

# The Age of Global Value Chains

## Maps and Policy Issues

Edited by João Amador and Filippo di Mauro



A VoxEU.org Book

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CEPR Press

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# Foreword

The study of global value chains is the only way to fully understand the nature of today's geographically dispersed production and trade. Not only do GVCs connect firms across the globe to the consumer, they also have a significant impact on the national and international economy and therefore on policy. Particularly after the Global Crisis, understanding the factors that foster GVCs, and the implications of their occurrence, has been more important than ever.

In this book, the contributing authors discuss many of these considerations, from the path of GVCs in the Eurozone, to their influence on the transmission of macroeconomic shocks.

CEPR is grateful to João Amador for his great efforts in bringing this eBook to fruition, and to the contributing authors for their valuable insights. We would also like to acknowledge the contribution of editors in conceiving the idea and finalising the eBook, as well as Charlie Anderson, Anil Shamdasani and Shreya Sinha for working on its publishing and launch processes.

CEPR acknowledges that the contents of this eBook reflect the views only of the authors, and they do not necessarily coincide with those of the institutions to which they are affiliated. CEPR, which takes no institutional positions on economic policy matters, is delighted to provide a platform for an exchange of views on this topic.

Tessa Ogden  
Deputy Director, CEPR  
July 2015

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# Introduction

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## **João Amador and Filippo di Mauro**

Banco de Portugal; European Central Bank

*Competitiveness is a wide and elusive concept that is more present than ever in economic policy debates. From a macroeconomic perspective, the existence of significant global imbalances, very low inflation and the pervasiveness of high indebtedness ratios in several economies have brought slow growth prospects to the forefront of economic concerns. However, in an ever more globalised world, the link between growth and cross-border economic relations is unavoidable. From a microeconomic perspective, firms play the leading role in the quest for improved economic performance. In this context, the modern organisation of the production processes and the role of imports for successful exporters become crucial dimensions of analysis. Both the macro and micro perspectives have thus brought international trade and, in particular, global value chains (GVCs) to the centre of the competitiveness debate.*

*Against this backdrop, in March 2012 the Eurosystem established the Competitiveness Research Network (CompNet) with participants from EU national central banks, as well as from international organisations interested in competitiveness issues. CompNet was created with a view to studying drivers and indicators of competitiveness in EU countries and firms, taking a holistic approach. Within CompNet, one workstream has focused on GVCs, and short versions of the resulting papers constitute the backbone of this eBook. In a nutshell, the eBook aims to contribute to the policy and academic debates on GVCs, both in terms of their mapping and their policy implications.*

## **1 Global value chains: Definition and scope**

Global value chains (GVCs) – referring to the cross-border flows of goods, investment, services, know-how and people associated with international production networks – have transformed the world. Their emergence has resulted in a complete reconfiguration of world trade in terms of participants and comparative advantages. Therefore, in order to assess a country’s degree of competitiveness and the impact of economic policies, it is now fundamental to take into account the cross-border dimension of production processes.

The economic literature has adopted different terminologies. A general definition, adapted from the Global Value Chain Initiative at Duke University, states that “[a] global value chain describes the full range of activities undertaken to bring a product or service from its conception to its end use and how these activities are distributed over geographic space and across international borders.” (DFAIT 2011, p.86). The international trade literature has referred to this phenomenon using a wide range of terms, including ‘vertical specialisation’, ‘outsourcing’, ‘offshoring’, ‘internationalisation of production’, ‘international production sharing’, ‘disintegration of production’, ‘multi-stage production’, ‘intra-product specialisation’, ‘production relocation’, ‘slicing up the value chain’, and ‘international segmentation of production’. Nevertheless, international trade theorists tend to call it ‘fragmentation’, a term originally proposed by Jones and Kierzkowski (1990).

GVCs have become the paradigm for the production of most goods and services around the world. Production is nowadays vertically fragmented across different countries, i.e. parts and components are produced in distinct locations and are assembled either sequentially along the supply chain or in a final location. The networks that operate GVCs are highly complex, involving firms in manufacturing, logistics, transportation and other services, as well as customs agents and other public authorities. Supply-chain trade is determined by input costs, unbundling costs and technology, which also shape how the different stages of production are linked. The importance of GVCs has

been steadily increasing in the last decades and, as reported in UNCTAD's 2013 World Investment Report, about 60% of global trade consists of trade in intermediate goods and services, which are then incorporated at different stages of production. The prevalence of GVCs in the world economy impacts strongly on trade and labour markets, but also on issues such as inequality, poverty and the environment. At present, even the measures that usually inform the policy debate, such as bilateral trade balances, export market shares or real exchange rates, need to be redefined in order to disentangle the domestic and foreign value added embodied in trade flows.

## **2 Structural changes in global production: A brief historical digression**

There is a vast literature detailing how and why production has become more and more integrated across the world. Globalisation is often considered to be a process that has taken place gradually over the past few centuries and that has involved a regular and steady fall in trade costs. Until the late 19th century, the production of goods was very much a local affair, with inputs, factors of production and markets being at only a marginal distance from one another. It was only after the 'steam revolution' that railroads and steamships started to be used for the transportation of goods, making the sale of excess production to other geographical areas feasible and profitable thanks to the exploitation of economies of scale. Baldwin (2006) refers to this as the first 'unbundling', i.e. the process that enabled production to be separated from consumption. The transport revolution did not affect all regions of the world in the same way. It had a positive impact on northern countries (Europe, North America and Japan), triggering a self-sustaining cycle of production and growth, but developing nations did not participate in industrialisation.

This transport revolution, while making trade cheaper and at the same time favouring large-scale production, led to the local clustering of production in factories and industrial areas. The geographical proximity of various stages of production made it easier to coordinate increasingly complex production processes and to minimise the associated

coordination costs. Due to coordination costs, proximity was very important up until the mid-1980s. It was only then that the information and communication technology (ICT) revolution made it possible to reduce those costs by enabling complexity to be coordinated at a distance. Thanks to the sharp progress in ICT, not only could consumption be separated from production, but production could also be broken up. The possibility of relocating the different stages of production theoretically enabled different tasks within a production process to be performed by geographically dispersed production units. This was termed the 'second unbundling' in international trade, leading to the sharing of production between developed and developing economies from the mid-1980s onwards.

The main reason for the offshoring of certain stages of production was the large wage differences between developed and developing countries. Thanks to production sharing, the latter countries had a wider choice of options available for diversification, industrialisation, growth and development. Whereas previously only countries with a well-functioning infrastructure and efficiently integrated production processes could participate in the global economy, developing countries could now join the existing global supply chains by specialising in certain stages of the production process, typically the most labour-intensive ones (for a discussion, see Baldwin 2014). The relocation of these stages of manufacturing to developing countries fostered high growth rates in emerging markets and was further enhanced by domestic policies aimed at attracting foreign capital. As a consequence, the 'second unbundling' reversed the previous industrialisation/non-industrialisation pattern prevalent in developed and developing countries. This change of fortunes represents one of the biggest economic transformations of the last decades and it reshaped, and will continue to shape, the balance of power in both international and economic relations.

### **3 Input-output matrices and measures of value added trade**

The emergence of GVCs has extended the use of input-output (I-O) matrices, enabling the impact of interdependencies between industries to be addressed across different countries. Two main strands of literature have emerged. A number of papers measure the foreign content of domestic production by evaluating the share of directly imported inputs in production or in total inputs. Feenstra and Hanson (1996) were the first to suggest and compute this measure, which has been used extensively in different formats. The second strand of the literature instead places emphasis on the direct and indirect import content of exports. This measure has been labelled ‘vertical specialisation’ after its initial formulation by Hummels et al. (2001), and it is suitable for capturing situations where production is carried out in two or more countries and the goods cross international borders at least twice. The second approach is narrower in that it adds the condition of having some of the resulting output exported but it is more comprehensive since it also includes the imported inputs indirectly used in the production of exports.

