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Fragmentation, Incomes, and Jobs

An Analysis of European Competitiveness

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Abstract

Increasing fragmentation of production across borders is changing the nature of international competition. As a result, conventional indicators of competitiveness based on gross exports are becoming less informative and new measures are needed. This paper proposes an ex-post accounting framework of the value added and workers that are directly and indirectly related to the production of final manufacturing goods. The framework focuses on manufactures global value chain income and manufactures global value chain jobs. The paper outlines these concepts and provides trends in European countries based on a recent multi-sector, input-output model of the world economy. The analysis finds that since 1995, revealed comparative advantage of the European Union 27 is shifting to activities related to the production of nonelectrical machinery and transport equipment. The workers involved in manufactures global value chains are increasingly in services, rather than manufacturing industries. The analysis also finds a strong shift toward activities carried out by high-skilled workers, highlighting the uneven distributional effects of fragmentation. The results show that a global value chain perspective is needed to inform the policy debates on competitiveness.

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Fragmentation, Incomes, and Jobs: An Analysis of European Competitiveness

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1. Introduction[1]

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 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 longstanding 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 fueled 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 (see e.g. Bobeica and F. di Mauro, 2013).

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, p.66-67): " [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) suggested that the increasing imports of intermediates, mainly from Eastern Europe, led to a decline in the value added by German factors in the production for exports. 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

[1] This paper is an abridged version of a paper prepared for the 57th Panel Meeting of Economic Policy, April 2013. The longer version will be published in *Economic Policy*, October 2013.

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". As there are no data available at the activity level within firms, we identify an activity by the industry in which it is performed, and the skill-type of labor involved. We focus on activities that are directly and indirectly involved in production of final manufacturing goods. 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, Johnson and Yi (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 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 is thus in the empirical application and in particular the interpretation of the results in the context of analyzing 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 (ed.), 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 (Dalia Marin, VOX, June 20, 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 growing much more slowly 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 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 in 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 for high-skilled workers increase much faster than those for medium- and low-skilled workers. And this increase is also faster than the increase in supply of high-skilled workers in the overall economy. 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 share in 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. These indirect contributions will be explicitly accounted for through the modelling of input-output linkages across sectors. Manufactures GVC income is thus not synonymous with manufacturing competitiveness as it excludes those activities in manufacturing involved in the production of non-manufacturing final goods and services (e.g. cement used in house construction) and includes some non-manufacturing activities. Summed across all countries manufactures GVC income will equal global final expenditure on manufactures.[2] It is also not the same as overall 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 incomes measure competitiveness of the domestic economy, i.e. based on activities carried out on the domestic territory of a country, rather than the national economy which would be based on the ownership of the production factors involved. This difference is typically small for employment, as labor migration is still limited and value added by domestic labor in a country will accrue as national income. Thus differences in the number of domestic and national GVC jobs will be small. But this is not necessarily true for value added

[2] Herrendorf, Rogerson and Valentinyi (2011) provide a related discussion of what they call the "consumption value added" and the "final consumption expenditure" perspectives. Our approach follows the former.

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. Manufactures GVC income of a country thus 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. A revealed comparative advantage analysis is carried out based on manufactures GVC incomes. 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 sub-section 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 labor and capital that reside in the country. GVC incomes are thus always related to a particular 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 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 analyze 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 stages of production. Recent case studies of electronic products such as the Nokia smartphone (Ali-Yrkkö, Rouvinen, Seppälä and Ylä-Anttila, 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 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). All in all, the value added in GVCs of

manufactures account for about 25 per cent of gross domestic product in 1995 and 21 per cent in 2011 (EU 27 median). In 2011, it ranged from a low 13% in Greece to 28% in Germany and even 31% in Hungary.

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.[3] An increasing part of world trade is in services, and only (part of) intermediate services are included in GVCs of manufactures. 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). GVCs of services cannot be analyzed 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 for example consultancy services. The lowest level of detail in the WIOD is "business services" which for the major part contains activities that are not internationally traded, and hence are much less interesting to analyze from a GVC perspective. Only 5 percent of final output of these services is added outside the domestic economy (EU 27 average in 2008), while this is 29 percent in manufacturing as shown later. This is all the more true for other services, such as for example 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 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 analyzing 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, GVC income will decline. Similarly, if German consumers shift demand to cars from Japan, GVC income in Germany will decline as well. In contrast, measures based on foreign demand and exports only 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. To the extent that the value is added by labor, this difference will be small as the majority of domestic workers are employed in the domestic economy. Typically in advanced nations about three-quarters of the value added generated in an industry is labor income. But the divergence between domestic and national is important for the remaining value added by capital. 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

[3] 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.

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 in interpreting the results. Given the small difference between domestic and national workers as labor migration is relatively small as a percentage of total jobs, this is not an important issue for our analysis of GVC jobs in the last part of the paper.

