Stehrer, Robert; Stöllinger, Roman

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The Central European Manufacturin Core: What is Driving Regional Production Sharing?

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„The Central European Manufacturing Core: What is Driving Regional Production Sharing?“

Robert Stehrer and Roman Stöllinger

Abstract

There is evidence that Europe's manufacturing activity is increasingly concentrated in a Central European (CE) core which the IMF in a recent publication also refers to as the German-Central European supply chain. This CE manufacturing core is dominated by Germany and in addition comprises Austria and the four Visegrád countries (the Czech Republic, Slovakia, Hungary and Poland). The case of Austria is particularly interesting because it is neither the primary technology leader within the country group, nor is it an offshoring destination and therefore takes an intermediate position. This study provides further empirical evidence for the growing concentration of European industrial production in the CE manufacturing core and explores in detail the structure and development of the regional supply chains over the period 1995-2011. This includes an analysis of the impact of international production integration on the value added share of manufacturing in the economy. The econometric results point towards differentiated effects for the members of the CE manufacturing core and the remaining EU Member States. Focusing on value added generated by the manufacturing sector, the industries which build the backbone of this regional manufacturing cluster are identified. Finally, the report investigates which factors are conducive to the intensification of international production sharing. In line with the notion of a production-investment-services nexus, it is found that (inward) FDI in the manufacturing sector is associated with higher degrees of production integration. Again, the econometric evidence suggests that some of the factors explaining international production sharing, such as the level of export sophistication, have differentiated effects for the members of the CE manufacturing core as compared to the other EU countries.

Keywords: European manufacturing, production integration, global value chains, structural change
JEL-codes: F14, F15, L16

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The Central European Manufacturing Core: What is Driving Regional Production Sharing?

Projektleitung: Roman Stöllinger
Wiener Institut für Internationale Wirtschaftsvergleiche (wiiw)
Rahlgasse 3, A-1060 Vienna, Austria
Roman.Stoellinger@wiiw.ac.at

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Abstract

There is evidence that Europe's manufacturing activity is increasingly concentrated in a Central European (CE) core which the IMF in a recent publication also refers to as the German-Central European supply chain. This CE manufacturing core is dominated by Germany and in addition comprises Austria and the four Visegrád countries (the Czech Republic, Slovakia, Hungary and Poland). The case of Austria is particularly interesting because it is neither the primary technology leader within the country group, nor is it an offshoring destination and therefore takes an intermediate position. This study provides further empirical evidence for the growing concentration of European industrial production in the CE manufacturing core and explores in detail the structure and development of the regional supply chains over the period 1995-2011. This includes an analysis of the impact of international production integration on the value added share of manufacturing in the economy. The econometric results point towards differentiated effects for the members of the CE manufacturing core and the remaining EU Member States. Focusing on value added generated by the manufacturing sector, the industries which build the backbone of this regional manufacturing cluster are identified. Finally, the report investigates which factors are conducive to the intensification of international production sharing. In line with the notion of a production-investment-services nexus, it is found that (inward) FDI in the manufacturing sector is associated with higher degrees of production integration. Again, the econometric evidence suggests that some of the factors explaining international production sharing, such as the level of export sophistication, have differentiated effects for the members of the CE manufacturing core as compared to the other EU countries.

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1 Introduction

There is evidence that Europe's manufacturing activity is increasingly concentrated in a Central European manufacturing core centred on Germany and comprising Austria, the Czech Republic, Hungary, Poland and Slovakia[1]. This new European manufacturing core partly replaces, partly supplements the traditional metropolitan axis known as the 'blue banana' (Roger, 1989) in Europe running from London to Milan (Hospers, 2003). In a recent report the IMF (2013) argues that a German-Central European supply chain has evolved which is producing and exporting manufacturing goods to the rest of the world.[2]

As in other economic areas with a concentration of economic activity, increasing returns to scale and agglomeration effects played a vital role in the creation of the Central European manufacturing core (for an overview see Simonis, 2002). This report, however, will not investigate the centrifugal forces that lead to the agglomeration of production that are emphasised by New Economic Geography models (e.g. Krugman 1991; Fujita, Krugman and Venables, 2001). Rather it will focus on international interdependencies in manufacturing production. The issues tackled in the report include a comparison of the relative specialisation in manufacturing between the members of the CE manufacturing core and other EU Member States and the concentration of manufacturing production and exports in this Central European region. Regression analysis will be used to investigate the relationship between participation in global value chains (GVC) and the relative specialisation in manufacturing. Another focus point of the study is the extent to which international production integration takes place between the members of the CE manufacturing core. We also try to identify the roles of the individual countries forming the CE manufacturing core within the group. Finally, we turn again to econometric analysis in order to identify the factors that help explain participation of EU Member States in GVCs. In this we chose a flexible specification which allows for different effects for the countries of the CE manufacturing core and other EU Member States.

To address all these issues, we exploit the information on international production inter-linkages using the World Input-Output Database (WIOD). Throughout the report, two indicators will be used intensively: the first key indicator is the share of foreign value added in a country's exports (Stehrer et al., 2012; IMF, 2013; Stöllinger et al., 2013; Stehrer and Stöllinger, 2013) which has been pioneered by Hummels, Ishii and Yi (2001). The foreign value added in trade is a measure for a country's backward integration. In order to capture also the forward dimension of production integration we use the participation in global value chains (GVC) as a second indicator (see Koopman et al., 2011). The GVC participation rate includes – in addition to the share of foreign value added in exports – also a country's value added that is embodied in foreign countries' exports. Therefore the GVC participation rate reflects both the backward and the forward integration in international production networks.

In addition to descriptive evidence concerning these indicators which is focused on the members of the CE manufacturing core, the study sheds light on factors that were supportive of the creation of the Central European supply chain (for a study on the growth impacts see Foster-McGregor et al., 2013). The factors investigated include foreign direct investment (FDI), the availability of skilled and

[1] Arguably the European manufacturing core also includes the Northern part of Italy and the Netherlands as well as Romania. For the purpose of this study we concentrate on the countries mentioned in the text.

[2] For an earlier contribution on the emergence of a leading Central and Eastern European region see, for example, Kooij and Pellenberg (1994).

unskilled labour, the general level of technology which is revealed by a country's 'export sophistication' (see Hausmann, Hwang and Rodrik, 2007; Reinstaller et al., 2012) as well as traditional gravity factors such as geographic proximity. Our econometric specification also allows for differentiated effects for the countries of the CE manufacturing core and other EU Member States of all the factors explaining the degree of international production sharing.

Throughout the analysis our primary interest is the CE manufacturing core. The role of Austria in the CE manufacturing core is particularly interesting because Austria is in an intermediate position: On the one hand it is neither the primary technology leader nor the major economy with respect to economic size within the country group – a position that is obviously occupied by Germany. On the other hand it is definitely not an offshoring destination as may be argued for the four Visegrád countries (i.e. the Czech Republic, Hungary, Poland and Slovakia).

The remainder of this report is structured as follows. Section 2 gives a snapshot of the methodology used throughout the report. Section 3 provides evidence on the emergence of the CE manufacturing core, including its contribution to EU manufacturing exports. An econometric analysis of the structural impact of international production sharing in the EU is presented in Section 4. Section 5 zooms into the CE manufacturing core and explores production inter-linkages among its members while section 6 turns to econometric methods for an investigation of the factors explaining international production sharing. Section 7 concludes.

2 Methodology and research focus

This study provides first of all evidence on the growing concentration of manufacturing activities in Central Europe, i.e. the emergence of the CE manufacturing core. Relying on a blend of descriptive and econometric methods, the study also investigates in detail the structure of the Central European supply chain. Furthermore, econometric analysis is used to examine which factors induce growing international interdependencies in European production. The econometric approach resembles a *'gravity-type'* regression based on a sample of 27 EU Member States observed over the period 1995-2011.

Throughout the analysis, we will heavily rely on input-output methodologies in order to obtain the relevant indicators, in particular the degree of vertical specialisation (following Hummels, Ishii and Yi, 2001), value added exports (Johnson and Noguera, 2012) as well as the rate of global value chain (GVC) participation as suggested by Koopman et al. (2011).

The GVC participation index combines a country's foreign value added in its exports and the part of a country's domestic value added in its exports which are used to produce another country's exports, or its 'indirect value added exports'. Formally, the foreign value added content of a country's exports is given by $\mathbf{v}^{-\mathrm{r}}\mathbf{L}\mathbf{x}^{\mathrm{r}}$ where $\mathbf{v}^{-\mathrm{r}}$ denotes an 1xNC-vector (N being the number of industries and C the number of countries in the global input-output table) of value added coefficients, i.e. value added divided by gross output, for all countries and sectors apart from the country under consideration r (for which these values are set to zero), $\mathbf{L}$ is the global Leontief inverse and $\mathbf{x}^{\mathrm{r}}$ denotes an NCx1 vector of country r's exports and zeroes otherwise. The indirect value added exports comprise the domestic value added embodied in other countries' gross exports (not returning back home), i.e. $\mathbf{v}^{\mathrm{r}}\mathbf{L}\mathbf{x}^{-\mathrm{r}}$ where $\mathbf{x}^{-\mathrm{r}}$ denotes an NCx1 vector of all other countries' gross exports though excluding

exports to country r. The global value chain participation index is then built as the sum of these two value added flows divided by country r's gross exports.

A country's foreign value added in trade is an indicator for a country's *backward production integration*, as it measures the amount of foreign value added in a country's gross exports. Often this indicator is also expressed in per cent of gross exports.

To measure *forward production integration*, one can look at the amount of value added that is exported by one country and enters the exports of the trading partners. We will also refer to this indicator as a country's value added contributions to foreign exports. It may again be expressed in per cent of gross exports of the country where the value added is generated.

These two measures can be combined, i.e. added up, to get an indicator for a country's participation in global supply chains (GVC) (see e.g. OECD, 2013; UNCTAD, 2013). As with the two individual measures for backward and forward production integration, also the degree of GVC participation can be expressed in per cent of gross exports, a measure which is referred to as GVC participation rate.

For the calculation of these indicators we will exploit the information from the WIOD as was done in Stehrer and Stöllinger (2013) with a specific focus on the members of the CE manufacturing core. The period of analysis is 1995 to 2011.

3 Evidence for the emerging Central European manufacturing core

We approach the issue of a Central European manufacturing core by looking at the importance of the manufacturing sector in the economy across EU Member States. To this end we make use of two indicators which are *(i)* the share of manufacturing in total value added and *(ii)* the manufacturing export intensities, i.e. value added exports per capita. In both cases the levels as well as the changes over time (between 1995 and 2011) are of interest.

3.1 The importance of the manufacturing sector in Europe

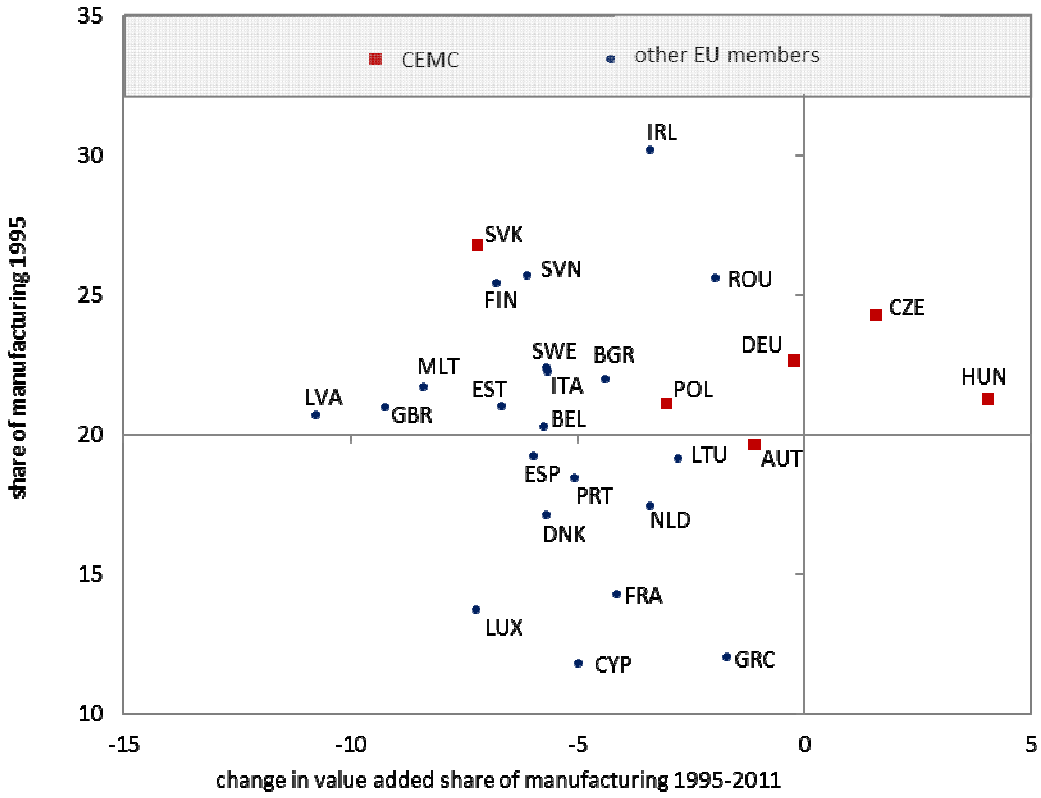
Most advanced economies show a structural shift away from the manufacturing sector and towards services. The EU is no exception to this trend. There are a number of factors contributing to the declining importance of manufacturing which also reinforce each other. These factors include the relative productivity developments across sectors, demand elasticities and international organisation of production.

Firstly, with regard to productivity developments, there is broad consensus that the manufacturing sector is the major source of technological progress (Baumol, 1967; Kaldor, 1968; UNIDO, 2002; Aiginger and Sieber, 2006; Helper et al., 2012).[3] While this does not automatically imply that total factor productivity growth is also higher in manufacturing than in the rest of the economy, empirically this turns out to be the case (see e.g. Peneder, 2014; Stöllinger et al., 2013). As a consequence, prices of manufactures have declined relative to those of services, resulting in a relative decline of value added generated in the manufacturing sector (above all in nominal terms).

[3] An important question in this context is whether it is necessary to have actual manufacturing production taking place in a country in order to achieve technological progress or whether it is sufficient to control strategic business functions along the value chains such as R&D.

Secondly, current demand structures play against the expansion of the manufacturing sector. Low price elasticities of demand, coupled with high income elasticities for several services (e.g. education, tourism, health, cultural activities), will tilt the structure of production towards services industries as per capita incomes rise to the detriment of manufactures (Baumol, 1967). The third point is related to the organisation of production and the ever more granular specialisation. As firms specialise on their core competencies, manufacturing firms outsource a large number of tasks or whole business function to specialised service providers. This again shifts value added out of the manufacturing sector to the services sector. This is also related to what Baldwin (2011) called the 'second unbundling' ignited by the information-technology-communication (ICT) revolution in the 1990s.

Figure 3.1: Share of manufacturing in valued added 1995 (in %) and changes in shares 1995-2011 (in p.p.)



Note: CEMC = Central European manufacturing core.

