Fragmentation, Incomes and Jobs. An analysis of European competitiveness

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Marcel P. Timmer [a,*]
Bart Los[a]
Robert Stehrer[b]
Gaaitzen de Vries[a]

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Affiliations
[a] Groningen Growth and Development Centre, Faculty of Economics and Business, University of Groningen
[b] The Vienna Institute for International Economic Studies (WIIW)

*** Corresponding Author**
Marcel P. Timmer
Groningen Growth and Development Centre
Faculty of Economics and Business
University of Groningen, The Netherlands
m.p.timmer@rug.nl

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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 become less informative and new measures are needed that focus on the value added of activities carried out in global value chains (GVCs). In this paper we propose two new measures based on the income and jobs in a country that are directly and indirectly related to the production of manufacturing goods, called manufactures GVC income and GVC jobs. We outline these concepts and provide trends based on a recent multi-sector input-output model of the world economy. We find that increased international fragmentation during 1995-2008 did not necessarily lead to a decline in manufactures GVC jobs in advanced countries. But the characteristics of the jobs involved are clearly changing. The number of GVC jobs located in the manufacturing sector declined in most advanced countries, but this was more than compensated for by job creation in supporting services. We also find a strong shift away from activities carried out by low-skilled workers towards higher skilled workers. Taken together our results show that a GVC perspective on competitiveness provides new measures that can inform the policy debates on globalisation.

NOTE: The main body paper of the paper focuses in particular on trends in the 27 countries of the European Union. But in an appendix we provide additional results for thirteen other major countries, including the United States.

1. Introduction

The competitiveness of nations is a topic that frequently returns in mass media, governmental reports and discussions of economic policy. While specific definitions of national competitiveness are much debated, most economists would agree that the concept refers to a country's ability to realise income and employment growth without running into long-run balance of payments difficulties. The emphasis put on these central economic policy goals of growth and stability is shifting, however. Not so long ago, the main concern in advanced nations was their ability to maintain "good jobs" in the face of rising global competition. The unleashing of the market economy in China and India opened up new markets but also added to global competitive pressures. The effects of this have been hotly debated as manufacturing employment in traditional industrial strongholds in Europe, Japan and the US declined rapidly. The debate became more prominent again as recovery was slow after the global financial crisis in 2008, fuelling demands for more active industrial policies around the world. The global financial crisis also exposed the imbalances in current accounts between various regions in the world, such as between China and the US. Within Europe, emphasis shifted to the divergence in competitive strengths of North versus South and its impact on the balances of payments and more in general financial stability. Building competitive strengths in lagging countries is therefore high on the policy agenda.

However, the emphasis on export success as the main indicator of the competitive strength of a country is increasingly doubted as the practice of international production fragmentation evolves. Fostered by rapidly falling communication and coordination costs, production processes fragment across borders as 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. When a country lost competitiveness in a sector, the whole industry went off.

But globalisation 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 (Baldwin 2006; 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 (2007, 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 gross exports measures have been expressed before. In his analysis of the German economy, Sinn (2006) highlighted the increasing disconnection between gross exports growth, which he even dubbed German's "pathological export boom", and the generation of incomes and jobs for workers. He 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 for the euro countries, Di Mauro and Foster (2008) find that in contrast to other advanced economies, the specialisation pattern of the euro area has not changed much during the 1990s and 2000s. There has been neither a decline in the specialisation in labour-intensive products, nor the expected shift towards more high-tech products. They also relate this surprising finding to the inability of gross exports statistics to capture the value added in fragmented production. More recently, Koopman et al. (2011) 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. Johnson and Noguera (2012a) confirmed this gap for a larger set of countries.

However, none of the studies so far have come up with a new value-added based measure of competitiveness that could replace the gross exports measure, and provide a link with income and job generation. In this paper we propose such a measure and define competitiveness of a country as "the ability to perform activities that meet the test of international competition and generate increasing income and employment". We address the links between fragmentation and the creation of income and jobs based on a new input-output model of the world economy. This is not a new methodology but extends the approach used in Johnson and Noguera (2012a) 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). This approach allows an ex-post accounting of the value countries add when carrying out activities in the production of manufacturing goods. We will extend this by further decomposing value added into the various factor input. 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. In particular, we try to shed new light on the divergence in competitive strengths within Europe, including the perceived "super-competitiveness" of the German economy (Dalia Marin,VOX, June 20, 2010).

In this paper we focus on activities carried out in countries that are directly and indirectly involved in production of final manufacturing goods. The income and jobs related to these activities are called global value chain (GVC) income and jobs. Indirect contributions are made through the delivery of intermediate goods and services. Importantly, this does not only involve activities in the manufacturing sector itself but also in supporting industries such as business, transport and communication and finance services. These indirect activities will be explicitly accounted for through the modelling of input-output linkages across sectors. By restricting

attention to manufacturing GVCs these measures do not cover all international trade but a major sub-set, as will be discussed later. Our main findings are as follows.

First, we confirm the increasing disconnection between gross exports and GVC incomes. The ratio between the two varies highly across countries, and is increasing over time for almost all European countries. As a result, growth in GVC income during 1995-2008 is much lower than growth in gross exports for all European countries, in particular for Austria, Germany, Greece, Spain and Eastern European countries, which rely heavily on imported intermediates. Gross exports are becoming a less and less appropriate indicator of the competitive strength of European countries, due to the process of production fragmentation.

Second, we find strong changes in revealed comparative advantages of the EU. 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, as expected. Delving more deeply, we find that there is a shift away from activities carried out by low-skilled workers towards those carried out by higher-skilled workers. Fragmentation of production seems to be related to a magnification of comparative advantages: EU countries increasingly specialise in activities that require high-skilled workers, while being less involved in low-skilled production activities. This is true both for old and new EU members. These findings seem to be more in line with expectations than the finding of no shifts in comparative advantage by di Mauro and Foster (2007) based on gross export data.

Third, 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 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 was in non-manufacturing sectors. A narrow focus on effects of trade and fragmentation on manufacturing only is missing out on this important trend.

Before moving to a description of our model and a discussion of the results, we outline some of the limitations of our analysis. The global input-output model is used for a decomposition of value added in GVC production and as such it is an ex-post accounting framework. It has limitations for counterfactual or ex-ante scenario analyses which are central in computable general equilibrium models such as for example in Levchenko and Zhang (2012), who provided a welfare assessment of the European Union integration process. But while CGE models are richer in the modelling of behavioural relationships, there is the additional need for econometric estimation of various key parameters of production and demand functions. Our aim is different and we build upon the approach by Johnson and Noguera (2012a) and Bems, Johnson and Yi (2011). An input-output model can be seen as a reduced form model and its parameters (in particular input shares in output) can be taken directly from available input-output tables. We use annual IO-tables such that cost shares in production and implied production functions are highly flexible. Shifting cost shares capture important trends in inter-country and inter-sectoral linkages

via intermediates trade. This characteristic of the model makes it particularly well-suited for our ex-post analysis of distribution of value added in fragmented production.

The accuracy of the empirical implementation will obviously depend on the quality of the data. We use a new public database that was recently released by Timmer (2012) and 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 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. This allows for a novel analysis of both the value added and jobs created in GVC production.

The rest of the paper is organised 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 summarise the main trends in the GVC incomes of the EU as a whole and for individual member states. Comparisons with indicators based on gross exports are made which highlight the differences for competitiveness analysis. The structure of GVC employment is central in section 5, discussing the shift in 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 advanced mathematics. 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 a new indicator, called *global value chain (GVC) income.* GVC income of a country is the value that is added by the country in any activity in the production process of a particular product. When products are produced in a global production network, each country will add value depending on the type of activities carried out in a particular stage of production. The value added accrues as income to production factors labour and capital that reside in the country. To measure GVC incomes we rely on a standard decomposition

methodology. Here 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. These intermediate inputs are sourced from other industries, either domestic or abroad, and as such production processes are linked across industries and countries. Based on a modelling of these linkages, one can trace the gross output in all stages of production that is needed to produce one unit of consumption. 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 flow of final demand, we can derive the value added by each participating industry in a second step. This is done simply by multiplying the induced gross output flows by the value-added to gross output ratio for each domestic and foreign industry. By construction the sum of value added across all industries involved in production will be equal to the value of the final demand flow. Following the same logic, one can also trace the number of workers that is directly and indirectly involved in GVC production. We will use this variant to analyse the changing job distribution in GVC production, both in terms of geography and skill level, in section 4.

It is important at this stage to clarify our approach and terminology. First, we will measure the contribution of a country by tracing the value added by its activities in a GVC. These activities are identified by the industry in which the activity is carried out and the production factors involved. We prefer to use the term “activities” rather than “tasks” when referring to what countries do in GVC production. Reference to “tasks” is popular in the “trade in task” literature (e,g, Grossman and Rossi-Hansberg 2008) but implicitly focuses on the role of labour only. The term “activity” captures operations performed by any combination of labour and capital. Thus we refer to the global value chain of a product as the collection of all activities needed to produce it. This concept is broader than the alternative terms used such as global supply chains or international production chains. The latter indicate only 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. 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 business literature, popularised by Porter (1985).