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).[4] 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 framework drawing on the exposition in Johnson and Noguera (2012) and then generalize their approach to analyze 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

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

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*. 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 **y** be the vector of production of dimension (SNx1),

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

which is obtained by stacking output levels in each country-sector. Define **f** as the vector of dimension (SNx1) 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 **A** of dimension (SNxSN). 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 **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 compact form as $\mathbf{y} = \mathbf{A}\mathbf{y} + \mathbf{f}$. Rearranging, we arrive at the fundamental input-output identity

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

where **I** is an (SNxSN) identity matrix with ones on the diagonal and zeros elsewhere. $(\mathbf{I} - \mathbf{A})^{-1}$ is famously known as the Leontief inverse (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 *n*th element representing an 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 $\mathbf{A}\mathbf{z}_n$. 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 purchaser's 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 **p** containing these 'direct' value added coefficients. To take 'indirect' contributions into account, we derive the SN-vector of value added levels **v** as generated to produce a final demand vector **f** by pre-multiplying the gross outputs needed for production of this final demand by the direct value added coefficients vector **p**:

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

in which a hat-symbol indicates a diagonal matrix with the elements of **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

[5] If **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 **v** should add up to the elements of **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 **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 $\mathbf{e}'\mathbf{v}_n = \mathbf{e}'\hat{\mathbf{p}}(\mathbf{I} - \mathbf{A})^{-1}\mathbf{z}_n =$

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 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 analyze the value and quantities used of specific production factors (labor 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 labor. To do so, we now define $p^L_i(s)$ as the direct labor input per unit of gross output produced in sector *s* in country *i*, for example the hours of low-skilled labor used in the Hungarian electronics sector to produce one euro of output. Analogous to the analysis of value added, the elements in $\mathbf{p}^L$ do not account for labor embodied in intermediate inputs used. Using equation (3), we can derive all direct and indirect labor 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 modeling of behavioral 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 summarize the combined effects of changes in relative input prices, in cross-elasticities and input-biased technical change (Christensen, Jorgenson and Lau 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

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$\mathbf{p}'(\mathbf{I}-\mathbf{A})^{-1}\mathbf{z}_n$**.** By definition, value added is production costs minus expenditures for intermediate inputs such that $\mathbf{p}' = \mathbf{e}'(\mathbf{I}-\mathbf{A})$. Substituting gives $\mathbf{e}'\mathbf{v}_n = \mathbf{e}'(\mathbf{I}-\mathbf{A})(\mathbf{I}-\mathbf{A})^{-1}\mathbf{z}_n = \mathbf{e}'\mathbf{z}_n$. 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*.

industry which has witnessed some strong changes in its organizational and geographical structures in the past two decades (Sturgeon, van Biesebroeck and Gereffi, 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.

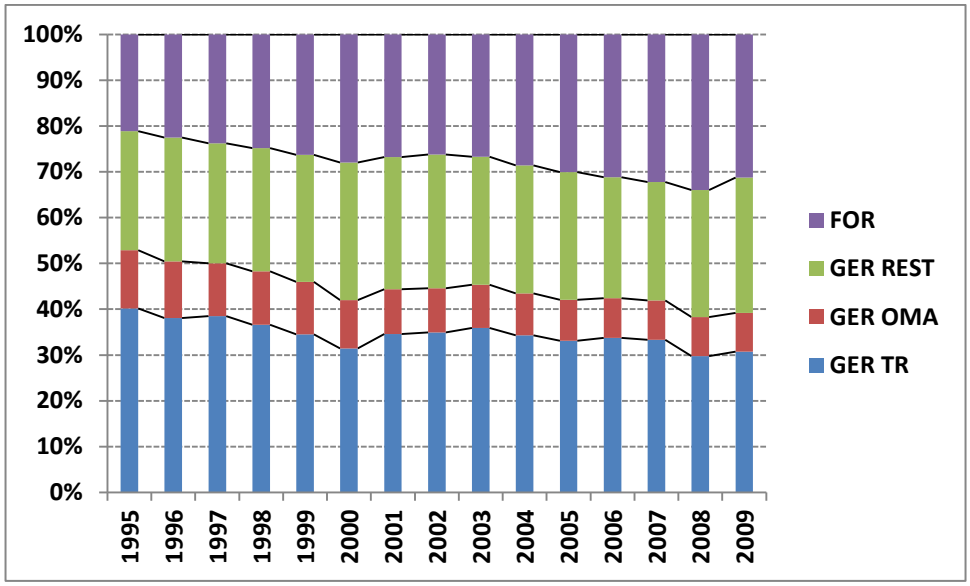
Using our database and methodology, we can provide a comparable decomposition for the output of the German car industry as a whole. We decompose the value of output of all final products delivered by the German transport equipment industry (NACE rev. 1 industries 34 and 35). This includes the value added 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 per cent in 2008. However, due to rapidly increasing demand for German cars, the number of German jobs has not declined but increased 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) off shoring 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 per cent, high-skilled increased by more than 50

