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Fragmentation, Incomes and Jobs. An analysis of European competitiveness

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Fragmentation, Incomes and Jobs. An analysis of European competitiveness

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Abstract

Increasing fragmentation of production across borders is changing the nature of international competition. It increasingly plays out at the level of activities within industries, rather than at the level of whole industries. As a result, current measures of competitiveness such as export market shares become less informative for the policy debate and new measures are needed. In this paper we study the links between fragmentation and the creation of income and jobs based on a recent multi-sector input-output model of the world economy. Using this model, we measure the income and jobs in a country that are directly and indirectly related to the production of manufacturing goods, called GVC (global value chain) income and jobs. We find that during 1995-2008 growth in GVC income and jobs is much lower than growth in gross exports in all European countries, in particular Germany and Eastern European countries that rely heavily on imported intermediates. We also find that fragmentation does not necessarily lead to destruction of jobs in advanced countries. The number of GVC jobs located in the manufacturing sector declined, but this was more than compensated for by GVC job creation in supporting services in most EU countries. Actually, in 2008, almost half of the jobs related to global manufacturing production were outside the manufacturing sector. We also find a magnification of comparative advantage of EU countries as there is a shift away from activities in GVC production carried out by low-skilled workers towards those carried out by 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.

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 activities in global production 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 (2012) confirmed this gap for a larger set of countries.

However, none of the studies so far have come up with a new activity-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, extending the approach used in Johnson and Noguera (2012) and Bems, Johnson and Yi (2011). This new approach allows an ex-post accounting of the activities countries carry out in the production of manufacturing goods. We will focus 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. Our main findings are the following.

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 (2012) 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 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, 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.

Third, 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. This is much less true for activities in production chains of non-tradable products. For example personal or retail services 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. Importantly, global manufacturing production does not only involve activities in the manufacturing sector itself. In fact, as will be shown in our results a major part of the activities in the production of manufacturing goods takes place in services 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.

Finally, GVC income can be derived in the production for domestic or foreign final demand, and is not necessarily linked 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.

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 (2012) 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 (2012) and then generalize their approach for our GVC measure.[1]

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

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

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

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

Using matrix algebra, the market clearing conditions for each of the SN goods can be combined to form a compact global input-output system. Let **y** be the vector of production of dimension (SNx1), 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)

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

$\mathbf{I}$ 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 euroof 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 $\mathbf{I}$ is obtained. Since $(\mathbf{I} - \mathbf{A})^{-1}\mathbf{I} = (\mathbf{I} - \mathbf{A})^{-1}$, our interpretation of the Leontief inverse is correct.

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. 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 $\mathbf{v}_n$ as generated to produce the unit final

demand vector $\mathbf{z}_n$ (introduced above) by pre-multiplying the gross outputs needed for production of this final demand by the direct value added coefficients vector **p**:

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

in which a hat indicates a diagonal matrix with the elements of a vector (in this case **p**) on the diagonal. If $\mathbf{v}_n$ 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 $\mathbf{v}_n$ should add up to 1. Intuitively, this should be true, since the Leontief inverse takes an infinite number of production rounds into account, as a consequence of which we model the production of a final good from scratch. The entire unit value of final demand must thus be attributed to country-sectors. We can show also mathematically that this is true. Let **e** an SN summation vector containing ones, and a prime denotes transposition, then using equation (4) the summation of all value added related to a unit final demand $(\mathbf{e'v_n})$ can be rewritten as $\mathbf{e'v_n} = \mathbf{e'}\hat{\mathbf{p}}(\mathbf{I} - \mathbf{A})^{-1}\mathbf{z_n} = \mathbf{p'}(\mathbf{I} - \mathbf{A})^{-1}\mathbf{z}_n$**.** By definition, value added is production costs minus expenditures for intermediate inputs such that $\mathbf{p'} = \mathbf{e'}(\mathbf{I} - \mathbf{A})$. Substituting gives $\mathbf{e'v_n} = \mathbf{e'}(\mathbf{I} - \mathbf{A})(\mathbf{I} - \mathbf{A})^{-1}\mathbf{z}_n = \mathbf{e'z}_n$. 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*. 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 manufacturing products of which the last stage of production (that is, before delivery to the user) takes place in Germany.

These value added levels will depend on the structure of the global production process as described by the global intermediate inputs coefficients matrix **A,** and the vector of value-added coefficients in each country-sector **p**. For example, **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 outlined above can be generalized to analyze the value and quantities used of specific production factors (labor or capital) in the production of a particular final good. In our empirical application we will study the changes in distribution of jobs in global production, both across countries and across different types of labor. To do so, we now define $p_i(s)$ 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 **p** 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 German car manufacturing

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 other countries. 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 decomposition methodology, we can provide a more comprehensive picture. 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 the **p** vector 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 was 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 extended the input-output data to 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, distinguishing 35 industries and 59 product groups. 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 world IO tables 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 (domestic intermediate use, domestic final demand or exports). These 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, but applied at a much more aggregate level, was followed by Johnson and Noguera (2012).

In a second stage the imports of products are broken down by country-industry origin and allocated to a use category. This type of information is not available in published input-output tables. Typically, researchers rely on the so-called import proportionality assumption, applying a product's economy-wide import share for all use categories (as e.g. Johnson and Noguera, 2012). Various studies have found that this assumption can be rather misleading as import shares vary significantly across use category (Feenstra and Jensen, 2012; Puzello 2012). To improve upon this, bilateral trade statistics have been used in WIOD to derive import shares for three end-use categories: intermediate use, final consumption use, or investment use. 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. Based on the detailed product description, goods were allocated to intermediate use, final consumption use, or investment use. 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. In addition, data on bilateral trade in services has been collected, integrating various international data sources (including OECD, Eurostat, IMF and WTO). 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 for free 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. Global value chain incomes in Europe

This section summarizes some of the main trends in the distribution of income in global value chains, based on the GVC income concept. Throughout we focus in particular on the position of the European Union as a whole and on developments within the 27 member states. The period studied is from 1995 to 2011 which covers two important developments in the integration of the European economy, namely 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 skilled and 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 trends until 2011.