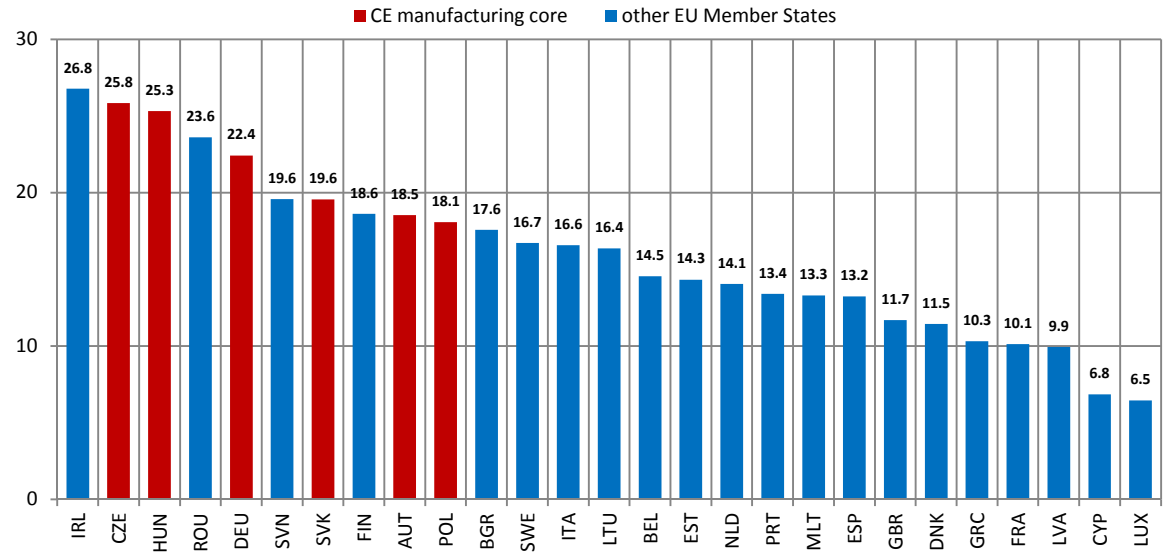
Source: WIOD, wiiw calculations.

Improved communication possibilities made it possible to locate production in different parts of the world according to comparative advantages giving rise to '21st century trade', which is characterised by complex interconnectedness between production, investment and services ('production-investment-services nexus'). For advanced economies this means that parts of the value added chain necessary for the production process are shifted – or 'offshored' – to foreign (low-cost) countries. Naturally, offshoring of parts of the value added chain or of 'tasks' reduces the value added generated in the offshoring economy. The combined effect of these factors related to relative productivity developments, demand structures and the international organisation of production on the structural developments in EU Member States is visualised in Figure 3.1. In the figure the change in the manufacturing share is shown on the horizontal axis whereas the share of manufacturing in 1995 is shown on the vertical axis.

Between 1995 and 2011 the share of manufacturing in nominal value added declined in all but two (Hungary and the Czech Republic) Member States. However, the extent of this structural shift was very different across Member States. It was very pronounced in countries such as Latvia, the UK or Spain but less so in Germany or Austria. Certainly, when considering these structural changes, the initial importance of manufacturing in Member States' economies needs to be taken into account (this is shown on the vertical axis in Figure 3.1). In 1995, the share of manufacturing in domestic value added was highest in Ireland – a fact that can be attributed to Ireland's successful strategy to attract foreign multinational companies (MNCs) including manufacturing MNCs –, Slovakia and Slovenia. In the latter two, the share of manufacturing declined considerably between 1995 and 2011 but both remain among the countries with the largest manufacturing sectors in relative terms.

The countries which for the purpose of this report are defined as members of the CE manufacturing core are highlighted in Figure 3.1. As can be easily seen, they all experienced only rather modest declines (or even increases) in the share of manufacturing – with the exception of Slovakia – and they are also among the countries where the manufacturing sector remained relatively important with a share in value added close to 20%. The situation in 2011 is summarised in Figure 3.2 with the members of the CE manufacturing core shown in red.

Figure 3.2: Share of manufacturing in valued added across Member States (in %), 2011

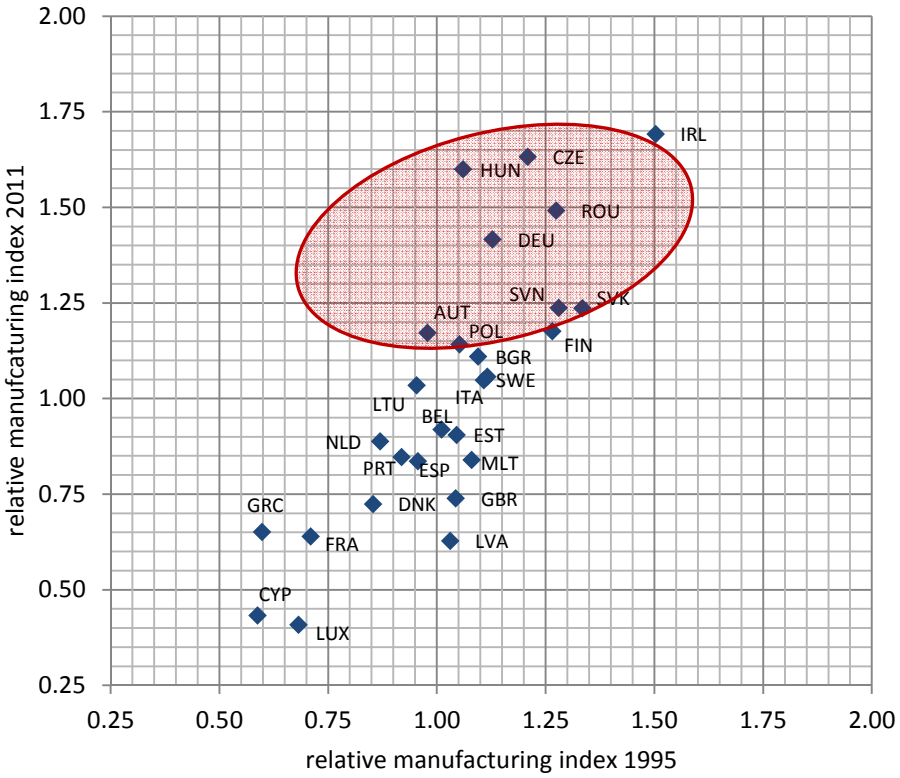


Source: WIOD, wiiw calculations.

A useful way to summarise both the relative importance of the manufacturing sector in the economy and its development over time is the relative manufacturing specialisation index. This manufacturing specialisation index is simply a Member State's share in EU manufacturing value added relative to its share in overall EU GDP. Figure 3.3 plots this manufacturing specialisation index both for the year 1995 (horizontal axis) and the year 2011 (vertical axis). In this figure countries that were already relatively specialised in the production of manufactures back in 1995 are found on the right-hand side of the graph. As can be seen, this includes the CE manufacturing core countries. Countries that intensified their specialisation in manufacturing production are found above the 45 degree line. This includes again all CE manufacturing core countries except for Slovakia which registered a slight

decline in this index. Figure 3.3 also suggests that Romania and Slovenia have a similar relative specialisation in manufacturing as the countries of the CE manufacturing core.

Figure 3.3: Manufacturing specialisation index of EU Member States, 1995 vs. 2011



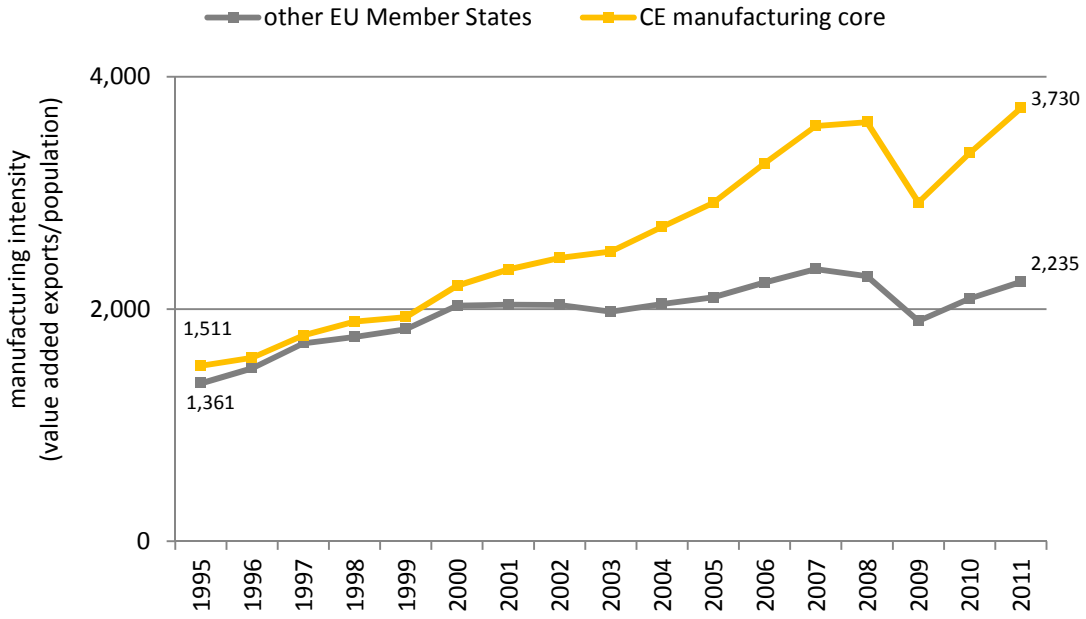
Source: WIOD, wiiw calculations.

Another indicator for the importance of the manufacturing sector in the economy is the manufacturing export intensity. The manufacturing export intensity, i.e. exports per capita, reflects both the relative importance of the manufacturing sector and its export orientation and hence its international competitiveness. It also reflects the general level of productivity, so that high-income countries tend to score higher in a comparison of manufacturing export intensities.

The export measure used to calculate the manufacturing export intensities are value added exports, i.e. value added generated in a country which is finally absorbed abroad. Figure 3.4 tracks the development of the manufacturing export intensity of EU Member States over time at the group level, i.e. it differentiates between the members of the CE manufacturing core and other EU Member States. This comparison shows that in contrast to the manufacturing shares discussed above, the manufacturing export intensities of the two groups of countries were not very different back in 1995. The manufacturing export intensity of the CE manufacturing core countries exceeded that of the other EU Member States by just 10% and the margin declined to a mere 5% at the end of the decade. From the early 2000s onwards, however, the two groups have embarked on divergent trends with the manufacturing core countries significantly increasing the export intensity per capita, climbing to some EUR 3,700, whereas that of the other Member States was basically stagnating, hovering around

EUR 2,000 for several years and reaching some EUR 2,200 in 2011. This implies a huge differential in export intensities between the two groups which has in fact swollen to 40% in 2011.

Figure 3.4: Manufacturing export intensity in the CE manufacturing core and other EU Member States, 1995-2011



Note: Manufacturing export intensity is calculated as value added exports over population.

Source: WIOD, wiiw calculations.

3.2 The role of the CE manufacturing core in the EU

The discussion of the structural developments and the differences in manufacturing specialisation and export intensities leads to the expectation that export market shares have developed differently across Member States. Sticking to value added exports as the preferred measure of manufacturing export performance, this section tracks the development of Member States' shares in total EU manufacturing exports with a focus on 'advanced' manufacturing industries. Advanced manufacturing industries for the purpose of this report include the chemicals industry (NACE 24), the machinery industry (NACE 29), the electric equipment industry (NACE 30t33) and the transport equipment industry (NACE 34t35). Table 3.1 shows the share in total EU manufacturing exports of various groups of Member States. For the countries forming the CE manufacturing core these export shares are also shown individually. A first observation is that, amounting to more than a third, the CE manufacturing core's share in manufacturing value added exports was already high in 1995. Until 2011 this share grew to 42.6%, an impressive increase of 8 percentage points. Note that this positive development of export market shares in manufacturing industries is found in each single member of the CE manufacturing core. Given their economic size, Germany and Poland contributed most strongly to this development with gains in market shares amounting to 2.4 and 1.9 percentage points respectively.

Table 3.1 Shares in EU manufacturing value added exports by groups of Member States, 1995-2011

	1995	2000	2005	2008	2011	change 1995-2011 (in p.p.)	change 2008-2011 (in p.p.)
CE manufacturing core	34.5%	33.8%	38.9%	41.6%	42.6%	8.1	1.0
Germany	*29.0%*	*27.1%*	*29.8%*	*30.8%*	*31.4%*	2.4	0.6
Austria	*2.6%*	*2.8%*	*3.1%*	*3.2%*	*3.1%*	0.5	-0.1
Czech Republic	*0.8%*	*1.1%*	*1.8%*	*2.3%*	*2.4%*	1.6	0.1
Hungary	*0.4%*	*0.8%*	*1.2%*	*1.4%*	*1.5%*	1.1	0.1
Poland	*1.3%*	*1.6%*	*2.3%*	*3.1%*	*3.2%*	1.9	0.1
Slovakia	*0.4%*	*0.4%*	*0.7%*	*1.0%*	*0.9%*	0.5	-0.1
Benelux	11.8%	9.8%	9.5%	9.4%	9.7%	-2.1	0.3
Nordic countries	8.7%	8.5%	7.8%	7.4%	6.9%	-1.8	-0.5
France	12.0%	12.8%	11.3%	10.4%	9.5%	-2.5	-0.9
Italy	11.8%	11.3%	10.7%	10.8%	10.5%	-1.3	-0.3
United Kingdom	12.6%	13.1%	10.3%	8.9%	9.1%	-3.5	0.2
Southern EU	5.8%	6.6%	6.9%	6.9%	6.9%	1.1	0.0
Other EU-MS	2.7%	4.1%	4.5%	4.6%	4.7%	2.0	0.1

Note: Nordic countries = Denmark, Sweden, Finland; Southern EU = Spain, Portugal, Greece, Malta, Cyprus; Other EU-MS = Bulgaria, Romania, Latvia, Estonia, Lithuania and Ireland. Manufacturing industries based on NACE Rev. 1 industry classification.

Source: WIOD, wiiw calculations.

Table 3.2 Shares in EU advanced manufacturing value added exports by groups of Member States, 1995-2011

	1995	2000	2005	2008	2011	change 1995-2011 (in p.p.)	change 2008-2011 (in p.p.)
CE manufacturing core	39.2%	37.1%	43.1%	46.3%	47.2%	8.0	0.9
Germany	34.9%	31.4%	34.8%	36.2%	36.9%	2.0	0.7
Austria	2.3%	2.5%	2.9%	3.0%	3.0%	0.7	0.0
Czech Republic	0.5%	0.9%	1.6%	2.1%	2.4%	1.9	0.3
Hungary	0.4%	0.9%	1.6%	1.7%	2.0%	1.6	0.3
Poland	0.8%	1.0%	1.7%	2.4%	2.1%	1.3	-0.3
Slovakia	0.2%	0.3%	0.5%	0.9%	0.8%	0.6	-0.1
Benelux	10.3%	8.4%	7.9%	7.6%	8.1%	-2.2	0.5
Nordic countries	8.0%	8.1%	7.9%	7.6%	7.1%	-0.9	-0.5
France	12.1%	12.9%	11.4%	10.3%	9.3%	-2.8	-1.0
Italy	9.0%	9.0%	8.7%	8.9%	8.8%	-0.2	-0.1
United Kingdom	13.9%	14.6%	11.0%	9.4%	9.5%	-4.4	0.1
Southern EU	4.9%	5.3%	5.7%	5.5%	5.4%	0.5	-0.1
Other EU-MS	2.6%	4.5%	4.4%	4.4%	4.7%	2.1	0.3

Note: Nordic countries = Denmark, Sweden, Finland; Southern EU = Spain, Portugal, Greece, Malta, Cyprus; Other EU-MS = Bulgaria, Romania, Latvia, Estonia, Lithuania and Ireland. Advanced manufacturing includes NACE industries 24 (chemicals), 29 (machinery), 30t33 (electrical equipment), 34t45 (transport equipment). Manufacturing industries based on NACE Rev. 1 industry classification.