The availability of global I-O matrices led to methodological contributions on new metrics of GVCs. Several recent articles generalise the concept of ‘vertical specialisation’ and capture different dimensions of value added embedded in trade. The initial studies on the measurement of the value added of trade in a global I-O framework were those of Johnson and Noguera (2012), Daudin et al. (2011) and Koopman et al. (2014).

In spite of substantial progress in recent years, there are still important gaps in the availability of I-O tables. Most of them include a rather limited sectoral breakdown, which cannot fully account for the complexity of the real production processes. Moreover, because I-O analysis assumes fixed technical coefficients, it does not allow for substitution between inputs and therefore assumes proportionality and constant returns to scale for all sectors. The Appendix of this eBook, by Bart Los and Marcel Timmer, presents the structure of global I-O matrices, the details of the World Input-

Output Database (WIOD), which is used to derive results in several chapters, as well as the methodology that underlies the calculation of several GVC-based indicators.

#### **4 The organisation of the book**

This book is organised in three parts. The chapters in the first part map GVCs along different dimensions. The simplest exercise involves computing measures of participation in GVCs and examining their evolution over time and across countries and sectors. Chapter 1, by **João Amador, Rita Cappariello and Robert Stehrer**, initially focuses on the comparison of value added flows in the Eurozone taken as a whole with those of other large trade blocks like the US, China and Japan. The chapter also looks at regional linkages, i.e. intra-Eurozone value added flows. In addition, European countries are examined individually and their role in GVCs is considered. The chapter finds an increasing trend in GVC participation in the Eurozone as a whole, which is comparable to that of other major world economic blocks. The analysis also shows that the Eurozone is still the main source of foreign value added in exports for most of its member countries.

A closely related approach involves assessing whether the expansion of GVCs exhibits regional or global patterns. Chapter 2, by **Bart Los, Marcel Timmer and Gaaitzen de Vries**, concludes that value chains have become considerably more global in nature since 2003. Increasing shares of the value of a product are added outside the region to which the country-of-completion belongs. Regional blocs like ‘Factory Europe’ are still important, but the construction of ‘Factory World’ is progressing rapidly.

A complementary analysis is to look at GVCs from the perspective of inputs used and their cost. Chapter 3, by **Bart Los, Marcel Timmer, Robert Stehrer and Gaaitzen de Vries**, examines the factor content of the production process and the compensation share of capital and different labour qualifications. The findings tell a story in which firms in mature economies relocate their unskilled labour-intensive production activities to lower-wage countries, while keeping strategic and high value added functions

concentrated at home where the skilled workers and intangible capital they need are available.

Another type of mapping draws on network theory, focusing on the visual representation of the major links of value-added flows between countries across time. This methodology is used in Chapter 4 by **João Amador and Sónia Cabral**, which confirms that larger countries play a vital role in GVCs, whose regional dimension is still dominant but is progressively giving place to a more global network. Moreover, manufacturing GVCs outpace those of services. At the country level, the central role of Germany and the US and the rising importance of China are also results derived from the analysis.

Chapter 5, by **Gianluca Santoni and Daria Taglioni**, takes the perspective of entry and upgrading in GVCs, combining network metrics and other explanatory variables. The chapter shows that being well integrated with suppliers that are in turn well integrated in GVCs is what matters most in terms of export outcomes and value added embodied in exports. Another result is that the key centres of technology and value added are Japan, the US and Germany/the EU, while Korea and China remain more peripheral.

Finally, the mapping of GVCs has a correspondence with the linkages established between multinational corporations and international business groups. Chapter 6, by **Carlo Altomonte, Italo Colantone, Armando Rungi and Tommaso Sonno**, builds on a dataset on multinational groups to investigate the relationship between the location decisions of business groups, their characteristics and value added flows. It concludes that the presence of multinational business groups at the bilateral country/industry level tends to correlate strongly with value added trade flows.

The second part of this eBook turns to the impacts of GVCs on several economic dimensions. The implications of GVCs for the way economists interpret macroeconomic developments and, ultimately, economic policy decisions are numerous and challenging. For instance, indicators such as revealed comparative advantage and real effective exchange rates are usually based on the measurement of trade in gross terms. However, the concept of ‘country of origin’ is increasingly difficult to apply, as the various

production operations are spread across the world. In fact, a country may appear to be a large exporter of a specific good relative to the world average without having contributed much value added to its production. As a result, the analysis of a country's export potential, competitiveness and labour market developments needs to take into account its integration in GVCs.

Chapter 7, by **João Amador and Sónia Cabral**, broadly surveys the empirical research on the impacts of GVCs on employment, wages and productivity. It finds that the rise of outsourcing accounts for a relevant part of the increase in the relative demand for skilled labour in developed countries. In addition, with regards to the overall effect on the level of employment, the numbers at the industry level seem small but they hide differences across skill categories and individual firms. Concerning productivity, studies using industry-level data tend to conclude that offshoring positively affects productivity, though firm-level data studies have so far found only mild evidence.

The recent global crisis showed that GVCs affect the magnitude and the international transmission of macroeconomic shocks. During this period, the collapse in global trade was severe, synchronised across the world, and particularly pronounced for trade in capital and intermediate goods. Several transmission mechanisms were at play, but GVCs appear to have had a central role in the transmission of what was initially a demand shock in some markets along with a severe credit shortage. Chapter 8, by **Arne Nagengast and Robert Stehrer**, shows that changes in vertical specialisation contributed substantially to the decline in value added trade during the crisis, and also highlights the importance of changes in the composition of final demand. Furthermore, in stark contrast to gross exports, both services and manufacturing sectors were strongly affected by the collapse in value added trade.

The increasing importance of GVCs has also changed the relationship between trade flows and aggregate macroeconomic dynamics, which constitutes a challenge for traditional macro models. Chapter 9, by **Alexander Al-Haschimi, Frauke Skudelny, Elena Vaccarino and Julia Wörz**, focuses on the importance of GVCs for the elasticity

of global trade to income and estimates an import demand function augmented by measures of GVC integration. Results suggest that the demand elasticity tends to be higher for emerging than for advanced economies. In addition, the import demand reacts more strongly when it is accompanied by stronger GVC participation, both in advanced and emerging economies.

Chapter 10, by **Konstantins Benkovskis and Julia Wörz**, examines the impact of GVCs on global market shares – a classical macroeconomic variable that is commonly associated with external performance. The chapter concludes that shifting the focus from traditional gross exports to value added in export market shares does not change the result that new EU countries are gaining market shares at the expense of old EU members. However, accounting for GVC participation reveals that price factors are more important in explaining such changes. In addition, although there is evidence of catching-up in the relative quality of production by the new EU member states, improvements in the relative quality of their exports often owe to the outsourcing process.

The pervasiveness of GVCs has a relevant impact in the interpretation of global imbalances. Accounting for trade in intermediate inputs does not change the overall trade balance of an individual country with the rest of the world. Nevertheless, the consideration of GVCs implies a redistribution of trade surpluses and deficits across partner countries. When bilateral trade balances are measured in gross terms, a deficit with an exporter of final goods can be overstated because it is affected by the value of inputs supplied to this exporter by third countries. In policy terms, under a scenario of persistent trade deficits, the pressure to rebalance increases the risk of protectionist responses, which could hit countries at the end of the GVC on the basis of an inaccurate perception of the origin of trade imbalances. Chapter 11, by **Arne Nagengast and Robert Stehrer**, presents a decomposition of imbalances that takes into account the impact of demand in third countries. It shows that a sizeable and increasing share of intra-EU gross bilateral trade balances was due to demand in countries other than the two trading partners.

