

Figure 1. Value added and workers involved in production of German transport equipment: (a) GVC income shares (in %); (b) number of GVC workers (in millions).

Notes: Panel (a) provides a decomposition of the value of final products from the German transport equipment industry (NACE rev. 1 industries 34 and 35) into the value added in German transport equipment industry itself (GER TR), other German manufacturing industries (GER OMA), all German non-manufacturing industries (GER REST) and in foreign industries. Panel (b) shows the number of workers directly and indirectly involved in production of these products, decomposed into foreign (FOR) and domestic (GER) workers, including low-skilled (LS), medium-skilled (MS) and high-skilled (HS). The skill level of workers is defined by level of educational attainment.

Source: Authors' calculations based on World Input–Output Database, April 2012.

from 1.3 million to 1.7 million over this period. This shows that the reorganization of the global production process does not necessarily lead to a decline in jobs in advanced countries. As hypothesized by Grossman and Rossi-Hansberg (2008) offshoring may lead to lower output prices and increased demand for the final output, such that the net effect on domestic jobs might be positive. But the increased demand for jobs is clearly skill-biased. While use of low-skilled and medium-skilled German workers increased by 6% and 24%, high-skilled increased by more than 50%. This

finding is suggestive of increased specialization in advanced nations, which we will return to in Section 5.

3. DATA FROM THE WORLD INPUT–OUTPUT DATABASE

To measure GVC incomes as in Equation (3), we need to track for each country gross output and value added by industry, the global input–output matrix and final goods shipments over time. This type of data is available from the recently released World Input–Output Database, available at www.wiod.org and described in Timmer (2012). The WIOD contains time-series of global input–output tables and supplementary labour accounts. It has been specifically designed and constructed for this type of analyses. The published database contains data up to 2009. For the purpose of this paper, we have revised the data for 2008 and 2009 based on the latest releases of the National Accounts. We also made preliminary estimates for 2010 and 2011 using the same construction methodology, but the quality is somewhat lower as less source material could be used due to limited availability of input–output tables for recent years.

In order to interpret and assess the empirical results, it is important to briefly discuss how the WIOD has dealt with two major challenges in data construction. First, the integration of time series of output and value added from national accounts statistics with benchmark input–output tables to derive time-series of input–output tables. Second, disaggregation of imports by country of origin and use category based on international trade statistics. This is discussed in Section 3.1. To measure GVC jobs we also need data on workers by skill type and industry which is covered in Section 3.2. Additional details regarding data construction and basic data sources can be found in Timmer (2012).

3.1. World input–output tables

The WIOD provides a time-series of world input–output tables (WIOTs) from 1995 onwards. It covers 40 countries, including all EU 27 countries and 13 other major advanced and emerging economies namely Australia, Brazil, Canada, China, India, Indonesia, Japan, Mexico, Russia, South Korea, Taiwan, Turkey and the United States. In total it covers more than 85% of world GDP in 2008. In addition, a model for the remaining non-covered part of the world economy is made such that the decomposition of final output as given in Equation (3) is complete.

The WIOTs have been constructed on the basis of national Supply and Use Tables (SUTs) which provide information on the intra-industry flows within a country. A Supply table indicates for each product its source (domestic industries and imports), while the Use table indicates for each product its destination (intermediate use by domestic industries, domestic final demand or exports). National SUTs have dimensions of 35 industries and 59 product groups. The 35 industries cover the overall economy and are mostly at the 2-digit NACE rev. 1 level or groups therefrom. They include agricul-

ture, mining, construction, utilities, 14 manufacturing industries, 8 trade and transport services, telecom, finance, business services, personal services, and 3 public services. The product groups are more finely defined and are all two-digits in the 2002 Classification of Products by Activity (CPA), including 23 manufacturing products. SUTs provide a more natural starting point than input–output tables which are typically derived from the underlying SUTs with additional assumptions. Moreover, SUTs can be easily combined with trade statistics that are product-based and employment statistics that are industry-based. It also allows one to take into account the multi-product nature of many firms and their so-called secondary production. In a supply table the output of firms is classified on a product basis such that it might be recorded in different product classes. However, there is no information on the possible differences in the production processes of the various products within a firm, or across firms in the same industry. A column for a particular industry in the Use table only provides the average production structure across all firms and all products in that industry. It has been found that these structures might be rather different for exporters and non-exporters and further evidence on this is needed (e.g. Koopman *et al.*, 2012; Ottaviano *et al.*, 2009).

National SUTs have been collected from national statistical institutes and harmonized in terms of concepts and classifications. National tables are only available for particular benchmark years which are infrequent, unevenly spread over time and asynchronous across countries. Moreover, they are not designed for comparisons over time; this becomes clear when comparing data from the SUTs with the national accounts statistics. While the latter are frequently revised and designed for inter-temporal comparisons, the former are not. To deal with both these issues simultaneously, a procedure was applied that imputes SUT coefficients subject to hard data constraints from the National Accounts Statistics (NAS). The unknown product shares of intermediate inputs, imports, exports and final expenditure are imputed using a constrained least square method akin to the well-known bi-proportional (RAS) updating method. The solution matches exactly the most recent NAS data on final expenditure categories (household and government consumption and investment), total exports and imports, and gross output and value added by detailed industry.

In a second stage the imports of products are broken down by country-industry origin and allocated to a use category. This type of information is not available in published input–output tables. Typically, researchers rely on the so-called import proportionality assumption, applying a product's economy-wide import share for all use categories (as e.g. Johnson and Noguera, 2012). Various studies have found that this assumption can be rather misleading as import shares vary significantly across use category (Feenstra and Jensen, 2012). To improve upon this, bilateral trade statistics have been used in WIOD to derive import shares for three end-use categories. Bilateral import flows of all countries covered in WIOD from all partners in the world at the 6-digit product level of the Harmonized System (HS) were taken from the UN COMTRADE database. We used the detailed description for about 5,000 products in

COMTRADE to refine the well-known BEC ('broad economic categories') codes which allocates to intermediate use, final consumption use or investment use. Within each end-use category, the allocation was based on the proportionality assumption (as dictated by a lack of additional information). For intermediate use by industries, for example, we had to apply ratios between imported use and total use that were equal across industries, but differed from the corresponding ratio for consumption purposes.

A similar procedure was used to split the imports table according to country of origin. Unlike under the standard proportionality assumption, country import shares differ across end-use categories (but not within these categories). To resolve the well-known inconsistency between mirror flows in bilateral trade data we inferred bilateral export shares as mirror flows from the bilateral import shares. In addition, data on bilateral trade in services has been collected, integrating various international data sources (including UN, OECD, Eurostat, IMF and WTO). This covers so-called Mode 1 (cross-border) services trade: services supplied from the territory of one country into the territory of another.[6] In total about 20 economic activities according to the Balance of Payments classification were distinguished which were mapped into the services industries. As is well-known, services trade data has not been collected with the same level of detail and accuracy as goods trade data and there is still much to be improved in particular in the coverage of intra-firm deliveries (Francois and Hoekman, 2010).

In the last stage, the national SUTs, expanded by bilateral trade data, are stacked into a World SUT, which is used to construct a World input–output table that has a 35 industry-by-industry structure, assuming that the sales structure of a product is independent of the industry in which it is being produced (see Dietzenbacher *et al.*, 2013 for technical details). The WIOTs used in this paper are expressed in basic prices, which means that the final demand value of manufacturing goods that is central in the analysis excludes net taxes and trade and transport margins. This fits our purpose to measure the distribution of value added in the production process of a good. Final demand for goods includes all goods that are consumed by household and government, or used for investment purposes. The tables are in current US dollars using exchange rates for currency conversion. Exchange rate movements will have an impact on the measured level of GVC income over time, but not across countries at a particular point in time. Comparisons across countries are hence invariant to the choice of currency numeraire. All WIOTs and underlying data sources are publicly available at www.wiod.org.

3.2. Employment by skill type

One unique characteristic of the WIOD is the availability of employment and wage data that can be used in conjunction with the WIOTs. Skill levels of workers are

[6] Mode 2 (consumption abroad) is also included in the WIOD, but not used in this analysis as the product composition of the expenditures is unknown.

proxied by their level of educational attainment. Data on the number of workers by educational attainment are available for a large set of countries, but WIOD provides an extension in two directions. First, it provides industry level data, which reflects the large heterogeneity in the skill levels used in various industries. Moreover, it provides relative wages by skill type that reflect the differences in remuneration of workers with different levels of education. For most advanced countries labour data is constructed by extending and updating the EU KLEMS database (www.euklems.org) using the methodologies, data sources and concepts described in O'Mahony and Timmer (2009). For other countries additional data has been collected according to the same principles, mainly from national labour force surveys, supplemented by household surveys for relative wages in case needed. Care has been taken to arrive at series which are time consistent, as breaks in methodology or coverage frequently occur. Data has been collected for the number of workers involved, including self-employed and family workers for which an imputation was made if necessary. Although hours worked would be a preferable measure, this data is not available on a large scale.

Labour skill types are classified on the basis of educational attainment levels as defined in the International Standard Classification of Education (ISCED). Low-skilled workers are those with an education level in ISCED categories 1 and 2, medium-skilled in ISCED 3 and 4 and high-skilled in ISCED 5 and 6. Despite international harmonization, comparisons across countries have to be made with care, given the differences in national educational systems. Developments over time in skill-shares can be traced with more confidence.

4. EUROPEAN VALUE ADDED IN GLOBAL PRODUCTION OF MANUFACTURES

This section summarizes some of the main trends in the distribution of income in global value chains, based on the GVC income concept. In principle many decompositions can be made across the various dimensions offered in the WIOD such as (groups of) countries, industries, products and factor inputs. In this paper 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 currently members of the EU. This group of countries is collectively referred to as EU 27 throughout the paper. EU15 ('old') and EU12 ('new') denote the countries that joined the EU before and after April 2004. The period studied is from 1995 to 2011 which covers two important developments in the integration of the European economy. The fixing of exchange rates in 1999 among 11 members of the European Monetary System was leading up to the introduction of the euro in 2002. Increasing trade and investment flows into Eastern Europe in the 1990s culminated in the accession of ten new member states to the European Union in 2004, and another two in 2007. It also contains some major economic shocks to the world economy. The opening up of the Chinese and Indian economies in the 1990s effectively enlarged the global pool of unskilled labour, in particular after China joined the WTO in 2001. And in 2008 the global financial crisis caused a major shock to the

world economy which is still reverberating. For most analyses we will therefore compare patterns in 1995 with those in 2008, rather than for a later year, although we will also indicate some preliminary trends until 2011.