Second, GVC incomes are measured for a specific subset of activities in the economy. 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 the process of international fragmentation. Most activities in these chains have a high degree of international contestability as 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 non-manufacturing products and will not be included. On average, 68% of the value added in manufacturing is in GVCs of manufactures (median across 27 EU countries in 2011). But on the other hand, GVCs of manufactures also include activities outside the manufacturing sector. In fact, as will be shown in our results a major part of these activities takes place in industries such as business services, transport and communication and finance, and in raw materials production in agriculture and mining. These indirect activities will be explicitly accounted for through the modelling of input-output linkages across sectors. The value added of these non-manufacturing activities was almost as large as the value added in manufacturing (median of 93% across EU 27). All in all, the activities in GVCs of manufactures account for about 21 % of GDP in 2011 (EU 27 median) down from 25% in 1995. In 2011, it ranged from a low 13% in Greece to 28% in Germany and even 31% in Hungary, as will be shown later.

Ideally, one would like to cover all activities that are internationally contestable in a measure of GVC income, and not only those in the production of manufactures.[1] An increasing part of world trade is in services, and only part of that is in intermediate services that are included in GVCs of manufactures. GVCs of manufactures cover about 59% of gross export flows in 1995 and 55% in 2008 (median across EU 27). Non-manufacturing GVCs cannot be included however, as the level of observation for services in our data is not fine enough to focus exclusively on that part of services that are mostly internationally traded. For example, 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 much less interesting to analyse from a GVC perspective. 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 hence not internationally contestable.

[1] 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.

Note also that the GVC income measure covers not only activities related to exports. To see this, assume that final demand for cars by German consumers is completely fulfilled by cars produced in the German car industry, and that all activities in the production process are in the domestic industry. In this case, the value of consumption accrues completely as income to German production factors. But in principle, part, or all, of these activities could also be carried out outside Germany. If German car producer 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.

Finally, GVC incomes are measured on a domestic, rather than a national basis. It includes the value added in a country on the domestic territory and hence measures competitiveness in terms of generating GDP, not national income. To the extent that the value added is generated by labour, this difference will be small as the majority of domestic workers are employed in the domestic economy. This is much less so in case of value added by capital, which is typically about a quarter of the value added generated in an industry in advanced nations. Much of the offshoring is done by multinational firms that maintain capital ownership and hence GVC income in the outsourcing country is underestimated and income in the receiving country is overestimated. Data on foreign ownership and returns on capital is needed to allow for an income analysis on a national rather than a domestic basis, which is left for future research (Baldwin and Kimura, 1998). For individual countries with large net FDI positions, this domestic-territory basis of the GVC income concept needs to be kept in mind in interpreting the results.

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 income shares for countries we extend the standard input-output decomposition technique introduced by Leontief (1936, 1941) towards a multi-country setting, as in Johnson and Noguera (2012a) and Bems, Johnson and Yi (2011). 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. The method allows one to measure the contribution of production factors in various countries to the output value of a particular product. We introduce our accounting framework drawing on the exposition in Johnson and Noguera (2012a) and then generalize their approach for our GVC measure.[2]

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

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

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), 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 and can be written as

$$\mathbf{A} \equiv \begin{bmatrix} \mathbf{A}_{11} & \mathbf{A}_{12} & \cdots & \mathbf{A}_{1N} \\ \mathbf{A}_{21} & \mathbf{A}_{22} & \cdots & \mathbf{A}_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{A}_{N1} & \mathbf{A}_{N2} & \cdots & \mathbf{A}_{NN} \end{bmatrix}$$ where $\mathbf{A}_{ij}$ is the SxS matrix with typical elements $a_{ij}(s,t)$. The diagonal sub-matrices track the requirements for domestic intermediate inputs, while the off-diagonal elements do this for foreign intermediate inputs. The matrix **A** thus summarizes the flows of all intermediate goods across sectors and countries and using this we can rewrite the stacked SN market clearing conditions from (1) as

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

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

$$\mathbf{y} = \mathbf{A}\mathbf{y} + \mathbf{f} \qquad (2)$$

Rearranging (2), we arrive at the fundamental input-output identity introduced by Leontief (1936)

$$\mathbf{y} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{f} \qquad (3)$$

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. The element in row m and column n of this matrix gives the total production value of sector m in all stages of production involved in the production of one unit of final output of product n. To see this, let $\mathbf{z}_n$ be a column vector with the nth element representing an euro of global consumption of goods from country-sector n (the German transport equipment manufacturing industry, for example), while all the remaining elements are zero. The production of final output $\mathbf{z}_n$ 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 all sectors 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 $(\mathbf{I} - \mathbf{A})^{-1}\mathbf{z}_n$. If we construct an SNxSN matrix in which the unit final demand SN-vectors $\mathbf{z}_1$, $\mathbf{z}_2$, …, $\mathbf{z}_n$, …, $\mathbf{z}_{SN}$ are included next to each other, the identity matrix **I** is obtained. Since $(\mathbf{I} - \mathbf{A})^{-1}\mathbf{I} = (\mathbf{I} - \mathbf{A})^{-1}$, our interpretation of the Leontief inverse is correct. Note that our GVC income measure is insensitive to the particular configuration of the production process. Baldwin and Venables (2010) introduced the concepts of "snakes" and "spiders" as two arch-type configurations of production systems. The snake refers to a production chain organised as a sequence of production stages, whereas the spider refers to an assembly 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 as an upstream or downstream, or assembly, activity.

Our aim is to attribute the value of final demand for a specific product into 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 $\mathbf{p}$ containing these 'direct' value added coefficients. The elements in $\mathbf{p}$ do not account for value added embodied in intermediate inputs used. To take these into account, we derive the SN-vector of value added levels $\mathbf{v}$ as generated to produce a final demand vector $\mathbf{f}$ by pre-multiplying the gross outputs needed for production of this final demand by the direct value added coefficients vector $\mathbf{p}$:

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

in which a hat-symbol indicates a diagonal matrix with the elements of a vector (in this case $\mathbf{p}$) on the diagonal. If $\mathbf{v}$ is indeed to give the distribution of the value of final output as attributed to sectors in the value chain of product n, the elements of $\mathbf{v}$ should add up to the elements of $\mathbf{f}$. Intuitively, this should be true, since the Leontief inverse takes an infinite number of production rounds into account, as a consequence of which we model the production of a final good from scratch. The entire unit value of final demand must thus be attributed to country-sectors.[3] We can now post-multiply $\hat{\mathbf{p}}(\mathbf{I}-\mathbf{A})^{-1}$ with any vector of final demand levels to find out what value added levels should be attributed to this particular set of final demand levels. We could, for example, consider the value added generated in all SN country-sectors that can be attributed to 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 $\mathbf{p}$. For example, $\mathbf{p}$ 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

[3] We can show also mathematically that this is true. Let $\mathbf{e}$ an SN summation vector containing ones, and a prime denotes transposition, then using equation (4) the summation of all value added related to a unit final demand ($\mathbf{e}'\mathbf{v}_n$) can be rewritten as $\mathbf{e}'\mathbf{v}_n = \mathbf{e}'\hat{\mathbf{p}}(\mathbf{I}-\mathbf{A})^{-1}\mathbf{z}_n = \mathbf{p}'(\mathbf{I}-\mathbf{A})^{-1}\mathbf{z}_n$. 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.

now define $p^L_i(s)$ as the direct labour input per unit of gross output produced in sector s in country i, for example the hours of low-skilled labour used in the Hungarian electronics sector to produce one euro of output. Analogous to the analysis of value added, the elements in $\mathbf{p}^L$ do not account for labor embodied in intermediate inputs used. Using equation (4), we can derive all direct and indirect labour inputs needed for the production of a specific final product.

We would like to stress that the decomposition methodology outlined above is basically an accounting framework rather than a fully specified economic model. It starts from exogenously given final demand and traces the value added in GVC production under the assumption that production technologies do not depend on the level and composition of final demand. It does not explicitly model the interaction of prices and quantities that are central in a full-fledged Computable General Equilibrium model (see, for example, Levchenko and Zhang, 2012). Instead an input-output model can be seen as a reduced form model featuring Cobb-Douglas production functions with unit substitution elasticities. The cost shares in production will change in each year as they are taken directly from the annual input-output tables, and need not to be estimated (or otherwise fixed) as in a CGE model. Shifting cost shares capture important trends in inter-country and inter-sectoral linkages via intermediates trade. This characteristic of the model makes it particularly well suited for our ex-post analysis of distribution of value added in vertical chains.

Another caveat of applying our decomposition methodology empirically lies in the implicit assumption that a country-sector produces a single homogenous product, whereas sectors typically produce ranges of products. Production processes might differ depending on the use of the product, such as for domestic or foreign consumption. Koopman, Wang and Wei (2011) showed that in China production functions for exports in so-called export processing zones differ substantially from production for domestic demand. More generally, 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. This however is precluded due to lack of more detailed data and further empirical evidence is needed.