In section 4.1 we first establish the universal nature of international fragmentation of production. In section 4.2 we analyse trends in the GVC income for the EU 27 and find that Europe as a whole was holding up relatively well in the past two decades. The shifting shares between old and new EU member states are discussed in section 4.3. We find that fragmentation has contributed significantly to this change. We also find that differences in competitiveness between old EU member states are smaller than expected based on traditional gross export flow analysis. This difference is analysed in depth in section 4.4.

4.1 International production fragmentation

The international fragmentation of production is a global phenomenon and can be seen in many countries around the world. It is driven by firms aiming to take advantage of differences in technologies, factor endowments and factor prices across countries. In Figure 2 we provide a simple indicator of fragmentation based on the WIOD, using the broad measure of vertical specialization (VS) from Feenstra and Hanson (1999). This measure is defined as the share of imports in the use of intermediate inputs in manufacturing industry. An increase indicates that a larger share of the intermediate inputs is sourced from outside the country, reflecting backward integration of a country's production process. It is shown that for all 27 European Union countries, except Cyprus and Luxembourg, fragmentation has increased between 1995 and 2008. Import shares increased by 10 percentage points or more in most countries, and rose the fastest in the new member states. Based on a bilateral breakdown of imports (not shown) it follows that the Eastern European countries that joined the EU in 2004 have shown rapid production integration the old EU15 countries. This process was facilitated by a massive inflow of foreign direct investment into Eastern Europe, in particular from Germany and Austria. This started already at the end of the 1990s and well before the formal entry in 2004 (Marin 2006, 2011). The results illustrate the universal nature of the international fragmentation process within Europe in the past two decades.

In a world with product variety one would expect bigger economies to have a lower import share (Hummels, Ishii and Yi, 2001) and this is generally borne out by the data for Europe. The imported intermediates share in Germany though is rather high given the size of its economy and in 2008 it is even higher than the next four biggest EU countries. This rapid increase prompted Hans-Werner Sinn to characterise the German economy as a Bazaar economy (Sinn, 2006). Although this characterisation is somewhat overdone as 65% of the inputs still originates from within Germany, Sinn rightfully pointed at the increasing divergence between the value of gross exports value and the value actually added in the German economy, a point we will return to later.

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 no longer the place where most of the value has been added. As highlighted by the WTO, nowadays products are "Made in the World". This prompted the development of the GVC income concept.

[Figure 2 about here]

4.2 Trends in EU27 competitiveness

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. 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 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 manufacturing products (in short manufactures). 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 nation 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.

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. Much of the offshoring is done by multinational firms that maintain capital ownership and hence GVC income (which consists of both capital and labour income) in the outsourcing country is underestimated. GVC income can only be measured on a domestic territory basis due to a lack of data on foreign ownership. As a result, income earned by capital is allocated to the place of production (in this case China), and not by ownership. 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). Obviously, the same is true for other countries or regions with large net outflows of FDI. As long as FDI flows within the regions distinguished above, this is not affecting the results. Similarly, in case there are comparable amounts of FDI in- and outflows between regions this problem is relatively minor. But for individual countries with large net FDI positions, this needs to be kept in mind in interpreting the results.

[Figure 3 about here]

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. A recent RCA analysis for the euro area by di Mauro and Foster (2008) found that in contrast to other advanced economies, the euro area specialisation overall has 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. Alternatively, the country may produce for a large domestic market.

In Figure 4 we provide 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 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 each product GVC.

[Figure 4 about here]

4.3 Competitiveness of EU countries

Aggregate EU27 performance hides substantial variation within the European Union. In this section we analyse GVC incomes and RCA for individual EU member states. 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. In Table 1 we present the share of individual EU countries in the overall GVC income in the EU27 region. This is an indicator of the competitiveness of European countries vis-à-vis each other. In Table 2 we present the RCA for member states, calculated as above, to track particular specialisation patterns.

As expected new member states more than doubled their share in EU27 GVC income, up to 10% in 2008. They particularly improved their positions in GVCs of transport equipment, all 5 major countries having RCAs higher than one or this product. RCAs in electrical equipment rapidly increased as well, but at a lower level. Also Spain in the 2000s and Ireland in the late

1990s increased their GVC income shares significantly, in particular improving RCAs in non-electrical machinery and chemicals respectively. The Netherlands (activities in food and chemical GVCs) and Sweden (electrical and non-electrical machinery) performed particularly well since 2000. Both countries were also able to increase their GVC income shares after the crisis.

In contrast, the competitive position of all major EU countries dwindled over this period. The French share declined slowly but steadily, losing in particular competitive advantage in transport equipment. Similarly, the share in the UK dropped after an initial increase in the late 1990s, losing competitiveness especially in electrical machinery and non-durables. The Italian decline was mainly concentrated in chemicals. Interestingly, Italy maintained a particular strong position in activities in the production of non-durables (textiles, wearing apparel and footwear). This 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.

The most important industrial economy of Europe, Germany, contributed more than a quarter to EU27 GVC income since 1995. But also the German share dropped at the end of the 1990s and did not significantly improve afterwards. German RCA in GVC activities dropped sharply for non-durables, but increased strongly for transport equipment to the highest level in Europe, apart from the Czech Republic.