In Section 4.1 we first establish the widespread pattern of international fragmentation of production. In Section 4.2 we analyse trends in the GVC income for the 27 EU countries and find that Europe as a whole was holding up relatively well in the past two decades. But some major shifts within Europe took place, in particular between old and new EU member states. The difference between trends in GVC incomes and gross exports is analysed in depth in Section 4.3. In Section 4.4 a revealed comparative advantage (RCA) analysis is carried out based on GVC incomes in particular product groups. We find that patterns in RCA of old EU member states based on GVC incomes are different than based on gross export flows.

4.1. International production fragmentation

In Figure 2 we provide a simple indicator of fragmentation based on the WIOD, using the broad measure of offshoring from Feenstra and Hanson (1999). This measure is defined as the share of imports in total intermediate inputs in manufacturing industry. An increase indicates that a larger share of the intermediate inputs is sourced from outside the country, reflecting backward integration of a country's production process. The figure provides clear evidence for the widespread process of fragmentation as European firms aim to take advantage of differences in technologies, factor endowments and factor prices across countries. For all 27 European Union countries, except Cyprus and Luxembourg, fragmentation has increased between 1995 and 2008. Import shares increased by 10 percentage points or more in most countries, and rose the fastest in the new member states. Based on a bilateral breakdown of imports (not shown) it follows that the Eastern European countries that joined the EU in 2004 have shown rapid production integration with the old EU15 countries. This process was facilitated by a massive inflow of foreign direct investment into Eastern Europe, in particular from Germany and Austria. This started already at the end of the 1990s and well before the formal entry into the EU in 2004 (Marin, 2006, 2011).

This finding of increasing international fragmentation is robust to the use of alternative or complementary measures. Hummels *et al.* (2001) developed a measure of vertical specialization in international trade by looking at the import content of production for exports, rather than overall production. In contrast to Feenstra and Hanson (1999) they take into account not only direct, but also indirect imports through the use of an input–output framework. The rank correlations across the EU 27 countries of these two measures are high (63% for 2008, 84% in 1995 and 55% for the change during 1995–2008) and pure correlations even higher. Los *et al.* (2013) extend the FH measure and provide an alternative based on countries' value added shares in final output. They also find clear trends towards increased fragmentation. One obvious implication of this is that it is increasingly hard to indicate the origin of a

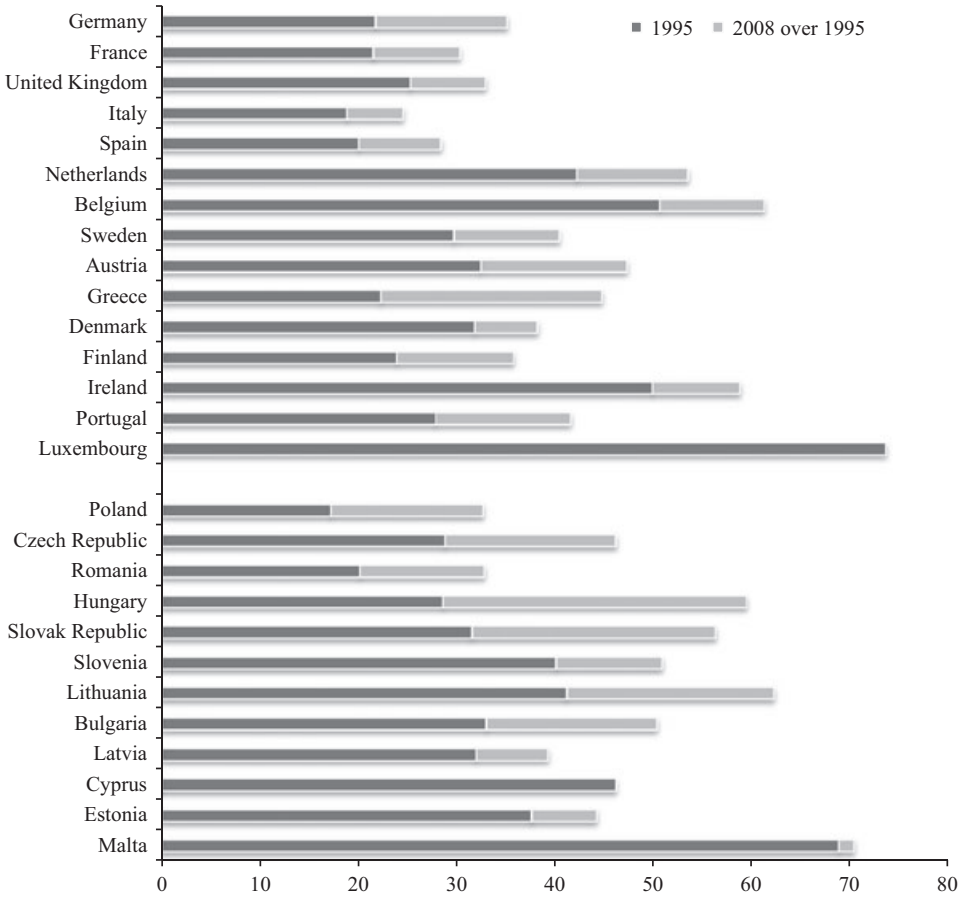

Figure 2. International fragmentation of production.

Note: Imported intermediate inputs as shares of total intermediate inputs in manufacturing industry (in %) in 1995 and 2008. A higher share indicates more international fragmentation of domestic production. Countries are grouped into EU15 and EU12 and within the group ranked on GDP in 2008 dollars.

Source: Authors' calculations based on World Input–Output Database, April 2012.

product. While one can indicate the geographical location where the last stage of production took place, this is not necessarily the place where most of the value has been added. As highlighted by the WTO, nowadays products are increasingly 'Made in the World'.

4.2. Trends in manufactures GVC incomes in Europe

In Section 2 we developed the concept of a country's manufactures GVC income which was defined as the income of all production factors in the country that have been directly and indirectly used in the production of final manufacturing goods. We can define 'World GVC income' simply as the GVC income summed over all countries in the world. By definition, world manufactures GVC income is equal to world

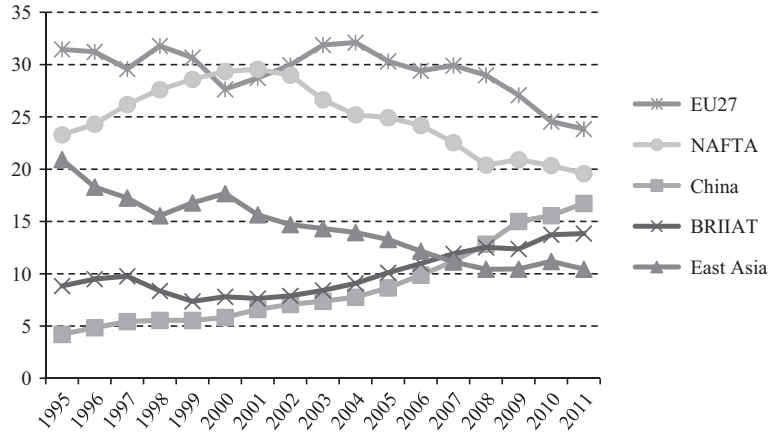

Figure 3. Regional shares in world GVC income for all manufactures (%).

Note: 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 have joined the European Union. NAFTA 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: Authors' calculations based on World Input–Output Database, April 2012, updated to 2011.

expenditure on manufacturing goods as we model all regions in the world in our empirical analysis. In this section we show trends in the distribution of world GVC income across countries and argue that it provides a novel indicator of the competitive strength of nations.

In Figure 3 we provide shares of regions in world GVC income in the production of manufactures. It follows that the share of the EU has been on a slightly declining trend from 32% in 1995 to 29% in 2008.[7] As is well known, the aftermath of the global financial crisis hit Europe in particular and its share dropped sharply to 24% in 2011. But up to the crisis, the EU was doing well, at least relative to other advanced regions. The share of the NAFTA countries (comprising Canada, Mexico and US) increased during the ICT bubble years, up to 30%, when its share was even higher than the EU. But it rapidly declined afterwards to 20% in 2008. GVC shares of East Asia (comprising Japan, South Korea and Taiwan) had already been on a long decline since the 1990s, falling from 21% in 1995 to 10% in 2008. On the other hand, the shares of China and other emerging markets were rapidly increasing. China was responsible for less than 5% of global manufactures GVC income in 1995, steadily increasing to 13% in 2008 and continuing to rise throughout the crisis to 17% in 2011.

[7] One might argue that this is due to a shift in the structure of global demand for manufactures. However, since 1995, this structure is rather stable with only a minor shift from demand for non-durables towards chemicals, but this shift is too small to account for the aggregate decline. Instead, the decline of the EU share in overall GVC income is due to losses in its value added share in each product GVC.

One might argue that these shifts in regional GVC income shares are unsurprising. It is a well-known fact that when countries grow richer, final demand is shifting first from agricultural goods to manufactures, and later on to services. The trends in Figure 3 might be a simple reflection of these non-homothetic tastes: demand in advanced nations is shifting to services, while demand in China and other emerging countries is shifting to manufactures. And in addition as GDP is growing faster in the latter group of countries, their share in global manufactures would be enlarged. However, these trends in domestic demand for manufactures do not necessarily translate one-to-one into value added shares of production because of international trade. This will depend on the extent to which domestic demand for manufactures has a strong home production bias; that is, is mainly geared towards goods with a high level of domestic value added. Given the high tradability of manufacturing goods and intermediates, this home bias is not obvious. Increased Chinese demand for manufactures can be as easily served by imports as by Chinese domestic production. And even if there is a bias towards domestically produced goods, a sizeable share of their value could still be captured by advanced countries through the delivery of key intermediate inputs and services. In 2008 about 40% of the value of Chinese domestic demand for manufactures was added outside China, which is amongst the lowest shares in the world. The corresponding shares for the US (45%) and France, Germany and the UK (above 63%) and especially small countries are much higher and indicate that the link between domestic demand for manufactures and the income earned in domestic production for manufactures is only weak.[8]

We therefore conclude that the falling shares in global GVC income for advanced regions in Figure 3 can be interpreted as a loss of competitiveness. They indicate that they failed to compete successfully for the increased market for manufacturing goods in emerging economies. At the same time they lost market shares domestically and the domestic value added content of their production declined as imports of final goods and intermediates increased. It should be kept in mind, however, that international competition is not a zero-sum game: the declining shares do not necessarily mean an absolute decline in GVC income. On the contrary, in real terms world GVC income on manufactures (deflating by the US CPI index) has increased by about one-third over the period 1995 to 2008. For the EU27 as a whole it increased by 22% (see Table 1).

Aggregate EU27 performance hides substantial variation within the European Union. In Table 1 we present the change in GVC income for individual EU countries. Throughout the paper, we will only present results for the 20 major EU countries to save space. Results for the remaining seven small European countries[9] are available upon request from the authors. The first two columns in Table 1 indicate that real GVC income has increased in all EU countries, with a major shift in the

[8] Calculations based on Equation (3) with final demand for manufactures for each country separately.

[9] Bulgaria, Cyprus, Estonia, Latvia, Lithuania, Malta and Slovenia.