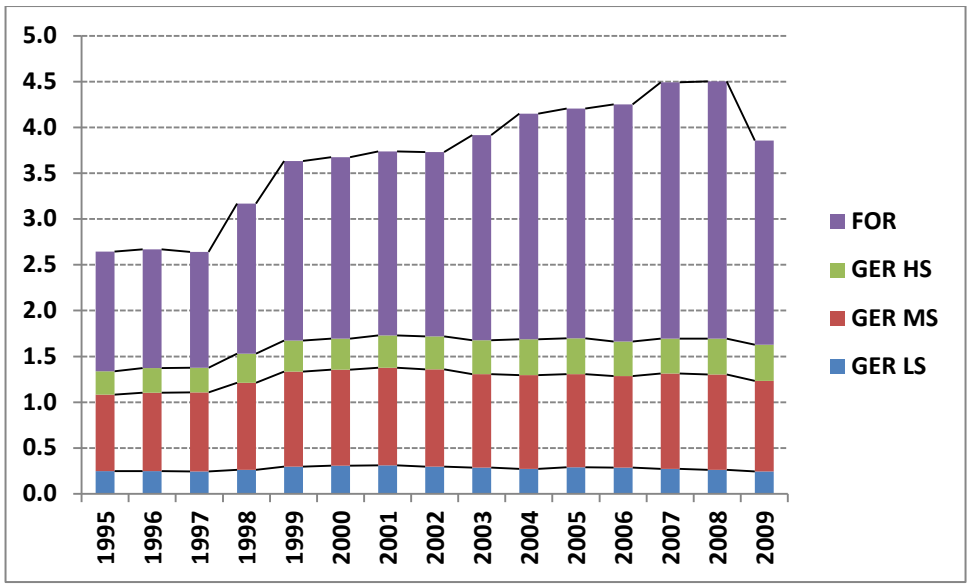
percent. This finding is suggestive of increased specialization in advanced nations, which we will return to in section 5.

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)



Note: 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: Author's calculations based on World Input-Output Database, April 2012.

3. Data from the World Input-Output Database

To measure GVC incomes a 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 (ed., 2012). The WIOD contains time-series of global input-output tables and supplementary labor 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. In addition to measure GVC jobs we also need data on workers by skill type and industry. This is covered in section 3.2. Additional details regarding data construction and basic data sources can be found in Timmer (ed., 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; the Republic of Korea; Taiwan, China; Turkey; and the United States. In total it covers more than 85 percent 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 there from. They include agriculture, mining, construction, utilities, fourteen manufacturing industries, eight trade and transport services, telecom, finance, business services, personal services, and three public services. The product groups are more finely defined and are all two-digits in the 2002 Classification of Products by Activity (CPA), including twenty-three 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 are 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 (e.g. Koopman, Wang and Wei, 2012; Ottaviano et al., 2009)

National supply and use tables 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 which 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, Winkler and Milberg, 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 end-use 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 exports as mirror flows from the bilateral import statistics. 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 linked 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$ 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. Shares like these are base invariant. 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 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 (compare e.g. agriculture and business services). 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 labor 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 labor force surveys, supplemented by household survey 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

[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.

workers for which an imputation was made if necessary. Although hours worked would be a preferable measure, these data are not available at a large scale. Labor 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 database 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 member of the EU. This group of countries is collectively denoted by EU 27 and held constant throughout the paper. 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 amongst eleven 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 joining 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 analyze trends in the GVC income for the EU 27 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. In section 4.3 a revealed comparative advantage (RCA) analysis is carried out based on GVC incomes in particular product groups. We find that differences in competitiveness and RCA between old EU member states based on GVC incomes are different than based on traditional gross export flows. This difference is analyzed more in depth in section 4.4.

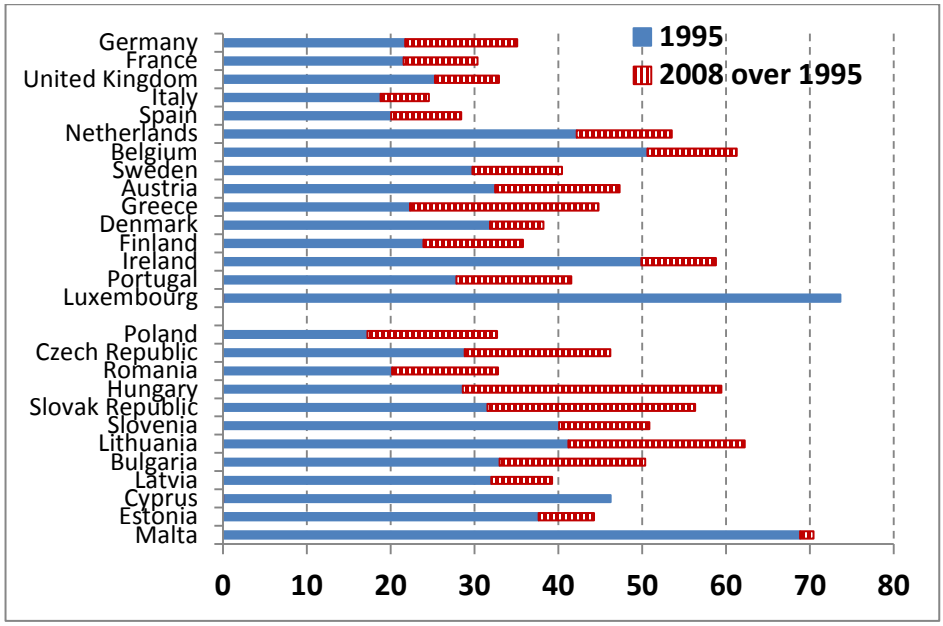
4.1 International production fragmentation

In Figure 2 we provide a simple indicator of fragmentation based on the WIOD, using the broad measure of outsourcing 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 in 2004 (Marin 2006, 2011).