The third part of the eBook takes the perspective of firms in a world of GVCs. The operation and organisation of GVCs mostly relates to the ability of firms to incorporate value added originating from different sources and sell their products for further transformation or final consumption, more than to the concept of comparative advantage applied at the aggregate sector-country dimension. The increasing availability of databases containing firm-level information and, ideally, firm-to-firm transactions will expand the research frontier in GVC research.

Chapter 12, by **Iulia Siedschlag and Gavin Murphy**, examines the extent and determinants of firms' engagement in outward international activities associated with global value chains. The empirical evidence indicates that, in the group of firms with outward international activities, a large number are only exporters, while a small number engage either in international sourcing or in foreign direct investment. Just a few firms engage simultaneously in more than one type of outward international activity. These firms are more mature, larger, more productive, and have higher product innovation rates.

The relationship between financial frictions and firms' exports and multinational activity is discussed in Chapter 13 by **Kalina Manova**, drawing on recent findings in the literature. These findings suggest that financial considerations govern the location and network decisions of multinational companies. One implication is that, *ceteris paribus*, stronger financial institutions in the host economy lower multinationals' incentives to pursue foreign direct investment for horizontal motives, and instead favour vertical and export-platform motives. The literature also suggests that credit-constrained firms might be stuck in low value added stages of GVCs and unable to pursue more profitable opportunities, raising the possibility that strengthening capital markets might be an important prerequisite for moving into higher value added, more profitable activities.

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# Part I

## Mapping global value chains

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# Foreign value added in Eurozone exports<sup>1</sup>

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*This chapter initially focuses on a comparison of value added flows in the Eurozone, taken as a whole, with those of other large trade blocs such as the US, China and Japan. The chapter then looks at regional linkages, i.e. intra-Eurozone value added flows, and the roles of individual European countries in global value chains are considered. The analysis covers the period between 2000 and 2011, i.e. the years just after the creation of the Eurozone, the eve of the crisis, the Great Trade Collapse and, finally, the subsequent rebound of international trade.*

## **1 External Eurozone linkages**

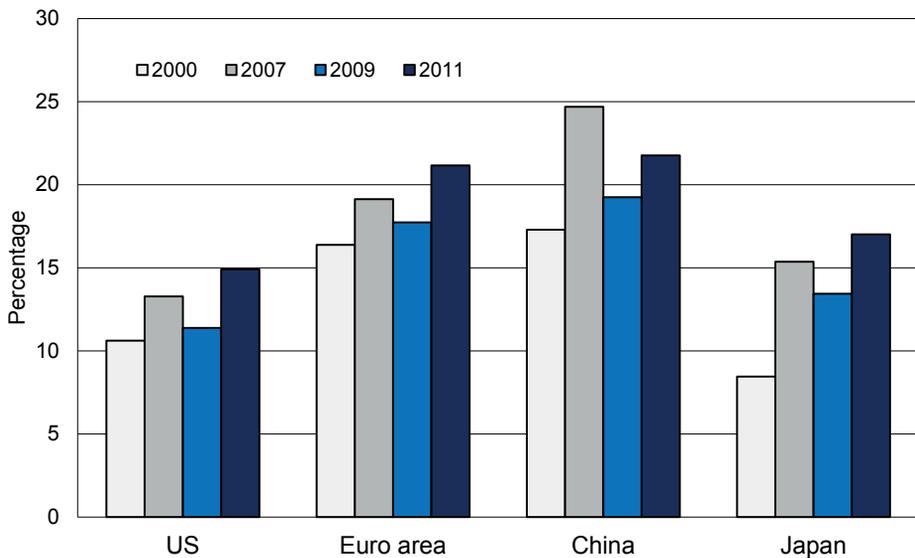
The identification and measurement of production linkages is a key issue for policy assessment, especially for highly integrated economies such as those in the Eurozone. The economic adjustment mechanisms in the monetary union as a whole are similar to those operating in the other major economic blocs (the US, China, Japan) because exchange rates are fixed and other dimensions of regional integration are strong. Figure 1 presents the foreign value added in exports<sup>2</sup> for these major economic blocs, with the Eurozone taken as a whole (i.e. excluding intra-regional trade). In the last decades, the

1 The analysis presented in this chapter borrows heavily from Amador, J, R Cappariello and R Stehrer (2015), "Global Value Chains: A View from the Euro Area", *Asian Economic Journal*, 29(2), pp. 99-120. The views expressed in the chapter are those of the authors and do not necessarily correspond to those of Banco de Portugal, Banca d'Italia or the Eurosystem.

2 The Appendix of this book includes an explanation of this indicator and describes the WIOD database, which is used in this and other chapters.

Eurozone has become more integrated into global value chains (GVCs). The foreign production linkages of the monetary union are comparable in magnitude to those of the other trade blocs, including China. In 2011, the share of foreign value added in Eurozone exports stood at 21.2% of total exports, a markedly higher percentage than that for the US and Japan, and similar to that for China.

**Figure 1.** Foreign value added in exports in major economies, as a percentage of total exports



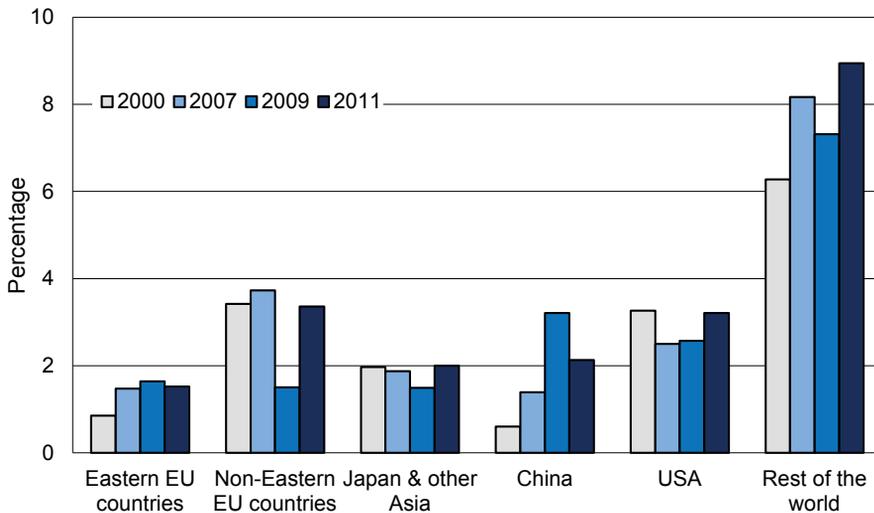
Note: The Eurozone is taken as a whole, i.e. intra-Eurozone trade flows are eliminated.

In addition to the increasing trend in the share of foreign value added in exports over the 11-year period under analysis, the integration of the Eurozone into GVCs shows different dynamics across the three different sub-periods. After the introduction and strengthening of the euro and the opening up of the Chinese economy to world trade, the Eurozone's participation in global production increased substantially. This pattern is common to the world's main economies. In 2008, the Great Trade Collapse was accompanied by a fall in foreign value added in the exports of all economic blocs, especially in the case of China. The high sensitivity of Chinese GVCs to this shock and the comparatively higher resilience of international supply chains in the Eurozone

after the rebound in world trade may point towards different natures of the production linkages prevailing in these economies.

The decomposition of foreign value added by country of origin provides interesting information on the production linkages of the monetary union with other country groups (Figure 2). The eastern EU countries increased their relevance as sources of value added in Eurozone exports, at least until 2009. The strengthening of supply chains with eastern economies has been driven by increasing investment flows from Eurozone multinational firms into these countries, which became EU members in either 2004 or 2007. Nevertheless, between 2000 and 2011, Chinese value added in Eurozone exports recorded such a significant increase that it surpassed that of eastern EU countries. The fall in the share from non-eastern EU countries (the UK, Denmark and Sweden) during the trade collapse was temporary and may have been the result of important exchange rate shifts. ‘Japan and other Asia’ and the US show a stable relevance as sources of value added for Eurozone exports, while the ‘Rest of the world’, which includes oil producers, displays an increase, mostly reflecting the rise of energy prices during the period.