Table 1. Real GVC income in EU27 countries, all manufactures

	Real GVC income (in constant $m)		Share in EU27 GVC income		Real GVC income due to foreign demand (%)	
	1995	2008	1995	2008	1995	2008
Germany	617,836	665,164	29.8	26.4	46.3	69.9
France	292,330	330,216	14.1	13.1	53.1	60.0
United Kingdom	253,548	260,443	12.2	10.3	52.6	68.5
Italy	289,055	354,158	13.9	14.0	45.2	52.8
Spain	127,696	171,836	6.2	6.8	39.1	53.3
Netherlands	94,133	118,973	4.5	4.7	79.3	87.8
Belgium	66,357	69,783	3.2	2.8	84.1	89.2
Sweden	55,536	70,548	2.7	2.8	70.3	77.5
Austria	50,081	62,674	2.4	2.5	53.9	78.5
Greece	20,468	30,564	1.0	1.2	17.5	31.3
Denmark	36,484	41,700	1.8	1.7	79.8	87.5
Finland	28,868	36,952	1.4	1.5	64.5	74.3
Ireland	21,583	40,480	1.0	1.6	88.3	88.1
Portugal	23,730	27,228	1.1	1.1	48.5	59.6
Luxembourg	3,784	6,743	0.2	0.3	94.1	97.5
All EU15	1,981,489	2,287,462	95.6	90.7		
Poland	33,439	85,700	1.6	3.4	42.7	63.0
Czech Republic	14,477	41,450	0.7	1.6	57.3	79.0
Romania	11,896	32,585	0.6	1.3	32.4	44.4
Hungary	11,120	27,140	0.5	1.1	44.9	73.1
Slovak Republic	5,060	17,624	0.2	0.7	64.4	79.8
Other EU12	14,694	31,019	0.7	1.2		
All EU12	90,686	235,518	4.4	9.3		
All EU 27	2,072,175	2,522,981	100.0	100.0		

Note: Real GVC income for all manufactures and in constant 1995 prices using US CPI as deflator. Decomposed into part due to domestic final demand and part due to foreign final demand.

Source: Authors' calculations based on World Input–Output Database, April 2012.

balance between the old EU15 and the new EU12. About one-third of the increase in the overall EU27 GVC income was earned on the EU12 territory, testifying to the importance of the new member states for growth in the European production capacity. In contrast, the competitive position of all major old EU countries dwindled over this period. The most important industrial economy of Europe is Germany, contributing more than a quarter to EU27 GVC income since 1995 (29.8% of total EU27 GVC income). But the German share dropped at the end of the 1990s and did not significantly improve afterwards (26.4% in 2008). The share in France declined slowly but steadily, and the share in the UK dropped severely after an initial increase in the late 1990s.

In interpreting these figures, one has to keep in mind that GVC income is measured on a territorial rather than a national basis, as discussed in Section 2. The decline in East Asian GVC income is likely to be less on a national basis because of foreign investment into China, which effectively became the assembly place of East Asia. For

the same reason one might argue that German competitiveness has not declined, but merely reflects a territorial shift of income generation towards Eastern Europe. Returns on German-owned capital in Eastern Europe should be taken into account for a measure of national competitiveness rather than the domestic-based concept discussed so far. There is no data on German ownership shares of Eastern European firms, but we can provide a back-of-the-envelope calculation to infer a plausible upper bound. For EU12, the share of capital income in value added is about 40%. If we assume that the increase in EU12 GVC capital income over 1995–2008 took place solely in wholly German-owned firms, national GVC income in Germany in 2008 would be about 8.7% higher than domestic GVC income. Even with this clearly upper bound estimate, the German share in EU27 GVC income would still have dropped over the period 1995–2008.

By splitting the final demand vector in the decomposition given in Equation (3), we can analyse the importance of domestic versus foreign final demand in the generation of GVC income in a country and observe trends in the dependence on external demand. The GVC income due to foreign demand is identical to what Johnson and Noguera (2012) refer to as 'exports of value added'.[10] The last columns in Table 1 provide the share of manufactures GVC income due to foreign demand. The overriding conclusion is that all EU countries have become increasingly dependent on foreign demand to generate manufactures GVC income, in particular in the EU15. The direction of this trend was to be expected as the income elasticity of demand for manufactures is low in these rich countries. The most extreme example of this shift towards foreign demand dependence, given the large size of its domestic market, is to be found in Germany. While 46% of its GVC income in 1995 was due to foreign final demand, this increased to 70% in 2008. Also foreign demand dependence in Austria and the UK rapidly increased over this period. Changes in shares were much smaller in the other large EU economies but also clearly positive. Taken together, the results are indicative of increased specialization in individual EU countries in particular activities and products, made possible by the continuous integration process of European and world product markets.

As our input–output accounting framework is a linear system of equations, an exact additive decomposition of the change in GVC income into a part due to the change in production structures and a part due to the change in final demand structures can be made. Changes in final demand structures reflect the shifting pattern of global demand for final output from the various industry-country pairs (say electronics industry in China or car industry in Germany). Changes in production structures reflect the many factors that have been highlighted in the literature, such as skill-biased technological change, offshoring of intermediate input production and changing geography of input sourcing. The combined effects of these are summarized by the changing cost

[10] Johnson and Noguera (2012) focused on foreign final demand for all goods and services, not only manufactures as we do here.

shares in production in our model, including intermediate and factor input shares. This type of shift-share decomposition can be made in various ways and we follow standard practice in using weights that are an average of begin and end year of the period under consideration. In that case the change in GVC income is decomposed exactly into a part due to changes in final demand structures and in a part due to changing production structures. Results are given in Table 2.

One major observation is that when final demand is kept constant, the reorganization of production chains would have led to a hypothetical decline in GVC income in almost all EU15 countries. This is mainly due to declining value added shares of these countries in GVCs of those products where the final stage of production takes place in the domestic economy. This is due to an actual shift of production facilities abroad, but also due to increased foreign sourcing of intermediates from non-affiliated parties. The declines are relatively small for most countries, but not for Belgium, France and Germany. Foreign sourcing of intermediate inputs has been prominent in Germany as discussed before. In France and Belgium there was in addition to this also a loss of

Table 2. Decomposition of change in manufactures GVC income due to change in production structure and final demand

		% of change when	
	Change in real GVC income (US$m)	keeping production structures constant	keeping final demand constant
Germany	47,328	236	−136
France	37,886	209	−109
United Kingdom	6,895	125	−25
Italy	65,104	129	−29
Spain	44,140	111	−11
Netherlands	24,840	108	−8
Belgium	3,426	368	−268
Sweden	15,012	123	−23
Austria	12,593	125	−25
Greece	10,095	109	−9
Denmark	5,217	132	−32
Finland	8,085	118	−18
Ireland	18,897	87	13
Portugal	3,498	103	−3
Luxembourg	2,959	54	46
All EU15	305,974	149	−49
Poland	52,261	92	8
Czech Republic	26,973	86	14
Romania	20,689	90	10
Hungary	16,020	90	10
Slovak Republic	12,564	90	10
Other EU12	16,325	77	23
All EU12	144,832	88	12

Note: Change in real GVC income from Table 1. The change is decomposed by keeping the production structures constant while final demand changes, and by keeping the final demand constant, while production structures change. This additive decomposition can be done keeping 1995 or 2008 levels constant, and average weights are used.

their position as intermediate input provider to other countries. For example, the WIOTs show that their production and exports of car parts declined substantially over this period. On the other hand, the results indicate that GVC income in all Eastern European countries and Ireland would have increased even when final demand was held constant. These countries were increasingly serving global demand through exporting intermediate products that were used in production by other countries. The magnitudes of these effects are relatively small though and not more than 15% of their actual GVC income increase.

The effects of changes in production structures are dwarfed, however, compared to the effects of increasing final demand. Keeping production structures constant, the increase in global final demand for manufactures hypothetically leads to an increase in real GVC income everywhere. As mentioned above, most of this increased demand is due to growing demand from emerging regions.

4.3. Comparing GVC incomes and gross exports

The finding of declining competitiveness of Germany in the previous section might be surprising given its much touted success in export markets. In this section we explain more in depth how rising exports do not necessarily correlate with increases in GVC incomes. In Box 1 we provide a hypothetical numerical example which clearly illustrates the conceptual differences between the GVC income and gross exports concepts. Below we will show that the difference also matters empirically.

Box Why gross exports and GVC income are different: a hypothetical example

In this box we provide a hypothetical example that illustrates the conceptual differences between GVC income and gross export values. We consider the effects of international fragmentation of the production process of a car. Assume that this production process is modular and consists of three activities namely part and component manufacturing, assembly of parts into the final product and services. These post-production services can be thought of as for example branding, logistics, distribution and finance activities. All activities are contestable and can be carried out anywhere irrespective of the location of other activities or the final consumer. To carry out the assembly activity in a plant, parts are obviously needed as input, but not the services. Transport costs are zero. The values added by these activities as a percentage of the output value are 10 for assembly (a), 50 for parts (p) and 40 for services (s). There are two countries A and B. Consumers in A purchase cars with total value of 100 million. Initially, all activities in the production process of these cars take place in A itself. In this case there are no exports from A to B or from B to A. As explained in the main text, the GVC income of a

country is the value added of all GVC activities carried out in a country, so in this case it is 100 million in A and 0 in B. What happens to GVC income and exports when the car production process is internationally fragmenting and part of the activities sequentially are moved from A to B? This is shown in the table below.

Activities carried out in		GVC income		Exports by	
A	B	A	B	A	B
a,p,s	-	100	0	0	0
p,s	*a*	90	10	50	60
s	*a,p*	40	60	0	60
-	*a,p,s*	0	100	0	100

Obviously, the GVC income in A is decreasing when more activities are offshored, while GVC income in B is increasing. The total GVC income of both countries always adds up to 100 million, which is by definition equal to the value of car consumption. The export statistics for A and B, however, show a rather different evolution. When assembly is offshored, A will export parts with a gross value of 50 million to B. After assembly, the parts will return but now with a gross value of 60 million as value has been added. B is exporting more than A, but still A is adding more value to the product and hence captures a larger share of the value of the final product (90 million for A while 10 million for B). Note that the value of the parts is recorded twice in the export values, creating the so-called 'double counting problem' in trade statistics (see, e.g., Koopman *et al.*, 2012). When the manufacturing of the parts is offshored as well, there is no longer export needed from A to B, and B is still exporting goods worth 60 million to A. However, now B is capturing the full value of this and GVC income increases to 60 million as well. Finally, with the offshoring of services activities, exports from B will increase in value to 100 million, as will its GVC income. In this situation domestic demand for cars in A is fully satisfied by imports from B.