[Table 1 about here]
[Table 2 about here]

Our input-output model also allows for counterfactual analysis, focusing on the role of production technology on the changes in GVC incomes earned by countries. To this end, we calculate the change in GVC income over the period 1995-2008 by keeping demand levels for final goods from each country-sector constant. In this case, the change in GVC income will be driven by reorganisation of global production. This reorganisation can be due to many factors that have been highlighted in the literature on trade, such as skill-biased technological change, offshoring of intermediate input production and changing the geography of input sourcing. The combined effects of these are described by the changing cost shares in production in our model, including both intermediate and factor input cost shares.

As final demand will shift in response to the changes in production, we calculate two extreme scenarios based on 1995 and 2008 final demand levels. The average of both effects is given in Figure 5, expressed as a percentage of the actual GVC income change over 1995-2008. We find that all Eastern European countries and Ireland benefitted from the changes in global production technologies. These countries have improved GVC income by increasingly serving global demand through exporting intermediate products that are used in production by other countries. The magnitude of these gains are relatively small though and typically 10% or less of

the actual change in GVC income. Most of their GVC income increase over the period is due to increased demand for products in which production process they have a relatively large contribution.

Most old EU member states did not benefit from the reorganisation of global production. This is mainly due to declining shares of these countries in GVCs, in particular of those products where the final stage of production takes place in the domestic economy. The losses are relatively small for most countries, except for Belgium, France and Germany where they are 20% or higher. 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, their production of car parts declined substantially over this period.

[Figure 5 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 helped 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. The ratio of gross exports to GVC income in 1995 and 2008 is shown for each country in Figure 6. In 2008 this ratio was ranging from slightly above one in Italy, Spain and the UK to around two or more in Belgium, Finland, Ireland, the Netherlands and some Eastern European countries. Comparing with 1995, it shows that the ratio increased in all major European countries. This indicates that for all countries growth in gross exports is overestimating growth in GVC incomes. But the figure shows that the increase in Germany has been particularly high, and comparable to increases in Eastern Europe. This pattern holds a fortiori for Austria where FDI flows to Eastern Europe have been particularly high (Marin, 2011).

In Table 3 we provide a direct comparison of the growth rates of gross exports and GVC incomes and confirm the pattern described above. 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 3 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 a patterns of offshoring have been rather different as discussed above. The biggest differences are found for Austria, Germany, Greece and Spain. A similar pattern is found when focusing at the more recent period from 2000 onwards.

[Figure 6 about here]
[Table 3 about here]

5 The structure of GVC employment

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 GVC workers. We will characterise GVC workers by wages, 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, job increase in supporting services is even higher than job loss in manufacturing. But we also find that only few countries in the EU have been able to increase GVC employment in conjunction with rising real wages. 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 EU countries in GVC activities performed by high-skilled workers. This is in line with broad Heckscher-Ohlin predictions of comparative advantage when production fragmentation is possible.

5.1 From GVC jobs in manufacturing to services

By using number of workers rather than value added per unit of output as the requirement vector in equation (4), we can trace the sector of employment of workers directly and indirectly involved in the production of manufacturing goods. In Table 4 we consider three sectors of employment for GVC workers in the EU27 countries: agriculture, manufacturing and services. The last four columns refer to the absolute number of workers in 2008, while the first four columns refer to the change over the period 1995-2008. Two main facts stand out clearly. Firstly, a sizeable share of manufacturing GVC workers is not employed in the manufacturing sector itself. In 2008, manufacturing accounted for just about half of the total number of GVC workers for the EU27 as a whole. 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.

Secondly, we find that the services share has steadily increased since 1995. As shown in the left hand side of Table 2, 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 3.5 million. It should be noted that these are jobs in services sector producing intermediate services such as wholesaling, transportation, finance and business services. Importantly, they exclude any jobs involved in the retailing of manufacturing goods as we analyse final demand at the basic price concept.

Faster growth in services jobs than in manufacturing can be seen in all twenty 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. This testifies to the increasing intertwines of manufacturing and services activities and argues against a myopic view on manufacturing jobs in discussion on GVC issues.

In particular it does not lend support to sector-specific policies such as currently being devised in various countries, including France and the US.

[Table 4 about here]

This shift in sectoral structure is at the background of a general decline in the overall number of GVC workers in the EU27 as a whole. Perhaps surprisingly, GVC worker numbers declined in Eastern Europe, 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. In seven out of the 15 old EU members GVC worker numbers also declined, with large declines relative to the size of the economy in the UK, Greece and Portugal. Job loss in the UK stands out in particular, as more than 1.6 million GVC jobs disappeared in this country alone. Declines were across all industries, but in particular in textiles and metal manufacturing.

A limited number of countries were able to increase job opportunities in manufacturing GVCs. But except for Spain (14%), increases were less than 7% over the period 1995-2008. But these job increases seem to coincide with restricted real wage developments. In Figure 7 we plot for 19 countries 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 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 has 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 the type of activities carried out by countries in global value chains is not only determined by unit labour costs, and also reflect competitive strengths in particular in the non-manufacturing parts of the production process (Fagerberg, 1988).

[Figure 7 about here]

5.2 From low-skilled to high-skilled GVC workers

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. A skill-abundant country will specialize in the HS activities in production of both goods, and a skill-scarce country in the LS activities. The range of comparative advantages across countries in activities will be greater than in final products.

To test this prediction we split GVC workers by skill type based on educational attainment levels as described in section 3 and repeat the decomposition equation (4) with the labour by skill requirement vector. Results are given in Table 5 for the change in employment of low- (LS), medium- (MS) and high-skilled (HS) GVC workers during 1995-2008. The left hand side shows that 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. The only exception is Denmark, but even there HS workers increased more than LS or MS. We also find this pattern for new member states which confirms the findings by Marin (2011) that German and Austrian firms make particularly use of higher skilled labour in their Eastern European subsidiaries.