This finding of increasing international fragmentation is robust to the use of alternative or complementary measures. Hummels, Ishii and Yi (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 the HIY and FH measures are high (63% for 2008, 84% in 1995 and 55% for the change during 1995-2008) and pure correlations even higher. Los, Timmer and de Vries (2013) extend the FH measure and provide an alternative based on shares in GVC incomes. 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 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 "Made in the World".

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

4.2 Trends in manufactures GVC incomes in Europe

In section 2 we developed the concept of a country's 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 (in short manufactures GVC income). 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 expenditure on manufacturing goods as we model all regions in the world in our empirical analysis. The share of a country in world GVC income is a novel indicator of the competitive strength of a nation. In this section we show trends in the distribution of world GVC income across countries.

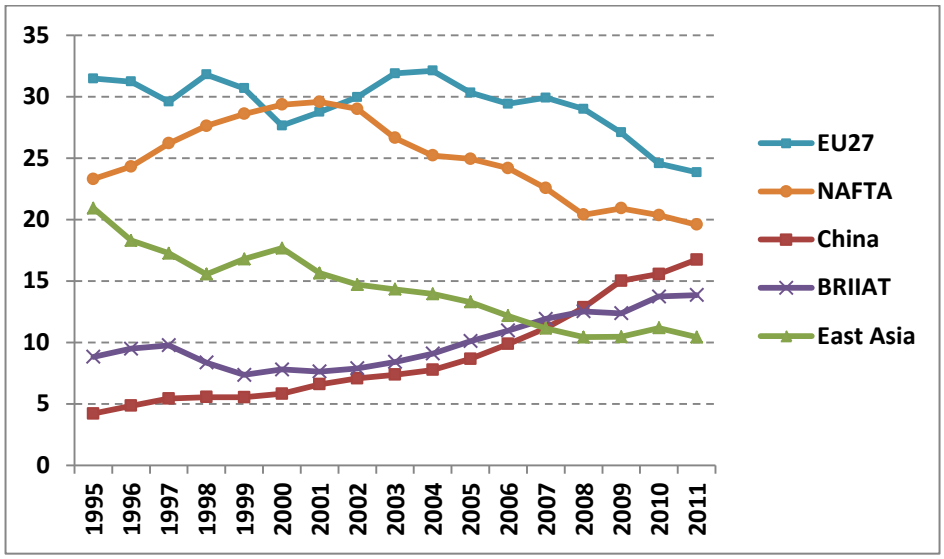
In Figure 3 we provide shares of regions in world GVC income in the production of manufactures. It follows that the share of the EU has been on a slightly declining trend from 32% in 1995 to 29% in 2008. This decline cannot be explained by shifts in the product structure of global manufacturing demand. Since 1995, global demand is shifting mainly away from 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 the value added in each product GVC. 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 after 2001 to 20% in 2008. GVC shares of East Asia (comprising Japan; Korea; and Taiwan, China) were on a long decline already since the 1990s, falling from 21% in 1995 to 10% in 2008. This can be explained primarily by slow growth in domestic demand for manufacturing goods in Japan. But one has to keep in mind that the decline in East Asian GVC income is likely overestimated as it is also related to the offshoring of activities to China, which effectively became the assembly place of East Asia. Income earned by East Asian capital is allocated to the place of production (in this case China), and not by ownership as discussed in section 2. This difference is probably larger for East Asian countries than for NAFTA or the EU which have larger FDI flows within the region (see below).

One might argue that these shifts in regional GVC income shares are unsurprising, given the faster growth of China and other emerging economies vis-à-vis advanced regions. Higher consumption in the home economy would naturally lead to higher GVC incomes. But this is only true to the extent that demand for manufactures has a strong home production bias, that is, mainly geared towards goods with a high level of domestic value added. Given the high tradability of manufacturing goods, this home bias is not obvious however. Increased Chinese demand for say chemicals or electronic equipment can be as easily served by imports as by Chinese domestic production. And in the latter case a sizeable share could still be captured by advanced countries through the delivery of key intermediate inputs and services. Falling shares in global GVC income for advanced regions in Figure 3 indicate that they failed

to capture a large part of the value of the increased market for manufacturing goods in emerging economies. And at the same time the domestic value added content of their own production declined. Both trends can be interpreted as a loss of competitiveness. International competition is not a zero-sum game however. And the declining shares in global GVC 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.

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; Korea; and Taiwan, China. 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:* Author's calculations based on World Input-Output Database, April 2012, updated to 2011.

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 7 small European countries[7] 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. About one third of the increase in the overall EU27 GVC income was earned on the EU12 territory which is much higher than their share in EU27 GDP (7.8% in 2008). This testifies to the importance of the new member states for growth in European production capacity. In contrast, the competitive position of all major EU countries dwindled over this period. The most important industrial economy of Europe, Germany, contributed 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). Also shares in other major old EU countries declined. The French decline was slow but steadily, and the share in the UK dropped severely after an initial increase in the late 1990s. But even in this country, the absolute level of

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

GVC income still increased over the period, testifying to the non-zero-sum nature of international competition.

As for the case of East Asia and China, one might argue that German competitiveness has not necessarily declined, but merely shifted 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 the possible difference. For EU12, the share of capital income in value added is about 40 percent. If we assume that the increase in EU12 GVC income over 1995-2008 took place solely in wholly-German-owned firms, national GVC income in Germany in 2008 is about 8.7 percent higher than domestic GVC income. Even with this clearly upper bound estimate, the German share in EU 27 GVC income would still have dropped over the period to 28.7 percent in 2008.