**Figure 2.** The Eurozone as whole: Foreign value added in exports by origin



*Note:* Eastern EU countries: Bulgaria, Czech Republic, Hungary, Lithuania, Latvia, Poland and Romania; non-eastern EU countries: The UK, Denmark and Sweden; Japan & other Asia: Japan, Indonesia, India, Korea and Taiwan.

Other important insights regarding the nature of the participation of the world’s major economic blocs in GVCs come from the ‘Re-exported domestic value added in imports’ indicator, presented in Table 1. This is a rough measure of a country’s involvement in upstream stages of a global supply chain, i.e. its involvement in the initial phases of the production chain. These stages can refer to very different kinds of activities, from the production of raw materials to design and R&D. When compared with China and, mostly, Japan, the Eurozone shows a stronger involvement in upstream stages of global supply chains. The scale of the Eurozone economy, the types of products exported and the organisational choices of Eurozone’s firms are key determinants for this relatively high share of value added re-imported from extra-Eurozone countries. A remarkable result from Table 1 is that between 2000 and 2011, China experienced a progressive ‘upstreamness’ of its exports.<sup>3</sup>

**Table 1** Indicators of value added in trade for the Eurozone as a whole

	Foreign value-added in exports (FVAiX) % extra area exports				Domestic value-added in imports (DVAiM) % extra area imports				Re-exported value-added in imports (RDVAiM) % of extra area exports			
	2000	2007	2009	2011	2000	2007	2009	2011	2000	2007	2009	2011
Euro zone	16.4	19.1	17.7	21.2	6.0	7.1	6.1	5.7	1.0	1.4	1.1	1.2
USA	10.6	13.3	11.4	14.9	8.2	5.6	4.9	4.6	0.9	0.7	0.6	0.7
China	17.3	24.7	19.3	21.8	1.2	3.0	3.1	3.2	0.2	0.7	0.6	0.7
Japan	8.5	15.4	13.4	17.0	2.6	2.1	1.7	1.5	0.2	0.3	0.2	0.3

*Note:* Domestic value added in exports from row country to column country, as a percentage of total intra-Eurozone value added trade. Cells above 2% are shaded in light grey, and those above 4% in dark grey.

## 2 Internal Eurozone linkages

When focusing on Eurozone’s regional supply linkages, we have to restrict the analysis to intra-Eurozone trade of internally generated value added. However, when analysing the results for the production linkages existing inside the Eurozone, we cannot forget

<sup>3</sup> For a more precise and elaborate measure of upstreamness, see Antràs et al. (2012).

that some of these internal value added flows would not exist in reality if extra-Eurozone trade were not present.

Table 2 provides a complete map of the flows of value added that were traded between country-pairs in the Eurozone in 2011. The geographical decomposition of each country's value added exported to the Eurozone is presented by row. Therefore, the marginal distribution as reported in the rows represents the share of a country as a supplier of value added, while the marginal distribution reported in the columns represents the share of the country as a user of value added. Germany plays the largest role in the internal Eurozone linkages, representing 28.8% of total Eurozone value added supplied, through exports, within the Eurozone and 23.0% of value added consumed. Other large suppliers – namely, France, the Netherlands and Italy – come somewhat behind Germany. When looking at the users of intra-Eurozone value added, the ranking changes, with France, Italy and Spain following Germany. Unsurprisingly, the key bilateral linkage lies between Germany and France, with each being the other's main client and supplier.

There is another set of results that emerges from Table 2. The difference between countries' marginal distributions reported in the respective rows and columns can be interpreted as a proxy for the 'bilateral balances of trade in value added' within the Eurozone. These numbers suggest that Germany runs a 'surplus in trade of value added' within the Eurozone. A similar position is found for Netherlands, whereas France shows a deficit. The similar magnitudes of shares in value added supplied and consumed within the Eurozone for Spain and Italy in 2011 suggest a position close to balance and a very small deficit, respectively.

**Table 2** Breakdown of intra-Eurozone value added flows, bilateral linkages, 2011 (%)

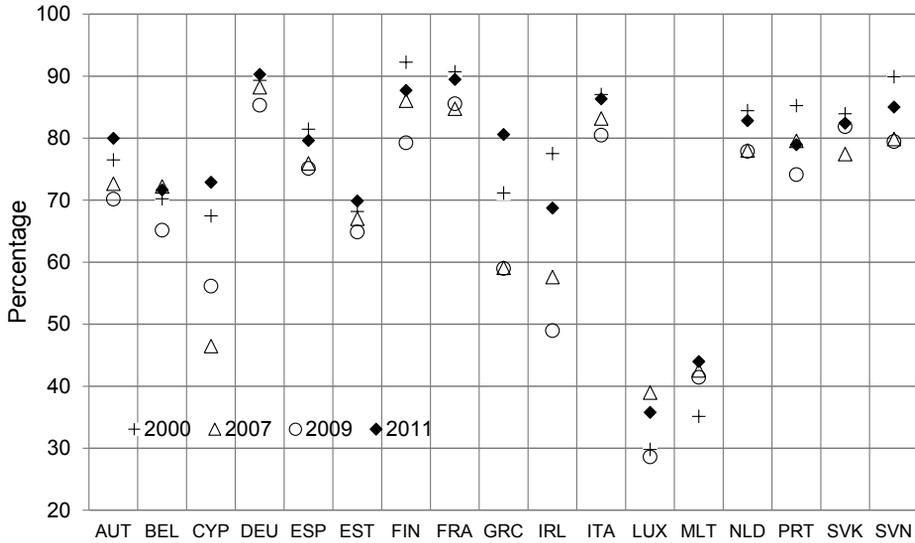
To:	Aut	Bel	Cyp	Deu	Esp	Est	Fin	Fra	Gre	Irl	Ita	Lux	Mlt	Nld	Prt	Svk	Svn	Euro zone
From:																		
<b>Aut</b>	-	0.2	0.0	2.6	0.2	0.0	0.0	0.3	0.0	0.0	0.7	0.1	0.0	0.1	0.0	0.1	0.1	4.4
<b>Bel</b>	0.2	-	0.0	2.2	0.6	0.0	0.1	1.8	0.1	0.1	0.8	0.4	0.0	1.5	0.1	0.0	0.0	8.0
<b>Cyp</b>	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
<b>Deu</b>	4.0	2.8	0.0	-	2.8	0.1	0.7	7.2	0.5	0.5	4.9	0.5	0.0	3.4	0.5	0.6	0.2	28.8
<b>Esp</b>	0.2	0.6	0.0	2.2	-	0.0	0.1	2.9	0.2	0.2	1.7	0.2	0.0	0.6	1.4	0.0	0.0	10.3
<b>Est</b>	0.0	0.0	0.0	0.0	0.0	-	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
<b>Fin</b>	0.0	0.1	0.0	0.5	0.1	0.1	-	0.1	0.0	0.0	0.1	0.0	0.0	0.2	0.0	0.0	0.0	1.3
<b>Fra</b>	0.3	1.9	0.0	4.9	2.7	0.0	0.1	-	0.2	0.3	2.6	0.3	0.0	1.0	0.3	0.1	0.1	14.8
<b>Gre</b>	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	-	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.3
<b>Irl</b>	0.0	0.2	0.0	0.6	0.3	0.0	0.0	0.3	0.0	-	0.3	0.0	0.0	0.2	0.0	0.0	0.0	2.0
<b>Ita</b>	0.7	0.6	0.0	4.1	1.7	0.0	0.1	3.1	0.5	0.2	-	0.1	0.1	0.5	0.2	0.1	0.2	12.2
<b>Lux</b>	0.0	0.2	0.0	0.2	0.0	0.0	0.0	0.2	0.0	0.0	0.1	-	0.0	0.0	0.0	0.0	0.0	0.9
<b>Mlt</b>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.1
<b>Nld</b>	0.2	3.0	0.0	4.2	1.0	0.0	0.3	1.4	0.2	0.3	1.5	0.1	0.0	-	0.2	0.1	0.0	12.5
<b>Prt</b>	0.0	0.1	0.0	0.3	0.7	0.0	0.0	0.3	0.0	0.0	0.1	0.0	0.0	0.1	-	0.0	0.0	1.7
<b>Svk</b>	0.2	0.0	0.0	0.5	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.0	-	0.0	1.2
<b>Svn</b>	0.2	0.0	0.0	0.5	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	-	1.2
<b>Euro zone</b>	6.1	9.9	0.2	23.0	10.1	0.2	1.7	18.0	1.9	1.8	13.2	1.7	0.2	7.6	2.8	1.1	0.7	100.0