Source: WIOD, wiiw calculations.

The flip side of this agglomeration of manufacturing activities in the CE manufacturing core is a significant decline in the share of EU manufacturing value added exports in other EU Member States, in particular in high-income countries including the Nordic and the Benelux countries and above all France and the United Kingdom.

In addition to the longer-term shifts in market shares in manufacturing exports, it may as well be interesting to look at the changes that have occurred since the Great Recession of 2008. Given that the time span since this crisis is much shorter, the changes in market shares are much less pronounced. Nevertheless, it is interesting to note that the positive trend in the CE manufacturing core seems to have continued after the crisis despite the severe drops in exports in the year 2008 in these countries. Between 2008 and 2011 the CE manufacturing core gained 1 percentage point in manufacturing value added export share, again with Germany as the driving force behind this development. Austria and Slovakia deviate slightly from this trend with mild declines in their market shares of 0.1 percentage points respectively. In general it seems that the crisis has neither led to an acceleration nor a reversal of the shifts in export performances across Member States. Two particular cases may be worth mentioning nevertheless as they deviate from this general pattern. The United Kingdom, which registered the largest loss of market shares in manufacturing value added exports, seems to have managed to stop the negative trend. This may be related to policy initiatives in the United Kingdom to rebuild a manufacturing base (e.g. Stiglitz et al., 2013; Crafts, 2012). These policy initiatives were also accompanied by slogans such as 'bring manufacturing back', which is similar to the 'bring manufacturing home' advocated in the reshoring campaign in the United States[4]. In contrast, France – which appears to be plagued by a loss of competitiveness of its manufacturing sector – lost another 0.9 percentage points in market shares between 2008 and 2011. There are many potential reasons for this unfavourable development in France including rigid labour markets (World Economic Forum, 2011) and a deteriorating cost competitiveness (Ferrero et al., 2014).

When narrowing the object of the analysis to advanced manufacturing industries the same patterns can be identified (Table 3.2). The CE manufacturing core managed to further reinforce its dominant position in advanced manufacturing, increasing its market share by 8 percentage points to reach almost half of total EU value added exports of advanced manufacturing industries in 2011. The fact that the German share in advanced manufacturing exports is significantly higher than its share in overall manufacturing exports signals Germany's pivotal position in the CE manufacturing core. Austria's share in advanced manufacturing value added exports amounted to 3% in 2011, which is basically identical to that in overall manufacturing with the long-term trend.

These shifts in competitiveness of both the overall manufacturing sector as well as advanced manufacturing industries in favour of the CE manufacturing core are closely related to the structural changes investigated in section 3.1. The next section will return to the issue of structural changes and investigate the role of the international supply chains in these developments.

[4] See: http://www.reshorenow.org/

4 The structural impact of global value chain participation

So far quite some evidence in favour of the emergence of a manufacturing core has been put forward. In this section the focus is set particularly on EU Member States' integration in global supply chains and its impact on economic structure. To this end a country's foreign value added in trade (FVAiT) in percent of gross exports and global value chain (GVC) participation rate are used as indicators for integration in international supply chains.

With respect to the structural effect, the development of the share of manufacturing in the economy is the variable of interest and it will serve as the dependent variable in the following regression. While a highly imperfect indicator for the competitiveness of a country's manufacturing performance, it still shows whether resources are – relatively speaking – attracted to or drawn from the manufacturing sector in an economy.

The working hypothesis here is that 'production sharing', i.e. integration in international supply chains, may affect different countries differently. In particular we hypothesise that the development of the manufacturing sector was different for the countries forming the CE manufacturing core ($CEMC$) and that this differential development was partly due to production sharing. This hypothesis is tested empirically with a regression model that tries to explain structural change – the change of the manufacturing share – with an indicator for production sharing and additional control variables. In order to allow for a different experience of the CE manufacturing core as compared to other EU Member States following production integration, a dummy variable that takes the value one for the CE manufacturing core countries and 0 for the other EU countries is added – directly and with an interaction term. The resulting model takes the following form:

$$(1) \qquad \Delta sh_{c,t}^{manuf} = \alpha + \beta_1 \cdot initial\ sh_{c,t}^{manuf} + \beta_2 \cdot GVC\ participiation_{c,t} + \beta_3 \cdot CEMC_c + \gamma \cdot \left(foreign\ VAiT_{c,t} \times CEMC_c\right) + \mathrm{X} \cdot \varphi + \delta_t + \varepsilon_{c,t}.$$

where $\Delta sh_{c,t}^{manuf}$ is the change in the share of manufacturing in GDP of country *c* in period *t*. For this purpose we subdivide the time span running from 1995 to 2011 into 4-year periods.[5] Therefore $\Delta sh_{c,t}^{manuf}$ represents differences of periods where these differences are based on period averages.

The variable $initial\ sh_{c,t}^{manuf}$ represents each country's share of manufacturing and GDP per capita at the beginning of each period and is used to control for potential level effects as countries with initially higher manufacturing shares may also be more prone to 'de-industrialise'. Moreover, the convergence hypothesis, which Rodrik (2013) has recently shown to hold unconditional for manufacturing industries at the global level, would suggest that the initial share of manufacturing is negatively correlated with the change in the manufacturing share. Put differently, countries with initially low shares of manufacturing in GDP should see the relative size of the sector increase by more (or decrease by less) than countries which initially had higher shares – if this type of convergence hypothesis holds true.

Of main interest are certainly the coefficients of the (GVC) participation rate as suggested by Koopman et al. (2011), $GVC\ participiation_{c,t}$, and the $CORE_c$ variable. The GVC participation takes

[5] We divide the 17 years of observations into 5 sub-periods (treating 1995 as a period in itself) in order to maintain a sufficient number of observations, on the one hand, but also have at least medium-term changes in industry structure (i.e. 4-year periods) as the dependent variable, on the other hand. Differences are based on averages of the 4-year periods.

into account both the foreign value added in a country's exports (*the foreign VAiT*) and a country's value added incorporated in the exports of all other countries. Since this indicator combines both the backward integration (i.e. the *foreign VAiT)* and the forward integration (i.e. domestic value added in foreign exports) it is considered to be a more comprehensive indicator for the integration in international supply chains and has become popular in policy reports (e.g. OECD, 2013; UNCTAD, 2013). In a variant to equation (1) the foreign value added in trade, $foreign\,VAiT_{c,t}$ is used as a proxy for international production.

If the proxies for international production integration turn out to have a negative coefficient, this would suggest that vertical specialisation and the integration in international supply chains have a negative effect on the share of manufacturing in the economy. For the high-income countries ('offshoring countries') this may be due to the loss of manufacturing value added because a part of the manufacturing activities that previously have been undertaken domestically are moved to another country in the process of increasing international production sharing. For the relatively low-income countries among the EU Member States, a negative effect from vertical specialisation may arise due to unfavourable specialisation in low value added parts of the value chain. Conversely, both groups of countries may benefit from such deep economic integration due to efficiency gains and in the case of the lower-income Member States due to the attraction of additional value added activities in the manufacturing sector.

Belonging to the CE manufacturing core, $CEMC_c$, is expected to yield a positive coefficient indicating that on average the structural change that was to the detriment of manufacturing was less pronounced in the *CE manufacturing core* economies. As a reminder, by including an interaction term between $GVC\ participiation_{c,t}$ (respectively the $foreign\,VAiT_{c,t}$) and $CEMC_c$, equation (1) also opens up the possibility that the effect of the former on structural change is different for the CE manufacturing countries and the other EU Member States.

Equation (1) also includes a set of time fixed effects, δ_t, as well as additional control variables. These additional control variables are the log of the initial level of real GDP per capita, $initial\ GDPcap_{c,t}$, the change in the average labour compensation, i.e. the wage costs (in log form), and the change of the real effective exchange rate (in log form). The real GDP per capita is also included in quadratic form. We expect the coefficient of $initial\ GDPcap_{c,t}$ to have a negative sign as suggested by the de-industrialisation/tertiarisation hypothesis (see e.g. Montresor and Marzetti, 2011). The quadratic $initial\ GDPcap_{c,t}$term would capture a situation where the impact of real GDP per capita on structural change was different for countries with different income levels. Finally, the effect of a rising exchange rate is expected to hurt the manufacturing sector because it is the main tradables sector and therefore a negative coefficient is expected.

The estimation results of equation (1) are summarised in Table 4.1. Since the results in the different specifications are rather similar, the discussion will mainly focus on the OLS specification[6] using the $GVC\ participiation$ as the main explanatory variable.

[6] Table 4.1 report random effects (RE) results. The RE estimation are almost identical to the pooled OLS regression. The conventional Hausman test to decide between a random and a fixed effects model fails because the error structure seems to be that of a pooled OLS model. This is evidence for the appropriateness of the pooled OLS approach.

Table 4.1: The effect of integration in international supply chains on structural change, 1995-2011

Dependent variable: Δ manufacturing share				
	foreign VAiT		GVC participation	
	OLS	RE	OLS	RE
initial manuf share	-0.0282	-0.0304	-0.0221	-0.0239
	(0.049)	(0.030)	(0.046)	(0.028)
initial GDPcap	-0.0802*	-0.0809**	-0.0882*	-0.0884**
	(0.046)	(0.037)	(0.051)	(0.037)
initial GDPcap - sq	0.0040	0.0040**	0.0044	0.0044**
	(0.002)	(0.002)	(0.003)	(0.002)
foreign VAiT	-0.0312**	-0.0323**		
	(0.015)	(0.016)		
foreign VAiT x CEMC	0.0594**	0.0609*		
	(0.027)	(0.031)		
CEMC	0.0082**	0.0083**	0.0074**	0.0075**
	(0.004)	(0.004)	(0.004)	(0.004)
GVC participation			-0.0353**	-0.0358***
			(0.017)	(0.013)
GVC participation x CEMC			0.0608**	0.0617**
			(0.028)	(0.030)
Δlabour costs	0.0307	0.0308	0.0312	0.0312
	(0.019)	(0.021)	(0.019)	(0.020)
Δreal FX	-0.0729**	-0.0733**	-0.0736**	-0.0740**
	(0.029)	(0.036)	(0.028)	(0.035)
F-test	5.54		6.28	
R^2	0.286	0.286	0.292	0.288
R^2-adj	0.200		0.201	
R^2-within		0.275		0.271
R^2-between		0.384		0.392
obs.	103	103	103	103

Note: OLS=Ordinary Least Square, RE=Random Effects. All regressions include a constant and time fixed effects. Δ manufacturing share are 4-year differences. Specifications including interaction terms are estimated using centred values (with zero mean) of the variables forming the interaction terms. ***,** and * indicate statistical significance at the 1%, 5% and 10% level respectively. Standard errors in parentheses. All regressions estimated with STATA.

A first interesting point is that, on average, vertical integration, i.e. a high $GVC\ participiation$, is associated with a higher decline in the share of manufacturing in the economy as indicated by the negative coefficient of -0.0353 in the OLS specification. Next, the positive coefficient of the CEMC dummy (0.0074) in the regression suggests that the decline of the manufacturing sector was milder in the CE manufacturing core countries than in the other EU Member States. Most importantly, the interaction between the $GVC\ participiation$ and the $CEMC$ is positive. In particular, with a magnitude of 0.0608 it is larger than the coefficient of the main effect of $GVC\ participiation$. This implies that the effect of vertical integration for the members of the CE manufacturing core is in fact positive.[7]

[7] The effect of $GVC\ participiation$ on the change in the value added share of manufacturing of the CE manufacturing core countries is obtained by adding the coefficients of the $GVC\ participiation$ and of the interaction term yielding a value of 0.0256 in the OLS specification.

All the coefficients mentioned are statistically significant (at least) at the 5% level. But there remains the question whether the estimated effects are economically relevant. To assess the economic relevance it is useful to first note that the average rate of structural change is -1.1 percentage points, i.e. the share of manufacturing declined on average by 1.1 percentage points.[8] Now, the coefficient of the CEMC dummy means that for CE manufacturing countries the rate of structural change is 0.7 percentage points higher than in the other EU Member States – a noticeable difference given the average rate of structural change. With regard to the effect of international production integration, the result suggests that a 10 percentage point higher $GVC\ participiation$ accelerates the negative rate of structural change of the average EU Member States *not* belonging to the CE manufacturing core by 0.35 percentage points. However, for the CEMC country a 10 percentage point higher $GVC\ participiation$ has a different effect: it slows down the negative rate of structural change by 0.26 percentage points ([-0.0353 + 0.0608] x 10). This result supports the view that the structural impact of global supply chain integration is country-specific. Some countries see their manufacturing sector strengthened by this development, for others it accelerates the 'de-industrialisation' process. Within the EU, there seems to be a different effect of supply chain integration observable for the members of the CE manufacturing core and the other EU countries. Therefore the integration into supply chains must be expected to have contributed to the concentration of manufacturing activities that were reported in the previous sections.

Table 4.1 equally reports the estimation results using the $foreign\ VAiT$ instead of the GVC participation rate as the main explanatory variable. The discussion of these additional results can be kept short because – as indicated above – the results are qualitatively the same as in the specification using the $GVC\ participiation$ indicator. Quantitatively, the results are also very similar, with the coefficients of the $foreign\ VAiT$ model being somewhat smaller. The resulting effect of the $foreign\ VAiT$ for the members of the CE manufacturing core on the rate of structural change, however, would be slightly larger amounting to 0.028 percentage points (or 0.28 percentage points for a 10 percentage point change of the $foreign\ VAiT$).

With regard to the control variables, the regression results suggest that changes in the real effective exchange rate are negatively correlated with changes in the manufacturing sector, which is as expected. Changes in the labour costs do not turn out to be statistically significant. This means that higher manufacturing wages do not systematically imply a shrinking manufacturing sector. The initial share of the manufacturing sector is not statistically significant either, suggesting that the sector's role as an escalator for convergence may be lower in the EU than in developing countries. Finally, the negative coefficient of the initial GDP, which is statistically significant at least at the 10% level, signals that manufacturing tends to decline in relative terms as income rises. Potentially, this effect declines with the level of income as indicated by the positive coefficient of the squared term of initial GDP per capita though these are statistically significant only in the random effects specifications.