By splitting the final demand vector in the decomposition given in equation (3), we can analyze the importance of domestic versus foreign final demand in the generation of GVC income in a country. The GVC income due to foreign demand is identical to what Johnson and Noguera (2012) refer to as "exports of value added".[8] 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 for the EU15. The direction of this trend was to be expected as the income elasticity of demand for manufactures is low and domestic demand was increasingly served through imports with high foreign value added. But this domestic decline was more than counteracted by a rapid increase in exports of value added in all EU countries. The most extreme example of this shift towards foreign demand dependence is to be found in Germany given the large size of its domestic market. While in 1995 46 per cent of its GVC income was due to foreign final demand, this increased to 70 per cent 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. Taken together we find a fundamental shift in the demand drivers of structural changes in European economies.

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 of 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 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

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

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 old 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 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 per cent of their actual GVC income increase.

Table 1 Real GVC income in EU27 countries, all manufactures

	Real GVC income (in mil constant $)		Shares in EU27 GVC income		Real GVC income due to foreign final 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: Author's calculations based on World Input-Output Database, April 2012.

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

	Change in real GVC income between 1995 and 2008		
	Total change (mil US$)	keeping production structures constant	keeping final demand constant
Germany	47,328	111,625	-64,297
France	37,886	79,199	-41,313
United Kingdom	6,895	8,637	-1,742
Italy	65,104	83,767	-18,664
Spain	44,140	49,120	-4,980
Netherlands	24,840	26,925	-2,086
Belgium	3,426	12,606	-9,180
Sweden	15,012	18,434	-3,422
Austria	12,593	15,799	-3,206
Greece	10,095	10,977	-882
Denmark	5,217	6,910	-1,694
Finland	8,085	9,549	-1,465
Ireland	18,897	16,383	2,514
Portugal	3,498	3,620	-121
Luxembourg	2,959	1,600	1,359
All EU15	305,974	455,153	-149,180
Poland	52,261	47,986	4,275
Czech Republic	26,973	23,229	3,743
Romania	20,689	18,584	2,105
Hungary	16,020	14,371	1,649
Slovak Republic	12,564	11,338	1,226
Other EU12	16,325	12,621	3,704
All EU12	144,832	128,130	16,702

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

4.3 Revealed comparative advantage in GVCs

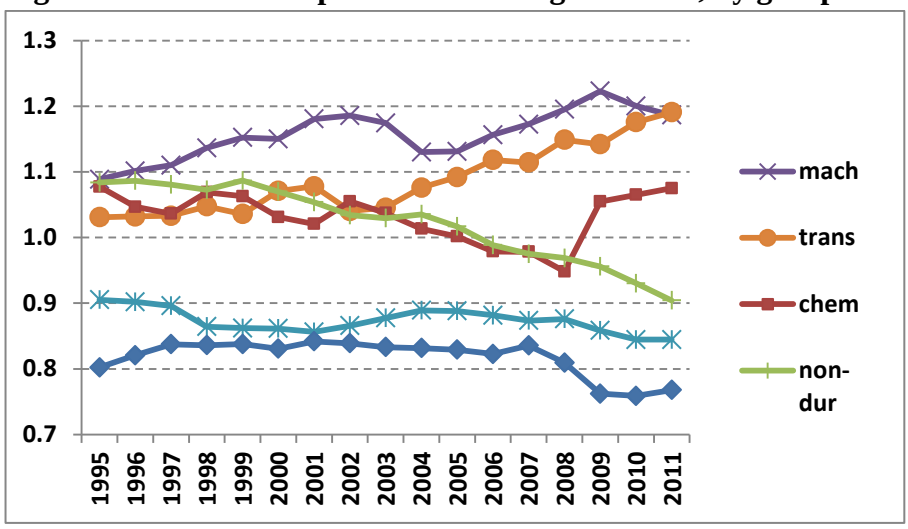
An interesting issue is to what extent Europe is specializing in particular activities within specific product GVCs. The standard tool to analyze this is revealed comparative advantage (RCA) analysis. Traditionally, this is based on comparing a country's share in world exports of a particular product group or industry 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 last one and a half decades. They found neither a decline in the specialization in labor-intensive products, nor the expected shift towards more skill-intensive production.

This surprising finding might be due to the fact that the RCA analysis is 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 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 groups. We find that the EU27 has a strong and increasing RCA in activities related to the production of machinery and transport equipment. 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. It has declined further since 2007.

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 same ratio for all manufactures. Final food manufacturing products (Food: produced in ISIC rev.3 industries 15 & 16), Other non-durable products (Tex: 17 to 20, 36, 37); Chemical products (Chem: 23 to 26), Machinery & metal products (Mach: 27 to 29); Electrical machinery products

(Elec: 30 to 33) and Transport equipment (Tra: 34, 35). *Source:* Author's calculations based on World Input-Output Database, April 2012, updated to 2011.

Aggregate EU27 specialization patterns hide substantial variation within the European Union. In Table 3 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 Czech Republic, Hungary and the Slovak Republic. Instead they developed comparative advantage in electrical and non-electrical equipment. Across the old EU 15 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 that grasped the opportunities. Germany specialized further in activities in the transport equipment and non-electrical machinery manufacturing; 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 basically suggests a shift of Italy in the non-durable value chains away from low-skill assembly and production activities towards higher skill activities, such as pre- and post-production services.