The underlying assumption in this example is that all activities are traded at full cost value and recorded as such in the statistics. When these activities all take place within one multinational enterprise (MNE), transfer pricing might drive a wedge between the value embodied in a product and its recorded export price. Moreover, assume that the MNE is headquartered in A then part of the GVC income earned with activities in B (namely the income for capital) will most likely not stay in B. This highlights the need to complement existing measurement of international transactions on the basis of geographical location with measures that centre on the ownership of firms (Baldwin and Kimura, 1998) and international finance flows. This simple example can also be easily

extended by introducing demand from a third country which can be served by various constellations of the production stages across A and B. But in all cases the basic message remains the same: GVC income measures will better reflect the redistribution of income when production fragments across borders than gross trade statistics.

For a good understanding of the differences between gross exports and GVC income it is important to reiterate two distinguishing characteristics of the GVC income concept. First, it indicates to what extent a country can compete with other nations in terms of *activities* related to global manufacturing, rather than competing in manufacturing *products* as measured by exports. It is measured through value added, not gross output. Second, it is a reflection of an economy's strength to compete in both domestic and global markets. Countries might gain income by serving foreign demand, but might at the same time lose income in production for the domestic market. The GVC income share of a country measures the combined net effect.

Real gross exports of manufacturing products from Germany increased by 98% over the period 1995–2008, whereas manufactures GVC income increased only by 7%. This is the net effect of two main factors. First, the domestic value added content of German production of final manufactures dropped quickly during this period due to offshoring and increasing imported intermediates. This process has been described extensively by Marin (2011) who relates Germany's competitiveness to increased offshoring to Eastern Europe, in particular since the early 2000s. Foreign sourcing of intermediates helped to keep German output prices low, in addition to domestic wage restraints. This enabled German firms to compete in global markets, but at the same time the domestic value added per unit of output was declining, prompting Hans-Werner Sinn to characterize Germany as a Bazaar economy (Sinn, 2005, 2006). Although this characterization is somewhat overdone as a major part of the value is still added in Germany, Sinn rightfully pointed at the increasing irrelevance of export statistics to gauge the success of a country. The second factor is sluggish domestic demand in the German economy. Due to slow GDP growth and low income elasticity, domestic demand for manufacturing goods was weak. Added to this, an increasing part of domestic demand was served by imports from China and Eastern Europe such as non-durables and electronics. The domestic demand effects held down German GVC income, but none of these effects will show up in German gross export statistics. As a consequence, the ratio of gross exports of manufactures to manufactures GVC income increased from 82% in 1995 to 153% in 2008, illustrating the dangers of relying on gross exports as an indicator of competitive strengths.

Obviously given increased fragmentation worldwide, this wedge between GVC income and gross exports is there also for other countries. In Table 3 we provide a direct comparison of the growth rates of gross exports of all manufactures and GVC incomes in production of final manufactures. We find that the former is growing

Table 3. Growth in real manufacturing exports and manufactures GVC income between 1995 and 2008 (%)

	Growth in gross export value	Growth in GVC income	Difference
Germany	98	7	91
France	56	13	43
United Kingdom	27	3	24
Italy	66	22	44
Spain	121	34	87
Netherlands	57	26	30
Belgium	40	5	35
Sweden	60	27	33
Austria	130	25	105
Greece	195	49	146
Denmark	34	14	20
Finland	84	28	56
Ireland	103	87	16
Portugal	70	15	55
Luxembourg	42	78	−35
Poland	397	156	241
Czech Republic	461	186	275
Romania	320	173	147
Hungary	595	144	452
Slovak Republic	477	248	230

Note: Exports refer to real gross export value of all manufacturing goods and GVC income refers to real GVC income in production of final manufactures. Growth rates calculated as (ratio of 2008 over 1995 minus one) times 100. All values are deflated by the US CPI.

Source: Author's calculations based on World Input–Output Database, April 2012.

much faster than the latter in all European countries (except Luxembourg). This indicates that for all countries growth in gross exports is overestimating growth in GVC incomes. The biggest differences are found for Austria, Germany, Greece and Spain. Clearly, there is a positive relationship between export and GVC income growth rates in a country, with a correlation higher than 0.9 over the 19 countries shown in the table. But this is mostly driven by the Eastern European countries. They have very high growth rates of exports and GVC income, although the latter is roughly only half the former. The correlation of exports and GVC income across EU15 countries is less than 0.6 as patterns of offshoring have been rather different as discussed above.

4.4. Revealed comparative advantage in GVCs

An interesting issue is to what extent Europe is specializing in activities within specific product GVCs. The standard tool to analyse specialization is revealed comparative advantage (RCA) analysis. Traditionally, this is based on comparing a country's share in world exports of a particular product to its share in overall exports. It is often used for informing industrial and trade policies by predicting which domestic sectors would

benefit from further global market opening, and which would be hurt in the future. This has led to some surprising findings in the past. An RCA analysis for the euro area by di Mauro and Forster (2008) found that in contrast to other advanced economies, euro area specialization patterns overall have not changed much over the last one and a half decades. They found neither a decline in the specialization in labour-intensive products, nor the expected shift towards more skill-intensive production.

This surprising finding might be due to the fact that the RCA analysis was performed on the basis of gross export values which do not fully reflect the effects of international production fragmentation as discussed above. As an alternative, RCA can be performed on the basis of GVC incomes in the production of final goods. Thus the usefulness of RCA analysis is retained, albeit with a different interpretation. Based on GVC incomes, an RCA larger than one for a product indicates that the country derives a higher share of its overall GVC income from adding value in the GVC production of this product, relative to other countries. Thus the country specializes in activities in the GVC production of this product. It does not necessarily follow that the country is also a major exporter of the product as it might carry out valuable activities upstream in the production process, or alternatively it may produce for a large domestic market.

In Figure 4 we provide 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. We find that the EU27 has a strong and increasing RCA in activities related to the production of machinery and transport equip-

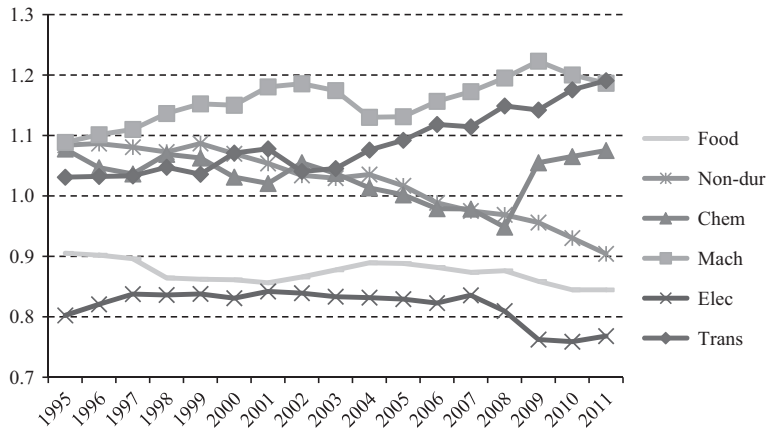

Figure 4. Revealed comparative advantage of EU27, by group of final manufactures (%).

Note: Revealed comparative advantage calculated as EU27 share in world GVC income for a group of manufactures divided by the same ratio for all manufactures. Final food manufacturing products (Food: produced in ISIC rev.3 industries 15 and 16), Other non-durable products (Tex: 17 to 20, 36, 37), Chemical products (Chem: 23 to 26), Machinery and metal products (Mach: 27 to 29), Electrical machinery products (Elec: 30 to 33) and Transport equipment (Tra: 34, 35).

Source: Authors' calculations based on World Input–Output Database, April 2012, updated to 2011.

ment. RCAs in non-durables and in chemical products are on a declining trend. The latter is rebounding since the crisis, but the former continues its secular decline. Participation of the EU27 in the production of electrical equipment is traditionally low, notwithstanding the presence of some very successful European firms in particular product niches.

Aggregate EU27 specialization patterns hide substantial variation within the European Union. In Table 4 we present the RCA for member states, calculated as above, to track particular specialization patterns. Major new member states particularly improved their positions in GVCs of transport equipment, in 2008 all five having RCAs higher than one. RCAs for non-durables, traditionally a stronghold for these countries, declined in all countries and provide no longer a comparative advantage in the Czech Republic, Hungary and the Slovak Republic. Instead they developed comparative advantage in electrical and non-electrical equipment. Across the old EU15 it seems that specialization patterns have been reinforced in those industries for which the possibilities for international fragmentation are the highest, and for those countries

Table 4. Revealed comparative advantage based on GVC incomes by product, major EU countries, 1995 and 2008

	Chemicals		Electrical machinery		Food products		Non-elec. machinery and metal		Non-durables		Transport equipment	
	1995	2008	1995	2008	1995	2008	1995	2008	1995	2008	1995	2008
Germany	1.10	0.80	0.87	0.95	0.72	0.67	1.37	1.43	0.76	0.65	1.26	1.54
France	1.08	1.08	0.80	0.72	0.99	1.04	0.86	0.93	0.85	0.77	1.38	1.30
UK	1.30	1.30	0.98	0.81	0.83	0.78	0.99	0.95	0.96	0.90	0.95	1.07
Italy	0.92	0.70	0.65	0.65	0.72	0.75	1.32	1.59	1.95	1.82	0.67	0.76
Spain	0.96	0.89	0.52	0.54	1.17	1.17	0.58	0.85	1.43	1.07	1.16	1.24
Netherlands	1.23	1.40	0.75	0.70	1.31	1.13	0.86	0.96	0.85	0.81	0.68	0.74
Belgium	1.30	1.30	0.67	0.69	0.96	0.95	0.95	1.04	0.99	0.87	1.16	1.05
Sweden	0.88	0.85	1.18	1.16	0.76	0.65	1.19	1.49	0.61	0.61	1.29	1.26
Austria	1.03	0.74	0.90	0.97	0.91	0.76	1.24	1.61	1.22	0.94	0.68	1.01
Greece	0.87	0.99	0.31	0.41	1.82	1.62	0.21	0.63	1.82	1.47	0.30	0.40
Denmark	0.99	1.42	0.70	0.90	1.43	1.09	1.03	1.20	1.02	0.75	0.47	0.52
Finland	0.74	0.70	1.26	1.56	0.97	0.77	1.22	1.50	0.75	0.63	0.62	0.75
Ireland	1.27	1.69	1.21	1.37	1.47	1.05	0.44	0.45	0.46	0.47	0.33	0.45
Portugal	0.81	0.76	0.50	0.64	1.04	1.06	0.53	0.72	2.69	2.22	0.54	0.71
Poland	0.92	0.84	0.51	0.60	1.42	1.25	0.73	0.92	1.33	1.09	0.72	1.03
Czech Rep.	0.88	0.61	0.60	0.97	1.13	0.81	1.27	1.25	1.16	0.90	0.84	1.51
Romania	0.87	0.76	0.49	0.45	1.55	1.35	0.75	0.76	1.55	1.48	0.54	1.06
Hungary	1.20	1.10	0.62	1.28	1.47	0.94	0.64	0.90	1.09	0.60	0.68	1.18
Slovak Rep.	1.23	0.60	0.62	1.18	1.09	0.66	0.88	1.24	1.26	0.92	0.79	1.39

Note: 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.3 industries 15 and 16), Other non-durable products (Tex: 17 to 20, 36, 37), Chemical products (Chem: 23 to 26), Machinery and metal products (Mach: 27 to 29), Electrical machinery products (Elec: 30 to 33) and Transport equipment (Tra: 34, 35).