This regression result puts a question mark on one of the key priorities to support the competitiveness of European industry defined in the latest Industrial Policy Communication of the European Commission (2014). This Communication stresses the integration of EU firms in global value chains as one of the strategies to improve manufacturing competitiveness. Our regression results show that this objective is to be questioned because apparently integration in global value chains does not have the same effect on all EU Member States. It may still be true that a highly

[8] Remember that these rates of structural change refer to 4-year periods.

productive CE manufacturing core is supporting EU competitiveness vis-à-vis third countries but it does not necessarily support the development of the manufacturing sector in each single Member State. This issue certainly required further analysis.

5 Production sharing within the Central European manufacturing core

As a next step, international production sharing within the CE manufacturing core will be analysed in detail. A starting point for this investigation will be standard trade flows, i.e. gross exports and imports of Member States' manufacturing industries, to reveal the directions of trade. In a next step, the gross flows are disaggregated into domestic and foreign value added where the role of the CE manufacturing sector within the latter will be highlighted. When tracing the origin of value added in export flows there are several possibilities how to define the 'manufacturing sector' depending on whether the trade flows or the origin of the value added are considered. The approach in this paper will be to focus on the domestic and foreign value added generated in manufacturing industries and embedded in exports – irrespective of whether the exporting industry is a manufacturing industry or a services industry.

The information on foreign value added content measures a country's degree of vertical specialisation but it basically stresses the 'backward integration'. To complete the picture, we also single out each country's value added contribution to its trading partners' exports, which is a measure for its 'forward integration', again with a focus on the CE manufacturing core. The forward and backward integration as revealed by the country's exports will further be disaggregated into value added content of the other members in the CE manufacturing core, other EU Member States and the 'Rest of the World'.

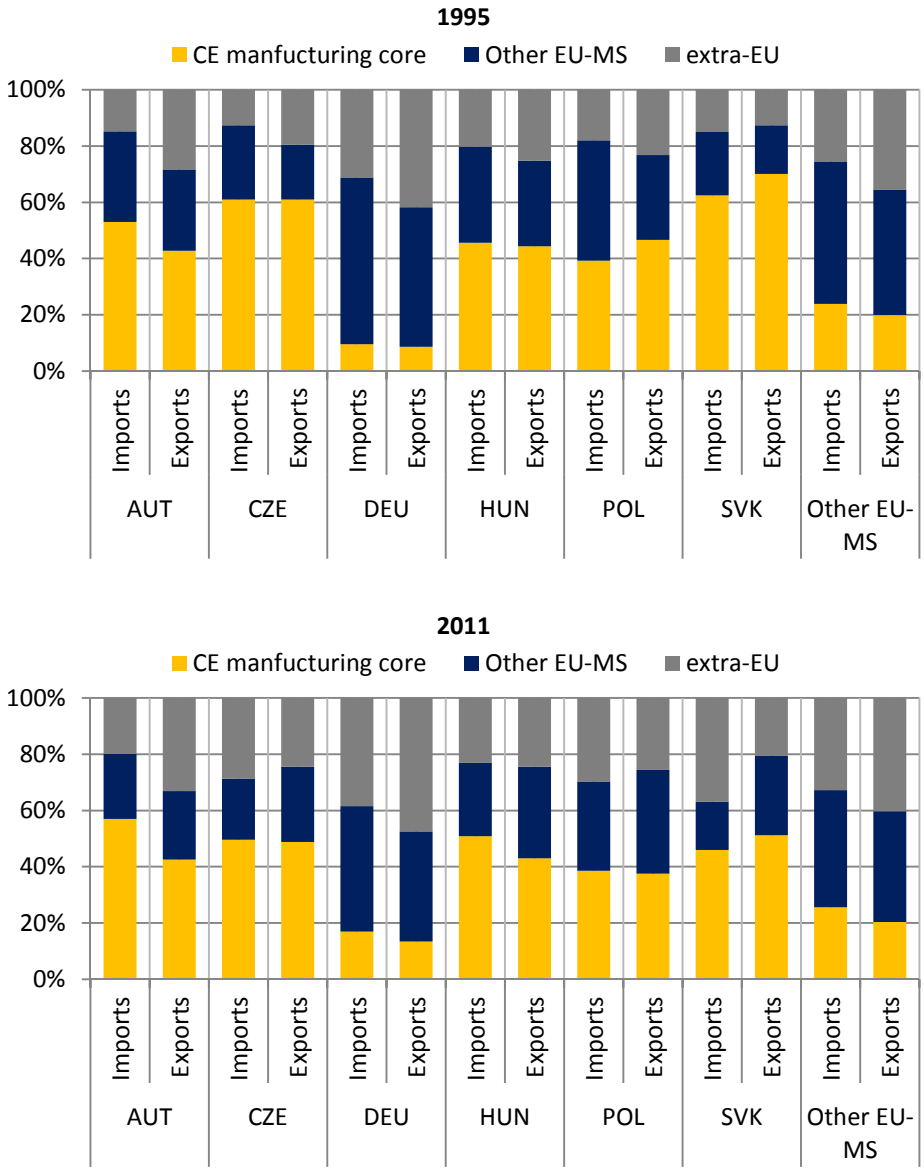
Moreover, the exports of the countries of the CE manufacturing core will be disaggregated by industry with a view to comparing the role of vertical specialisation across industries as well as each industry's importance for economy-wide production sharing. Taken together, this analysis will show which industries are driving the production sharing and therefore build the backbone of the CE supply chain. It will indicate how important the CE supply chain is for each of the participating countries.

5.1 Production sharing within the CE manufacturing core

5.1.1 Central European manufacturing core – directions of trade

When considering the CE manufacturing core one should be aware of the dominant role of the German economy, which alone accounts for 70% of the group's gross exports. Poland and Austria account for approximately 8% each, followed closely by the Czech Republic with a share of about 7% of total CE manufacturing exports. This particular position of Germany should be kept in mind when looking at the geographical trade patterns of the CE manufacturing core countries and other EU Member States, which are depicted in Figure 5.1.

Figure 5.1: Manufacturing gross exports and imports of the CE manufacturing core and other EU Member States by destination, 1995 and 2011



Source: WIOD, wiiw calculations.

As one would expect, general trade links among the members of the CE manufacturing core are much stronger than between other EU Member States and the CE manufacturing core. Considering 2011 and neglecting Germany for the moment, one finds that the share of other CE manufacturing core countries in the manufacturing exports of the CEMC members ranged from 38% in Poland to 51% in Slovakia in 2011. This is far higher than the share of the CE manufacturing core in other EU countries' manufacturing exports, which amounted to 20%. A similar picture emerges on the import side, where the CE manufacturing core countries' accounted for between 57% (Austria) and 39% (Poland) of the import demand of the group. For the other EU Member States, this share is just above a quarter.

For Germany, the trade orientation towards the CE manufacturing core appears to be much lower than for the other members of the group. Nevertheless, the share of German manufacturing trade with the CE manufacturing core grew considerably between 1995 and 2011, from below 10% to 17%

on the import side and from about 9% to more than 13% on the export side. This is evidence for a considerable re-orientation of German trade flows towards the CE manufacturing core. Interestingly, this concentration of trade with other members of the CE manufacturing core is not found for the Czech Republic, Slovakia and Poland which seemed to have diversified their exports and imports to other countries, though in the case of the two former countries starting from a very high geographic export concentration on the CE manufacturing core which reached 70% in the case of Slovak exports.[9]

In the case of Austria, on the import side, the CE manufacturing core has gained in importance whereas the share of manufacturing exports to this group of countries remained constant at about 43%.

The importance of intra-group trade of the CE manufacturing core countries is not surprising given the geographic proximity of these countries and the prominence of distance in the determination of trade flows. A general picture of the bilateral trade structure is however useful as an introduction to the decomposition of the gross trade flows into value added components of different countries.

5.1.2 Foreign value added in trade, value added contributions to foreign exports and global value chain participation

Let the analysis of trade linkages now shift from a gross perspective to a value added perspective. This means that the gross export flows of each country are decomposed into domestic and foreign value added contributions. The share of foreign value added in a country's exports serves as a measure for its backward production integration. Likewise, as pointed out in the methodology section, it is possible to sum up a country's value added contributions to the exports of all its trading partners to get a measure for a country's forward production integration. The measures for backward and forward production integration together yield the global value chain (GVC) participation.

Calculating these indicators for the total economy is rather straightforward. Since the focus of this report is on the manufacturing sector, the analysis will be trimmed down to manufacturing. But there are several possibilities how to confine the analysis to 'manufacturing'. There are basically three options:

A.1 Consider only exports of manufacturing industries and include value added contributions of all industries

A.2 Consider exports of all industries but include value added contributions of manufacturing industries only

A.3 Consider only exports of manufacturing industries and include value added contributions of manufacturing industries only.

Each of these indicators has its merits and can be used to tackle different questions. For example, variant A.1 might be interesting if the focus is on the interconnectedness between services and

[9] Within the CE manufacturing core Slovakia's main trading partners are Germany which absorbed 22.2% of Slovak exports and the Czech Republic with 11.2%. In the latter case, the common history of the two countries may be part of the explanation for the tight trade relations (in addition to geographic proximity).

manufactures (see below). Since we are mainly interested in the production sharing within the manufacturing sector we will later concentrate on A.2 because this approach focuses on the actual value added generated by manufacturing industries – irrespective of which industries are responsible for the export of this value added. With a view to the competitiveness of the manufacturing sector, we believe it is appropriate to use the value added generated as the defining element for 'manufacturing' instead of defining the scope of the analysis by the valued added which is exported by manufacturing industries – irrespective of the origin of the value added.

Finally, one could only consider manufacturing value added that is exported by manufacturing industries (A.3). For our purposes there is no convincing reason why manufacturing value added exported via services industries should be excluded from the analysis though the differences between the approaches A2 and A3 are only marginal.

Table 5.1 shows the degree of backward and forward integration of production for these three options (A.1-A.3) together with those for the entire economy (A.0).

Starting with the standard approach of considering the entire economy one finds the usual results. For example, in the case of Austria the foreign value added in trade (FVAiT) accounts for 34.2% of Austrian total gross exports, which amount to USD 212,267 million. These are the figures reported in the FIW research report on Austria's value added trade (Stehrer and Stöllinger, 2013). Comparing these results with those in A.1, which considers only exports of manufacturing industries, the general pattern is that the foreign value added shares are significantly higher both in the case of backward and forward production integration. The reason is that manufacturing exports embody more foreign value added.

Another possibility is to compare the situation of the total economy (A.0) with one where all exporting industries are considered but only the value added contributions of manufacturing industries (both domestic and foreign) are taken into account (A.2). This way of defining manufacturing yields very similar shares of foreign value added in exports in both backward and forward production integration. The reason for this is that manufacturing industries in A.0 also contain (directly and indirectly) a high share of services value added which is also partly sourced from abroad. This confirms the assertion in Stöllinger et al. (2013) that manufacturing provides a carrier function for other parts of the economy, in particular services value added, which by themselves are not necessarily tradable but which may well be exported indirectly (via manufactured products).

It is equally possible to confine the analysis to manufacturing both along the dimension of exports and value added contributions (A.3). Interestingly, the EU Member States appear to have slightly lower shares of foreign value added contributions from manufacturing industries in manufacturing exports than in the standard case, i.e. when the entire economy is taken into account. Note also that the difference in the magnitude of gross exports between A.2 and A.3 is very small, which implies that services industries export very little value added generated by manufacturing industries.

For the purpose of this report we consider the variant which takes into account the value added of manufacturing industries irrespective of the exporting industry (i.e. A.2) as the most relevant because it captures best the capabilities and internationalisation of manufacturing for the reason explained above.

Table 5.1 Backward and forward production integration in the CE manufacturing core and other Member States in the total economy, manufacturing industries and manufacturing value added contributions, 2011