2.3 Illustrative example: GVC distribution of final output of German transport equipment

Before discussing our general results, we illustrate our methodology by decomposing output from the German transport equipment industry. The global automotive industry has witnessed some strong changes in its organisational and geographical structures in the past two decades as described by 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 final assembly activities which now takes 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. Developments in the German car industry reflect these global trends as illustrated by the global value chain analysis of a Porsche Cayenne given in

Dudenhöffer (2005). The last stage of production of a Porsche Cayenne before sold to German consumers takes place in Leipzig. But the activity involved is the placement of an engine in a near-finished car assembled in Bratislava, Slovakia. Slovakian assembly is based on a wide variety of components such as car body parts, interior and exterior components, some of which are (partly) made in Germany itself, but others are sourced from around the world. All in all, Dudenhöffer (2005) estimates that the value added by German manufacturing is about one-third of the final value of the Porsche Cayenne.

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 value includes all the value added by activities 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 by activities in Germany and abroad. Through offshoring of various activities, partly to Eastern European countries, the value added share of the rest of the world in the production of German cars increased rapidly from 21% in 1995 to 34% in 2008. Conversely, the German share in the GVC income of this chain dropped steadily to 66% in 2008. Importantly, the share includes value added in the German 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 (GER REST). The share of non-manufacturing activities, mainly in services, has rapidly 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 the GVC of German cars, using labour quantity input requirements (workers per unit of output) in equation (4). Off-shoring has had a major impact on the distribution of jobs related to the production for German cars. The number of foreign GVC jobs was 50% in 1995, which is much higher than the share in GVC income. This is obviously related to the fact that foreign workers are on average much lower paid than its German counterparts, even for similar levels of education. Lower unit labour costs in particular for medium-skilled technical workers were one of the main attractions for German firms to offshore to Eastern Europe (Marin 2006). The foreign share increased to 62% in 2008. Conversely, the share of workers directly and indirectly involved in Germany 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 reorganisation 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. The increase in jobs is however not uniform across various categories of workers. We distinguish workers by skills defined by the level of educational attainment. Demand for low-skilled and medium-skilled German jobs in this chain increased by 6 and 24 per cent.

Demand for high-skilled German workers increased by more than 50 per cent suggesting a strong specialisation in skill-intensive activities in Germany. We will return to these issues in a more general setting below after a discussion of the data used.

[Figure 1 about here]

3. Data from the World Input-Output Database

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

3.1 World input-output tables

The WIOD provides a time-series of world input-output tables (WIOTs) from 1995 onwards. It covers forty countries, including all EU 27 countries and 13 other major advanced and emerging economies namely Australia, Brazil, Canada, China, India, Indonesia, Japan, Mexico, Russia, South Korea, Taiwan, Turkey and the United States. In total it covers more than 85 per cent 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 (4) 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 a dimension of 35 industries and 59 products, and are a natural starting point as they can be easily combined with trade statistics that are product-based and industry statistics that are industry based. National SUTs are stacked into a World SUT, which is used to construct a World input-output table that has an 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. for technical details). 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.

National supply and use tables have been collected from national statistical institutes and harmonised 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 (Temurshoev and Timmer, 2011). 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. A comparable approach in spirit, but applied at a much more aggregate level, was followed by Johnson and Noguera (2012b).

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, 2012a). Various studies have found that this assumption can be rather misleading as import shares vary significantly across use category (Feenstra and Jensen, 2012; Puzello 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. The well-known inconsistency between mirror trade flows in international trade data was resolved by giving prominence to import flows: we inferred bilateral exports as mirror flows from the import statistics. 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).

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. 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).

The WIOTs used in this paper are at 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. The tables are in current US$ using exchange rates for currency conversion. 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 (such as in Barro and Lee, 2010), 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 labour data is constructed by extending and updating the EU KLEMS database (www.euklems.org) using the methodologies, data sources and concepts described in O'Mahony and Timmer (2009). For other countries additional data has been collected according to the same principles, mainly from national labour force surveys, supplemented by household 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 workers for which an imputation was made if necessary. Although hours worked would be a preferable measure, this data is not available at a large scale. Labour skill types are classified on the basis of educational attainment levels as defined in the International

Standard Classification of Education (ISCED). Low-skilled workers are those with an education level in ISCED categories 1 and 2, medium-skilled in ISCED 3 and 4 and high-skilled in ISCED 5 and 6. Despite international harmonisation, 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. 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 within 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, namely the fixing of exchange rates in 1999 leading up to the introduction of the euro in 2002, and the accession of ten new member states to the European Union in 2004. 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 analyse 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 analysis is carried out based on GVC incomes. We find that differences in competitiveness between old EU member states based on GVC incomes are smaller than based on traditional gross export flows. This difference is analysed more in depth in section 4.4.

4.1 International production fragmentation

Various measures of international production fragmentation have been suggested in the past. Feenstra and Hanson (1996) proposed an "outsourcing index" defined simply as the share of imports in intermediate inputs used in an industry. Hummels, Ishii and Yi (2001) developed a measure of vertical specialization by looking at the import content of exports, taking into account

both direct and indirect contributions in an input-output framework. Building upon these ideas, we define a straightforward measure of fragmentation of production based on our GVC income decomposition, namely the foreign value added share in the output value of final manufactures produced in a country. A higher share indicates more international fragmentation of production. Results for all EU 27 countries are shown in Figure 2. It provides clear evidence for the wide spread process of fragmentation as European firms aim to take advantage of differences in technologies, factor endowments and factor prices. Between 1995 and 2008 foreign value added shares increased in all economies, except the smallest ones (Cyprus, Estonia and Malta). On average the foreign value added share of EU countries increased by ten percentage points. Los, Timmer and de Vries (2013) provide an overview of various alternative measures and show that this finding of wide-spread fragmentation is robust to other measures.[4] One obvious implication of this fragmentation process 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".

Foreign shares 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 rapidly integrated production 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, starting already at the end of the 1990s (Marin 2006, 2011). It also led to the rapid increase in foreign value added in German production. In 2008, thirty per cent of the final output value was added outside the German territory, and this is comparable to the shares in other economies. This is a remarkable finding taking into account the much larger size of the German economy. In a world with product variety one would expect bigger economies to have a lower import shares (Hummels, Ishii and Yi, 2001), but this is not the case for Germany. In fact, its foreign value added share increased much faster than that of most other EU countries which prompted Hans-Werner Sinn to characterise Germany as a Bazaar economy (Sinn, 2006). Although this characterisation is somewhat overdone as seventy per cent 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 in international markets, a point we will return to later.

[Figure 2 about here]

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 GVC income is equal to world expenditure on manufacturing goods as we

[4] More analysis can be found in European Commission (2012).

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.[5] It follows that the share of the EU has been on a slightly declining trend from 32% in 1995 to 29% in 2008. 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, South Korea and Taiwan) were on a long decline already since the 1990s, falling from 21% in 1995 to 10% in 2008. This can be explained primarily be 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 above. This difference is probably larger for East Asian countries than for NAFTA or the EU which have larger FDI flows within the region.

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 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 foreign production as by domestic production. Falling shares in global GVC income for advanced regions indicate that they failed to capture a large part of the value of the increased market for manufacturing goods in emerging economies. This can be interpreted as a loss of competitiveness. But 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 has increased by about one-third over the period 1995 to 2008 (deflating by the US CPI index).

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 present results for the 19 major EU countries only to save space. Results for the remaining 8 small countries 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

[5] In all tables, we use US$ as the base currency. 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.

the increase in the overall EU27 GVC income was earned on the EU12 territory which is much higher than their share in EU27 GDP. 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. But the German share dropped at the end of the 1990s and did not significantly improve afterwards. The French share declined slowly but steadily, and the share in the UK dropped after an initial increase in the late 1990s.

By splitting the final demand vector in the decomposition given in equation (4), we can analyse 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 (2012a) refer to as "exports of value added". 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 old 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 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 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 still positive. Taken together the results are indicative of increased specialisation 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

[Table 1 about here]

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 summarised 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 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 reorganisation 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, in particular of those products where the final stage of production takes place in the domestic economy. The declines are relatively small for most countries, but not for Belgium, France and Germany. Offshoring of intermediate input production has been prominent in Germany as discussed before. In France and Belgium there was in addition to offshoring 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 are 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 2 about here]

4.3 Revealed comparative advantage in GVCs

An interesting issue is to what extent Europe is specialising in particular activities. The standard tool to analyse this is revealed comparative advantage (RCA) analysis. It 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 Foster (2008) found that in contrast to other advanced economies, euro area specialisation patterns overall have not changed much over last one and a half decades. They found neither a decline in the specialisation in labour-intensive products, nor the expected shift towards more skill-intensive production.

This surprising finding might be due to the fact that the RCA analysis 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. 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 specialises 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 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 6 groups of 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, although the latter is rebounding since the crisis. 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. The declining aggregate trend for the EU shown in Figure 4 cannot be explained by shifts in the 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.