Source: Authors' calculations based on World Input–Output Database, April 2012.

that grasped the opportunities. Germany specialized further in activities in the production of transport equipment and non-electrical machinery; the Netherlands and Ireland in chemicals; Austria and Sweden in non-electrical machinery; and Finland in electrical and non-electrical machinery. Specialization patterns in other countries have changed much less during this period. For example, Italy maintained its strong position in non-durables, the UK in chemicals and France in transport equipment, but they did not increase it. Italy's particular strong position in activities in the production of non-durables (textiles, wearing apparel and footwear) might be surprising, given the perceived low-skill intensive nature of the production process of these products, and the massive increase in exports from Asia. But this might suggest a shift of Italy in the non-durable value chains away from low-skill assembly and production activities towards higher skill activities, such as branding and design.

The differences with an RCA analysis based on gross exports (not shown here) can be large. For example, the EU27 has a comparative advantage in food based on gross exports, but not in terms of GVC income. The RCA in electronics for exports is low and rapidly declining, but the RCA based on GVC income is much more stable. Conversely, RCA for machinery is stable for gross exports, but steadily increasing for GVC income. At the country level, differences are bigger. For example, based on gross exports France and the UK strongly improved their RCA in transport equipment, while on the basis of GVC income they did not. Especially for small countries differences in signs of changes in RCA based on gross export and GVC income are frequent, and movements over time of the former are much wilder than the latter.

5. THE STRUCTURE OF EUROPEAN EMPLOYMENT IN GLOBAL PRODUCTION OF MANUFACTURES

Many policy concerns surrounding globalization issues are ultimately about jobs – good jobs in particular. The disappearance of manufacturing jobs in advanced nations is occasionally linked to production fragmentation and associated offshoring of activities. It is thus useful to look at the structure of employment 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.[11] For each country, we will measure the number of workers involved on the domestic territory. As the mobility of labour is much lower than of capital, GVC jobs will be closer to a national concept than GVC income. We will characterize GVC workers by sector of employment and level of skills. In Section 5.1 we show 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 is growing. In most countries, manufactures GVC job increase in ser-

[11] We will use the term 'jobs' instead of 'number of workers' to be parsimonious. But the underlying data pertains to number of workers rather than jobs. Ideally, one would like to measure hours worked.

vices is even higher than job loss in manufacturing. In Section 5.2 we analyse the skill structure of GVC workers and find a shift away from low-skilled towards high-skilled workers. This increase is faster than the overall economy trend, suggesting increased specialization of advanced EU countries in GVC activities performed by high-skilled workers. This is in line with broad Heckscher–Ohlin predictions of comparative advantage when possibilities for international production fragmentation increase.

5.1. The shift towards services jobs in manufactures GVCs

By using number of workers rather than value added per unit of output in each industry-country as the requirement vector in Equation (3), we can trace the number of workers directly and indirectly involved in the production of manufacturing goods, and their sector of employment. Developments in the main EU27 countries over the period from 1995 to 2008 are shown in Table 5. The first two columns indicate the share of manufacturing GVC workers as a percentage of the overall workforce in the economy. In the next columns the sectoral structure of employment of these workers is shown. Three sectors are considered: agriculture, manufacturing and services (also including mining, construction and utilities). The first set of columns refers to the number of GVC workers by sector in 2008, while the last four columns refer to the change over the period 1995–2008. Two main facts clearly stand out. First, the declining importance of global production of manufactures for overall employment in Europe. And second, the strong shift of the sector of employment of these workers, away from the manufacturing sector towards the services sector.

The first two columns of Table 5 illustrate the decline in importance of manufactures GVCs in providing jobs in the economy across the European Union. In 1995, manufactures GVC workers made up 26% of the total employed labour force in the EU27, and this declined to 22% in 2008. The decline took place in almost all EU countries, in particular in the EU15 with shares in Greece, Ireland, Portugal, Spain and the UK dropping by 5.5 percentage points or more. Job loss in the UK stands out, as more than 1.6 million GVC jobs disappeared in this country alone. Declines were across all UK industries, but in particular in textiles and metal manufacturing. The only exception to this trend is Germany. In 2008, 26% of the German employment was still involved in the global production of manufactures which is by far the highest share across the EU15 countries. Perhaps surprisingly, GVC workers also declined in the new member states, but this was mainly due to job loss in agriculture, reflecting rapid improvements in labour productivity and technologies as this sector was rationalized as part of the EU accession process. One might argue that a drop in the overall economy share of GVC jobs is a simple reflection of higher productivity growth in manufacturing relative to non-traded services, known as Baumol's cost disease hypothesis. In a closed economy with increasing income per capita final demand for manufactures is declining relative to domestic services as income elasticity is lower, such that fewer workers are needed. But for open economies increasing foreign

Table 5. Manufactures GVC workers, 1995 and 2008, by sector

	Manufactures GVC workers as (%) share of all workers in the economy		Manufactures GVC workers in 2008 by sector				Change in manufactures GVC workers between 1995 and 2008 (in %)			
	1995	2008	Agriculture (% of total)	Manufacturing (% of total)	Services (% of total)	Total (in thousands)	Agriculture	Manufacturing	Services	Total
Germany	26.8	26.4	3.8	51.5	44.8	10,647	−28.7	−10.8	41.1	5.6
France	22.0	18.7	6.2	45.2	48.5	4,853	−24.0	−16.2	18.5	−3.0
United Kingdom	20.1	12.6	2.9	48.7	48.4	3,992	−52.7	−37.1	−15.2	−28.9
Italy	29.1	25.5	5.2	55.1	39.7	6,444	−36.6	−6.2	25.3	1.4
Spain	23.2	17.5	7.5	50.9	41.6	3,592	−26.4	11.3	30.9	14.0
Netherlands	22.8	19.0	5.3	38.7	55.9	1,661	−32.0	−11.9	20.5	1.8
Belgium	25.0	20.9	3.3	42.8	53.9	933	−37.3	−17.6	16.7	−3.3
Sweden	22.7	21.0	3.7	50.1	46.2	959	−39.2	−9.2	27.1	2.4
Austria	24.8	22.6	10.9	48.2	40.9	960	−30.7	−6.9	44.2	4.3
Greece	21.0	15.0	13.5	52.1	34.4	717	−67.6	4.8	16.0	−17.4
Denmark	23.9	19.6	7.2	47.6	45.1	569	−38.2	−19.7	24.6	−6.7
Finland	23.6	19.7	7.8	49.9	42.4	498	−39.0	−4.6	31.7	2.9
Ireland	31.5	18.8	14.9	42.6	42.5	394	−37.0	−9.1	31.8	−2.7
Portugal	28.9	21.7	16.8	53.0	30.2	1,136	−22.9	−18.8	6.2	−13.4
Luxembourg	20.3	17.4	2.3	38.1	59.6	61	−30.4	6.3	80.9	38.7
All EU15	24.4	20.4	5.6	49.9	44.5	37,416	−35.3	−12.9	21.4	−2.5
Poland	31.0	28.8	20.2	50.2	29.7	4,542	−33.8	3.7	37.6	−0.4
Czech Republic	30.8	30.9	5.7	60.5	33.8	1,636	−38.8	8.1	6.8	3.2
Romania	34.0	27.6	26.4	53.6	20.0	2,588	−34.2	−13.8	−11.7	−20.0
Hungary	31.6	29.3	10.7	56.1	33.2	1,204	−53.0	2.0	18.5	−5.5
Slovak Republic	28.2	29.6	3.3	59.1	37.6	663	−61.5	5.2	51.7	11.6
Other EU12	29.0	24.2	17.2	53.4	29.4	2,098	−19.2	−16.3	18.9	−8.9
All EU12	31.2	28.0	17.3	53.8	28.9	12,732	−34.3	−3.5	18.7	−6.1
Total EU 27	25.9	21.9	8.6	50.9	40.5	50,148	−34.7	−10.5	20.9	−3.4

Note: 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 2008. And the last four columns indicate the change in the number of GVC workers by sector between 1995 and 2008.

Source: Authors' calculations based on World Input–Output Database, April 2012.

demand for manufactures might counteract this tendency. Indeed, from Table 1 it appeared that countries differed greatly in their ability to benefit from increasing demand for manufactures in emerging markets.

Moreover, it seems that countries that have been relatively successful in retaining GVC jobs did so while moderating real wages. In Figure 5 we plot for the biggest 19 EU countries for which we have CPI data, the increase in GVC jobs and in real wages over the period 1995–2008. Real wages are defined as the average labour income per worker in manufactures GVCs, deflated by the national CPI. Note that this real wage includes only GVC income that accrues to labour as we have taken out the share of capital in GVC income by appropriate choice of the requirements vector **p**. The negative correlation between job and real wage increases in the figure does not imply causality but illustrates that only few countries have been able to combine increasing GVC job opportunities and a substantial rise in real wages. Relatively abundant growth in GVC jobs in Austria, Germany and Spain coincided with limited real wage growth. Conversely, rapid wage increases in Greece, Portugal and the UK have most likely led to strong declines in GVC employment. Only some Eastern European countries, Finland and Sweden have been able to escape this negative correlation between jobs and wages in manufactures GVCs. They show that success in global value chains

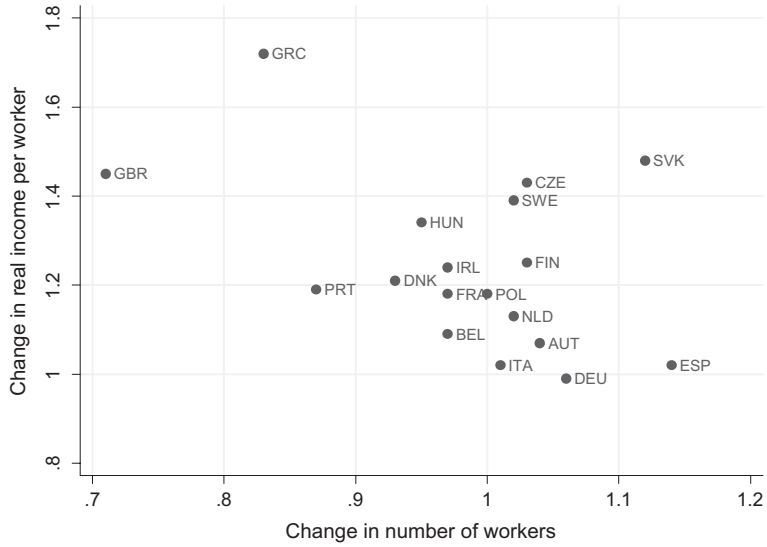

Figure 5. Change in employment versus change in real wage in manufactures GVCs, 1995–2008 (1995 = 1).