This finding in itself however is not sufficient to confirm the magnified comparative advantage hypothesis, as it might reflect the overall skill upgrading trend that is present in all economies as overall educational attainment levels steadily increase. Therefore we divided the increase in GVC jobs by the increase in overall economy workers of the same skill type. This will indicate whether the skill distribution of the GVC workers is becoming more skewed towards higher skills than the distribution of all workers. Results are given in the right-hand side of Table 5. We find strong support for the magnifying hypothesis. In all EU countries, with the exception of the Czech Republic, the share of high-skilled in GVC workers increased (much) faster than in the overall economy workforce. This is true in particular in Austria, Italy and Sweden. Also, the share of MS workers increased faster in most countries, adding further evidence that EU countries are specialising in carrying out higher skilled activities in the GVC production of manufacturing goods.

[Table 5 about here]

6. Concluding remarks

Production is increasingly organised in global value chains with different stages of production fragmented across borders. In this world, international competition increasingly plays out at the level of activities within industries, rather than at the level of whole 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 gap 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 income measures. The EU's comparative advantage is increasing in activities carried out in the production of non-electrical machinery and transport equipment, while declining in the production of non-durables, as expected. 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 (p), assembly of parts in to the final product (a) and services (s). 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 respectively 10, 50 and 40 per cent 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

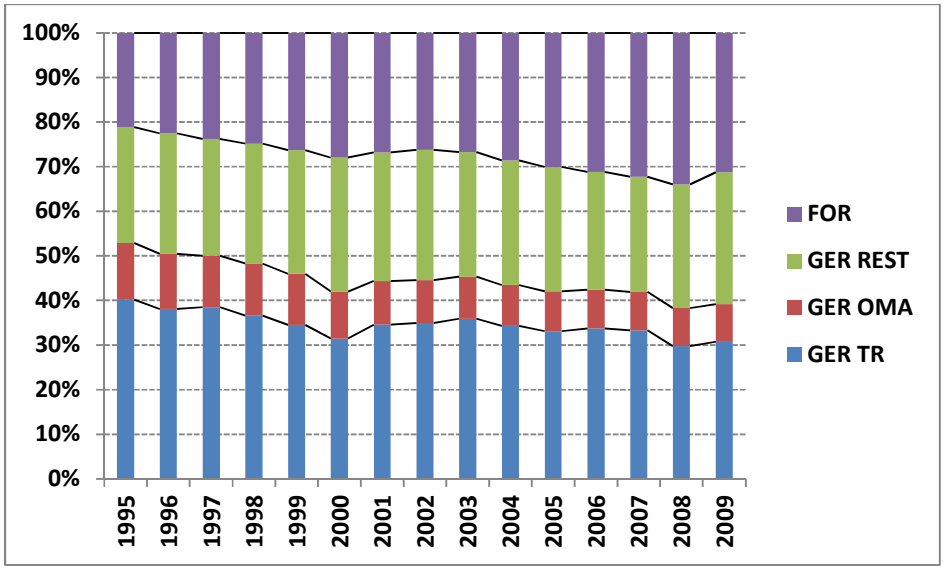
Obviously, the GVC income in A is decreasing when more activities are offshored, while GVC income in B is increasing. The total GVC income of both countries always adds up to 100 million, which is by definition equal to the value of car consumption. The export statistics for A and B however, show a rather 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.

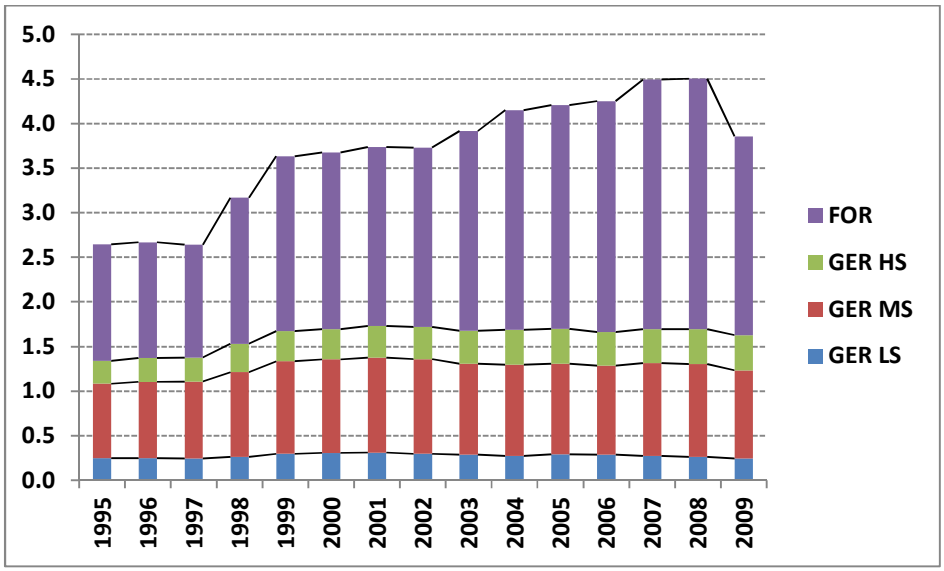
The underlying assumption in this example is that all activities are traded at arm's length (or at least at full cost value) between unaffiliated firms in the two countries. But when these activities all take place within one multi-national enterprise, transfer pricing might drive a wedge between the 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 geographic 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 process 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 global production of German transport equipment products

(a) GVC income shares (in %)