Note: Domestic value added in exports from row country to column country, as percentage of total intra-euro area value added trade. Cells above 2% are shaded in light grey and above 4% in dark blue.

The analysis of the sectoral dimension of intra-Eurozone production linkages from 2000 to 2011 is also relevant, because GVCs are inherently linked with input-output relations. Although it would be possible to detail the flows of value added between Eurozone countries across a large number of sectors, such an analysis is mostly suited for country- or industry-specific studies. Instead, in this section we put forward simple results regarding the manufacturing and services sectors. The share of manufacturing in total foreign value added in exports decreased in many countries, especially in the period between 2007 and 2009. This path reveals the resilience of services and the increasing importance of these activities in the overall functioning of European GVCs. Luxembourg and Malta exhibit the largest share of value added produced in the services sector to other Eurozone economies, while Germany shows the largest share of value added in manufacturing supplied to other Eurozone countries (Figure 3). Conversely,

more than half of the value added moving from most Eurozone countries into Ireland and Luxembourg corresponds to services. The position of Ireland and Luxembourg as users of services in the Eurozone is consistent with their roles as a location for headquarters of multinational corporations (Ireland) and as a financial centre (Luxembourg).

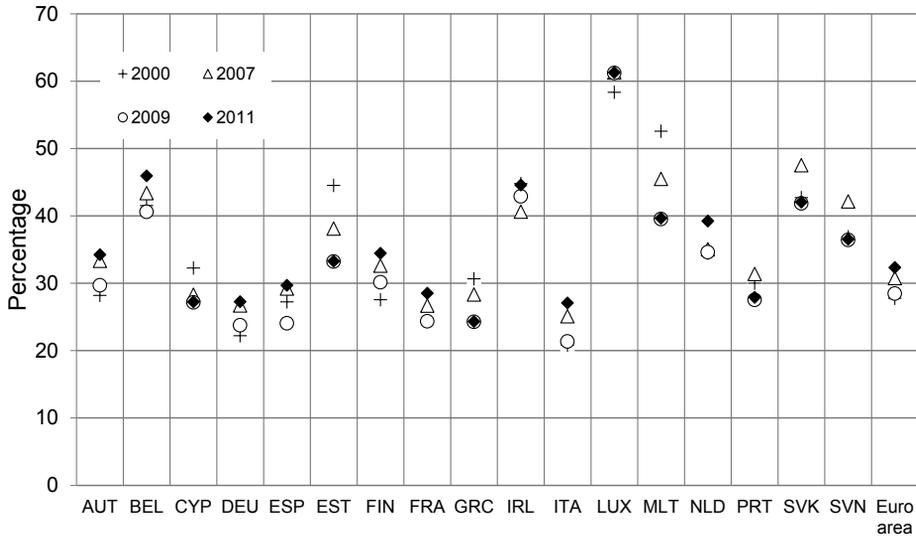
**Figure 3.** Share of manufacturing in value added exported to the Eurozone, 2000-2011



### 3 Global value chains for individual Eurozone countries

Taking individual Eurozone countries as they are usually treated, i.e. as autonomous countries trading with both intra- and extra-Eurozone countries, substantial heterogeneity emerges (Figure 4). The foreign value added content of Eurozone countries' exports generally increased from 2000 to 2011, with some exceptions. Finland, Austria, Italy and Germany experienced a strong growth in the foreign content of exports, while Greece, Cyprus and Portugal witnessed a significant reduction. The figure confirms, at the individual country level, the cyclical pattern observed for the major trade blocs, i.e. the growth of foreign content of exports during the 2000s, the drop during the Great Trade Collapse, and the rebound after it.

**Figure 4.** Foreign value added in exports, 2000-2011 (% of gross exports)



Regarding the nature of the participation of single countries in supply chains, the re-exported domestic value added in imports is generally low, with the notable exception of Germany and, to a less extent, the Netherlands (Figure 5). The comparatively higher value for Germany is partially explained by its specialisation in the production of transport equipment and the organisational choices of German firms in this sector. In fact, over the last two decades developments in the German automobile industry have deviated somewhat from developments in the global car industry, where assembly stages have largely been kept close to consumption markets, mainly to facilitate penetration and reduce transport costs. Although there is strong global and regional integration in the acquisition of parts and components, the delocalisation of the last stages of production in Germany’s automobile industry, before delivery to the final consumer, is relatively weak compared with the automobile industries of other countries. The orientation of the German car industry towards high-quality segments – signalled by labelling ‘made in Germany’ or, as we could more correctly say, ‘completed in Germany’ – may explain the organisational choices of these firms, whose initial and final stages of production are located in the country (Timmer et al. 2013). For this reason, the measure of foreign

value added in exports for Germany is in line with those for Italy and France, but German re-exported domestic value added in imports is higher.