Note: Change in number of workers and real income per worker over 1995–2008 in manufactures GVCs. Real income is measured as GVC labour income per worker deflated with the national CPI. Data are for all EU15 countries and Poland, Czech Republic, Hungary and Slovak Republic. Data for Czech Republic refers to 1996–2008.

Source: Authors' calculations based on World Input–Output Database, April 2012. CPI from OECD National Accounts Statistics.

is not solely determined by unit labour costs, and also reflect competitive strengths in particular in the non-manufacturing parts of the production process (Fagerberg, 1988).

Another important finding on the basis of Table 5 is the strong shift towards services jobs in the global production of manufactures since 1995. As shown in the right-hand side of Table 5, overall employment in manufactures GVCs in the EU27 declined by 1.8 million jobs between 1995 and 2008 (minus 10.5%). But this decline was solely due to job losses in the agriculture and manufacturing sectors. In contrast, the number of GVC workers in services increased by a staggering 3.5 million (21% growth). Faster growth in services jobs than in manufacturing can be seen in all 20 major EU countries, except in the Czech Republic. In 11 of the EU15 member countries, the creation of new GVC jobs in services was even bigger in an absolute sense than the loss of old GVC jobs in manufacturing. And even in new member states GVC jobs in the manufacturing sector increased only modestly or even declined. As a result, in 2008, the manufacturing sector accounted for just about half of the total number of manufactures GVC jobs in the EU27. The other half is employed in agriculture and in particular in services. They are involved in the production of intermediate goods and services used in the manufacturing process. This half-half division roughly holds true for all EU countries with somewhat higher manufacturing shares in Eastern Europe and Italy, and somewhat higher services shares in France, Ireland and the Netherlands. These findings testify to the increasing intertwines of manufacturing and services activities and argues against a myopic view on manufacturing jobs in discussions on GVC issues. In particular it does not lend support to policies that are targeted at particular sectors, such as currently being discussed and implemented in, for example, France and the US.

Again, this shift in the sectoral distribution of the GVC jobs might be interpreted as the result of differential productivity growth in manufacturing and services following Baumol's hypothesis. But while there is clear evidence that productivity growth in manufacturing is higher than in services overall, this does not necessarily hold for the services activities in manufactures GVCs. These only form a subset of the services sector, and involve in particular intermediate services such as wholesaling, transportation, finance and several business services.[12] These activities are generally open for international competition and likely to have much higher rates of innovation and productivity growth than services activities for domestic demand which are dominated by personal services, education, health and public administration (Inklaar *et al.*, 2008). Hence it seems more likely that our findings are indicative of a fundamental shift in the type of activities carried out by European countries in the global production of manufactures, away from blue-collar manufacturing to white-collar services activities. This hypothesis is confirmed when one analyses the skill-content of GVC jobs as is done in the next section.

[12] It should be noted that these numbers exclude any jobs involved in the retailing of manufacturing goods as we analyse final demand at the basic price concept.

5.2. Specialization in high-skilled activities in manufactures GVCs

In a world with international production fragmentation, the broad Heckscher–Ohlin predictions will still hold: countries will carry out activities which local value added content is relatively intensive in their relatively abundant factors. In fact increased opportunities for international production fragmentation may have the tendency to increase specialization of countries as suggested by Baldwin and Evenett (2012). A simple example will illustrate. Assume two goods A and B which are both produced with two activities: a low-skilled (LS) and a high-skilled (HS) activity. Before unbundling, goods A and B are bundles of production activities with different skill intensities. Assume that good A is on average more skill intensive than B as the HS activity is more important in production of A than B. The relatively skill-abundant country would specialize in production of A, and the skill-scarce country in B. After unbundling, each nation specializes in specific production activities. The skill-abundant country will specialize in the HS activities in production of both goods, and a skill-scarce country in the LS activities. As a result, the potential range of comparative advantages across countries in activities will be greater than in final products and this might lead to enhanced specialization (see e.g. Deardorff, 2001).

To test this prediction we analyse the number of workers by skill type needed in manufactures GVCs using Equation (3) in combination with a skill requirement vector. This vector is based on a characterization of workers in each industry and country by their observable educational attainment levels, as described in Section 3. This delivers the number of low- (LS), medium- (MS) and high-skilled (HS) workers in manufactures GVCs of which growth rates are shown in Table 6. We find that during 1995–2008 in all EU15 countries the growth in HS GVC workers was higher than the growth in MS workers, which in turn was higher than growth in LS workers (except for Denmark). In Ireland, Italy, Luxembourg, Spain and Sweden the number of HS workers more than doubled. Clearly, the EU15 countries have enhanced their specialization in high-skilled work.

While one would predict specialization in skills in the EU15, this is less obvious for the new member countries. Given their rapid integration in the European economy, the change in their skill distribution of GVC workers since 1995 will partly depend on the skill level of activities that have been outsourced from the old EU relative to their 'old' activities. Surprisingly, for the EU12 as a whole we find a similar pattern as for the old EU15 as HS workers in GVCs are growing faster than MS, and MS much faster than LS. A similar pattern is found at the individual country level. This confirms the findings based on firm-level data by Marin (2011) that German and Austrian firms, which have been the main investors in Eastern Europe, particularly make use of medium skilled labour which is cheap relative to domestic workers. From the perspective of competitiveness, an increase of high-skilled jobs in manufactures GVC is a clear indication of a country's ability to realize employment growth in activities that are productive and relatively well paid in a highly competitive international environment.

Table 6. Growth in manufactures GVC workers (in %), by skill level, 1995–2008

	Low skilled	Medium skilled	High skilled
Germany	−9.2	1.8	33.2
France	−39.7	2.4	64.2
United Kingdom	−56.0	−22.8	18.1
Italy	−30.3	41.1	135.9
Spain	−23.3	82.6	111.6
Netherlands	−18.5	−7.1	88.9
Belgium	−48.2	24.2	54.0
Sweden	−40.2	5.8	102.2
Austria	−24.1	4.1	98.1
Greece	−48.4	29.9	72.5
Denmark	−7.4	−22.9	57.5
Finland	−36.3	13.7	31.3
Ireland	−38.1	−6.5	109.3
Portugal	−20.6	15.8	63.4
Luxembourg	−15.8	81.3	110.6
All EU15	−31.5	5.9	56.0
Poland	−41.7	0.0	118.6
Czech Republic	−31.3	4.2	40.2
Romania	−25.5	8.2	65.0
Hungary	−35.4	−3.1	52.3
Slovak Republic	−54.3	15.9	52.3
All EU12	−26.2	0.1	66.8
Total EU 27	−30.2	4.2	57.5

Note: Manufactures GVC workers are workers directly and indirectly involved in the production of final manufacturing goods.

Source: Authors' calculations based on World Input–Output Database, April 2012.

Taken together, the results of Sections 4 and 5 show that international fragmentation in the production of manufactures has been accompanied by a rapid specialization in higher-skilled activities in the EU. These activities are increasingly carried out in the services sector, instead of the manufacturing sector. As such, it contributes to the so-called job polarization in advanced economies as the displaced manufacturing workers are likely to be absorbed in personal and distributional services where low-skilled employment opportunities are still growing (Goos *et al.*, 2011).

6. CONCLUDING REMARKS AND LESSONS FOR POLICY

In the past decades, production became increasingly organized in global value chains with different stages of production fragmenting across borders. As a result international competition increasingly plays out at the level of activities within industries, rather than at the level of whole industries. It is now recognized that traditional measures that are routinely used in assessing a country's competitive stance, such as shares in world gross exports, are becoming less informative for policymaking. To reflect the new reality, we have proposed a novel measure of a country's competitiveness that

measures the value a country adds in the production of final manufacturing goods, called manufactures GVC income. A related concept, namely GVC jobs, measures the number and types of workers in a country who are involved in GVC production. These measures are derived using a new input–output model of the world economy. Our analyses shed new light on two surprising findings in traditional competitiveness analysis.

First, the strong performance of some EU countries in terms of manufacturing export growth does not seem to correlate strongly anymore with income and job creation in the manufacturing sector. This can be understood from our GVC perspective. We find that gross exports overestimate the competitiveness of countries that rely heavily on imported intermediates, such as Germany and small open economies. Importantly, this bias in traditional measures has increased over time. We also find that only about half of the jobs involved are actually manufacturing jobs, and their number is declining in almost all EU countries over the period 1995–2008. However, this is counteracted by an increasing number of manufactures GVC jobs in non-manufacturing sectors, in particular in business services. For the EU as a whole, this increase is even bigger than the decline in manufacturing jobs. Across the EU we also find that there is a shift away from activities carried out by low-skilled workers towards those carried out by higher-skilled workers. This enhanced specialization was especially strong in advanced countries. International fragmentation of production thus seems to be related to a shift away from manufacturing and low skilled jobs rather than an overall net destruction of the number of jobs involved.

Second, traditional analyses of revealed comparative advantage based on gross exports suggested that the European Union was stuck in low- and medium-tech industries. In contrast, we find strong changes in comparative advantages of the EU using our GVC income-based measures. The EU's comparative advantage is increasingly in activities carried out in global production networks of non-electrical machinery and transport equipment, while declining in the production of non-durables. Across the more successful countries it seems that specialization patterns have been reinforced in those industries for which the possibilities for international fragmentation are the highest: Germany specialized further in activities in the production of transport equipment and non-electrical machinery; the Netherlands and Ireland in chemicals; Austria and Sweden in non-electrical machinery; and Finland in electrical and non-electrical machinery. Major new member states particularly improved their positions in GVCs of transport equipment. In contrast in France, Italy and the UK, comparative advantages barely shifted.

One of the main policy lessons of this paper is that international production fragmentation greatly reduces the usefulness of traditional comparative advantage analysis as a policy guide. Based on gross exports shares, governments predicted future winners and losers of international trade and devised industry-specific policies to help shift resources from losing sectors to winning sectors. But nowadays globalization is affecting the economy at the level of stages of production, not sectors. More in general, we

argued that with fragmenting production, sectors are becoming the wrong operational unit when framing policies and evaluating performance. The emphasis in trade and industrial policies should therefore not be sector-specific but rather focus on the type of activities carried out, taking into account patterns of vertical integration of production within and across countries. More generally, to ensure a broad distribution of the benefits of globalization, there is a need for policy measures that contribute to unfettered reallocation of resources across firms. Flexible labour markets and a well-functioning financial system are key in sustaining the creative destruction process. Sustaining efforts in schooling are needed to maintain comparative advantages in international production networks. And the uneven distributional consequences of the fragmentation process highlight the importance of assistance and provision of training to those workers that are facing layoff.