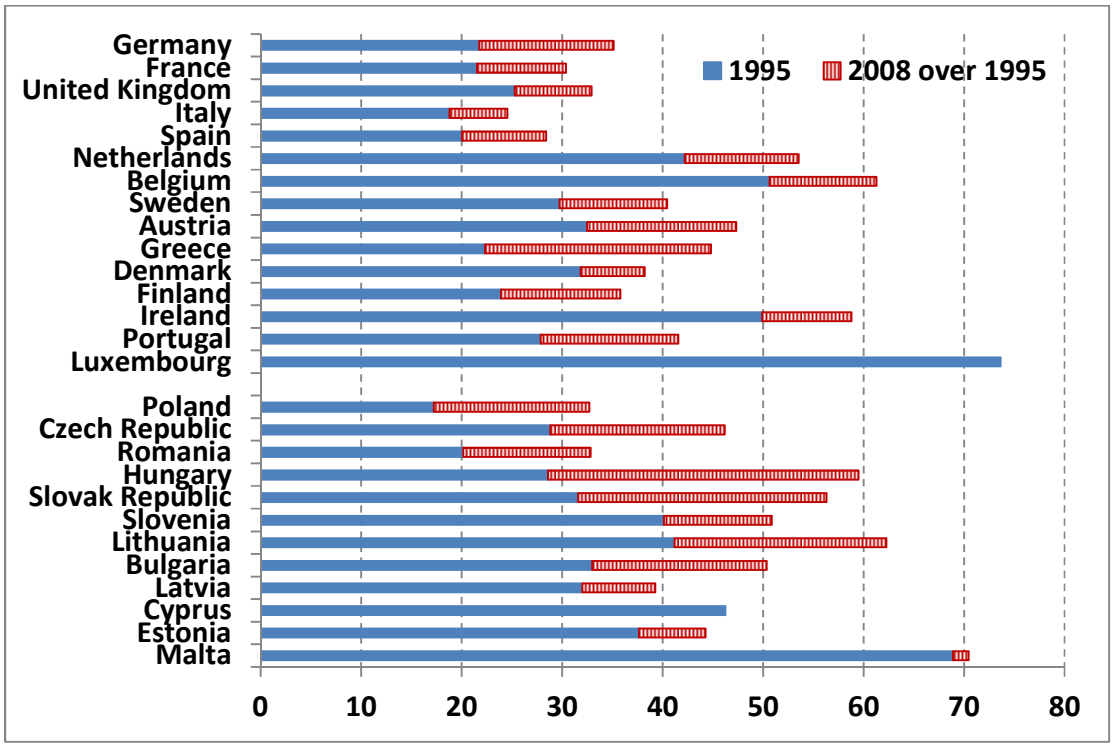
(b) Number of workers (in millions)



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.

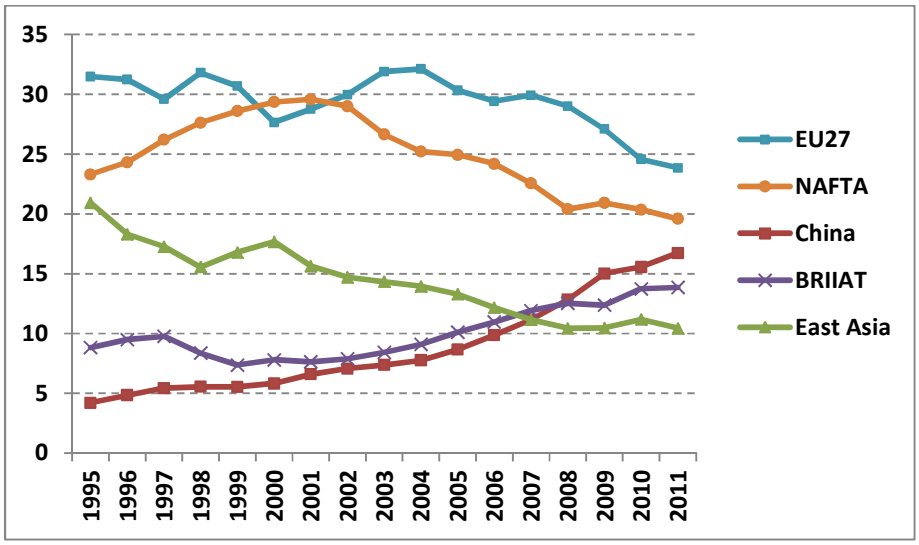
Figure 2 International fragmentation index



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

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

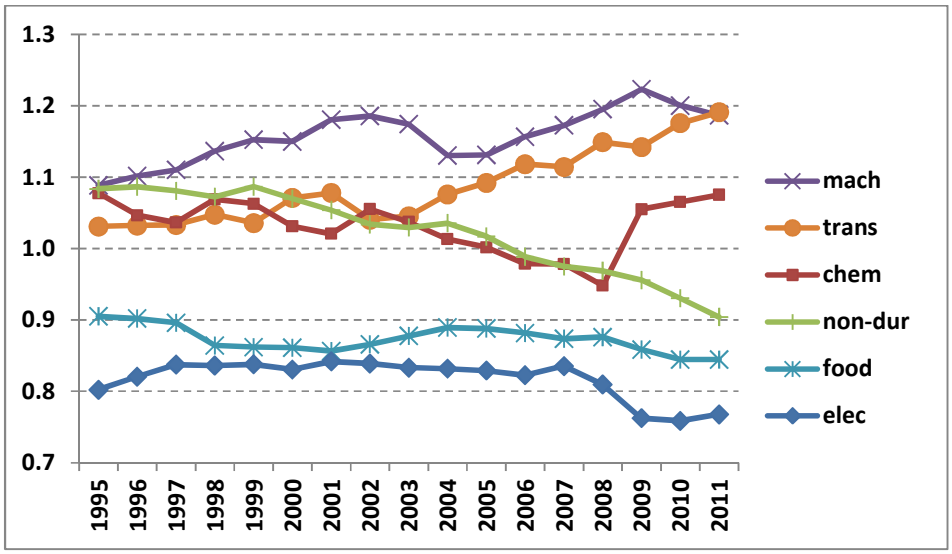
Figure 3 Regional share in world GVC income for all manufactures (%)



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.