[Figure 4 about here]

Aggregate EU27 performance hides substantial variation within the European Union. In Table 3 we present the RCA for member states, calculated as above, to track particular specialisation patterns. Major new member states particularly improved their positions in GVCs of transport equipment, in 2008 having RCAs higher than one. RCAs in electrical equipment increased as well, but at a lower level. Across the old EU 15 it seems that specialisation 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 specialised further in activities in the transport equipment manufacturing; The Netherlands and Ireland in chemicals; Austria and Sweden in non-electrical machinery; and Finland in electrical machinery. Specialisation 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 it basically indicates 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 about here]

4.4 Comparing GVC incomes and gross exports

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

[Insert Box 1 around here]

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 measures by exports. 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 from Germany increased by 180% over the period 1995-2008, whereas GVC income increased only by 52%. This is the net effects of two main factors. First, the domestic value added content of German industrial production dropped quickly during this period due to outsourcing 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 (see also Sinn 2006). The second factor is the slow and changing domestic demand in the German economy. Due to slow GDP growth, domestic demand for manufacturing goods was weak. Given the relatively large share of domestic value added in production for 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 to 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 and GVC incomes in manufactures and 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 between the 14 old EU countries is less than 0.6 as patterns of offshoring have been rather different as discussed above.

[Table 4 about here]

5 The structure of European employment in global production of manufactures

Many policy concerns surrounding globalisation 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 outsourcing of activities. It is thus useful to look at the structure of employment in global value chains and analyse the changes in the characteristics of workers directly and indirectly involved in the production of manufacturing goods, in short manufactures GVC workers. For each country, we will measure the number of workers involved on the domestic territory. As the mobility of labour is much lower than of capital, this will be closer to a national concept than GVC income. We will characterise 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 analyse the skill structure of GVC workers and find a shift away from low-skilled towards high-skilled workers. This increase is faster than the overall economy trend, suggesting increased specialisation of advanced EU countries in GVC activities performed by high-skilled workers. This is in line with broad Heckscher-Ohlin predictions of comparative advantage when possibilities for international production fragmentation increase.

5.1 The shift towards services jobs in global production of manufactures

By using number of workers rather than value added per unit of output in each industry-country as the requirement vector in equation (4), 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 (including also mining, construction and utilities). The first set columns refer 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 stand out clearly. First, the declining importance of global production of manufactures for overall employment in Europe. And second, the strong shift of the sector of employment of these workers, away from the manufacturing sector towards the services sector.

The first two columns of Table 5 show the decline in importance of manufactures GVC in providing jobs in the economy across the European Union. In 1995, manufactures GVC workers made up 26 per cent of the total employed labour force in the EU 27, and this declined to 22 per cent in 2008. The decline took place in almost all EU countries, in particular in the old EU 15. Shares in Greece, Ireland, Portugal, Spain and the UK dropped 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 old EU15 countries.

Perhaps surprisingly, GVC workers also declined in the new member states (EU 12), but this was mainly due to job loss in agriculture, reflecting rapid improvements in labour productivity and technologies as this sector was rationalized as part of the EU accession process. More in general a drop in importance of GVC workers is to be expected, presuming that the labour productivity growth in activities in manufactures GVC is higher than in other activities in the economy which are much less internationally contestable. But this higher productivity growth will only lead to lower employment shares when final demand for manufactures is declining relative to services. This is expected to be true for a closed economy with increasing income per capita as the income elasticity of demand for manufactures is low. But increasing foreign demand for manufactures might counteract this trend. Indeed, from Table 1 it appeared that countries differed greatly in their ability to benefit from increasing foreign demand for manufactures. The overall decline in importance of manufactures GVC jobs across Europe is worrisome, given that these jobs, which operate in an internationally competitive environment, most likely have higher productivity growth rates than jobs in the sheltered part of the economy.

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 19 EU countries for which we have wage data, the increase in GVC jobs and in real wages over the period 1995-2008. Real wages are defined as the average labour income in GVC per worker, deflated by the national CPI. Note that this real wage includes only GVC income that accrues to labour as we have taken out the share of capital in GVC income by appropriate choice of the requirement 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 manufacturing GVCs. They show that success in global value chains is not solely determined by unit labour costs, and also reflect competitive strengths in particular in the non-manufacturing parts of the production process (Fagerberg, 1988).

Another important finding on the basis of Table 5 is the strong shift towards services jobs in the global production of manufactures since 1995. As shown in the right hand side of Table 5, overall employment in 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 out of the 15 old EU 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. 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 about here]
[Figure 5 about here]

The shift in the sectoral distribution of the GVC jobs might be interpreted as the result of differential productivity growth in manufacturing and services. But while there is clear evidence that the productivity growth in manufacturing is higher than the services sector, this does not necessarily hold for the services activities in GVCs which form only a sub-set of the services sector, and involve in particular intermediate services such as wholesaling, transportation, finance and several business services.[6] 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

[6] 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.

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.

5.2 Specialisation in high-skilled activities in global production of manufactures

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

To test this prediction we analyse the number of workers by skill type needed in manufactures GVCs using equation (4) in combination with a skill requirement vector. This vector is based on a characterisation of workers in each industry and country by their observable educational attainment levels, as described in section 3. This delivers the number of low- (LS), medium- (MS) and high-skilled (HS) GVC workers for a particular year. We find that during 1995-2008 in all EU countries the growth in HS GVC workers was higher than the growth in MS workers, which in turn was higher than growth in LS workers. This finding in itself however is not sufficient to confirm the magnified comparative advantage hypothesis, as it might simply reflect the steady increase in educational attainment levels in the EU economies. Therefore we divided the ratio of GVC jobs in 2008 over 1995 by the same ratio for overall economy workers of the same skill type. This will indicate whether the skill distribution of the GVC workers is becoming more skewed than the distribution of all workers in the economy. The results are given in Table 6.

We find strong support for the magnification hypothesis for the old EU countries. Relative to the overall labour force, the share of high-skilled workers in total GVC employment increased (much) faster than the shares of MS workers in all fifteen countries. This can be seen by comparing the ratios in the second with the third column. An extreme example is Austria where the number of high skilled workers in the overall economy increased by 60% over the period, but the number of HS GVC workers by 98% (ratio of 1.24). In contrast the growth in MS GVC workers (4%) was lower than overall MS worker growth (14%) with a ratio of 0.91. In turn, columns one and two show that the relative growth of MS workers in GVCs was higher

than of LS workers in most countries. Clearly, the skill distribution of GVC workers has become more skewed towards higher skills than the overall economy skill distribution.

While one would predict specialisation in skills in the old EU, this is less obvious for the new member countries. Given their rapid integration in the European economy, the change in their skill distribution of GVC workers since 1995 will partly depend on the skill level of activities that have been outsourced from the old EU relative to their "old" activities. Surprisingly, for the EU12 as a whole we find a similar pattern as for the old EU15 as HS workers in GVCs are growing faster than MS, and MS much faster than LS. A similar pattern is found at the individual country level, with the exception of the Czech Republic where MS workers have increased the most. This confirms the findings based on firm-level data by Marin (2011) that German and Austrian firms, which have been the main investors in Eastern Europe, make particularly use of higher skilled labour which is cheap relative to domestic workers.

From the perspective of competitiveness, the increase of high-skilled jobs in manufactures GVC is a clear indication of a country's ability to realise employment growth in activities that are productive and relatively well paid in a highly competitive international environment. Only few countries have been able to realise this growth, as indicated by the last column. From the old EU15 only Austria, Sweden and Italy increased their HS workers ratio in GVC by 5% or more than their overall economy HS ratio. In contrast Portugal, and in particular Ireland and the UK, have not been able to increase the participation of their HS workers in GVC relative to the growth of HS in their economies. Also the German economy has not been particularly successful in creating opportunities for HS workers. Growth in German GVC activities is particularly characterised by the increasing use of medium skilled labour relative to other EU15 countries.[7]

[Table 6 about here]

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. The displaced manufacturing workers are likely to be absorbed by less skill-demanding jobs in personal services where employment opportunities are still growing, a process described as job polarization (Goos, Manning and Salomons 2011).

6. Concluding remarks

In the past decades, production was increasingly organised 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

[7] The German educational system has a larger emphasize on vocational training than most other countries, and hence relative wages of workers classified as medium-skilled are generally higher. When evaluating the success of job creation in GVCs, these differences in relative wages should be taken into account as well.

industries. As a consequence, it is now recognised 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 in the production of final manufacturing goods, called GVC income. A related concept, namely GVC jobs, measures the number and types of jobs in a country that are involved in GVC production. These measures are derived based on 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 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 divergence has increased over time. We also find that only about half of the jobs directly or indirectly involved in 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 GVC jobs in non-manufacturing, in particular in business services. For the EU as a whole, the increase in services jobs related to GVC production 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, we do not confirm the finding based on analysis of gross exports that the revealed comparative advantage of the European Union in global markets appeared to be 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 the production of non-electrical machinery and transport equipment, while declining in the production of non-durables. In particular, we find that across the EU there is a shift away from activities carried out by low-skilled workers towards those carried out by higher-skilled workers. Fragmentation of production thus seems to be related to a magnification of comparative advantages.

We believe that our results show that a GVC perspective on competitiveness provides new and useful measures that can serve the debate on globalisation. In order to make systematic use of these measures for economic policy, 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. 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.