A second lesson is that competitiveness is no longer only determined within borders and coordination problems arise. In the past, goods were bundles of national inputs and the ultimate determinants of competitiveness were therefore national. Nowadays, goods are bundles of many nations' inputs interlocking competitiveness across countries as the costs of imported intermediate inputs will also drive the comparative advantage of the importing countries. Unbundling of production processes magnifies the importance of transaction, transport and trade costs and the potential for international spillovers. For example, the impact of bilateral trade agreements and tariffs will be more difficult to assess and might have unintended consequences due to tariff accumulation along the production chain (Yi, 2003). And improvements in, say, infrastructure in one region might generate positive spillovers to trading patterns as intermediates' prices fall. Adjusting to ongoing globalization is then a task that requires multilateral assessment and coordination of industrial and trade policy measures in order to maximize regional competitiveness that includes these knock-on effects. Baldwin and Evenett (2012) provide an excellent and extensive discussion of these policy issues.

In order to make systematic use for economic policy of the new GVC measures, there is a need for a firmer statistical basis for quantification. Although the WIOD has been constructed making maximum use of official statistics, there is room for improvement. We therefore welcome the recent initiative of the OECD and WTO to continue this line of work and establish it firmer in the international statistical community.[13] We urge for a better and more complete data collection, in particular concerning statistics on trade in services, and the import and export propensity of industries at a deeper level of disaggregation to account for heterogeneous production patterns. This will allow the extension of the GVC analysis beyond manufactures GVC which are central in this paper, and also analyse the GVCs of final services. In addition, more information on the foreign ownership of firms and profits is needed to properly allocate capital income in order to analyse GVC income both

[13] See e.g. speech by Paul Schreyer on 'The OECD-WTO Trade in Value-Added Database', WTO Trade Data Day, Geneva, 16 January 2013.

on a domestic and a national basis. The latter is preferable when analysing national competitiveness.

At the same time there is a need for other indicators based on micro analysis, besides the macro-indicators proposed here. Due to the industry-level nature of our data, we have to implicitly assume that each country-sector produces a single homogenous product with a production structure which is an average across all firms. But it has been found that, for example, exporting firms have a different input structure than non-exporters and to take this heterogeneity into account a more disaggregate approach is required. Altomonte *et al.* (2012) propose additional measures that are based on micro databases and can thus reflect distribution shapes of firm-level performance in international activities and its drivers (see also Ottaviano *et al.*, 2009). Another important development is the initiative to open up the black box of a firm, by surveying the type of business functions that are carried out domestically and those that are offshored. Eurostat and the US Bureau of Labor Statistics have already carried out pilot projects to investigate the possibilities for large-scale surveys, as described in Sturgeon *et al.* (2012). One main lesson from this work is the finding of a continuum of different manufacturing and services tasks in production and the increased blurring between manufacturing and services firms. These initiatives will undoubtedly lead to a deeper understanding of the effects of trade and fragmentation on incomes and jobs, and helpful in better informing and formulating future policies.

Discussion

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Fragmentation of production, the process by which different production stages of final goods are carried out in different countries, has been increasing over the last decades. On the face of it, a German car, for instance, is not so German any more as a big share of intermediate production stages are carried out in some other European countries and because more of the value in German cars is produced abroad, the share of German manufacturing exports in the World total may not reflect well the competitiveness of the German economy.

The paper *Fragmentation, Incomes and Jobs. An Analysis of European Competitiveness* takes the World fragmentation process seriously and introduces a novel measure of competitiveness that corrects for it. In particular, it uses a newly released time series of input–output data of the World (40 countries, 35 industries, between 1995 and 2008/11) and it computes global value chains (GVC) by extending the methodology of Trefler and Zhu (2010), Bems, Johnson and Yi (2011), and Johnson and Noguera (2012). In particular, for every pair of *final good* × *country of use* the authors obtain a vector with the value added generated in every possible *sector* × *country of origin* and a vector with

the number of workers involved in every possible *sector* × *country of origin*. Then, they invert and aggregate the data to obtain the total value added and the number of workers in every country used to produce the World *final manufactured goods*. They call these measures GVCm income and GVCm jobs. In addition, they also keep track of the sectors in every country (even services and agriculture) that originate the GVCm income and jobs.

The most important findings are the following. First, since early 2000s there has been an increasing share of GVCm income produced in BRIIAT and China and a decline in the GVCm income produced in the EU27, NAFTA and East Asia (see Figure 3). The authors interpret this as an increase of competitiveness in emerging economies and a fall in rich ones. Second, Germany, France and UK reduced their share of GVCm income within Europe, while all other countries – but mainly the former Eastern European ones – increased it (see Table 1). This, the authors argue, shows a decline in competitiveness of Germany. Third, within Europe, the destruction of GVCm jobs in manufacturing is smaller than the increase of GVCm jobs in services (see Table 5). This implies that there are no job losses owing to offshoring of manufacturing activities because a larger share of value added in services is incorporated in the final manufactured goods. Fourth, also within Europe, the increase of highly educated workers in GVCm jobs is larger than in the overall economy (see Table 6). This seems to accord with theories of comparative advantage, which state that countries tend to specialize on those tradable goods that are more intensive in relatively abundant factors.

1. GENERAL COMMENTS

The calculation of GVC incomes is a very interesting methodology to deal with increasing fragmentation of production, and it surely adds more useful information about competitiveness than the raw export data. In the next paragraphs I would like to discuss a bit on some issues. Specifically, I will argue that one has to be cautious in interpreting trends in GVCm income as trends in competitiveness; that there are very interesting patterns of specialization within different manufacturing final goods; that this fantastic body of descriptive statistics should be very useful for further research; and finally I will discuss briefly the policy implications that arise from these data.

2. AGGREGATE DATA: TRENDS IN GVCM INCOME

Suggestive as they are, these data trends are not easy to interpret as trends in competitiveness. Indeed they mirror the broad patterns of structural change to be found in aggregate data: rich countries specialize in services, while emerging economies specialize in manufacturing.[14] The current work shows a similar pattern in three different

[14] See for instance Herrendorf, Rogerson, and Valentinyi (2013a).

slices of the data. First, the evolution of sectoral content of GVCm income and jobs in EU shows a shift away from manufacturing and towards services. That is, in the production pro- cess of final manufacturing goods, Europe is increasing its share of services value added and decreasing its share of manufacturing value added. Second, the increase in GVCm income within Europe is larger in Eastern European countries than in richer ones (see Table 1). Third, the GVCm income produced in EU countries is increasingly spent by developing economies. For instance, 46% of GVCm income produced in Germany was spent abroad in 1995, while in 2008 the share was up to 70% (see Table 1). These three patterns in the data are very interesting on their own, and complement nicely the evidence in aggregate data. The question here, however, is whether the cause of structural change is the loss of competitiveness in producing final manufactured goods, or rather it is owing to other causes. These data alone cannot tell, and there is a buoyant research activity trying to find out.

A different matter is that if we computed the GVC income for agriculture, manufacturing, and services we would have the whole GDP for every country

$$GDP = GVCa + GVCm + GVCs$$

Adding the three together seems a more comprehensive measure of competitiveness as it includes all goods and services, but it is not clear that we would like to look at trends in the shares of GDP as measures in the trends of competitiveness. Or maybe yes?

All and all, GVCm is surely a better measure of competitiveness than shares of exports in manufacturing and the comparison of the two in Table 3 is very good food for thought, clearly pointing out the drawbacks of export shares as measures of competitiveness.

3. DISAGGREGATED DATA: GVC BY INDUSTRIES

Beyond the trends in GVCm income and jobs, the data work here is also very useful to obtain revealed specialization patterns within different manufactured goods. Indeed, the specialization ratios obtained through GVC represent a clear improvement over export ra- tios. The data in Table 4 shows that EU specializes towards *non-electrical machinery* and *transport equipment*, and away from *textiles, clothing, shoes*. However, more interestingly, there is a large variation within the EU, and one observes relatively similarly specialized countries evolving very differently over the years. For instance, in 1995 both Spain and Italy where specialized in the production of non-durables (textiles, wearing apparel and footwear). However, in 2008 only Italy retained this same pattern of specialization while Spain did not. This suggests that while the low-skilled production processed was off-shored to Asia or North Africa Italy was able to retain value in higher skill activities like design. Why Italy managed to do so and Spain did not can help shed light on how to reap the benefit of globalization.

4. APPLICATIONS

The data work produced in this paper can be used to shed light on the causes of structural change. As shown by Herrendorf, Rogerson and Valentinyi (2013b), structural change may be interpreted as coming from non-homothetic demands or from asymmetric productivity growth depending on whether one uses data of production or data of consumption expenditure. To make progress in this research agenda we need good time series of input–output tables of the World. This allows to map value added sectoral shares, which are the ones that should enter the production functions, into consumption sectoral shares, which are the ones that should enter the utility functions. In addition, the import–export dimension of the data is key because of the different implications of productivity changes in open vs closed economies.

A related use of these data is to learn about the 'right' level of sectoral aggregation when talking about structural change. Research in structural change tends to focus on very broad sectors: *agriculture*, *manufacturing* and *services*, but maybe this is too much aggregation. Value added of some services goes embedded in tradable manufactured goods (*wholesale*, *business services*, *banking*, *transport*), while value added of other services are clearly non-tradable (*personal services*, *government*, *health*, *education*). To understand patterns of structural change and development it may be important to measure the evolution of value added, employment and productivity of different service sectors.

5. POLICY IMPLICATIONS

Without theory, it is hard to think about policy implications. Is there any market failure here? A coordination problem? Externalities? Public goods? Shall governments support already strong industries to foster specialization? Or rather, it should baby sit weak ones in order to develop new strengths? There cannot be an answer to all these questions by just looking at data.

Many people in Europe and in the USA have been increasingly worried about the offshoring of manufacturing production to Asia in general and to China in particular. While this offshoring was taking place, this paper shows strong evidence of reallocation of GVCm jobs from manufacturing towards services and from low to high skilled workers. My reading of this evidence is that it should make us optimistic about globalization and production fragmentation. Indeed, since globalization forces cannot be stopped, the best policy recommendation would be to ensure that our economies and citizens reap their benefits and the best policies here would be just to make sure that we do not harm the labour and capital reallocation process.

In particular, as the authors also argue, one can point at the following four policy lines. First, ensure flexible labour markets. Labour needs to be reallocated from stagnant to booming sectors and this requires closing down firms and firing workers as well as opening new firms and hiring new workers. Second, ensure healthy banks. New firms in emerging sectors need to obtain credit. The current balance sheet situa-

tion of banks in Southern Europe does not facilitate this process. Third, increase human capital of new cohorts: improve schools and colleges. Europe will succeed in specializing in the high human capital portion of production processes if it is able to produce human capital abundantly. Fourth, keep safety nets for job losers. No sectoral reallocation process will lead to pareto improvements. Some people losing their jobs will find it hard to reallocate, some regions might suffer a disproportionate share of industrial collapse. It is only fair that the winners compensate the losers. It is also the only way to ensure that globalization and productivity growth is not blocked by those not benefitting from it.