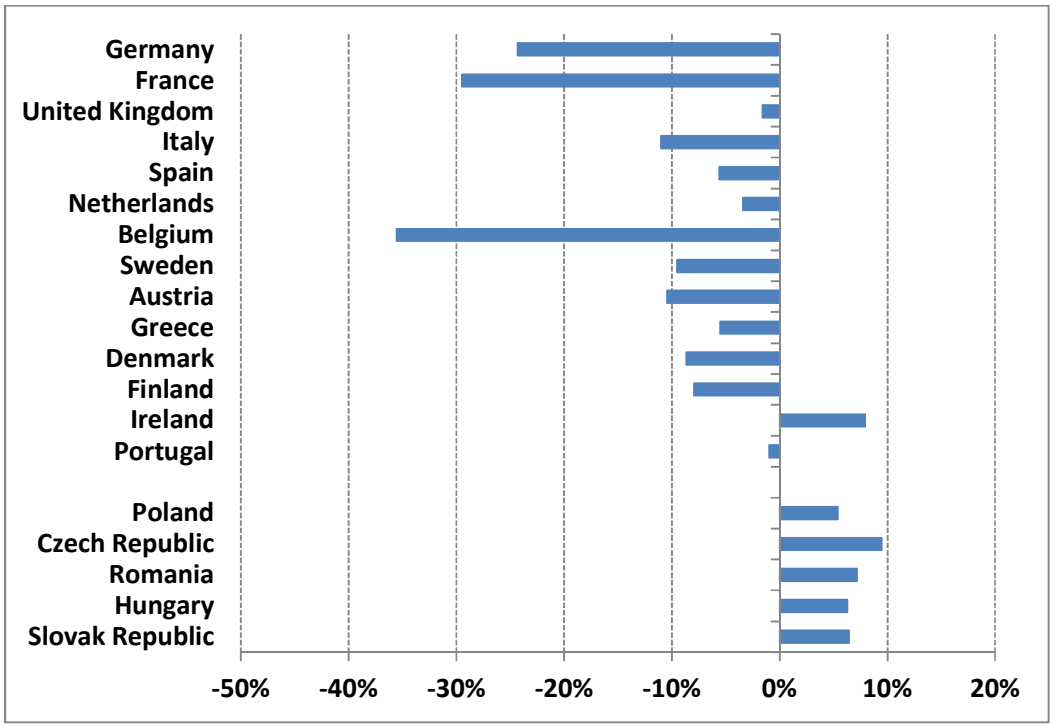
Figure 4 Revealed comparative advantage of EU27, by group of manufactures (%)



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.

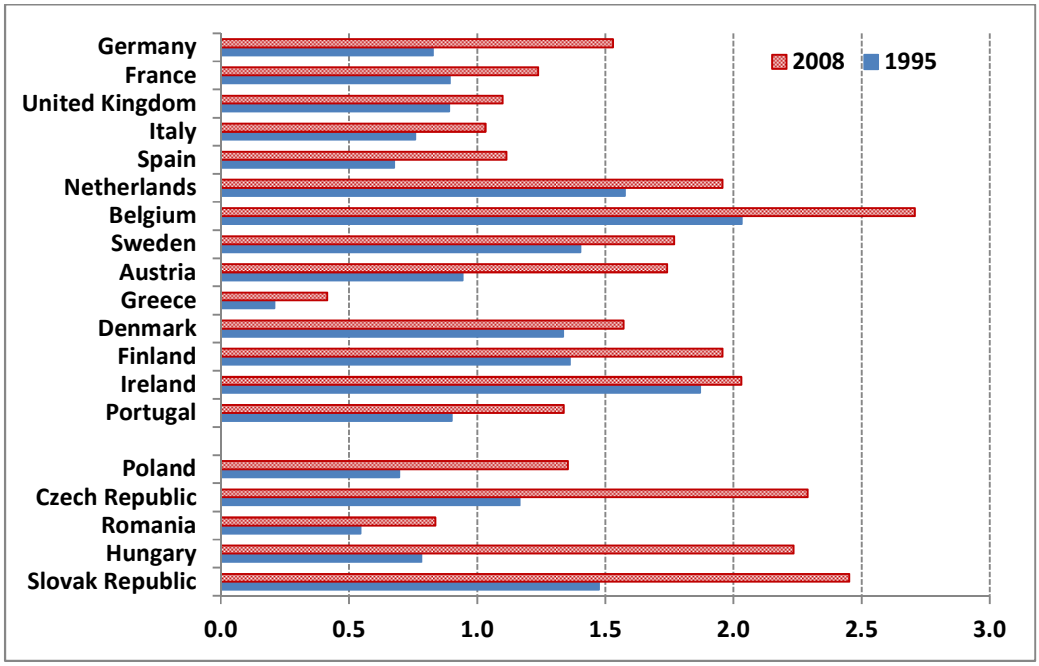
Figure 5 Hypothetical change in GVC income due to change in production



Note: Based on calculations of two counterfactual scenarios: change in GVC income over the period 1995-2008 due to change in technology when keeping demand for final goods from each country-sector constant at 1995 and at 2008 level.. The average of the two scenarios is shown in this figure, expressed as a percentage of the actual change in GVC income during 1995-2008. GVC income for all manufactures.