At the same time there is a need for other indicators based on micro analysis, besides the macro-indicators proposed here. Building upon the insights that firm-level performance is highly heterogeneous and only a limited number of firms are engaged in exporting, Ottaviano et al. (2008) propose additional measures that are based on micro databases and can thus reflect distribution shapes of firm-level performance. 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). These initiatives will lead to a deeper understanding of the effects of trade and fragmentation.

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 industry-specific but rather on the type of activities carried out. It also highlights the increasing interdependencies of economies and the need for a multilateral assessment and coordination of policy measures in a wide range of policy areas. A number of examples might suffice. With increasing fragmentation, domestic multiplier effects of fiscal stimulus programs will be lower, while foreign spillovers increase. 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). Fragmentation also leads to the interlocking of competitiveness across countries as the costs of intermediate input determine the competitiveness of the importing countries. As a result, regional comparative advantages must be taken into account alongside the individual competitive strengths of countries. Clearly, in a world of fragmenting production and increasing integration the impact of national policies is becoming more uncertain. We believe that the new measures presented here might be helpful in better informing and formulating future policies.

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BOX 1 Why gross exports and GVC income are different: a hypothetical example.

In this box we provide a hypothetical example that illustrates the conceptual and numerical differences between GVC income and gross export values. We consider the effects of international fragmentation of the production process of a car. Assume that this production process is modular and consists of three activities namely part and component manufacturing, assembly of parts in to the final product and services. These post-production services can be thought of as for example branding, logistics, distribution and finance activities. All activities are contestable and can be carried out anywhere irrespective of the location of other activities or the final consumer. To carry out the assembly activity in a plant, parts are obviously needed as input, but not the services. The values added by these activities are 10 for assembly (a), 50 for parts (p) and 40 per cent for services (s) of the car value. There are two countries A and B. Consumers in A purchase cars with total value of 100 million. Initially, all activities in the production process of these cars take place in A itself. In this case there are no exports from A to B or from B to A. As explained in the main text, the GVC income of a country is the value added of all GVC activities carried out in a country, so in this case it is 100 million in A and 0 in B. What happens to GVC income and exports when the car production process is internationally fragmenting and part of the activities sequentially are moved from A to B? This is shown in the following table (in millions)

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

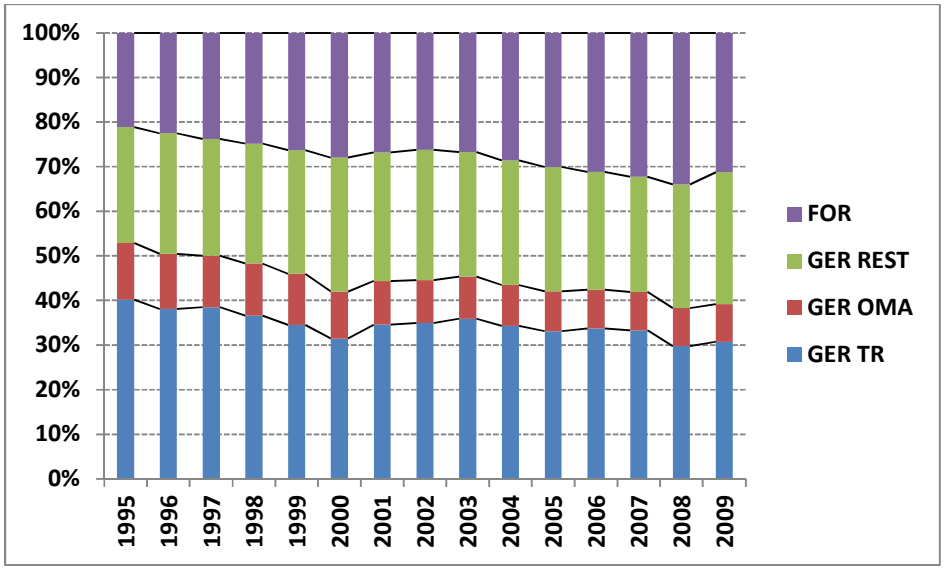
Obviously, the GVC income in A is decreasing when more activities are offshored, while GVC income in B is increasing. The total GVC income of both countries always adds up to 100 million, which is by definition equal to the value of car consumption. The export statistics for A and B however, show a rather different evolution. When assembly is offshored, A will export parts with a gross value of 50 million to B. After assembly, the parts will return but now with a gross value of 60 million as value has been added. B is exporting more than A, but still A is adding more value to the product and hence captures a larger share of the value of the final product (90 million for A while 10 million for B). Note that the value of the parts is recorded twice in the export values, creating the so-called "double counting problem" in trade statistics (see e.g. Koopman, Wei and Wang 2011). When the manufacturing of the parts is off-shored as well, there is no longer export needed from A to B, and B is still exporting goods worth 60 million to A. However, now B is capturing the full value of this and GVC income increases to 60 million as well. Finally, with the offshoring of services activities, exports from B will increase in

value to 100 million, as will its GVC income. In this situation domestic demand for cars in A is fully satisfied by imports from B.

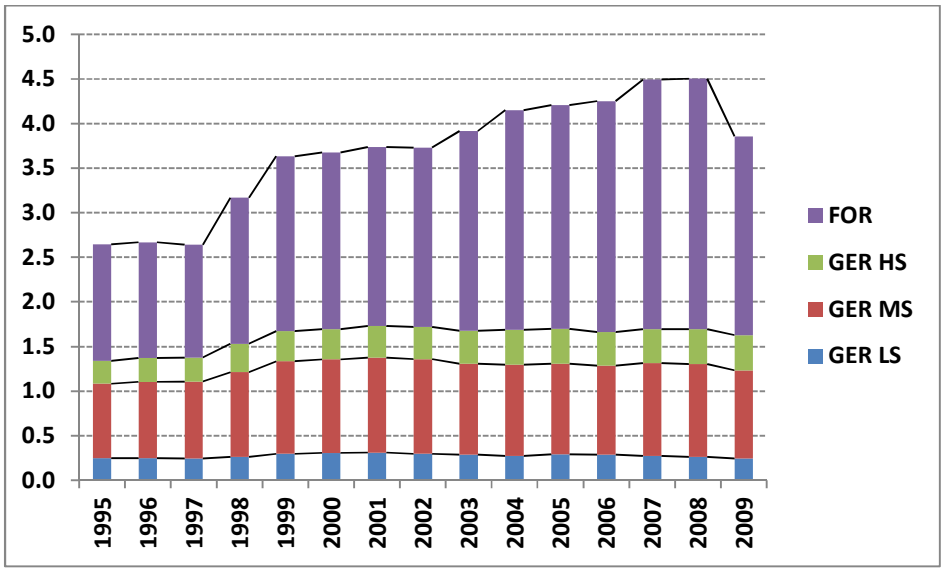
The underlying assumption in this example is that all activities are traded at arm's length (or at least at full cost value) between unaffiliated firms in the two countries. But when these activities all take place within one multi-national enterprise, transfer pricing might drive a wedge between the value embodied in a product and its recorded export price. Moreover, assume that the MNE is headquartered in A then part of the GVC income earned with activities in B (namely the income for capital) will most likely not stay in B. This highlights the need to complement existing measurement of international transactions on the basis of geographical location with measures that centre on the ownership of firms (Baldwin and Kimura, 1998) and international finance flows. This simple example can also be easily extended by introducing demand from a third country which can be served by various constellations of the production stages across A and B. But in all cases the basic message remains the same: GVC income measures will better reflect the redistribution of income and jobs when production fragments across borders than trade statistics.

Figure 1 GVC income and workers in final output of transport equipment in Germany

(a) GVC income shares (in %)