	A.0				A.1				A.2				A.3			
exports:	**Total exports**				**Manufacturing exports**				**Total exports**				**Manufacturing exports**			
value added:	**VA supplied by all industries**				**VA supplied by all industries**				**VA supplied by manufacturing industries**				**VA supplied by manufacturing industries**			
	gross exports	**FVAiT**	**VAcFE**	**GVC**	**gross exports**	**FVAiT**	**VAcFE**	**GVC**	**gross exports**	**FVAiT**	**VAcFE**	**GVC**	**gross exports**	**FVAiT**	**VAcFE**	**GVC**
	in USD bn	**in % of gross exports**			**in USD bn**	**in % of gross exports**			**in USD bn**	**in % of gross exports**			**in USD bn**	**in % of gross exports**		
AUT	212,267	34.2%	24.1%	58.4%	148,751	40.8%	29.3%	70.1%	90,259	33.8%	27.3%	61.1%	85,744	31.9%	26.4%	58.3%
CZE	164,829	46.5%	21.2%	67.7%	135,387	51.9%	22.4%	74.3%	84,139	45.1%	22.1%	67.2%	81,199	44.3%	20.9%	65.2%
DEU	1,602,979	27.3%	23.1%	50.4%	1,367,700	29.8%	23.2%	53.0%	814,851	23.7%	24.9%	48.6%	800,783	23.1%	22.6%	45.7%
HUN	114,320	46.0%	19.2%	65.2%	83,271	53.5%	22.5%	76.0%	52,144	44.6%	21.4%	66.0%	48,922	43.0%	20.8%	63.8%
POL	226,831	34.3%	23.8%	58.2%	175,604	38.6%	26.5%	65.0%	94,691	35.0%	24.0%	59.0%	89,293	33.3%	23.0%	56.3%
SVK	62,822	42.0%	25.2%	67.3%	51,398	47.2%	26.8%	73.9%	29,831	42.6%	25.8%	68.3%	28,885	41.5%	24.3%	65.7%
CEMC	**2,384,048**	**31.2%**	**23.0%**	**54.2%**	**1,962,111**	**34.4%**	**24.0%**	**58.4%**	**1,165,915**	**28.3%**	**24.7%**	**53.0%**	**1,134,826**	**27.4%**	**22.8%**	**50.2%**
BEL	371,397	46.0%	20.6%	66.5%	260,287	54.2%	23.7%	78.0%	127,833	42.7%	23.3%	66.0%	120,259	40.2%	22.5%	62.6%
BGR	23,898	34.7%	21.4%	56.1%	13,749	42.5%	30.1%	72.6%	7,789	35.8%	21.2%	57.0%	6,599	30.4%	22.3%	52.8%
CYP	4,868	27.2%	17.3%	44.5%	1,561	35.6%	38.2%	73.8%	999	38.6%	16.5%	55.1%	819	29.1%	17.8%	46.9%
DNK	159,118	37.2%	19.5%	56.6%	84,094	33.8%	30.5%	64.4%	48,346	32.8%	18.4%	51.1%	43,030	26.3%	18.5%	44.8%
ESP	386,534	29.7%	21.7%	51.4%	286,247	35.3%	24.1%	59.3%	145,553	25.3%	24.5%	49.8%	138,502	24.2%	23.2%	47.4%
EST	11,484	33.3%	24.1%	57.4%	7,251	37.4%	28.6%	66.0%	4,187	37.0%	22.1%	59.1%	3,805	32.5%	21.0%	53.5%
FIN	104,298	34.5%	25.5%	60.0%	83,113	38.4%	26.8%	65.2%	43,299	25.4%	30.6%	55.9%	41,578	24.2%	27.8%	52.0%
FRA	691,460	28.5%	22.0%	50.5%	554,565	32.5%	23.4%	55.8%	269,209	31.7%	22.2%	53.9%	260,370	30.7%	20.7%	51.3%
GBR	701,475	21.6%	29.5%	51.1%	398,292	30.8%	37.5%	68.3%	228,541	24.1%	23.9%	47.9%	217,155	22.4%	22.0%	44.4%
GRC	42,561	24.3%	19.9%	44.2%	11,390	33.7%	57.2%	90.9%	7,367	25.6%	20.8%	46.4%	6,052	16.9%	22.0%	38.9%
IRL	217,243	44.6%	13.7%	58.2%	117,640	51.6%	18.3%	69.9%	65,317	24.3%	18.7%	43.0%	60,204	20.6%	17.8%	38.4%
ITA	596,637	27.1%	21.8%	48.9%	493,166	30.1%	22.8%	52.9%	257,722	22.1%	24.2%	46.4%	250,552	21.4%	22.5%	43.9%
LTU	20,305	33.9%	19.5%	53.4%	11,570	47.6%	24.7%	72.2%	6,274	28.4%	21.2%	49.6%	5,601	23.9%	19.6%	43.5%
LUX	90,519	61.3%	13.0%	74.2%	10,882	51.9%	83.1%	135.0%	8,304	55.4%	24.2%	79.6%	5,785	37.4%	32.2%	69.6%
LVA	10,529	24.6%	24.2%	48.8%	4,514	34.1%	38.6%	72.7%	2,874	35.4%	21.3%	56.6%	2,430	28.3%	21.3%	49.5%
MLT	5,513	39.7%	18.3%	58.0%	2,338	52.3%	30.5%	82.8%	1,718	48.3%	17.9%	66.2%	1,446	41.0%	19.3%	60.2%
NLD	537,108	39.2%	22.7%	62.0%	345,192	48.3%	29.6%	77.9%	164,641	33.8%	23.5%	57.3%	153,298	30.8%	22.6%	53.4%
PRT	57,468	27.9%	22.1%	50.1%	39,568	33.0%	26.6%	59.6%	22,645	26.3%	23.2%	49.5%	21,511	24.8%	22.0%	46.8%
ROU	54,126	23.9%	25.6%	49.6%	32,826	29.7%	34.6%	64.3%	23,177	24.3%	26.7%	51.0%	20,738	21.3%	26.8%	48.0%
SVN	25,314	36.5%	22.5%	59.1%	20,149	40.4%	24.4%	64.8%	12,296	34.6%	24.1%	58.7%	11,880	33.1%	22.6%	55.7%
SWE	249,485	31.9%	24.2%	56.1%	174,012	37.8%	28.6%	66.4%	92,625	28.3%	25.3%	53.6%	87,461	26.5%	23.7%	50.3%
other EU-MS	**4,361,340**	**32.3%**	**22.6%**	**54.9%**	**2,952,406**	**37.4%**	**27.0%**	**64.4%**	**1,540,716**	**28.8%**	**23.5%**	**52.3%**	**1,459,075**	**26.8%**	**22.2%**	**49.0%**
EU-27	***6,745,388***	***31.7%***	***22.8%***	***54.5%***	***6,876,628***	***35.7%***	***25.3%***	***61.0%***	***3,872,546***	***28.6%***	***24.0%***	***52.6%***	***3,728,727***	***27.1%***	***22.4%***	***49.5%***

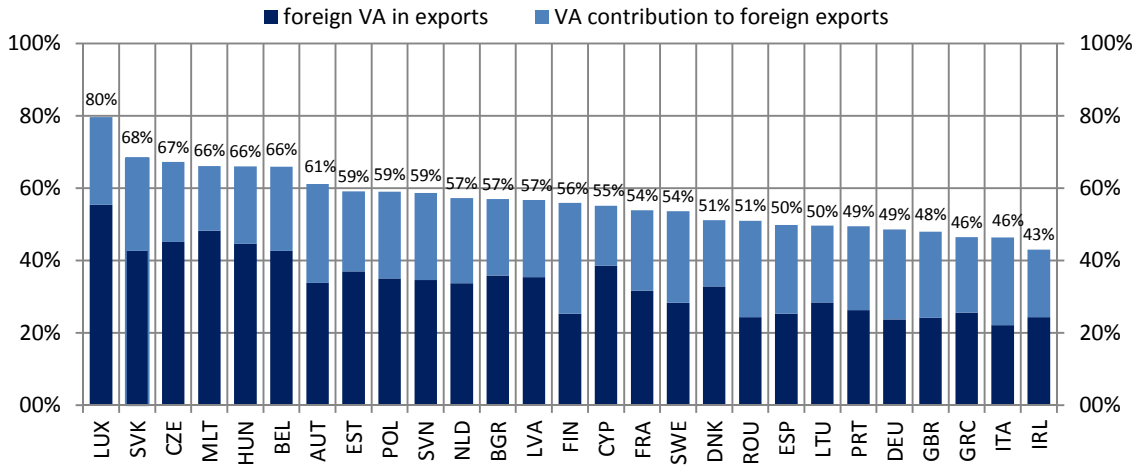
Note: FVAiT = foreign value added in trade; VAcFE = value added contributions to foreign exports; GVC = global value chain participation rate, which is the sum of the foreign value added in a country's exports and the country's value added contributions to other countries' exports, expressed as a percentage of gross exports.

Source: WIOD, wiiw calculations.

Based on the data from column A.2, Table 5.2 shows the general backward production integration (foreign value added in exports) and forward production integration (domestic value added contributions to foreign exports) of EU Member States – here expressed in per cent of gross *manufacturing* exports – as well as the resulting global value chain (GVC) participation rates.

The figure shows that GVC participation is among the highest in the CE manufacturing core countries, with Slovakia and the Czech Republic ranking second and third with a GVC participation rate of around 66% to 67%. With a share of 49% of gross exports, Germany is the only member of the CE manufacturing core that is quite far down the GVC ranking, which can be attributed to country size. This relatively low degree of backward and forward production integration in Germany is also the explanation why the (weighted) group average of the six CE manufacturing core countries is basically the same as that of the other EU Member States (see Table 5.1 above).

Figure 5.2: Foreign value added in manufacturing exports and domestic value added contributions to foreign manufacturing exports, in % of gross manufacturing exports, 2011



Note: The countries are ranked according to the GVC participation rate, which is the sum of the foreign value added in a country's exports and the country's value added contributions to other countries' exports, expressed as a percentage of gross exports.

Source: WIOD, wiiw calculations.

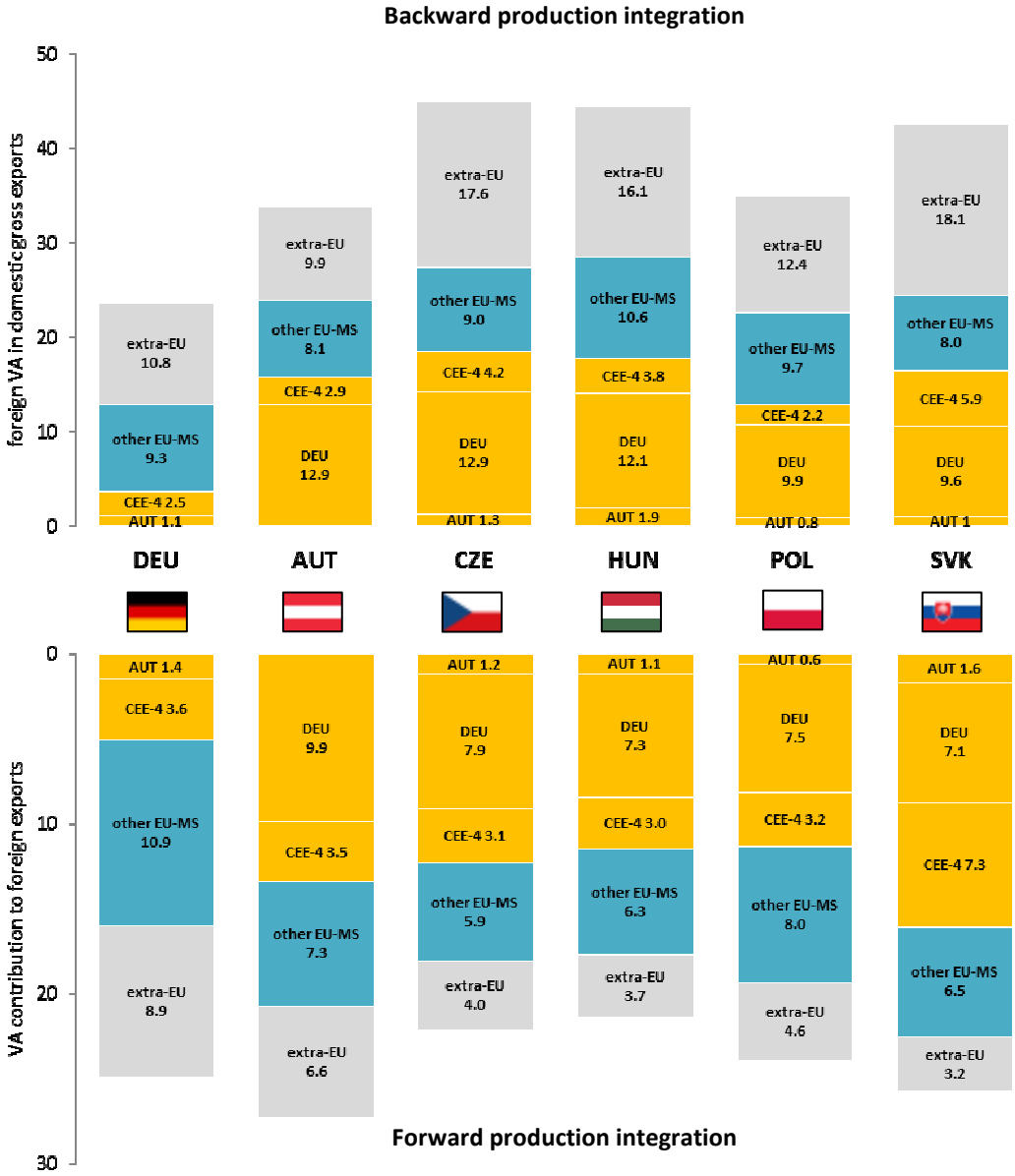
Another fact to note is that the foreign value added content in domestic exports contributes to a larger extent to the GVC participation in the four Visegrád countries (i.e. in the Czech Republic, Slovakia, Poland and Hungary) than in Austria and Germany. In contrast, the domestic value added contributions to trading partners' exports – here also expressed in per cent of gross manufacturing exports – tends to be larger in Austria and Germany, amounting to 27% and 25% of gross exports respectively.

This difference in the intensity of backward versus forward integration suggests that Germany and Austria are relatively more involved in the export of inputs that are then processed and re-exported than the Visegrád countries. The Visegrád countries in turn are relatively more involved in onward processing and assembling of inputs purchased from other countries.

We explore these backward and forward linkages further for the CE manufacturing countries and disentangle the foreign value added in exports and domestic value added contributions to foreign exports by partner countries (Figure 5.3).

The upper part of Figure 5.3 depicts the respective country's backward production integration while the forward production integration is shown in the lower part. The figure is best explained by focusing on a particular country, which will be Austria.

Figure 5.3: Backward and forward production integration of the CE manufacturing core countries by partners, in % of gross manufacturing exports, 2011



Note: Both foreign value added in exports and domestic value added contributions to foreign exports are expressed in per cent of gross manufacturing exports of the respective country. CEE = Czech Republic, Hungary, Poland, Slovakia.

Source: WIOD, wiiw calculations.

The height of the bar in the upper panel represents the extent of the foreign value added content (backward integration), which in the case of Austria amounts to 34% of gross exports in 2011 as already discussed. Of these 34% Germany contributed 12.9 percentage points (p.p.). The remaining members of the CE manufacturing core, labelled CEE-4 in Figure 5.3, account for another 2.9 p.p. This implies that almost half (47%) of total foreign value added embedded in Austrian exports originates from the CE manufacturing core countries.

A comparison of the importance of backward integration among the members of the CE manufacturing core shows that Austria's backward integration with the CE manufacturing core is very strong, in fact stronger than in the other members of the core. While the yellow bars – which represent the CE manufacturing core – are higher in the case of the Czech Republic and Hungary (which is due to the overall higher degree of backward integration), in relative terms the CE manufacturing core countries account for between 36% (Poland) and 40% (Czech Republic) of the total foreign value added content in exports in the Visegrád countries. Hence, the production integration of the Austrian economy is more geared towards the CE manufacturing core than that of the Visegrád countries. Again, since Germany clearly emerges as the main source of foreign value added in all CE manufacturing core countries, Germany itself does not appear to have a strong backward dependence on the manufacturing core.

Despite the fact that production integration is very tight among the members of the CE manufacturing core, it is not limited to these countries. In fact, 9.9% of Austria's gross exports constitute value added originating from non-EU countries. This shows that despite the close trade integration within the European core, this group of countries cannot act in isolation but also interacts with the global economy. What is remarkable, however, is that production sharing with other EU Member States does not seem to be that developed. In the Austrian case, just about 8% of gross exports are made of value added from other EU Member States.

Next, we turn to the CE manufacturing core countries' value added contributions to their trading partners' exports, which are again expressed in per cent of gross *manufacturing* exports of the value added generating country, i.e. to the forward production integration. The lower part of Figure 5.3 shows that forward production integration is even more focused on the CE manufacturing core than backward integration. While in general the degree of forward integration is somewhat lower, ranging from 21.4% in Hungary to 27.3% in Austria, the value added contributions to the gross exports of the other CE manufacturing core countries is larger, reaching 55% und 62% in the case of the Czech Republic and Slovakia respectively. Austria's value added embedded in German and Visegrád countries' exports add 9.9 p.p. and 3.5 p.p. respectively to Austria's total value added contributions to other countries' gross exports (i.e. the 27.3% of gross exports).