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

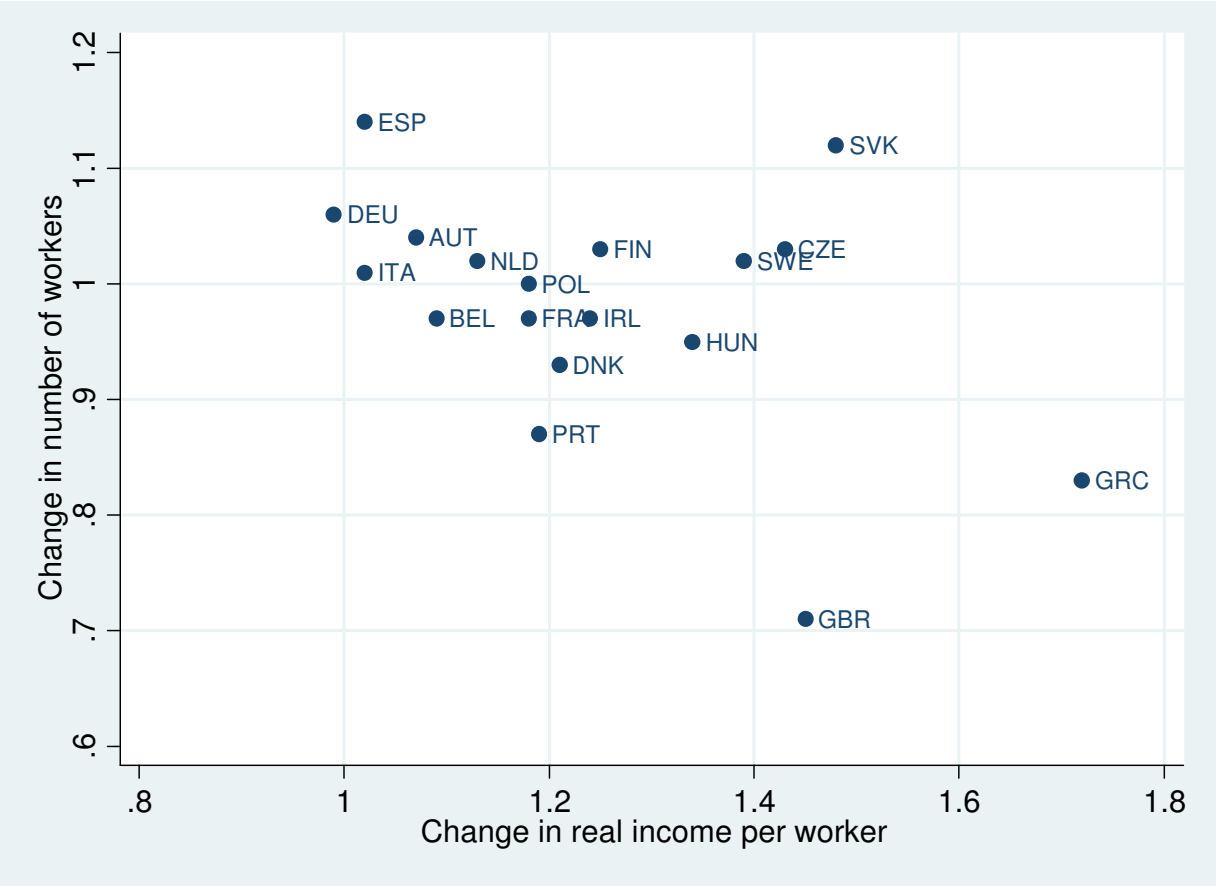
Figure 6 Ratio of gross exports to GVC income, 1995 and 2008.



Note: Exports refer to exports of manufacturing goods and GVC income refers to GVC income in production of manufactures.

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

Figure 7 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 Country shares in GVC income of EU27, all manufactures (in %)

	1995	2001	2008	2011	2008 minus 1995	2011 minus 2001
Germany	29.8	26.3	26.4	27.1	-3.5	0.9
France	14.1	14.3	13.1	12.9	-1.0	-1.3
United Kingdom	12.2	14.2	10.3	10.2	-1.9	-4.0
Italy	13.9	14.6	14.0	13.2	0.1	-1.4
Spain	6.2	6.3	6.8	6.9	0.6	0.6
Netherlands	4.5	4.3	4.7	4.9	0.2	0.6
Belgium	3.2	2.8	2.8	2.8	-0.4	0.0
Sweden	2.7	2.7	2.8	3.1	0.1	0.5
Austria	2.4	2.2	2.5	2.5	0.1	0.3
Greece	1.0	0.9	1.2	1.0	0.2	0.1
Denmark	1.8	1.7	1.7	1.5	-0.1	-0.1
Finland	1.4	1.4	1.5	1.3	0.1	-0.1
Ireland	1.0	1.6	1.6	1.6	0.6	0.0
Portugal	1.1	1.1	1.1	1.1	-0.1	-0.1
Luxembourg	0.1	0.1	0.1	0.1	0.0	0.0
all EU15	95.5	94.3	90.5	90.3	-5.0	-4.0
Poland	1.6	2.2	3.4	3.5	1.8	1.3
Czech Republic	0.7	1.0	1.6	1.7	0.9	0.7
Romania	0.6	0.6	1.3	1.3	0.7	0.7
Hungary	0.5	0.7	1.1	1.1	0.5	0.4
Slovak Republic	0.2	0.3	0.7	0.7	0.5	0.4
Other EU12	0.8	0.9	1.4	1.4	0.6	0.4
all EU 12	4.5	5.7	9.5	9.7	5.0	4.0
Total EU27	100.0	100.0	100.0	100.0	0.0	0.0

Note: a country's GVC income as percentage of GVC income in all EU27 countries.