**Figure 5.** Re-exported domestic value added in imports, 2000-2011

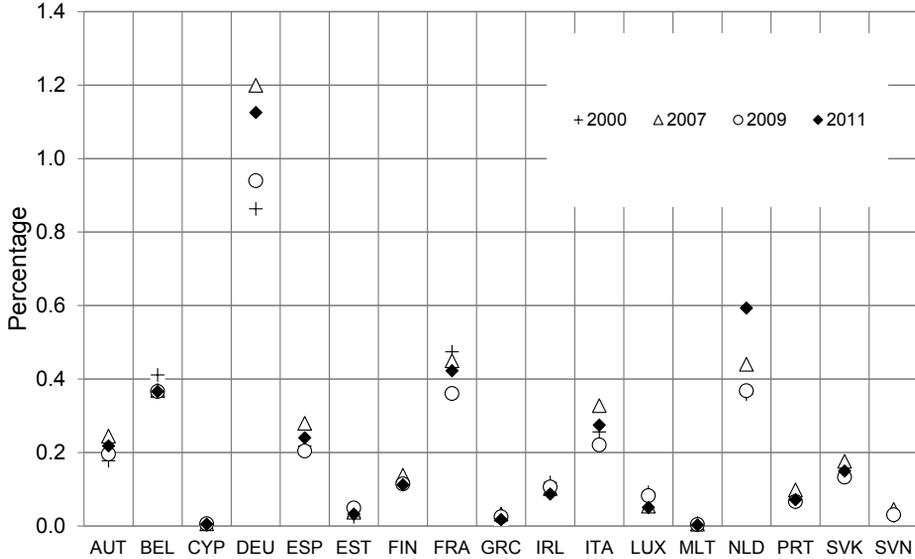
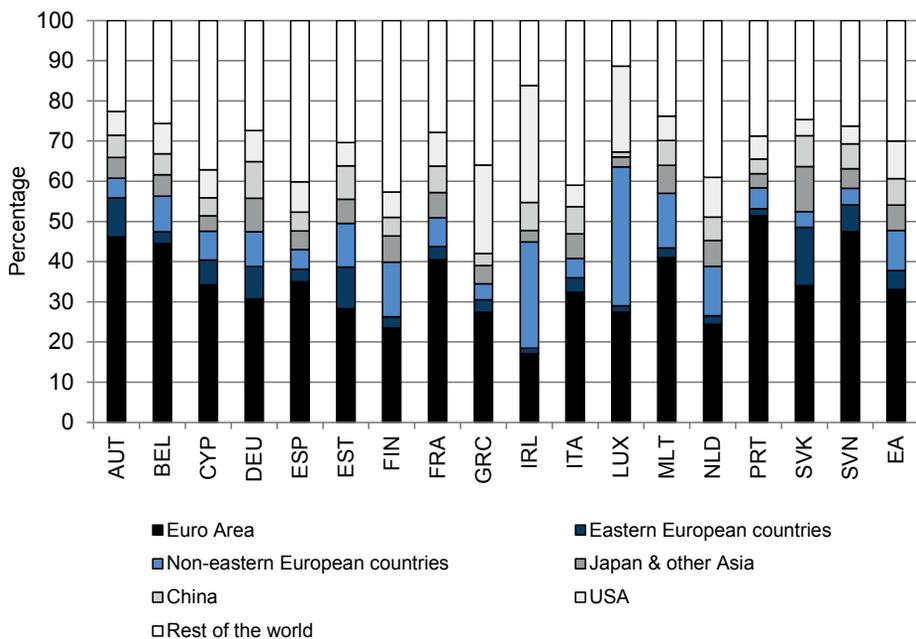


Figure 6 decomposes the foreign value added in the exports of each Eurozone country by main geographic origins in 2011, with two main results emerging. First, the share of the other Eurozone countries as a source of value added is typically highest, i.e. the Eurozone is, in most cases, the dominant part of the global value chains for each individual member. In 2011, about 11% of Eurozone countries' exports, on average, was sourced inside the Eurozone (a stable number with respect to 2000). Second, at least for the largest economies, the growing relevance of external suppliers (and the consequent increase of foreign value added in exports) does not reflect a weakening of the production links within the Eurozone, but instead a substitution of each country's domestic value added by extra-Eurozone sourcing (for an analysis of the regional versus global nature of GVCs, see Chapter 2). It is also important to refer to the role of China as a source of value added in Eurozone countries. Although China is widely considered to be a key part of global value chains, for around half of the Eurozone countries it

represents less than 6% of value added in total exports. Nevertheless, China’s relevance as input provider increased rapidly in the period under analysis, with a slowdown only in 2009. In 2011, the value added sourced from China and embodied in Eurozone exports was larger than that coming from the eastern EU economies, similar to that of ‘Japan & other Asia’, but still lower than that of the US.

**Figure 6.** Decomposition of foreign value added in exports by origin, 2011 (% of total foreign value added in exports)



#### 4 Final remarks

This chapter has revealed an increasing trend in the share of foreign value added in exports in the Eurozone as a whole, and also in the world’s other major economic blocs, with a cyclical pattern during the Great Trade Collapse. In 2011, the foreign production linkages of the Eurozone were comparable in magnitude to those of other important trade blocs, including China. The high relevance of GVCs in the Eurozone, measured by the share of foreign value added in exports, is accompanied by their comparatively stronger resilience in the face of the trade collapse. In addition, the

bilateral intra-Eurozone value added flows make it clear that Germany plays a core role in such production linkages, notably with France. Moreover, manufacturing retains a dominant role in most of these linkages. The analysis also shows that the Eurozone is still the main source of foreign value added in exports for most member countries. In other words, the growing relevance of suppliers that are external to the Eurozone does not reflect a weakening of the production links within the monetary union, but instead a substitution of each country's domestic value added by extra-Eurozone sourcing.

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# Global value chains: 'Factory World' is emerging

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*Are global value chains truly global, or does the omnipresent use of the adjective 'global' give a wrong impression? Baldwin and Lopez-Gonzalez (2014) suggest this. They use data on international trade in intermediate products and conclude that "[t]he global production network is marked by regional blocs, what could be called Factory Asia, Factory North America, and Factory Europe". Analyses of gross export flows, however, can be highly misleading due to double-counting of trade in intermediate inputs (see Koopman et al. 2014). In this chapter, we introduce a novel indicator for the international fragmentation of value chains that does not suffer from this problem. Our indicator quantifies characteristics of one or more value chains, as opposed to the foreign value added in exports indicator used in Chapter 1 of this eBook by Amador, Cappariello and Stehrer, which focuses on the role of one or more countries in the full network of international trade flows.<sup>1</sup> Using our indicator and the World Input-Output Database, we show that fragmentation across regional blocs increased much more in the 2000s than fragmentation within these blocs. This result is in line with the conclusion of Amador et al. for the EU in Chapter 1, who state that domestic value added has mainly been substituted by value added outside the EU. Furthermore, our findings suggest that the Global Crisis has not caused more than a temporary hiccup in this tendency. We conclude that global value chains are really becoming global, although regional linkages in value chains cannot be neglected.*

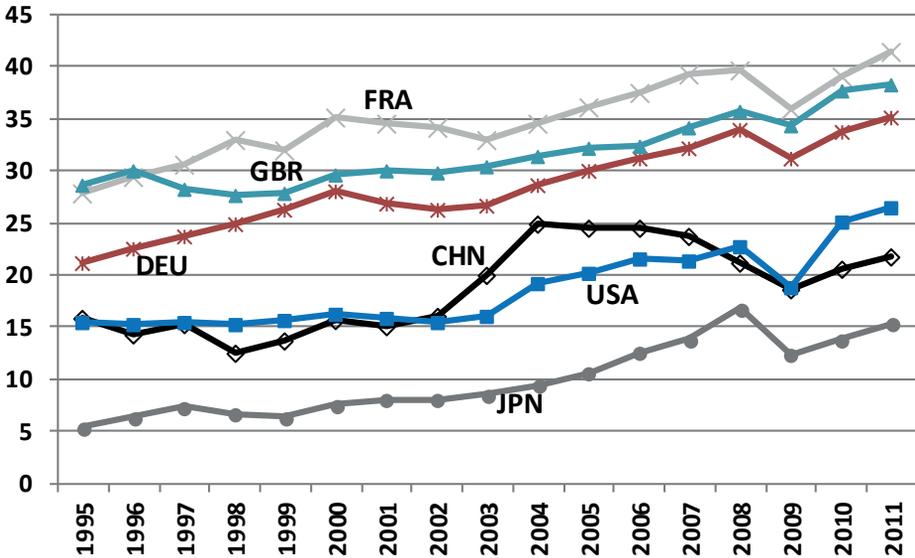
<sup>1</sup> See the Appendix for a brief introduction of the two types of indicators, including a discussion of the main similarities and differences.

## **1 International value chain fragmentation**

We define a value chain (VC) as all activities that directly and indirectly contribute to a final product, i.e. a consumption product or a capital good. To measure the international fragmentation of such VCs, we introduce a generalisation of Feenstra and Hanson's (1999) 'broad' offshoring measure. We define the foreign value added (FVA) share as the part of the value of final output of an industry that is contributed by industries in other countries (for details, see Los et al. 2015). We label the country that delivers the final product the 'country-of-completion'. Figure 1, taken from Timmer et al. (2015), provides such information for the VCs of transport equipment in six major countries-of-completion.