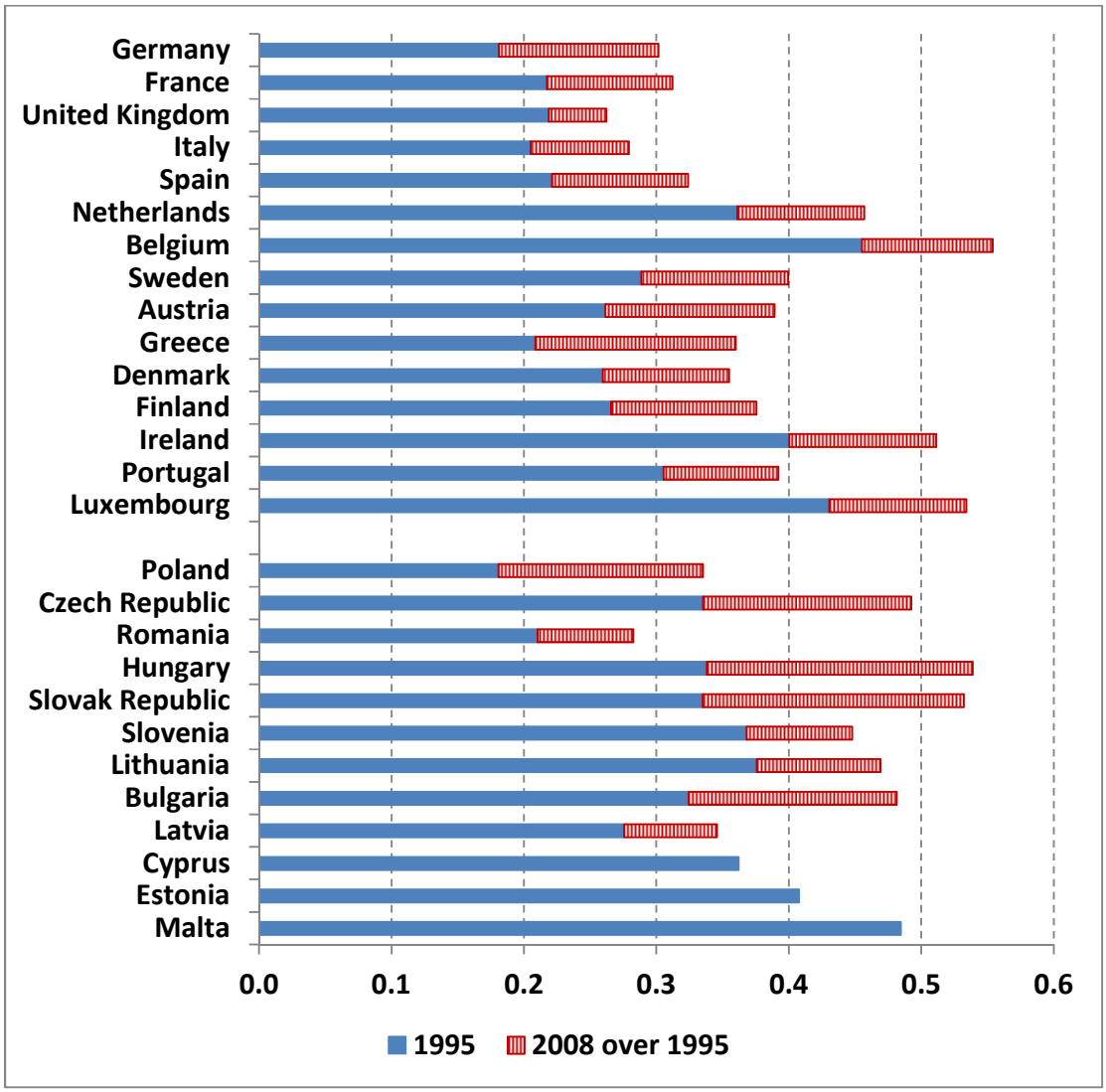
(b) Number of GVC workers (in millions)



Note: Panel (a) provides a decomposition of value of final products from the German transport equipment industry (NACE rev. 1 industries 34 and 35) into 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, decomposed into foreign (FOR) and domestic (GER) workers, including low-skilled (LS), medium-skilled (MS) and high-skilled (HS). Skill level of workers is defined by level of educational attainment.

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

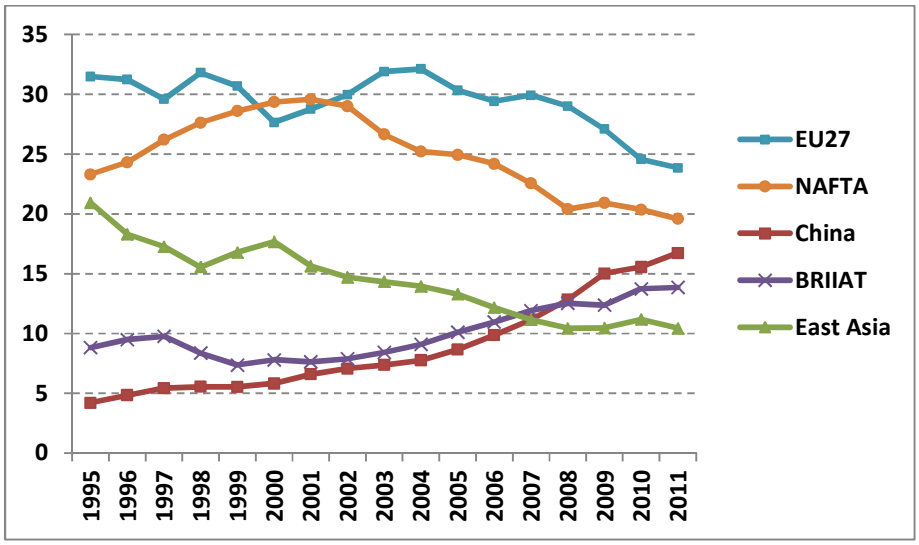
Figure 2 Share of foreign value added in output of final manufacturing products.



Note: This graph shows the foreign value added share in the output value of final manufacturing products produced in a country. The remaining share is value added by the domestic economy. Share in 1995 and change during 1995-2008 period. A higher share indicates more international fragmentation of production. Cyprus, Estonia and Malta have minimally declining shares which are not shown. Countries are grouped into EU15 and EU12 and within each group ranked on GDP in $ 2008.

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

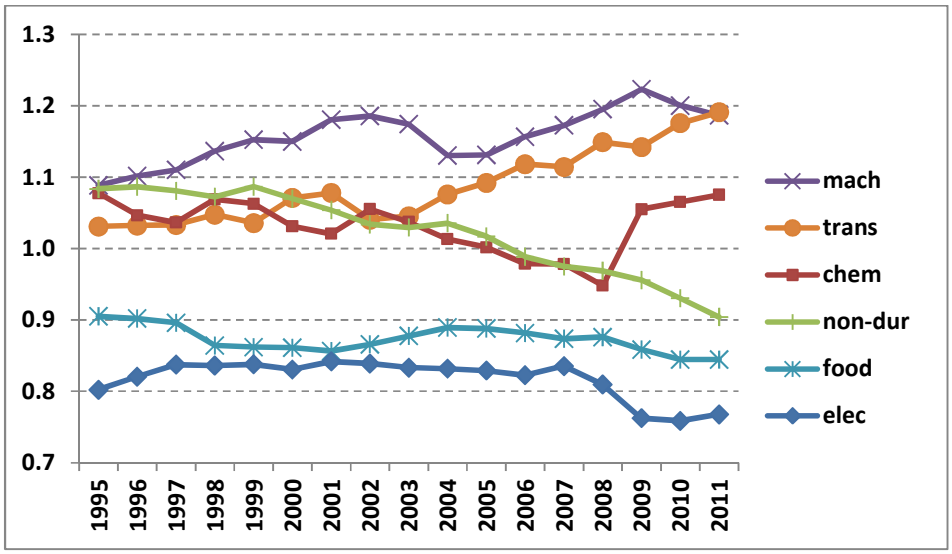
Figure 3 Regional share in world GVC income for all manufactures (%)



Note: East Asia includes Japan, South Korea and Taiwan. BRIIAT includes Brazil, Russia, India, Indonesia, Australia, and Turkey. EU27 includes all European countries that have joined the European Union. NAFTA includes Canada, Mexico and the US. Shares do not add up to 100% as the remainder is the share of all other countries in the world.

Source: Author's calculations based on World Input-Output Database, April 2012, updated to 2011.

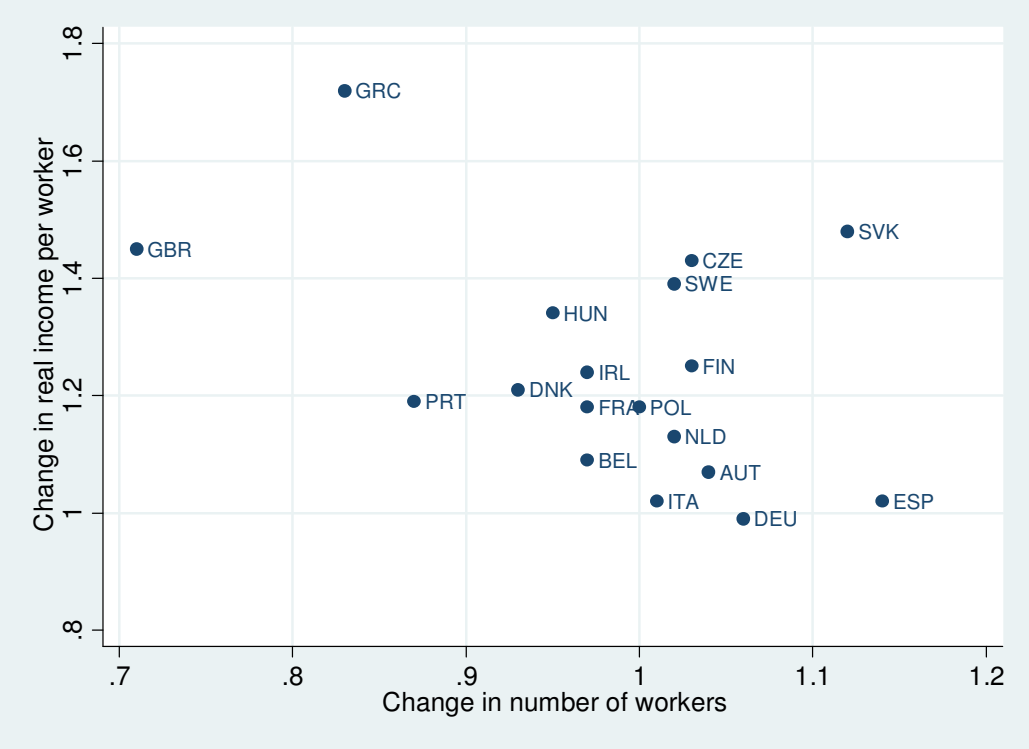
Figure 4 Revealed comparative advantage of EU27, by group of manufactures (%)



Note: Revealed comparative advantage calculated as EU27 share in world GVC income for a group of manufactures divided by same ratio for all manufactures. 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.