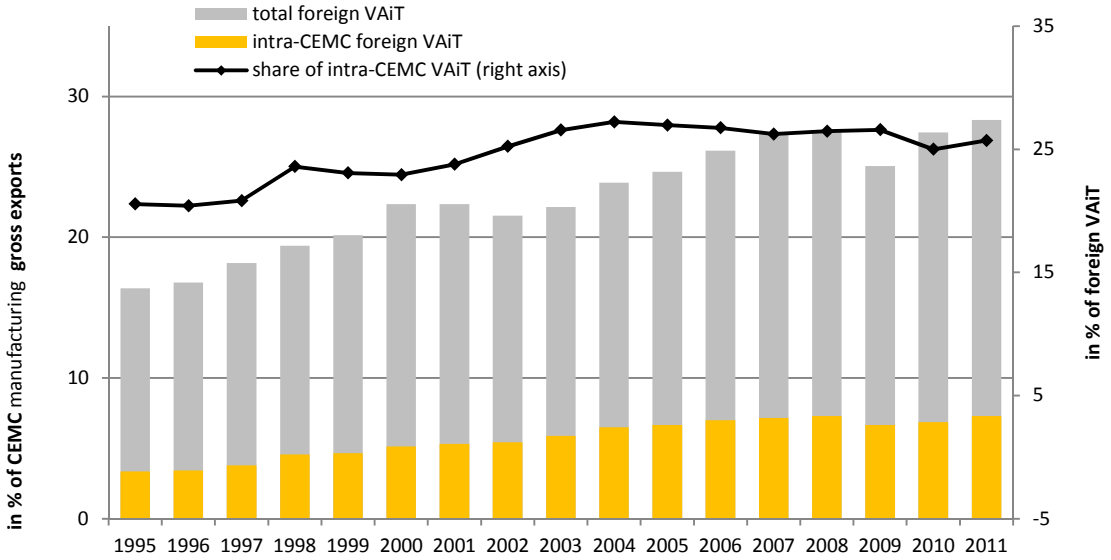
The conclusions to be drawn from Figure 5.2 and Figure 5.3 is that the German economy is at the centre of the CE manufacturing core as must have been expected given the economic size of Germany and the technological excellence of German firms. This can be seen from the fact that Germany is the dominant source of foreign manufacturing value added in the exports of the other CE manufacturing core countries ranging from 10% (Poland) to 13% (Austria and Czech Republic). Germany is also the country which embeds into its exports the highest shares of manufacturing value added originating from the CE manufacturing core countries, ranging from around 7% (Slovakia) to almost 10% (Austria).

Looking specifically at the role of Austria in the CE manufacturing supply chain, one resemblance between Austrian and Germany is detectable. This resemblance is that both countries have relatively stronger forward production integration. As mentioned above, this suggests that the role of Germany and Austria in the CE manufacturing core is primarily that of suppliers of specialised inputs, i.e. the role of technology providers. At the same time, however, it is also clear from Figure 5.3 that the importance of Austria, both as a supplier of inputs for other CE manufacturing core members' exports and as a destination for onward-processing, is very limited. Hence, overall it seems that the

CE supply chain is very much driven and presumably also managed by the activities of German lead firms.

Despite the fact that Germany's backward and forward integration appears to be less centred on the CE manufacturing core, the trend is towards more production sharing with this group of countries. This is generally true for the members of the CE manufacturing core as depicted in Figure 5.4 and Figure 5.5.

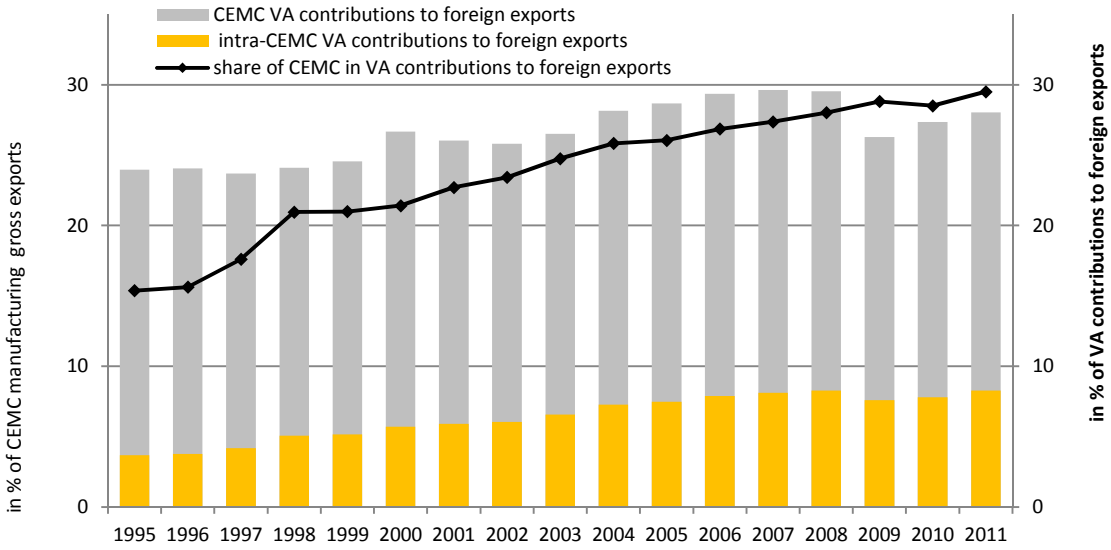
Figure 5.4: Development of the CE manufacturing core's backward production integration, 1995-2011



Note: CEMC = Central European manufacturing core.

Source: WIOD, wiiw calculations.

Figure 5.5: Development of the CE manufacturing core's forward production integration, 1995-2011



Note: CEMC= Central European manufacturing core.

Source: WIOD, wiiw calculations.

Figure 5.4 shows that the degree of backward integration of production in the CE manufacturing core – both globally and within the CE manufacturing core – has increased between 1995 and 2011. For example, the share of other CE manufacturing core members' value added in the CE manufacturing core's exports, i.e. intra-CEMC backward production integration, increased from 3.4% in 1995 to more than 7% of CEMC gross exports in 2011 (expressed again in per cent of gross exports). In fact, intra-CEMC backward production sharing has increased by more than production sharing with other countries. This resulted in an increase in the CE manufacturing core's share in the group's overall foreign value added in exports, which rose from 20% in 1995 to more than 25% in 2011. This re-orientation of production sharing within the CE manufacturing core occurred between 1995 and 2004. Since then the development has been more or less flat. So it seems that the crisis has not left its trace on the geographic orientation of international backward production integration – at least not yet.

Turning to the forward integration of production, i.e. the foreign value added contributions to the manufacturing exports of the members of the CE manufacturing core, one also finds increasing trends – both generally and within the CE core countries. Note also that the intra-CEMC forward integration (i.e. the CE manufacturing core countries' value added contributions to the manufacturing exports of the other members of the core) is by definition equal to the CEMC backward integration. This must be the case in the same manner as (theoretically) intra-EU exports must equal intra-EU imports. The logic behind this is that restricting the analysis to the CE manufacturing core, the foreign value added contributions to foreign exports must equal the foreign value added content of domestic imports. Therefore the yellow bars, which indicate the intra-CEMC production integration in Figure 5.5, exactly match those in Figure 5.4. In relative terms, however, i.e. considered as a share of the CE manufacturing core countries' value added contributions to all foreign exports, intra-CEMC forward production integration has increased considerably. Intra-CEMC forward production integration doubled from 15% in 1995 to 30% in 2011. Here, too, the positive trend may have flattened somewhat since 2004 but continued thereafter.

5.1.3 International production sharing at the industry level

The indicators for backward and forward production integration, i.e. the foreign value added in trade (FVAiT) and the value added contributions to foreign exports (VAcFE), can also be calculated at the industry level. We stick to our approach of considering exports from all industries but looking only at the value added contributions of domestic and foreign manufacturing industries. Hence, for example, the column labelled gross exports in Table 5.2 indicates *manufacturing* valued added embodied in exports of each industry including primary, manufacturing and services industries.

Table 5.2 shows the overriding importance of a small number of manufacturing industries for the phenomenon of international production sharing. Looking at the GVC participation rate, the transport equipment industry (NACE 34t35), the electronic equipment industry (NACE 30t33), the metallurgy industry, including metals and metal products (NACE 27t28), the machinery industry (NACE 29) and the chemical industry (NACE 24) have contributed most strongly to the total amount of foreign value added in exports and the value added contributions to foreign exports in the CE manufacturing core. The entire manufacturing sector accounts for 92% of the GVC participation, with the above-mentioned five industries alone accounting for more than three quarters of the value added considered relevant for global value participation.

Table 5.2 Backward and forward production integration in the CE manufacturing core based on exports of all industries and including value added from manufacturing industries, 2011

exporting industry	Gross exports	FVAiT	VAcFE	GVC	industry's share in value of FVAiT	industry's share in value of VAcFE	industry's share in value of GVC
		in million USD				in %	
AtB	3493	2107	3155	5262	**0.6%**	**1.1%**	**0.9%**
C	1819	1133	6106	7239	**0.3%**	**2.1%**	**1.2%**
15t16	48306	8345	8858	17203	**2.5%**	**3.1%**	**2.8%**
17t18	26699	7160	7499	14658	**2.2%**	**2.6%**	**2.4%**
19	4933	1412	1444	2856	**0.4%**	**0.5%**	**0.5%**
20	11298	2307	1802	4109	**0.7%**	**0.6%**	**0.7%**
21t22	38259	7052	4936	11988	**2.1%**	**1.7%**	**1.9%**
23	14811	3908	6633	10541	**1.2%**	**2.3%**	**1.7%**
24	126295	28014	29154	57168	**8.5%**	**10.1%**	**9.3%**
25	50541	13176	8937	22113	**4.0%**	**3.1%**	**3.6%**
26	17046	2686	2206	4892	**0.8%**	**0.8%**	**0.8%**
27t28	147753	42105	33419	75524	**12.7%**	**11.6%**	**12.2%**
29	174323	40283	31601	71884	**12.2%**	**11.0%**	**11.6%**
30t33	195686	63742	49219	112962	**19.3%**	**17.1%**	**18.3%**
34t35	249637	83950	64559	148509	**25.4%**	**22.4%**	**24.0%**
36t37	29238	6966	8247	15214	**2.1%**	**2.9%**	**2.5%**
E	2083	1334	769	2102	**0.4%**	**0.3%**	**0.3%**
F	2948	1695	1168	2863	**0.5%**	**0.4%**	**0.5%**
50	239	165	278	443	**0.0%**	**0.1%**	**0.1%**
51	2398	1518	2290	3808	**0.5%**	**0.8%**	**0.6%**
52	448	292	486	777	**0.1%**	**0.2%**	**0.1%**
H	1423	687	610	1297	**0.2%**	**0.2%**	**0.2%**
60	3351	2219	2623	4842	**0.7%**	**0.9%**	**0.8%**
61	2035	1149	1323	2472	**0.3%**	**0.5%**	**0.4%**
62	2203	1584	1699	3283	**0.5%**	**0.6%**	**0.5%**
63	1739	1044	1082	2126	**0.3%**	**0.4%**	**0.3%**
64	728	524	759	1283	**0.2%**	**0.3%**	**0.2%**
J	928	530	1222	1752	**0.2%**	**0.4%**	**0.3%**
70	137	82	136	219	**0.0%**	**0.0%**	**0.0%**
71t74	4142	2439	4392	6831	**0.7%**	**1.5%**	**1.1%**
L	157	103	221	324	**0.0%**	**0.1%**	**0.1%**
M	24	16	57	73	**0.0%**	**0.0%**	**0.0%**
N	148	120	109	229	**0.0%**	**0.0%**	**0.0%**
O	646	415	717	1132	**0.1%**	**0.2%**	**0.2%**
Total	**1165916**	**330261**	**287718**	**617979**	**100.0%**	**100.0%**	**100.0%**
Memorandum							
Primary	*5312*	*3240*	*9261*	12501	*1%*	*3%*	*2%*
Manufacturing	*1134825*	*311106*	*258515*	569622	*94%*	*90%*	*92%*
Construction	*2083*	*1334*	*769*	2102	*0%*	*0%*	*0%*
Utilities	*2948*	*1695*	*1168*	2863	*1%*	*0%*	*0%*
Services	*20746*	*12887*	*18004*	30891	*4%*	*6%*	*5%*

Note: FVAiT = foreign value added in trade; VAcFE = value added contributions to foreign exports; GVC = global value chain participation rate, which is the sum of the foreign value added in a country's exports and the country's value added contributions to other countries' exports, expressed as a percentage of gross exports. Private households with employed persons (NACE P) not shown but included in totals.

Source: WIOD, wiiw calculations.

Table 5.3 and Table 5.4 focus on these five industries. Since the dimensions keep increasing, only the results for one country of the CE manufacturing core – Austria – are shown. In Table 5.3 the columns contain the value of the manufacturing exports of value added generated by the five major manufacturing industries in Austria while the row dimension indicates the origin of the value added. In Table 5.4 the columns contain information about the amount of Austrian value added embedded in foreign exports and the rows provide information on the country in whose exports' this Austrian value added enters. This is again shown for the five selected industries.

Table 5.3 Backward production integration in selected Austrian industries, manufacturing value added, 2011

	chemicals		metals		machinery		transport equip.		electronic equip.	
origin of VA	VA in mn USD	share of VA supplied	VA in mn USD	share of VA supplied	VA in mn USD	share of VA supplied	VA in mn USD	share of VA supplied	VA in mn USD	share of VA supplied
AUT	5494	75.28%	10334	62.34%	9461	70.00%	8652	71.15%	8197	56.67%
CZE	37	0.51%	156	0.94%	114	0.84%	92	0.76%	206	1.42%
DEU	643	8.82%	2486	15.00%	1664	12.31%	1259	10.35%	2543	17.58%
HUN	27	0.38%	109	0.66%	77	0.57%	71	0.59%	119	0.82%
POL	26	0.36%	120	0.73%	69	0.51%	50	0.41%	116	0.80%
SVK	16	0.23%	138	0.83%	63	0.46%	50	0.41%	81	0.56%
other EU-MS	451	6.17%	1596	9.63%	977	7.23%	701	5.76%	1607	11.11%
extra-EU	602	8.25%	1637	9.87%	1092	8.08%	1284	10.56%	1593	11.02%
manufacturing VA exported	7298	100.00%	16576	100.00%	13516	100.00%	12159	100.00%	14463	100.00%
Total foreign	1804	24.72%	6242	37.66%	4055	30.00%	3507	28.85%	6266	43.33%
CEMC	751	10.29%	3010	18.16%	1986	14.69%	1522	12.52%	3065	21.20%
share CEMC	42%	42%	48%	48%	49%	49%	43%	43%	49%	49%

Note: VA = value added.

Source: WIOD, wiiw calculations.

Table 5.4 Forward production integration in selected Austrian industries, manufacturing value added, 2011

	chemicals		metals		machinery		transport equip.		Electronic equip.	
VA in exports of	VA in mn USD	share of VA supplied	VA in mn USD	share of VA supplied	VA in mn USD	share of VA supplied	VA in mn USD	share of VA supplied	VA in mn USD	share of VA supplied
AUT	5494	72.70%	10334	76.24%	9461	75.96%	8652	68.71%	8197	56.32%
CZE	65	0.86%	134	0.99%	134	1.08%	260	2.06%	247	1.69%
DEU	615	8.14%	1360	10.03%	1302	10.45%	1040	8.26%	3317	22.79%
HUN	79	1.04%	74	0.55%	111	0.89%	279	2.22%	189	1.30%
POL	46	0.61%	109	0.81%	52	0.41%	76	0.60%	243	1.67%
SVK	15	0.20%	34	0.25%	23	0.19%	67	0.53%	72	0.49%
other EU-MS	768	10.16%	937	6.91%	771	6.19%	680	5.40%	1440	9.90%
extra-EU	475	6.29%	572	4.22%	602	4.84%	1538	12.22%	851	5.84%
manufacturing VA supplied	7557	100.00%	13554	100.00%	12455	100.00%	12592	100.00%	14554	100.00%
to foreign	2063	27.30%	3220	23.76%	2994	24.04%	3940	31.29%	6358	43.68%
to CEMC	820	10.85%	1711	12.63%	1621	13.02%	1722	13.67%	4067	27.94%
share CEMC	40%	40%	53%	53%	54%	54%	44%	44%	64%	64%

Note: VA = value added.