Table 3 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
United Kingdom	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 Republic	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 Republic	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 & 16), Other non-durable products (Tex: 17 to 20, 36, 37); Chemical products (Chem: 23 to 26), Machinery & metal products (Mach: 27 to 29); Electrical machinery products (Elec: 30 to 33) and Transport equipment (Tra: 34, 35).
Source: Author's calculations based on World Input-Output Database, April 2012.

4.4 Comparing GVC incomes and gross exports

The finding of declining competitiveness of Germany in the previous sections 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. 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 loose income in production for the domestic market. The GVC income share of a country measures the combined net effect.

Nominal gross exports of manufactures from Germany increased by 180% over the period 1995-2008, whereas manufactures GVC income increased only by 52%. This is the net effect of two main factors. First, the domestic value added content of German industrial production 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, 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. Given the relatively large share of domestic value added in production for final domestic demand (akin to the home production bias in international trade), this depressed German GVC income. Added to this, an increasing part of domestic demand was served by imports of final manufacturing goods 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 much faster than the latter in all European countries. 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 Table 4 for the period 1995-2008. But this is solely 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.

Table 4 Growth in manufacturing exports and manufactures GVC income between 1995 and 2008 (%)

	Growth in gross export value	Growth in GVC income	Difference
Germany	180	52	-129
France	121	59	-61
United Kingdom	79	45	-34
Italy	135	73	-62
Spain	213	90	-123
Netherlands	121	78	-43
Belgium	97	48	-49
Sweden	126	79	-47
Austria	225	76	-149
Greece	317	111	-206
Denmark	90	61	-28
Finland	159	80	-79
Ireland	187	164	-23
Portugal	140	62	-78
Luxembourg	101	151	50
Poland	603	261	-341
Czech Republic	692	304	-389
Romania	494	286	-207
Hungary	882	244	-638
Slovak Republic	716	391	-325
Slovenia	234	134	-100

Note: Exports refer to gross export value of all manufacturing goods and GVC refers to GVC income in production of final manufactures. Growth rates calculated as (ratio of 2008 over 1995 minus one) times 100.
Source: Author's calculations based on World Input-Output Database, April 2012.

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, see contributions in Bardhan, A., D. Jaffee and C. Kroll (2013) for an overview. It is thus useful to look at the structure of employment in global value chains and analyze the changes in the characteristics of workers directly and indirectly involved in the production of manufacturing goods, in short manufactures

GVC jobs.[9] For each country, we will measure the number of workers involved on the domestic territory. As the mobility of labor 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 manufacturing 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, GVC job increase in services is even higher than job loss in manufacturing. In section 5.2 we analyze 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.

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 work force 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 absolute 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 is the declining importance of global production of manufactures for overall employment in Europe. And second is 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 show 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 percent of the total employed labor force in the EU 27, and this declined to 22 percent 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 per cent of the German employment was 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 labor 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 demand

[9] 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.

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 labor income per worker in manufactures GVCs, deflated by the national CPI. Note that this real wage includes only GVC income that accrues to labor 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 is not solely determined by unit labor 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 manufacturing GVCs in the EU27 declined by 1.8 million jobs between 1995 and 2008. 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. Faster growth in services jobs than in manufacturing can be seen in all twenty 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 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.

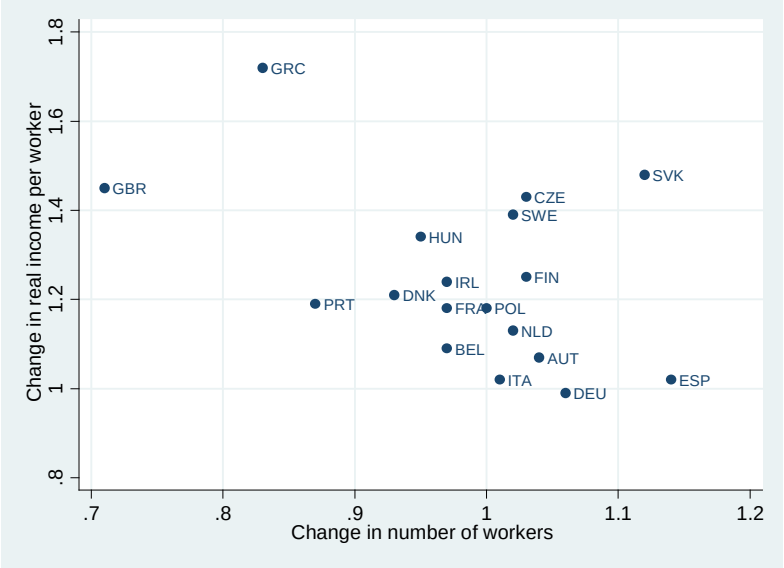
Table 5 Manufactures GVC workers, 1995 and 2008, by sector