Figure 5 Change in employment versus change in real wage in manufacturing GVCs, 1995-2008.



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 national CPI. Data 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

Table 1 Real GVC income in EU27 countries, all manufactures

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

Note: Real GVC income for all manufactures and in constant 1995 prices using US CPI as deflator. Decomposed into part due to domestic demand and part due to foreign demand.
Source: Author's calculations based on World Input-Output Database, April 2012.

Table 2 Decomposition of change in 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.

Table 3 Revealed comparative advantage, 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.

Table 4 Growth in exports and GVC income in manufactures 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 manufacturing goods and GVC refers to GVC income in production of manufactures. Growth rates calculated as (ratio of end year over begin year minus one) times 100.

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

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 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.

Table 6 Growth in manufactures GVC workers relative to all workers in the economy, by skill level, 1995-2008.

	Change in GVC workers relative to total economy		
	Low skilled	Medium skilled	High skilled
Germany	0.92	1.00	1.03
France	0.81	0.83	1.03
United Kingdom	0.65	0.63	0.71
Italy	0.87	0.98	1.12
Spain	0.74	0.79	0.93
Netherlands	0.82	0.84	1.04
Belgium	0.79	0.91	0.91
Sweden	0.92	0.98	1.15
Austria	0.87	0.91	1.24
Greece	0.67	0.88	1.01
Denmark	0.76	0.83	1.02
Finland	0.81	0.84	0.92
Ireland	0.60	0.59	0.77
Portugal	0.78	0.77	0.90
Luxembourg	0.81	0.87	0.95
all EU15	0.81	0.88	0.94
Poland	1.04	0.97	1.09
Czech Republic	1.01	1.04	0.98
Romania	0.83	0.79	1.10
Hungary	0.97	0.95	1.04
Slovak Republic	0.95	1.08	1.08
all EU12	0.88	0.95	1.04
Total EU 27	0.82	0.90	0.95

Note: Manufactures GVC workers are workers directly and indirectly involved in the production of manufacturing goods. Table indicates the change in GVC workers relative to the change in number of workers of same skill type in the overall economy.

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

Fragmentation, Incomes and Jobs.
An analysis of European competitiveness

Appendix
Tables and figures for full set of 40 countries

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

	Real GVC income (in mil constant $)		Real GVC income due to foreign demand (%)	
	1995	2008	1995	2008
United States	1,311,507	1,376,188	25.9	33.0
Japan	1,153,965	677,803	24.6	41.8
China	277,033	1,116,642	35.3	48.7
Germany	617,836	665,164	46.3	69.9
France	292,330	330,216	53.1	60.0
United Kingdom	253,548	260,443	52.6	68.5
Italy	289,055	354,158	45.2	52.8
Spain	127,696	171,836	39.1	53.3
Russian Federation	80,174	246,830	42.6	47.3
Brazil	163,652	265,070	15.7	26.0
Canada	123,880	190,037	65.8	65.8
India	113,531	229,321	17.7	29.3
Mexico	98,526	208,217	32.9	36.5
Australia	67,599	112,593	43.9	55.3
South Korea	141,553	157,002	45.2	67.8
Netherlands	94,133	118,973	79.3	87.8
Turkey	73,333	122,295	22.5	35.3
Indonesia	83,421	113,625	28.5	38.7
Poland	33,439	85,700	42.7	63.0
Belgium	66,357	69,783	84.1	89.2
Sweden	55,536	70,548	70.3	77.5
Taiwan	82,727	73,053	60.9	79.4
Austria	50,081	62,674	53.9	78.5
Greece	20,468	30,564	17.5	31.3
Denmark	36,484	41,700	79.8	87.5
Finland	28,868	36,952	64.5	74.3
Ireland	21,583	40,480	88.3	88.1
Portugal	23,730	27,228	48.5	59.6
Czech Republic	14,477	41,450	57.3	79.0
Romania	11,896	32,585	32.4	44.4
Hungary	11,120	27,140	44.9	73.1
Slovak Republic	5,060	17,624	64.4	79.8
Luxembourg	3,784	6,743	94.1	97.5
Slovenia	5,150	8,548	69.0	86.3
Lithuania	1,522	6,637	54.0	64.0
Bulgaria	3,900	7,134	44.7	65.0
Latvia	1,028	3,108	57.4	69.1
Cyprus	1,304	1,547	43.7	52.2
Estonia	936	3,041	68.7	82.0
Malta	854	1,003	50.4	78.5

Note: Real GVC income for all manufactures and in constant 1995 prices using US CPI as deflator. Decomposed into part due to domestic demand and part due to foreign demand. *Source:* Author's calculations based on World Input-Output Database, April 2012

Appendix 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
United States	64,681	171,915	-107,234
Japan	-476,162	-320,264	-155,898
China	839,609	738,239	101,370
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
Russian Federation	166,656	127,872	38,784
Brazil	101,418	102,843	-1,425
Canada	66,157	48,487	17,670
India	115,790	116,648	-858
Mexico	109,690	97,749	11,941
Australia	44,993	28,409	16,584
South Korea	15,449	31,724	-16,275
Netherlands	24,840	26,925	-2,086
Turkey	48,963	50,299	-1,336
Indonesia	30,204	20,167	10,037
Poland	52,261	47,986	4,275
Belgium	3,426	12,606	-9,180
Sweden	15,012	18,434	-3,422
Taiwan	-9,675	-2,414	-7,260
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
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
Luxembourg	2,959	1,600	1,359
Slovenia	3,398	2,694	704
Lithuania	5,115	3,930	1,185
Bulgaria	3,235	2,997	238
Latvia	2,080	1,590	490
Cyprus	243	84	159
Estonia	2,106	1,321	785
Malta	148	5	144

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.

Appendix Table 3 Revealed comparative advantage, 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
United States	1.00	1.17	1.12	1.07	0.88	0.97	0.83	0.80	0.81	0.62	1.27	1.10
Japan	0.58	0.54	1.51	1.33	0.88	0.88	1.48	1.55	0.65	0.39	1.09	1.42
China	0.87	0.36	0.97	1.75	1.03	0.83	0.99	1.07	1.77	1.65	0.55	0.86
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
Russian Federation	1.73	2.00	0.48	0.50	1.27	1.11	1.00	1.06	0.72	0.59	0.79	0.65
Brazil	1.20	1.00	0.78	0.62	1.16	1.16	0.69	0.99	1.47	1.13	0.79	1.03
Canada	0.99	1.37	0.66	0.56	0.98	0.98	0.72	0.78	0.74	0.73	1.64	1.33
India	0.93	0.87	0.41	0.77	1.06	1.11	0.80	0.99	2.08	1.87	0.78	0.62
Mexico	1.91	1.70	0.59	0.57	1.35	1.36	0.50	0.51	0.64	0.56	0.98	1.02
Australia	1.03	0.93	0.52	0.79	1.50	1.18	0.73	1.14	1.08	0.82	0.70	0.86
South Korea	0.54	0.34	1.33	1.83	0.79	0.53	0.93	1.12	1.29	0.81	1.37	1.80
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
Turkey	1.21	0.63	0.40	0.42	1.12	1.32	0.89	0.76	1.95	2.53	0.57	0.50
Indonesia	0.87	0.96	0.63	0.70	1.53	1.53	0.32	0.42	1.53	1.28	0.86	0.93
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

(see next page)

Appendix Table 3 Revealed comparative advantage, major EU countries, 1995 and 2008. (continued)

	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
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
Taiwan	0.78	0.50	1.43	2.59	0.76	0.52	1.27	1.29	1.40	0.94	0.77	0.80
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
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
Luxembourg	1.18	0.87	0.72	0.88	0.86	0.83	1.21	1.28	1.05	1.23	1.01	1.01
Slovenia	1.16	1.17	0.80	0.87	0.72	0.59	1.06	1.45	1.78	1.14	0.75	0.99
Lithuania	1.17	1.30	0.37	0.42	1.66	1.42	0.68	0.68	1.50	1.34	0.32	0.57
Bulgaria	0.97	0.78	0.28	0.50	1.73	1.32	0.58	1.16	1.46	1.76	0.42	0.47
Latvia	0.61	0.61	0.41	0.52	1.58	1.56	0.54	0.73	1.61	1.28	0.41	0.67
Cyprus	0.87	0.90	0.23	0.44	1.60	1.65	0.41	0.69	2.03	0.95	0.20	0.43
Estonia	0.74	0.73	0.49	0.85	1.59	1.12	0.50	0.93	1.87	1.56	0.28	0.63
Malta	1.13	1.20	0.95	1.28	0.75	0.75	0.62	0.64	2.17	1.42	0.68	0.96

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.