Source: WIOD, wiiw calculations.

This split-up of the vertical production inter-linkages by industries and countries, however, provides few additional insights. It merely confirms the overarching role of Germany as the centre of production integration in Europe throughout the industries. There is some variation across industries though. For example, with regard to backward integration, Germany provides about 18% of the Austrian value added exported in the electronics industry whereas this value comes down to 10% in the transport equipment industry, presumably due to the very strong Austrian supplier firms in the automotive industry.

Another feature of the supply inter-linkages which has already been mentioned is the fact that the four Visegrád countries play a more prominent role in backward production integration in the CE manufacturing core than in forward production integration. This can be seen from the fact that in all of the five industries shown, none of the Visegrád countries contribute more than 1% to Austrian manufacturing value added exported. In contrast, the Czech Republic, Hungary and Poland embed more than 1% of Austria's exported manufacturing value added into their further exports in the electronic equipment industry. In the transport equipment industries the share of Austrian manufacturing value added entering the exports of the Czech Republic and Hungary even exceed 2%.

Finally, we take a look at the sourcing patterns among the countries of the manufacturing core. For this purpose we focus on the transport equipment industry and look at the manufacturing value added exported by this industry in each of the six CE manufacturing core countries and the origin of the value added. Table 5.5 gives a snapshot of the backward production integration in this industry. The transport equipment industry is a good example to illustrate once more the roles of the countries in the CE manufacturing core. As can be seen, the domestic value added content of exports (shown in bold) becomes very low in the case of the Czech Republic, Hungary and Slovakia. This is due to the fact that a large part of inputs are imported – primarily from Germany, but there is also a considerable role of extra-EU countries.

Table 5.5 Backward production integration in the transport equipment industry in the CE manufacturing core, manufacturing value added, 2011

Exporting country origin of VA	AUT	CZE	DEU	HUN	POL	SVK
AUT	**71.15%**	1.22%	0.79%	1.89%	0.80%	1.01%
CZE	0.76%	**37.13%**	0.73%	1.01%	1.08%	2.89%
DEU	10.35%	13.69%	**76.88%**	13.71%	9.47%	9.94%
HUN	0.59%	0.75%	0.49%	**40.73%**	0.75%	2.61%
POL	0.41%	1.51%	0.58%	2.21%	**56.47%**	1.44%
SVK	0.41%	0.90%	0.24%	1.03%	0.66%	**45.93%**
other EU-MS	5.76%	8.61%	6.56%	11.03%	10.50%	8.30%
extra-EU	10.56%	36.18%	13.73%	28.38%	20.26%	27.90%
Total foreign	28.85%	62.87%	23.12%	59.27%	43.53%	54.07%
CEMC foreign	12.52%	18.08%	2.83%	19.85%	12.77%	17.88%
share CEMC	43%	29%	12%	34%	29%	33%

Note: VA = value added.

Source: WIOD, wiiw calculations.

The situation is different for Austria which, despite the fact that it does not have an original equipment manufacturer (OEM) in the automotive industry, has a number of important tier one suppliers, allowing the Austrian automotive industry to capture a large domestic value added share of the exports of the industry.

Hence, this deeper look into some of the industry details of production integration in the CE manufacturing core supports the findings of the analysis at the aggregate level.

6 Explaining international production sharing

This section investigates the degree of international production sharing (*IPS*) in more detail by exploring potential factors that are conducive to further economic integration and factors that may hamper it. More precisely we will turn to regression analysis to find out whether foreign direct investment, a more skilled workforce, higher R&D intensity, or a more sophisticated export basket help explain a country's foreign value added in trade and global value chain participation respectively. In the regression we implicitly assume that – as has been demonstrated in the previous section – Germany is the anchor of the CE supply chain (see also IMF, 2013). This allows us to use a country-level version of the classical gravity model to include the distance to Germany and the relative GDP to Germany as explanatory variables for the degree of international production sharing. This regression model is estimated at the country level but limited to the foreign value added in trade and global value chain participation obtained for the manufacturing sector (or the value added contributions of this sector to be more precise – see Table 5.1). The sample includes 26 countries, i.e. the 27 EU Member States less Germany, over the period 1995-2011.

The regression takes the form

$$(2) \qquad IPE_{c,t} = \alpha + \beta_1 \cdot FDI_{c,t}^{inw} + \beta_2 \cdot FDI_{c,t}^{outw} + \beta_3 \cdot \frac{wage_{c,t}}{wage_t^{DEU}} + \beta_4 \cdot l_{c,t}^{med-sk} + \beta_5 \cdot l_{c,t}^{high-sk} +$$

$$\beta_6 \cdot EXPY_{c,t} + \beta_7 \cdot dist_c^{DEU} + \beta_8 \cdot \frac{GDP_t^{DEU}}{GDP_{c,t}} + \beta_9 \cdot pop_{c,t} + \beta_{10} \cdot CORE_c + \delta_t + \varepsilon_{c,t}$$

where $IPE_{c,t}$ is alternatively the share of foreign value added in trade ($FVAiT_{c,t}$) or the global value chain participation rate ($GVC_{c,t}$) of country *c* at time *t*. $FDI_{c,t}^{inw}$ and $FDI_{c,t}^{outw}$ are the inward and outward manufacturing FDI stocks respectively;. $\frac{wage_{c,t}}{wage_t^{DEU}}$ is labour compensation in country *c* at time *t* in the industrial sector relative to that of Germany, which serves as a proxy for the relative wage level and was also taken from Eurostat, and $l_{c,t}^{med-sk}$ and $l_{c,t}^{high-sk}$ are the shares of medium-skilled and high-skilled workers in total employment in the economy. The data for these three indicators was obtained from Eurostat. $EXPY_{c,t}$ is the level of export sophistication as suggested by Hausmann, Hwang and Rodrik (2007) which is based on detailed trade data from the UN Comtrade database[10]. The $EXPY_{c,t}$ is an empirically-derived proxy for a country's level of technology. The export sophistication of a country is large if a country predominantly exports goods that are also exported by high-income countries and it is low if the country's export basked strongly overlaps with low-income countries. $dist_c^{DEU}$is the distance between country *c* and Germany obtained from CEPII's

[10] The authors would like to thank Neil Foster for providing the data on export sophistication.

GeoDist database, $\frac{GDP_t^{DEU}}{GDP_{c,t}}$ is the relative GDP level with respect to Germany with the GDP data coming from the European Commission's State Aid Scoreboard and $pop_{c,t}$ is the population of country *c* which is included to control for country size. Importantly, we also include the CORE dummy variable again in order to see whether there is a distinct effect independent of the other factors that can be attributed to the integration in the CE manufacturing core. As before, $CORE_c$, is a dummy variable taking the value 1 for members of the CE manufacturing core and zero otherwise. Time fixed effects are denoted by δ_t, and $\varepsilon_{c,t}$ is an error term. The FDI variables, the export sophistication measure as well as distance enter the regression in log form.

The results from this regression are presented in Table 6.1 where specifications (1) and (3) are based on the model in equation (2). Specifications (2) and (4) are a variant of equation (2) which includes country fixed effects.

Table 6.1: Determinants of international production sharing, 1995-2011

Dependent variable:	**Foreign Value Added in Trade (FVAiT)**				**Global Value Chain (GVC)**			
	(1)		(2)		(3)		(4)	
ln inward FDI	0.0201	***	0.0075		0.0281	***	0.0082	
	(0.004)		(0.006)		(0.005)		(0.005)	
ln outward FDI	-0.0004		0.0063		0.0030		0.0052	
	(0.003)		(0.006)		(0.003)		(0.005)	
share medium-skilled labour	-0.1126	***	-0.1178		0.0036		-0.0088	
	(0.018)		(0.097)		(0.020)		(0.086)	
share high-skilled labour	-0.0464		-0.0569		-0.0692	*	0.0359	
	(0.033)		(0.095)		(0.036)		(0.090)	
ln population	-0.0860	***	0.2073	*	-0.0860	***	0.1655	
	(0.006)		(0.120)		(0.007)		(0.130)	
relative GDP (to Germany)	0.1056	***	-0.1333		0.0906	***	-0.2697	***
	(0.017)		(0.121)		(0.019)		(0.081)	
ln EXPY	-0.1523	***	-0.0685		-0.1373	***	-0.0562	
	(0.030)		(0.059)		(0.039)		(0.068)	
relative wage (to Germany)	-0.0900	***	-0.0618		-0.0839	***	-0.0406	
	(0.018)		(0.045)		(0.016)		(0.039)	
ln distance	-0.0604	***			-0.0480	***		
	(0.005)				(0.006)			
CEMC	0.0960	***			0.0928	***		
	(0.009)				(0.008)			
country effects	no		yes		no		yes	
time effects	yes		yes		yes		yes	
F-test	110.40		383.16		105.62		2117.45	
R-sq	0.847		0.958		0.834		0.965	
R-sq adj.	0.833		0.950		0.819		0.959	
Obs.	311		311		311		311	

Note: ***,** and * indicate statistical significance at the 1%, 5% and 10% level respectively. Standard errors in parentheses. All regressions estimated with STATA using xtreg. . All continuous regressors are estimated using centred values because of the inclusion of the interaction term. All regressions include a constant.

The model specifications with fixed effects, however, convey little information because the fixed effects swamp almost all the explanatory power of the regressors in the model. Moreover, the fixed effects specification does not allow for the inclusion of the dummy variable for the member of the CE

manufacturing core. For this reason – and in line with Rahman and Zao (2013) – we focus the discussion on specifications (1) and (3), i.e. the model without country fixed effects.

In both, specification (1) and (2), the *R-square* of the regression (i.e. its explanatory power) is quite high indicating that the omitted variable bias due to the lack of country fixed effects may be limited. Starting with the effect of FDI stocks, we find that larger inward FDI is associated with higher FVAiT (specification 1) and also with higher GVC rates (specification 3). This reflects the fact that international production sharing goes hand in hand with FDI as suggested by Baldwin's (2011) notion of the trade-investment-services nexus that characterises modern trade patterns. In contrast, outward FDI does not turn out to be statistically significant. This is what could be expected in specification 1 because it has the backward production integration (i.e. the FVAiT) as the dependent variable but it also does not result in a statistically significant estimate in specification 3 which reflects both backward and forward production integration.

The labour-related variables deliver a somewhat surprising result, at least in the specification with FVAiT as the dependent variable. The negative coefficient for the share of medium-skilled labour in the workforce suggests that more medium-skilled labour, which includes the important group of skilled production workers, reduces backward production integration.

The negative coefficient of the population variable simply reflects the fact that larger countries tend to have, ceteris paribus, a lower degree of forward and backward integration. The relative GDP of the two countries in this context suggests that the 'mass' (economic size) of the countries matters. In any case, this result for the relative GDP should not be considered independent of the result for population.[11]

The coefficient of the relative wage to Germany comes out negatively and it is statistically significant. The interpretation of this negative coefficient is that integration in production networks is accompanied by efficiency-seeking FDI flows. Put differently, EU Member States with relatively low wage levels tend to attract FDI by investors seeking to reduce labour costs. Efficiency-seeking FDI operations are typically characterised by a high degree of intermediate inputs, resulting in a high foreign value added share in exports. Taken together, this yields a negative relationship between wages and integration in international production networks.

A related explanation may be offered for the negative coefficient of the export sophistication variable. The more sophisticated a country's export base, the greater are the skills and capabilities of the country. This in turn makes the country less dependent on imported inputs and therefore reduces the share of foreign value added in exports.

Concerning the distance to Germany also a negative coefficient is obtained. This result is in line with the asserted role of Germany as the major hub of the Central European production network. It confirms the important role of distance for trade links and international production integration. The closer a country is to Germany, the larger is – ceteris paribus – its integration in international production networks.

Finally, the particular role of the members of the CE manufacturing core is also confirmed in this regression. The positive coefficient of the CEMC dummy indicates that even when controlling for all

[11] The coefficient of the relative GDPs turns negative if the population variable is excluded from the regression.

the factors just discussed, the members of the CE manufacturing core still have higher participation rates in global value chains.

In a next step this particular role of the CE manufacturing core is further explored by including interaction terms between all the explanatory variables on the one hand and the CEMC dummy variable on the other hand. Denoting the entire set of explanatory variables in equation (2) by a matrix X, this regression model can be written as

(3) $IPE_{c,t} = \alpha + \mathrm{X} \cdot \beta + (\mathrm{X} \times \mathrm{CORE}_c) \cdot \gamma + CORE_c + \delta_t + \varepsilon_{c,t}$

where X is a *n* x *k* matrix containing the information of *n* observations for each of the *k* explanatory variables in its columns and β is a column vector of dimension *k* with the corresponding coefficients. Likewise, $\mathrm{X} \times \mathrm{CORE}_c$ is also an *n* x *k* matrix. It summarises the interaction terms between the explanatory variables and the CORE dummy variable. γ is the corresponding vector of coefficients. In order to facilitate the interpretation of coefficients, the regression is estimated using centred variables so that the estimated coefficients can be interpreted as the result for the average country. The results are presented in Table 6.2.

The inclusion of the set of interaction terms slightly increases the explanatory power of the regression with the *R-square* reaching 0.89 and the adjusted *R-square* reaching 0.88.

The regression results have to be read as follows: the coefficients of the main effects, i.e. of the explanatory variables, indicate the effect on the share of foreign value added in trade (specification 1) and the rate of global value chain participation (specification 2) respectively for the average EU Member State that is not part of the CE manufacturing core. For the members of the CE manufacturing core, the effect is given by the coefficient of the main effect plus the coefficient of the interaction term.

The results suggest that there are a number of cases where the factors have differentiated effects on the degree of international production sharing for members and non-members of the CE manufacturing core. The obvious case is distance. While distance to Germany is still hampering the integration into international production networks (the coefficient is -0.061, i.e. negative) for the average EU Member State, it does not have a negative effect on the CE manufacturing core countries because they are all sufficiently close to Germany anyway. The overall effect for the CE manufacturing core countries is even positive (0.0798 = -0.0606 + 0.1404).