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

Table 2 Revealed comparative advantage, 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 3 Growth in exports and GVC income in manufactures (%)

	1995-2008			2000-2008		
	Exports	GVC	Exp-GVC	Exports	GVC	Exp-GVC
Germany	1.80	0.52	1.29	1.67	0.91	0.76
France	1.21	0.59	0.61	1.02	0.74	0.28
United Kingdom	0.79	0.45	0.34	0.58	0.30	0.28
Italy	1.35	0.73	0.62	1.28	0.85	0.43
Spain	2.13	0.90	1.23	1.50	1.11	0.39
Netherlands	1.21	0.78	0.43	1.33	1.09	0.24
Belgium	0.97	0.48	0.49	1.22	0.84	0.39
Sweden	1.26	0.79	0.47	1.04	0.76	0.28
Austria	2.25	0.76	1.49	1.80	1.13	0.67
Greece	3.17	1.11	2.06	2.61	1.62	0.99
Denmark	0.90	0.61	0.28	1.19	0.86	0.32
Finland	1.59	0.80	0.79	1.24	0.89	0.35
Ireland	1.87	1.64	0.23	0.67	0.98	-0.31
Portugal	1.40	0.62	0.78	1.28	0.88	0.40
Poland	6.03	2.61	3.41	3.98	2.16	1.83
Czech Republic	6.92	3.04	3.89	4.16	2.57	1.59
Romania	4.94	2.86	2.07	3.95	3.55	0.40
Hungary	8.82	2.44	6.38	2.82	2.05	0.77
Slovak Republic	7.16	3.91	3.25	4.61	3.45	1.15

Note: Exports refer to exports of manufacturing goods and GVC refers to GVC income in production of manufactures. Growth rate 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 4 GVC workers, 1995 and 2008, by sector (thousands)

	Change between 1995 and 2008					2008			
	Agriculture	Manufacturing	Services	Total		Agriculture	Manufacturing	Services	Total
Germany	-161	-666	1,388	561		400	5,481	4,766	10,647
France	-96	-423	368	-151		303	2,195	2,355	4,853
United Kingdom	-128	-1,148	-347	-1,624		115	1,946	1,931	3,992
Italy	-192	-234	517	91		333	3,553	2,559	6,444
Spain	-97	185	353	440		271	1,827	1,494	3,592
Netherlands	-42	-87	158	29		89	643	929	1,661
Belgium	-18	-86	72	-32		31	399	503	933
Sweden	-23	-49	94	22		36	481	443	959
Austria	-46	-35	120	40		104	463	393	960
Greece	-202	17	34	-151		97	374	247	717
Denmark	-25	-66	51	-41		41	271	257	569
Finland	-25	-12	51	14		39	248	211	498
Ireland	-35	-17	40	-11		59	168	168	394
Portugal	-57	-139	20	-176		191	602	343	1,136
Luxembourg	-1	1	16	17		1	23	36	61
all EU15	-1,149	-2,758	2,936	-971		2,110	18,674	16,632	37,416
Poland	-468	81	368	-19		917	2,278	1,347	4,542
Czech Republic	-59	74	35	50		93	990	553	1,636
Romania	-356	-222	-68	-646		684	1,388	517	2,588
Hungary	-145	13	63	-69		129	675	400	1,204
Slovak Republic	-35	19	85	69		22	392	249	663
Other EU12	-86	-217	98	-205		362	1,121	616	2,098
all EU12	-1,150	-251	580	-820		2,207	6,844	3,682	12,732
Total EU 27	-2,298	-3,009	3,517	-1,791		4,316	25,518	20,314	50,148

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. Last four columns indicate the total number of GVC workers by sector in 2008.

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

Table 5 Change in GVC workers, by skill level, 1995-2008.

	Change in GVC workers				Change in GVC workers relative to total economy			
	Low skilled	Medium skilled	High skilled	All	Low skilled	Medium skilled	High skilled	All
Germany	0.91	1.02	1.33	1.06	0.92	1.00	1.03	0.99
France	0.60	1.02	1.64	0.97	0.81	0.83	1.03	0.85
United Kingdom	0.44	0.77	1.18	0.71	0.65	0.63	0.71	0.63
Italy	0.70	1.41	2.36	1.01	0.87	0.98	1.12	0.88
Spain	0.77	1.83	2.12	1.14	0.74	0.79	0.93	0.75
Netherlands	0.81	0.93	1.89	1.02	0.82	0.84	1.04	0.83
Belgium	0.52	1.24	1.54	0.97	0.79	0.91	0.91	0.84
Sweden	0.60	1.06	2.02	1.02	0.92	0.98	1.15	0.93
Austria	0.76	1.04	1.98	1.04	0.87	0.91	1.24	0.91
Greece	0.52	1.30	1.73	0.83	0.67	0.88	1.01	0.71
Denmark	0.93	0.77	1.58	0.93	0.76	0.83	1.02	0.82
Finland	0.64	1.14	1.31	1.03	0.81	0.84	0.92	0.84
Ireland	0.62	0.93	2.09	0.97	0.60	0.59	0.77	0.60
Portugal	0.79	1.16	1.63	0.87	0.78	0.77	0.90	0.75
Luxembourg	0.84	1.81	2.11	1.39	0.81	0.87	0.95	0.86
all EU15	0.68	1.06	1.56	0.97	0.81	0.88	0.94	0.84
Poland	0.58	1.00	2.19	1.00	1.04	0.97	1.09	0.93
Czech Republic	0.69	1.04	1.40	1.03	1.01	1.04	0.98	1.00
Romania	0.75	1.08	1.65	0.80	0.83	0.79	1.10	0.81
Hungary	0.65	0.97	1.52	0.95	0.97	0.95	1.04	0.92
Slovak Republic	0.46	1.16	1.52	1.12	0.95	1.08	1.08	1.05
all EU12	0.74	1.00	1.67	0.94	0.88	0.95	1.04	0.90
Total EU 27	0.69	1.05	1.57	0.97	0.82	0.90	0.95	0.85

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.