	Manufactures GVC workers as (%) share of all workers in the economy		Manufactures GVC workers in 2008 (in thousands) employed in				Change in manufactures GVC workers between 1995 and 2008 (in thousands) employed in			
			Agriculture	Manufacturing	Services	All sectors	Agriculture	Manufacturing	Services	All sectors
	1995	2008								
Germany	26.8	26.4	400	5,481	4,766	10,647	-161	-666	1,388	561
France	22.0	18.7	303	2,195	2,355	4,853	-96	-423	368	-151
United Kingdom	20.1	12.6	115	1,946	1,931	3,992	-128	-1,148	-347	-1,624
Italy	29.1	25.5	333	3,553	2,559	6,444	-192	-234	517	91
Spain	23.2	17.5	271	1,827	1,494	3,592	-97	185	353	440
Netherlands	22.8	19.0	89	643	929	1,661	-42	-87	158	29
Belgium	25.0	20.9	31	399	503	933	-18	-86	72	-32
Sweden	22.7	21.0	36	481	443	959	-23	-49	94	22
Austria	24.8	22.6	104	463	393	960	-46	-35	120	40
Greece	21.0	15.0	97	374	247	717	-202	17	34	-151
Denmark	23.9	19.6	41	271	257	569	-25	-66	51	-41
Finland	23.6	19.7	39	248	211	498	-25	-12	51	14
Ireland	31.5	18.8	59	168	168	394	-35	-17	40	-11
Portugal	28.9	21.7	191	602	343	1,136	-57	-139	20	-176
Luxembourg	20.3	17.4	1	23	36	61	-1	1	16	17
all EU15	24.4	20.4	2,110	18,674	16,632	37,416	-1,149	-2,758	2,936	-971
Poland	31.0	28.8	917	2,278	1,347	4,542	-468	81	368	-19
Czech Republic	30.8	30.9	93	990	553	1,636	-59	74	35	50
Romania	34.0	27.6	684	1,388	517	2,588	-356	-222	-68	-646
Hungary	31.6	29.3	129	675	400	1,204	-145	13	63	-69
Slovak Republic	28.2	29.6	22	392	249	663	-35	19	85	69
Other EU12	29.0	24.2	362	1,121	616	2,098	-86	-217	98	-205
all EU12	31.2	28.0	2,207	6,844	3,682	12,732	-1,150	-251	580	-820
Total EU 27	25.9	21.9	4,316	25,518	20,314	50,148	-2,298	-3,009	3,517	-1,791

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

Figure 5 Employment versus real wage in manufacturing GVCs, 1995-2008 (1995=1).



Note: Change in number of workers and real income per worker over 1995-2008 in manufacturing 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:* Author's calculations based on World Input-Output Database, April 2012. CPI from OECD National Accounts Statistics.

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 sub-set of the services sector, and involve in particular intermediate services such as wholesaling, transportation, finance and several business services.[10] 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., 2009). 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.

Taken together, the results of sections 4 and 5 show that international fragmentation in the production of manufactures has been accompanied by a rapid shift towards higher-skilled activities in the EU. These activities are increasingly carried out in the services sector, and no longer in the manufacturing sector itself. 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, Manning and Salomons 2011).

[10] 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.

6. Concluding remarks and lessons for policy

In the past decades, production has become increasingly organized in global value chains with different stages of production fragmented 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 policy making. 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 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 Germany and small open economies that rely heavily on imported intermediates. Importantly, this bias in traditional measures has increased over time. We also find that only about half of the jobs directly or indirectly involved in manufactures GVC production are actually manufacturing jobs. Furthermore, their number is declining in almost all EU countries over the period 1995-2008. However, the narrow focus on declining jobs in manufacturing overlooks the increasing number of manufactures GVC jobs in non-manufacturing, in particular in business services. For the EU as a whole, this increase is even bigger than the decline in manufacturing jobs. It shows that international fragmentation does not necessarily lead to overall job destruction in advanced nations.

Second, analyses of gross exports comparative advantage 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–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 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 shift is more pronounced than expected on the basis of the overall economy increase in skill supply. Fragmentation of production thus seems to be related to a magnification of comparative advantages in advanced economies.

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. As a result traditional comparative advantage analysis does a poor job in guiding policy reactions to globalization. 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 not be sector-

specific but rather focus on the type of activities carried out, taking into account vertical integration of production within and across countries.

A second lesson is that comparative advantage is no longer only determined within borders. 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 through cost-linkages improvements in 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 policy measures in order to maximize regional competitiveness that includes these knock-on effects. Industrial and trade policies need to be well-aligned. 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 presented, though, there is a need for a firmer statistical basis to quantify these. Although the WIOD database 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.[11] 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 analyze 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 analyze GVC income both on a domestic and a national basis. The latter is preferable when analyzing national competitiveness, rather than domestic as in this paper.

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 (Bernard et al., 2007). To take this heterogeneity into account a more disaggregate approach is required. Building upon the insights that firm-level performance is highly heterogeneous, Ottaviano et al. (2009) 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.[12] 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 (Sturgeon and Gereffi, 2009). Eurostat and the US Bureau of Labor Statistics have already carried out pilot projects to investigate the possibilities for large-scale surveys and first results are described in

[11] See e.g. speech by Paul Schreyer on "The OECD-WTO Trade in Value-Added Database", WTO Trade Data Day Geneva, 16 January 2013.
[12] See the recently released EFIGE dataset for a good example (Altomonte and Aquilante, 2012).