Table 6.2: Determinants of international production sharing including interaction terms, 1995-2011

Dependent variable:	Foreign Value Added in Trade (1)		Global Value Chain Participation (2)	
ln inward FDI	0.0188	***	0.0283	***
	(0.004)		(0.006)	
ln inward FDI × CEMC	0.0030		-0.0045	
	(0.008)		(0.010)	
ln outward FDI	-0.0071	***	-0.0011	
	(0.003)		(0.003)	
ln outward FDI × CEMC	0.0210	***	0.0063	
	(0.006)		(0.008)	
share medium-skilled labour	-0.1086	***	0.0092	
	(0.018)		(0.021)	
share medium-skilled labour × CEMC	0.2802	*	0.2213	
	(0.170)		(0.198)	
share high-skilled labour	-0.0983	***	-0.1028	**
	(0.035)		(0.041)	
share high-skilled labour × CEMC	-0.0874		0.0251	
	(0.183)		(0.213)	
ln population	-0.0871	***	-0.0867	***
	(0.007)		(0.009)	
ln population × CEMC	0.0741	***	0.0311	
	(0.027)		(0.031)	
relative GDP (to Germany)	0.1291	***	0.1034	***
	(0.019)		(0.021)	
relative GDP (to Germany) × CEMC	-1.3659	***	-0.3763	
	(0.491)		(0.547)	
ln EXPY	-0.1925	***	-0.1551	***
	(0.028)		(0.042)	
ln EXPY × CEMC	0.4840	***	0.3922	***
	(0.111)		(0.145)	
relative wage (to Germany)	0.0020		-0.0366	
	(0.019)		(0.022)	
relative wage (to Germany) × CEMC	-0.1526		-0.1097	
	(0.066)	**	(0.073)	
ln distance	-0.0606	***	-0.0487	***
	(0.005)		(0.006)	
ln distance × CEMC	0.1404	***	0.1309	***
	(0.033)		(0.036)	
CEMC	-6.8069	***	-5.0766	***
	(1.354)		(1.706)	
country effects	no		no	
time effects	yes		yes	
F-test	186.55		146.17	
R-sq	0.892		0.848	
R-sq adj.	0.879		0.829	
Obs.	311		311	

Note: ***,** and * indicate statistical significance at the 1%, 5% and 10% level respectively. Standard errors in parentheses. All regressions estimated with STATA using xtreg. All continuous regressors are estimated using centred values because of the inclusion of the interaction term. All regressions include a constant.

There are a number of additional variables where the effects are different. The most interesting ones are relative wages (relative labour compensation). In specification (1) the coefficient of relative wages is negative and statistically significant (at the 1% level) only for the CE manufacturing core countries while for the remaining countries no significant effect is obtained. This means that the efficiency-seeking driven outsourcing which drives up the foreign value added in exports is mainly an issue within the CE manufacturing core. It should be mentioned, however, that inward FDI in the manufacturing sector remains conducive to international production sharing for all EU Member States.

The second very interesting result concerns the export sophistication variable. According to the results, in the average EU Member State higher export sophistication is associated with a lower degree of international production integration. The opposite, however, is true for the average CE manufacturing core country where the interaction term is positive and considerably larger than the main effect. Our explanation for this pattern is that while higher export sophistication reduces the need for imported inputs (reducing both FVAiT and GVC), a certain level of export sophistication – which reflects a country's production capabilities – is needed in order to serve as a partner in international production networks.

7 Conclusions

There is evidence that Europe's manufacturing activity is increasingly concentrated in a Central European (CE) core which the IMF in a recent publication also refers to as the German-Central European supply chain. This CE manufacturing core comprises Germany, which assumes a pivotal role in the organisation of the region's production networks, Austria as well as the four Visegrád countries, i.e. the Czech Republic, Slovakia, Hungary and Poland.

This study provided further empirical evidence concerning this CE manufacturing core and explored in detail the structure and development of the regional supply chains over the period 1995-2011.

We started out with the fact that the CE manufacturing core countries are among the EU countries with the highest share in manufacturing in GDP, reaching close to 20% in most countries, and that they are also the countries where the structural shift out of manufacturing was less pronounced than in other EU Member States – or even positive.

CE manufacturing core countries are also the countries with the highest manufacturing intensity measured as value added exports per capita. In contrast to the manufacturing shares discussed above, the average manufacturing export intensity was not very different in the group of CE manufacturing core countries and other EU Member States back in 1995; from the early 2000s onwards, however, the two groups have embarked on divergent trends with the manufacturing core countries significantly increasing the export intensity per capita, climbing to some EUR 3,700, whereas that of the other Member States was basically stagnating, hovering around EUR 2,000 for several years and reaching some EUR 2,200 in 2011. This implies a huge differential in export intensities between the two groups which has in fact swollen to 40% in 2011.

This development is paralleled by an impressive 8 percentage points increase in the CE manufacturing core's share in total EU value added exports to 42.6% in 2011. This positive

development of export market shares in manufacturing industries is found in each single member of the CE manufacturing core. Given their economic size, Germany and Poland contributed most strongly to this development with gains in market shares amounting to 2.4 and 1.9 percentage points respectively. The flip side of this agglomeration of manufacturing activities in the CE manufacturing core is a significant decline in the share of EU manufacturing value added exports in other EU Member States, in particular in high-income countries including the Nordic and the Benelux countries and above all France and the United Kingdom.

A key result of the report is that the integration in international production chains can have very different structural impacts. In particular the regression results in the report suggest that in the average EU Member State, the share of manufacturing in the economy is negatively affected by international production sharing: a 10 percentage point higher GVC participation rate accelerates the negative rate of structural change of the average EU Member State *not* belonging to the CE manufacturing core by 0.35 percentage points. The result is, however, very different for the members of the CE manufacturing core: for the average CEMC country a 10 percentage point higher GVC participation rate slows down the structural shift out of manufacturing by 0.26 percentage points. This result supports the view that the structural impact of global supply chain integration is country-specific. Some countries see their manufacturing sector strengthened by this development, while in others it accelerates the 'de-industrialisation' process. Within the EU, there seems to be a different effect of supply chain integration observable for the members of the CE manufacturing core and the other EU countries. The integration into supply chains therefore has contributed to the concentration of manufacturing activities that were reported in the previous sections.

The in-depth analysis of the production integration among the members of the CE manufacturing core revealed a strong orientation towards integration with other members, i.e. a high share of 'intra-CEMC' production sharing. While the overall degree of both backward and forward production sharing is shown to be highest in the Czech Republic and in Slovakia, the focus on intra-CEMC production integration is most pronounced in Austria. Another important aspect in the pattern of production integration is that Germany and Austria – in stark contrast to the Visegrád countries – are characterised by relatively stronger forward production integration than backward integration. This suggests that the role of Germany and Austria in the CE manufacturing core is primarily that of suppliers of specialised inputs, i.e. the role of technology providers. At the same time, however, it is also clear that the importance of Austria, both as a supplier of inputs for other CE manufacturing core members' exports and as a destination for onward-processing, is very limited. Overall it therefore seems that the CE supply chain is very much driven and presumably also managed by the activities of German lead firms. In fact, Germany is the dominant source of foreign manufacturing value added in the exports of the other CE manufacturing core countries, ranging from 10% (Poland) to 13% (Austria and the Czech Republic), and it is also the country which absorbs the highest shares of manufacturing value added originating from the CE manufacturing core countries (ranging from around 7% in Slovakia to almost 10% in Austria) in its own exports.

Intra-CEMC production integration has also increased over time, with the CE manufacturing core's share in the group's overall foreign value added in exports rising from 20% in 1995 to more than 25% in 2011. This re-orientation of production sharing within the CE manufacturing core occurred between 1995 and 2004. Since then the development has been more or less flat. So it seems that the crisis has not left its trace on the geographic orientation of international backward production integration – at least not yet.

Looking at the industry dimension, the transport equipment industry, the electronic equipment industry, the metallurgy industry, including metals and metal products, the machinery industry and the chemical industry emerge as the key drivers of international production sharing. This result is based on these sectors' contributions to the economy-wide foreign value added in exports and their contributions to domestic value added embodied in foreign exports.

When trying to explain the factors that determine international production sharing, we find that – in line with the notion of a production-investment-services nexus – (inward) FDI in the manufacturing sector is associated with higher degrees of production integration. Moreover, lower relative wages and geographic proximity to Germany seem to foster production integration, which is in line with the central result in this report – that Germany is indeed at the heart of the CE manufacturing core. The econometric evidence also suggests that some of the factors explaining international production sharing, such as the level of export sophistication, have different effects for the members of the CE manufacturing core as compared to the other EU countries. On average, EU Member States' higher export sophistication is associated with a lower degree of international production integration. The opposite, however, is true for the average CE manufacturing core country where the interaction term is positive and considerably larger than the main effect. Our explanation for this pattern is that while higher export sophistication reduces the need for imported inputs (reducing both FVAiT and GVC), a certain level of export sophistication – which reflects a country's production capabilities – is needed in order to serve as a partner in international production networks.

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Appendix

A.1. Country and industry lists

Table A.1.1: List of countries in the WIOD (country abbreviations)

country code	country	group
AUT	Austria	CEMC
BEL	Belgium	Other EU-MS
BGR	Bulgaria	Other EU-MS
CYP	Cyprus	Other EU-MS
CZE	Czech Republic	CEMC
DEU	Germany	CEMC
DNK	Denmark	Other EU-MS
ESP	Spain	Other EU-MS
EST	Estonia	Other EU-MS
FIN	Finland	Other EU-MS
FRA	France	Other EU-MS
GBR	United Kingdom	Other EU-MS
GRC	Greece	Other EU-MS
HUN	Hungary	CEMC
IRL	Ireland	Other EU-MS
ITA	Italy	Other EU-MS
LTU	Lithuania	Other EU-MS
LUX	Luxembourg	Other EU-MS
LVA	Latvia	Other EU-MS
MLT	Malta	Other EU-MS
NLD	Netherlands	Other EU-MS
POL	Poland	CEMC
PRT	Portugal	Other EU-MS
ROU	Romania	Other EU-MS
SVK	Slovakia	CEMC
SVN	Slovenia	Other EU-MS
SWE	Sweden	Other EU-MS
AUS	Australia	Extra-EU
BRA	Brazil	Extra-EU
CAN	Canada	Extra-EU
CHN	China	Extra-EU
KOR	South Korea	Extra-EU
IDN	Indonesia	Extra-EU
IND	India	Extra-EU
JPN	Japan	Extra-EU
MEX	Mexico	Extra-EU
RUS	Russia	Extra-EU
USA	USA	Extra-EU
TUR	Turkey	Extra-EU
TWN	Taiwan	Extra-EU
ZROW	Rest of the World	Extra-EU

Table A.1.2: Industry classification (based on NACE Rev. 1)

WIOD No.	Industry code	Industry Description
1	AtB	Agriculture, Hunting, Forestry and Fishing
2	C	Mining and Quarrying
3	15t16	Food, Beverages and Tobacco
4	17t18	Textiles and Textile Products
5	19	Leather, Leather and Footwear
6	20	Wood and Products of Wood and Cork
7	21t22	Pulp, Paper, Paper , Printing and Publishing
8	23	Coke, Refined Petroleum and Nuclear Fuel
9	24	Chemicals and Chemical Products
10	25	Rubber and Plastics
11	26	Other Non-Metallic Mineral
12	27t28	Basic Metals and Fabricated Metal
13	29	Machinery, Nec
14	30t33	Electrical and Optical Equipment
15	34t35	Transport Equipment
16	36t37	Manufacturing, Nec; Recycling
17	E	Electricity, Gas and Water Supply
18	F	Construction
19	50	Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel
20	51	Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles
21	52	Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods
22	H	Hotels and Restaurants
23	60	Inland Transport
24	61	Water Transport
25	62	Air Transport
26	63	Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies
27	64	Post and Telecommunications
28	J	Financial Intermediation
29	70	Real Estate Activities
30	71t74	Renting of M&Eq and Other Business Activities
31	L	Public Admin and Defence; Compulsory Social Security
32	M	Education
33	N	Health and Social Work
34	O	Other Community, Social and Personal Services
35	P	Private Households with Employed Persons

A.2. Additional Results

Table A.2.1: Backward and forward production integration in the CE manufacturing core based on exports of all industries and including value added from all industries, 2011

exporting industry	Gross exports	FVAiT	VAcFE	GVC	industry's share in value of FVAiT	industry's share in value of VAcFE	industry's share in value of GVC
		in million USD				in %	
AtB	27727	5964	7401	13365	**0.8%**	**1.3%**	**1.0%**
C	15971	3084	14765	17849	**0.4%**	**2.7%**	**1.4%**
15t16	115701	29908	22965	52873	**4.0%**	**4.2%**	**4.1%**
17t18	45763	14921	15462	30383	**2.0%**	**2.8%**	**2.4%**
19	8395	2950	2897	5848	**0.4%**	**0.5%**	**0.5%**
20	21400	5859	3791	9650	**0.8%**	**0.7%**	**0.7%**
21t22	68414	16768	9930	26698	**2.3%**	**1.8%**	**2.1%**
23	47976	20649	17715	38365	**2.8%**	**3.2%**	**3.0%**
24	231357	69536	59111	128646	**9.4%**	**10.8%**	**10.0%**
25	85770	28899	16150	45049	**3.9%**	**2.9%**	**3.5%**
26	30778	7390	4432	11822	**1.0%**	**0.8%**	**0.9%**
27t28	247377	94359	57581	151940	**12.7%**	**10.5%**	**11.8%**
29	268772	80987	52619	133606	**10.9%**	**9.6%**	**10.3%**
30t33	314018	121704	86557	208261	**16.4%**	**15.8%**	**16.1%**
34t35	426179	165829	106132	271961	**22.3%**	**19.3%**	**21.0%**
36t37	50209	15008	15110	30118	**2.0%**	**2.8%**	**2.3%**
E	25733	5074	2204	7277	**0.7%**	**0.4%**	**0.6%**
F	16321	3914	2103	6017	**0.5%**	**0.4%**	**0.5%**
50	2007	438	526	964	**0.1%**	**0.1%**	**0.1%**
51	40439	5488	6201	11689	**0.7%**	**1.1%**	**0.9%**
52	6502	1019	1173	2192	**0.1%**	**0.2%**	**0.2%**
H	16797	2291	1618	3910	**0.3%**	**0.3%**	**0.3%**
60	36936	7790	5976	13766	**1.0%**	**1.1%**	**1.1%**
61	31999	6229	5511	11740	**0.8%**	**1.0%**	**0.9%**
62	17363	5493	4653	10146	**0.7%**	**0.8%**	**0.8%**
63	26851	4912	3429	8341	**0.7%**	**0.6%**	**0.6%**
64	10980	1727	1919	3646	**0.2%**	**0.3%**	**0.3%**
J	30885	3372	6084	9456	**0.5%**	**1.1%**	**0.7%**
70	3202	258	379	637	**0.0%**	**0.1%**	**0.0%**
71t74	98142	9164	11806	20970	**1.2%**	**2.2%**	**1.6%**
L	2797	296	513	809	**0.0%**	**0.1%**	**0.1%**
M	683	47	139	186	**0.0%**	**0.0%**	**0.0%**
N	1651	297	234	531	**0.0%**	**0.0%**	**0.0%**
O	8951	1431	1837	3268	**0.2%**	**0.3%**	**0.3%**
Total	**2384048**	**743055**	**548926**	**1291981**	**100.0%**	**100.0%**	**100.0%**
Memorandum					0		
Primary	*43698*	*9048*	*22166*	31214	*1%*	*4%*	*2%*
Manufacturing	*1962109*	*674767*	*470453*	1145220	*91%*	*86%*	*89%*
Construction	*25733*	*5074*	*2204*	7277	*1%*	*0%*	*1%*
Utilities	*16321*	*3914*	*2103*	6017	*1%*	*0%*	*0%*
Services	*336185*	*50252*	*51999*	*102251*	*7%*	*9%*	*8%*