All FVA shares in Figure 1 were higher in 2011 than in 1995, which indicates that production processes in the manufacturing of transportation equipment have become increasingly internationally fragmented. This tendency has generally been rather steady over the period studied here, with the exception of a temporary dip immediately after the Global Crisis hit. The VC for Chinese transport equipment is the only one for which a non-regular pattern is found. The international fragmentation of this VC increased quickly after China accessed the WTO, but decreased somewhat between 2004 and the onset of the Crisis.

**Figure 1** Foreign value added shares in final output of transport equipment manufacturing industries (six countries-of-completion)



Source: Timmer et al. (2015), based on the World Input-Output Database (November 2013 release).

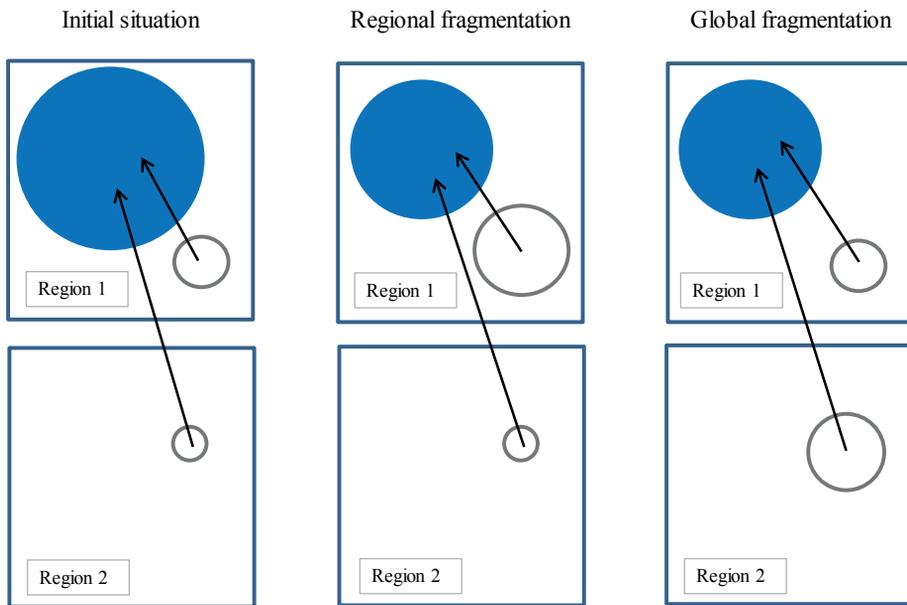
## 2 Transport equipment: Global fragmentation dominates regional fragmentation

Two archetypes of international production fragmentation could lead to the type of trends revealed by Figure 1. Figure 2 presents these in stylised form. The left-hand panel depicts the VC in the initial situation. The country where the final product is completed (located in Region 1) generates by far the largest part of the value of the final output, which is indicated by the large radius of the blue circle. Another country in Region 1 contributes a limited amount of value added and a third country, located in Region 2, generates even less value added within this VC (the grey circles are much smaller).

In the central panel, the share of final output value added by the country-of-completion is smaller than in the first situation, which would be reflected by a higher FVA share. The second country in Region 1 has captured this value added, while the share of Region

2 does not change. This is what we label 'regional fragmentation' and is the type of VC fragmentation stressed by Baldwin and Lopez-Gonzalez (2014); for example, a car assembled in a German factory contains more and more materials and components of which the production has been relocated to other countries, but mainly within Europe.

**Figure 2** Regional fragmentation versus global fragmentation (stylised representation)



The second archetype of international production fragmentation is observed when comparing the right-hand panel to the initial situation. Again, the value added share of the country-of-completion has decreased, but in this case it is the country in Region 2 to which value-adding stages of production have been relocated. Sturgeon et al. (2008) find that western car manufacturers tend to source components that are very specific from nearby suppliers, but have increasingly relied on low-cost suppliers in China and other countries in the Far East for the production of highly standardised components, thereby benefiting from scale economies. We call this 'global fragmentation', because VCs tend to span increasing parts of the globe in this archetype of international fragmentation.

To study whether increased international fragmentation is predominantly due to regional fragmentation or global fragmentation, we split FVA into regional FVA (RFVA) and global FVA (GFVA). RFVA comprises all foreign value added generated in the trade bloc to which the country-of-completion belongs, while GFVA includes all value added contributed by all countries outside the trade bloc. In line with Baldwin and Lopez-Gonzalez’s (2014) idea of three regional ‘Factories’ and considering the country coverage of WIOD, we define three trading blocs: the EU27, NAFTA (Canada, Mexico and the US) and East Asia (Japan, South Korea, Taiwan and China). Value added in Slovakia in the production of components for cars completed in Germany thus contributes to RFVA in this value chain, while the associated value added created in Australian iron ore mining is included in GFVA.

Table 1 documents the results of the decomposition of the value of final output of the five major transport equipment manufacturing industries in Europe into domestic value added, regional foreign value added and global foreign value added, for the pre-Crisis year 2008 and for 1995.

**Table 1** Regional and global fragmentation in European automotive manufacturing

Country-of-Completion	Final output (US\$m) in 2008	Value added shares in 2008			Changes in shares (2008 minus 1995)		
		Domestic	Regional	Global	Domestic	Regional	Global
Germany	248,374	0.66	0.19	0.15	-0.13	0.05	0.07
France	117,710	0.60	0.24	0.16	-0.12	0.05	0.07
UK	58,855	0.64	0.18	0.17	-0.07	0.01	0.06
Spain	56,055	0.61	0.25	0.14	-0.08	0.02	0.06
Italy	52,600	0.68	0.17	0.15	-0.09	0.03	0.07

Source: Timmer et al. (2015), based on the World Input-Output Database (November 2013 release).

The domestic value added shares in Table 1 could also be derived from Figure 1, since these are the complement of the FVA shares. The results in the right-hand columns show that global fragmentation has been faster than regional fragmentation in all

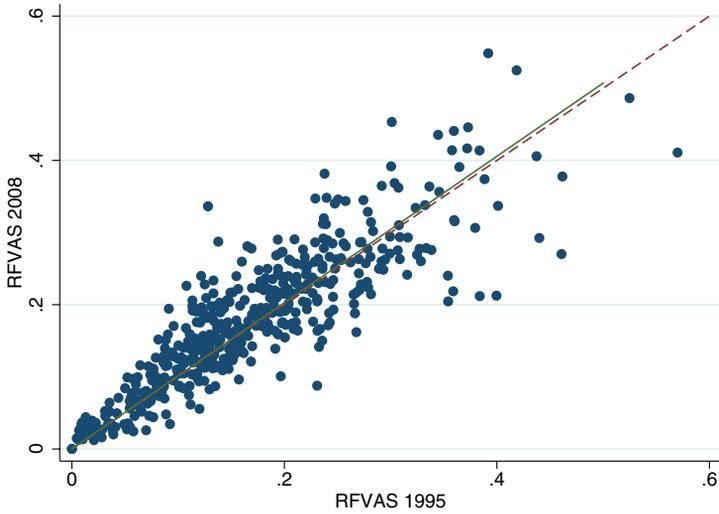
five automotive VCs considered. The differences are most prominent for the UK and Spanish VCs. The value added shares in 2008 indicate that RFVA shares are still higher than GFVA shares, but the latter are sizeable. The GFVA shares are almost as large as RFVA for the UK and Italian VCs.

### **3 Global fragmentation is more rapid than regional fragmentation across the board**

The results for the VCs for transport equipment provide some first evidence supporting our claim that the international fragmentation of production processes has a strong global nature. In what follows, we will broaden the scope of the analysis to value chains of all kinds of manufacturing products to see whether the results discussed are representative of a more general phenomenon.