Alajääskö et al. (2011) and Brown (2008). These initiatives will undoubtedly lead to a deeper understanding of the effects of trade and fragmentation on incomes and jobs, and be helpful in better informing and formulating future policies.

References

Alajääskö, P., P.B. Nielsen, S. Rikama and J. Sisto (2011), "Global value chains - international sourcing to China and India", available at http://epp.eurostat.ec.europa.eu/ statistics_explained

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*, vol. 11(3), pp. 263-278.

Altomonte, C. and T. Aquilante (2012), "The EU-EFIGE/Bruegel-Unicredit Dataset", Bruegel working paper nr. 13.

Baldwin, R.E. (2006), "Globalisation: The Great Unbundling(s)", in *Globalisation Challenges for Europe*, Helsinki: Office of the Prime Minister of Finland.

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, pp. 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.

Bardhan, A., D. Jaffee and C. Kroll (eds.) (2013), *The Oxford Handbook of Offshoring and Global Employment*, Oxford University Press: New York.

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

Bernard, A., J. B. Jensen, S. Redding and P. Schott (2007), "Firms in International Trade" *Journal of Economic Perspectives*, vol. 21(3), pp. 105-130.

Bobeica, E. and F. di Mauro (2013), *Competitiveness Research Network: First Year Results*, European Central Bank, June 2013.

Brown, S.P. (2008), "Business Processes and Business Functions: a new way of looking at employment", *Monthly Labour Review*, pp.51-70

Christensen, L. R., D. W. Jorgenson and L.J. Lau (1971), "Conjugate Duality and the Transcendental Logarithmic Function", *Econometrica*, 39: 225-256

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.

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), pp. 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*, forthcoming.

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), pp. 355-374.

Feenstra, R.C. (1998), "Integration of Trade and Disintegration of Production in the Global Economy," *Journal of Economic Perspectives*, vol. 12(4), pp. 31-50.

Feenstra, R.C. (2010) *Offshoring in the Global Economy: Microeconomic Structure and Macroeconomic Implications*, MIT Press.

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), pp. 907-940.

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), pp. 642-692.

Goos, Maarten & Manning, Alan & Salomons, Anna, (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, pp. 59-102.

Grossman, G. and E. Rossi-Hansberg (2008), "Trading Tasks: A Simple Theory of Offshoring," *American Economic Review*, 98(5), pp. 1978-1997.

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.

Hummels, David & Ishii, Jun & Yi, Kei-Mu (2001), "The nature and growth of vertical specialization in world trade," *Journal of International Economics*, vol. 54(1), pp. 75-96

Inklaar, R., M. P. Timmer and B. van Ark (2008), "Market Services Productivity Across Europe and the US", *Economic Policy*, 23, pp. 141-194 .

Isard, W. (1951), "Interregional and Regional Input-Output Analysis: A Model of a Space-Economy," *Review of Economics and Statistics*, pp. 318-328

Johnson, R. C. and G. Noguera (2012), "Accounting for Intermediates: Production Sharing and Trade in Value Added", *Journal of International Economics* 86(2), pp. 224-236.

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), pp. 178–189.

Leontief, W. (1936) "Quantitative Input-Output Relations in the Economic System of the United States", *Review of Economics and Statistics*, 18, pp.105-125.

Levchenko, A.A. and J. Zhang (2012), "Comparative advantage and the welfare impact of European integration", *Economic Policy*, 27(72), pp. 567-602.

Los, B., M.P. Timmer and G.J. de Vries (2013), "Made in Europe? Trends in International Production Fragmentation", GDDC Research Memorandum nr. 131, 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*, vol. 4(2-3), pp. 612-622.

Marin, D. (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.

Miller, Ronald E (1966),"Interregional Feedback Effects in Input-Output Models: Some Preliminary Results", *Papers in Regional Science*, 17, pp.105-125.

Miller, R.E. and P.D. Blair (2009), *Input-output Analysis: Foundations and Extensions*, Cambridge University Press.

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), pp. F374-F403

Ottaviano, G., D. Taglioni and F. di Mauro (2009), "The euro and the competitiveness of European firms", *Economic Policy*, 24(57), pp. 5-53.

Porter, M.E. (1985), *Competitive Advantage*, Free Press, New York

Sinn, H-W (2006), "The Pathological Export Boom and the Bazaar Effect: How to Solve the German Puzzle," *The World Economy*, 29(9), pp. 1157-1175

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), pp. 297-321.

Sturgeon, T.J., and G. Gereffi (2009), “Measuring success in the global economy: international trade, industrial upgrading, and business function outsourcing in global value chains”, *Transnational Corporations*, 18(2).

Timmer, M.P. (ed., 2012), *The World Input-Output Database (WIOD): Contents, Sources and Methods*, WIOD working paper nr. 10, available at www.wiod.org.

Trefler, D. and S. C. Zhu (2010), “The Structure of Factor Content Predictions”, *Journal of International Economics*, Volume 82(2), pp. 195-207.

Winkler, D. and W. Milberg (2012), “Bias in the ‘Proportionality Assumption‘ Used in the Measurement of Offshoring”, *World Economics*, Vol. 13, Issue 4, 2012, pp. 39-60.

Yi, K-M (2003), "Can Vertical Specialization Explain the Growth of World Trade?" *Journal of Political Economy*, 111(1), pp. 52-102.