Panel discussion

With reference to the bar chart showing the change in the number of GVC workers by sector, Alan Taylor noted that the production structure of a firm may not have been drastically altered over time. Specifically, he questioned how much worker relabelling (within firms) was done as opposed to actual structural change taking place. Ester Faia pointed out that ultimately we would be interested in foreign vs. domestic ownership in order to understand where income is accrued. In relation to the increase in employment in German car manufacturing, Hans-Werner Sinn explained that the general trend was a decline in the manufacturing sector in Western countries, including Germany. Moreover, he said that this does not imply that value added falls, arguing instead that it is kept constant. Second, Sinn asked if second and third round effects are taken into account in the sense that intermediate products being imported from abroad may contain value added from the destination country. Given the authors' analysis, Catherine Thomas asked if certain policy-making institutions will have to be restructured in order to improve their ability to promote, for instance, productivity growth.

Marcel Timmer firstly made clear that the nature of the data set and the Leontief approach employed deal with the second and third round effects. Next, he confirmed that income is measured from the domestic side and that they do not know the foreign share of capital. He informed the panel that the next wave of research will aim to obtain these foreign shares. Timmer then clarified that competitiveness is about generating income for domestic labor and capital and that one should be careful about equating price competitiveness with GVC income competitiveness. With respect to policy implications, Timmer first noted that manufacturing jobs are becoming more and more service activity oriented (something which cannot be dealt with in their data set) and that job or firm surveys will be required in order to identify the true nature of a worker's position or firm's function. He stressed that it no longer makes sense to speak about industrial competitiveness given the heightened mingling of manufactur-

ing and service activities both within and across sectors. Moreover, he argued that national policy-makers need to understand that competitiveness is no longer derived within the domestic confinements alone. Second, Timmer stated that distributional issues, not only across countries but also across workers, are apparent in a more fragmented world. In particular, high-skilled workers and capital holders are gaining more than low (and medium)-skilled labor in advanced economies. Adding to this, he pointed out that in another paper they show that capital income is growing in all value chains relative to labor income. On a final note, Timmer expressed his appreciation for the suggestions on future research and said that these ideas would be given due consideration.

REFERENCES

Ali-Yrkkö, J., P. Rouvinen, T. Seppälä and P. Ylä-Anttila (2011). 'Who captures value in global supply chains?', *Journal of Industry, Competition and Trade*, 11(3), 263–78.

Altomonte, C., T. Aquilante and G.I.P. Ottaviano (2012). 'The triggers of competitiveness: the EFIGE cross-country report', Bruegel Blueprint 17, Brussels.

Baldwin, R.E. (2006). 'Globalisation: the great unbundling(s)', in *Globalisation Challenges for Europe*, Office of the Prime Minister of Finland, Helsinki.

Baldwin, R.E. and S.J. Evenett (2012). 'Value creation and trade in the 21st century manufacturing: what policies for UK manufacturing?', Chapter 4 in Greenaway (ed.), *The UK in a Global World*, Centre for Economic Policy Research, London.

Baldwin, R.E. and F. Kimura (1998). 'Measuring U.S. international goods and services transactions', in R.E. Baldwin, R. E. Lipsey and J.D. Richardson (eds), *Geography and Ownership as Bases for Economic Accounting*, NBER Chicago, 49–80.

Baldwin, R.E. and A. Venables (2010). 'Relocating the value chain: offshoring and agglomeration in the global economy', NBER Working Papers No. 16611.

Bems, R., R. C. Johnson and K.-M. Yi (2011). 'Vertical linkages and the collapse of global trade', *American Economic Review*, 101(3), 308–12.

Christensen, L. R., D. W. Jorgenson and L.J. Lau (1971). 'Conjugate duality and the transcendental logarithmic function', *Econometrica*, 39(4), 225–56.

Deardorff, A.V. (2001). 'Fragmentation across cones', Chapter 3 in S.W. Arndt and H. Kierzkowski (eds.), *Fragmentation: New Production Patterns in the World Economy*, Oxford University Press, Oxford.

Dedrick, J., K.L. Kraemer and G. Linden (2010). 'Who profits from innovation in global value chains? A study of the iPod and notebook PCs', *Industrial and Corporate Change*, 19(1), 81–116.

Dietzenbacher, E., B. Los, R. Stehrer, M. Timmer and G.J. de Vries (2013). 'The construction of world input–output tables in the WIOD project', *Economic Systems Research*, 25(1), 71–98.

Di Mauro, F. and K. Forster (2008). 'Globalisation and the competitiveness of the euro area', ECB Occasional Paper No. 97.

Dudenhöffer, F. (2005). 'Wie viel Deutschland steckt im Porsche?', *Ifo Schnelldienst*, 58(24).

Fagerberg, J. (1988). 'International competitiveness', *The Economic Journal*, 98(3), 355–74.

Feenstra, R.C. (1998). 'Integration of trade and disintegration of production in the global economy', *Journal of Economic Perspectives*, 12(4), 31–50.

—— (2010) *Offshoring in the Global Economy: Microeconomic Structure and Macroeconomic Implications*, MIT Press, Cambridge, MA.

Feenstra, R.C. and G.H. Hanson (1999). 'The impact of outsourcing and high-technology capital on wages: estimates for the U.S., 1979–1990,' *Quarterly Journal of Economics*, 114(3), 907–40.

Feenstra, R.C. and J. B. Jensen (2012). 'Evaluating estimates of materials offshoring from U.S. manufacturing', NBER Working Paper No. 17916.

Francois, J. and B. Hoekman (2010). 'Services trade and policy', *Journal of Economic Literature*, 48 (3), 642–92.
Goos, M., A. Manning and A. Salomons (2011). 'Explaining job polarization: the roles of technology, offshoring and institutions', mimeo, Katholieke Universiteit Leuven.
Grossman, G. and E. Rossi-Hansberg (2006). 'The rise of offshoring: it's not wine for cloth anymore', Proceedings, Federal Reserve Bank of Kansas City, 59–102.
Grossman, G. and E. Rossi-Hansberg (2008). 'Trading tasks: a simple theory of offshoring', *American Economic Review*, 98(5), 1978–97.
Herrendorf, B., R. Rogerson and A. Valentinyi (2011). 'Two perspectives on preferences and structural transformation', IEHAS Discussion Papers 1134, Institute of Economics, Hungarian Academy of Sciences.
Herrendorf, B., R. Rogerson and A. Valentinyi (2013a). 'Growth and structural transformation', in *Handbook of Economic Growth*. Elsevier, Amsterdam, forthcoming
——, —— and ——(2013b). 'Two perspectives on preferences and structural transformation', *American Economic Review*, forthcoming.
Hummels, D., J. Ishii and K.-M. Yi (2001). 'The nature and growth of vertical specialization in world trade', *Journal of International Economics*, 54(1), 75–96.
Inklaar, R., M. P. Timmer and B. van Ark (2008). 'Market services productivity across Europe and the US', *Economic Policy*, 23(53), 141–94.
Isard, W. (1951). 'Interregional and regional input–output analysis: a model of a space-economy', *Review of Economics and Statistics*, 33(4), 318–28.
Johnson, R. and G. Noguera (2012). 'Accounting for intermediates: production sharing and trade in value added', *Journal of International Economics*, 86(2), 224–36.
Koopman, R., Z. Wang and S-J. Wei (2012). 'Estimating domestic content in exports when processing trade is pervasive', *Journal of Development Economics*, 99(1), 178–89.
Leontief, W. (1936). 'Quantitative input–output relations in the economic system of the United States', *Review of Economics and Statistics*, 18(3), 105–25.
Levchenko, A.A. and J. Zhang (2012). 'Comparative advantage and the welfare impact of European integration', *Economic Policy*, 27(72), 567–602.
Los, B., M.P. Timmer and G.J. de Vries (2013). 'Globalization or regionalization? A new approach to measure international fragmentation of value chains', GDDC Research Memorandum No. 138, University of Groningen.
Marin, D. (2006). 'A new international division of labor in Europe: outsourcing and offshoring to Eastern Europe', *Journal of the European Economic Association*, 4(2–3), 612–22.
—— (2010). 'Germany's super competitiveness: a helping hand from Eastern Europe', *VOX*, 20 June.
—— (2011). 'The opening up of Eastern Europe at 20: jobs, skills, and "reverse maquiladoras"', in M. Jovanovic (ed.), *Handbook of International Economics*, Vol. 2, Edward Elgar, Cheltenham.
Miller, R.E. (1966). 'Interregional feedback effects in input–output models: some preliminary results', *Papers in Regional Science*, 17(1), 105–25.
Miller, R.E. and P.D. Blair (2009). *Input–output Analysis: Foundations and Extensions*, Cambridge University Press, Cambridge.
O'Mahony, M. and M.P. Timmer (2009). 'Output, input and productivity measures at the industry level: the EU KLEMS database', *Economic Journal*, 119(538), F374–403.
Ottaviano, G., D. Taglioni and F. di Mauro (2009). 'The euro and the competitiveness of European firms', *Economic Policy*, 24(57), 5–53.
Porter, M.E. (1985). *Competitive Advantage*, Free Press, New York.
Sinn, H-W. (2005). *Die Basar-Ökonomie. Deutschland: Exportweltmeister oder Schlusslicht?*, Econ Verlag, Berlin.
—— (2006). 'The pathological export boom and the bazaar effect: how to solve the German puzzle', *The World Economy*, 29(9), 1157–75.
Sturgeon, T.J., P. B. Nielsen, G. Linden, G. Gereffi and C. Brown (2012). 'Direct measurement of global value chains: collecting product- and firm-level statistics on value added and business function outsourcing and offshoring', forthcoming in World Bank, The Fragmentation of Global Production.
Sturgeon, T., J. Van Biesebroeck and G. Gereffi (2008). 'Value chains, networks and clusters: reframing the global automotive industry', *Journal of Economic Geography*, 8(3), 297–321.

Timmer, M.P. (ed.) (2012). *The World Input–Output Database (WIOD): Contents, Sources and Methods*, WIOD Working Paper No. 10, available at www.wiod.org.
Timmer, M.P., A.A. Erumban, B. Los, R. Stehrer and G.J. de Vries (2013). 'Slicing up global value chains', GDDC Research Memorandum No. 135, University of Groningen.
Trefler, D. and S. Zhu (2010). 'The structure of factor content predictions', *Journal of International Economics*, 82(2), 195–207.
Yi, K.-M. (2003). 'Can vertical specialization explain the growth of world trade?' *Journal of Political Economy*, 111(1), 52–102.