Appendix Table 5 Manufactures GVC workers, 1995 and 2008

	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								
United States	16.0	11.1	1,143	8,837	6,892	16,872	-331	-3,144	-1,138	-4,612
Japan	22.6	19.4	1,298	6,491	4,417	12,207	-794	-2,225	148	-2,871
China	31.7	33.3	121,342	87,568	49,468	258,378	9,963	20,508	11,965	42,436
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
Russian Federatic	24.7	21.9	4,259	6,749	6,228	17,237	-1,403	-2,120	2,198	-1,325
Brazil	29.6	28.7	8,347	9,490	9,823	27,660	-705	2,450	4,118	5,863
Canada	20.8	16.0	157	1,138	1,482	2,777	-102	-136	193	-45
India	27.9	27.3	57,926	41,933	26,483	126,343	2,118	10,896	7,025	20,039
Mexico	30.3	24.4	2,817	6,128	3,205	12,150	-400	1,403	1,121	2,124
Australia	18.2	14.5	165	641	855	1,661	-48	3	196	150
South Korea	29.7	22.8	655	2,646	2,077	5,378	-468	-735	524	-679
Netherlands	22.8	19.0	89	643	929	1,661	-42	-87	158	29
Turkey	27.1	30.4	1,778	3,115	1,554	6,446	-341	620	584	863
Indonesia	32.1	25.6	13,921	7,427	5,725	27,073	-1,899	-425	1,380	-944
Poland	31.0	28.8	917	2,278	1,347	4,542	-468	81	368	-19
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
Taiwan	30.9	29.2	113	1,900	1,028	3,041	-204	159	187	142
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
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
Luxembourg	20.3	17.4	1	23	36	61	-1	1	16	17
Slovenia	34.0	26.9	20	163	83	266	-10	-47	11	-46
Lithuania	26.8	21.3	32	183	109	324	-61	-27	14	-73
Bulgaria	30.7	28.6	276	544	276	1,096	32	-73	58	17
Latvia	23.4	16.9	20	102	69	191	-20	-32	16	-36
Cyprus	18.5	11.5	3	24	19	46	-2	-12	4	-9
Estonia	31.7	22.4	10	88	49	147	-26	-20	-8	-53
Malta	24.0	17.9	1	17	12	29	0	-6	2	-4

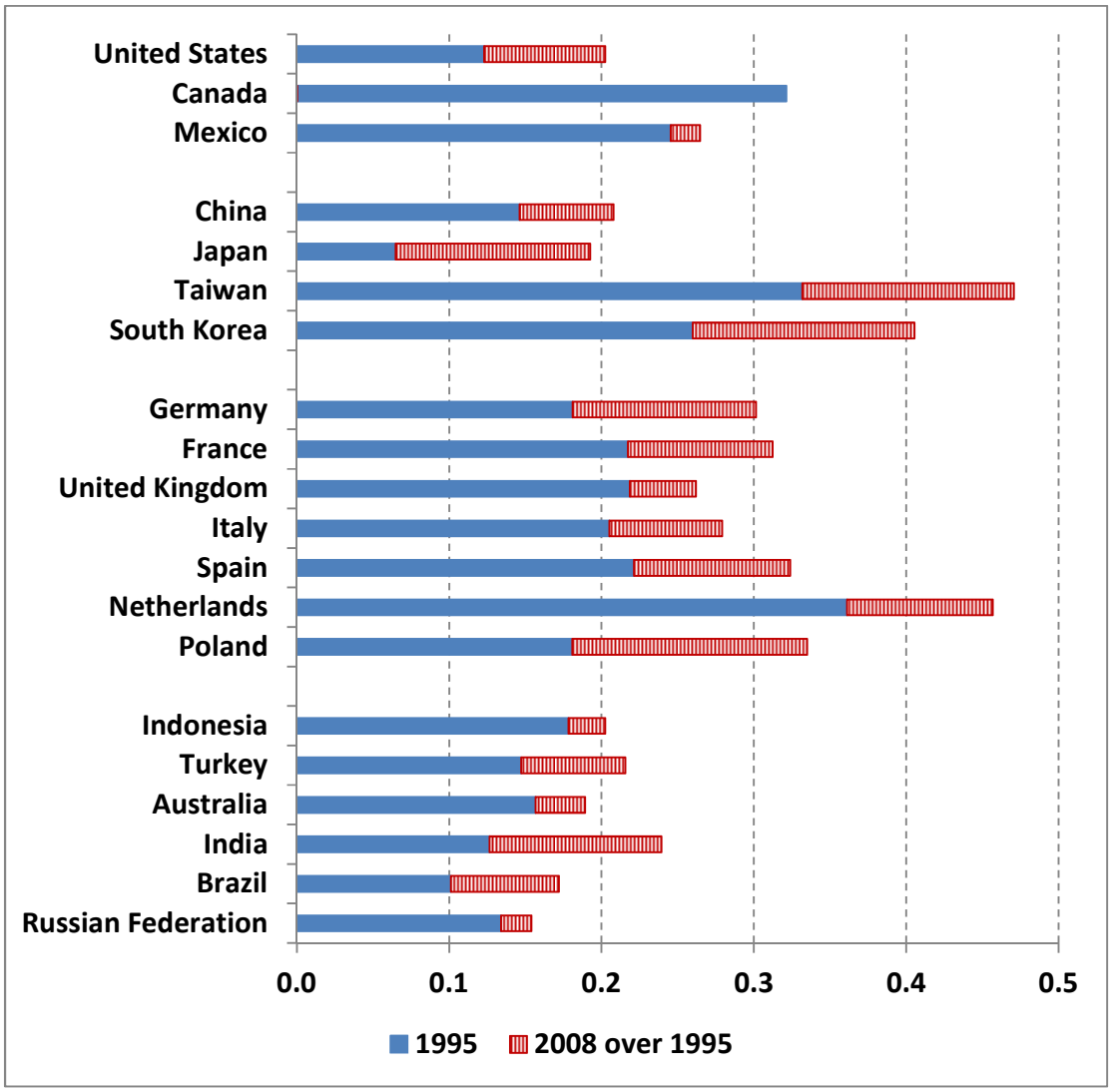
Note: GVC workers are workers directly and indirectly involved in the production of manufacturing goods. First four columns indicate the change in the number of GVC workers by sector between 1995 and 2008. Next four columns indicate the total number of GVC workers by sector in 2008. Last column is the total number of workers in the economy.*Source:* Author's calculations based on World Input-Output Database, April 2012.

Appendix Table 6 Change in Manufactures GVC workers, by skill level, 1995-2008.

	Change in GVC workers relative to total economy		
	Low skilled	Medium skilled	High skilled
United States	0.66	0.71	0.69
Japan	0.92	0.90	0.87
China	1.12	0.99	1.00
Germany	0.92	1.00	1.03
France	0.81	0.83	1.03
United Kingdom	0.65	0.63	0.71
Italy	0.87	0.98	1.12
Spain	0.74	0.79	0.93
Russian Federation	0.90	0.90	0.98
Brazil	0.99	1.18	1.00
Canada	0.74	0.77	0.91
India	0.97	0.99	1.00
Mexico	0.82	0.78	0.96
Australia	0.81	0.82	0.90
South Korea	0.68	0.85	0.86
Netherlands	0.82	0.84	1.04
Turkey	1.21	1.14	1.03
Indonesia	0.81	0.96	0.94
Poland	1.04	0.97	1.09
Belgium	0.79	0.91	0.91
Sweden	0.92	0.98	1.15
Taiwan	0.99	1.03	1.00
Austria	0.87	0.91	1.24
Greece	0.67	0.88	1.01
Denmark	0.76	0.83	1.02
Finland	0.81	0.84	0.92
Ireland	0.60	0.59	0.77
Portugal	0.78	0.77	0.90
Czech Republic	1.01	1.04	0.98
Romania	0.83	0.79	1.10
Hungary	0.97	0.95	1.04
Slovak Republic	0.95	1.08	1.08
Luxembourg	0.81	0.87	0.95
Slovenia	0.85	0.82	0.85
Lithuania	0.75	0.80	0.93
Bulgaria	0.94	0.98	1.53
Latvia	0.69	0.71	0.88
Cyprus	0.60	0.68	0.65
Estonia	0.65	0.68	0.81
Malta	0.74	0.86	1.23

Note: GVC workers are workers directly and indirectly involved in the production of manufacturing goods. First four columns indicate the change in the number of GVC workers by skill type. Last four columns indicate the change in GVC workers relative to the change in number of workers of same skill type in the overall economy.
Source: Author's calculations based on World Input-Output Database, April 2012.

Figure 2 Share of foreign value added in production of final manufacturing products.



Note: This graph shows the foreign value added share in the output value of final manufacturing products produced in a country. The remaining share is value added by the domestic economy. Share in 1995 and change during 1995-2008 period. A higher share indicates more international fragmentation of production.

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