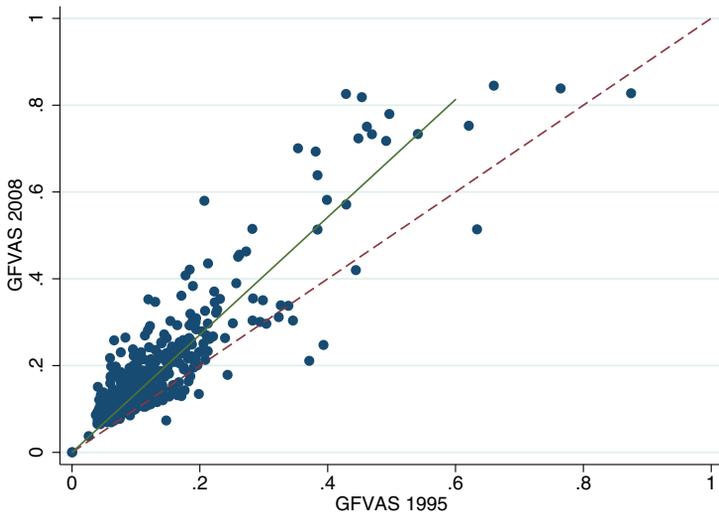
Figure 3 shows how regional and global foreign value added shares evolved over the period 1995-2008. We distinguish between value chains for 14 manufacturing product groups and 40 countries-of-completion, which each dot representing one VC. Dots located on the red dashed 45-degree lines reflect value chains for which the RFVA share (panel a) or GFVA share (panel b) in 2008 was equal to that in 1995. The solid green lines have been obtained via output-weighted regression through the origin. The lines in both panels have slopes that are larger than one, which implies that both types of fragmentation increased over 1995-2008. However, the slope for the evolution of the global FVA shares (1.36) is considerably steeper than that for regional FVA shares (1.01). This is a strong indication that global fragmentation has contributed much more to the growth of international fragmentation of VCs.

**Figure 3** Foreign value added shares in output of final manufactures  
(a) Foreign value added from within the region (regional fragmentation)



Source: Los et al. (2015), based on the World Input-Output Database (November 2013 release).

(b) Foreign value added outside the region (global fragmentation)

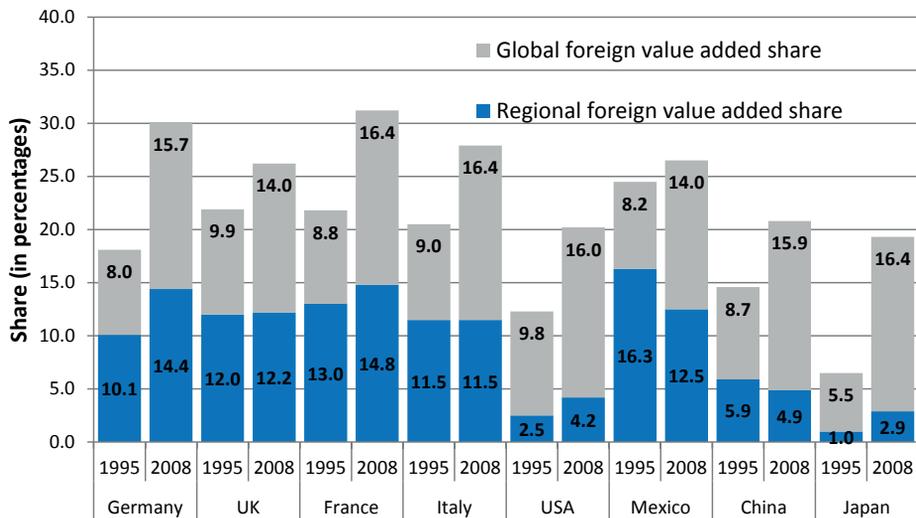


Source: Los et al. (2015), based on the World Input-Output Database (November 2013 release).

Why do these results differ so much from what Baldwin and Lopez-Gonzalez (2014), for example, found? In Los et al. (2015), we speculate that the double-counting of value added when using gross trade statistics, as stressed by Koopman et al. (2014), is the culprit. If countries within regions mainly sell products in downstream stages of production to each other, the value added in far-away countries in more upstream stages will also be included in the value of within-region trade measured in gross value terms. This bias towards trade in the outputs of downstream stages of production is absent in our accounting framework.

Figure 4 provides further evidence for our finding that value chains are truly becoming global. The figure presents results for eight large economies.<sup>2</sup>

**Figure 4** RFVA and GFVA shares for selected countries, 1995-2008 (%)



Source: Los et al. (2015), based on the World Input-Output Database (November 2013 release).

The results in Figure 4 refer to output-weighted averages of RFVA and GFVA shares for all 14 value chains for manufactures in the eight countries-of-completion. For VCs with the last stage of production in Germany, for example, the share of foreign value

<sup>2</sup> See [http://www.wiod.org/new\\_site/gvc.htm](http://www.wiod.org/new_site/gvc.htm) for detailed results for all countries present in the World Input-Output Database.

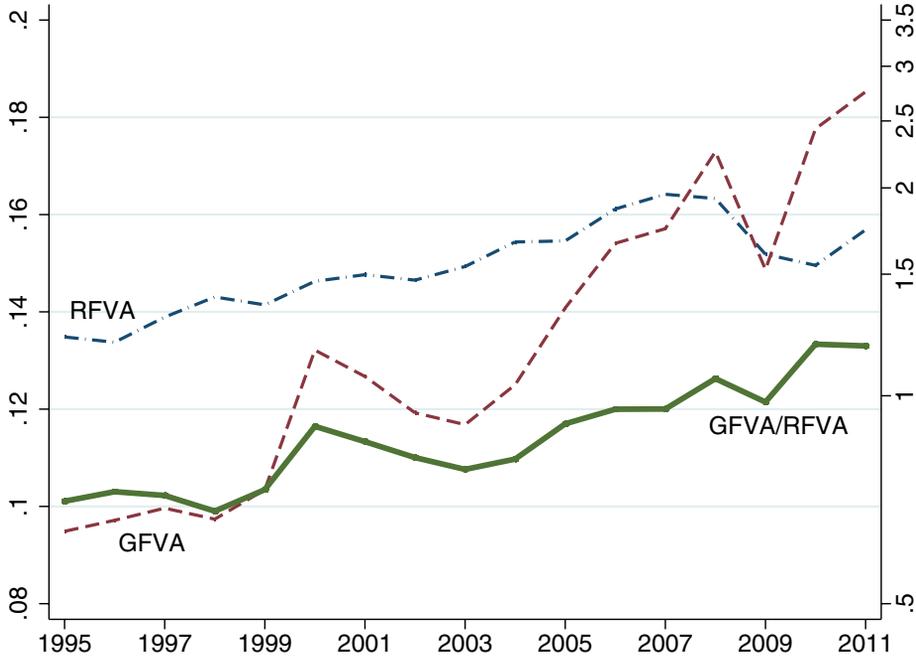
added (the sum of RFVA and GFVA shares) increased from 18.1% (=10.1 + 8.0) in 1995 to 30.1% (=14.4 + 15.7) in 2008. The share of domestic value added, which is the residual, has correspondingly declined from 81.9% to 69.9%. Interestingly, in 1995 the RFVA share was higher than the GFVA share, but in 2008 this was reversed. GFVA has grown much faster than RFVA.

In the majority of the countries, both regional and global foreign value added shares grew over the period 1995-2008. We find that without exception, GFVA shares have increased considerably faster than RFVA shares, which again points to the emergence of truly global VCs. In 2008, VCs for each of the eight countries-of-completion contained more foreign value added outside the region than value added in other countries of the same region. In Los et al. (2015), we show that global fragmentation is increasing at a much faster pace than regional fragmentation in smaller countries as well, but that their GFVA shares are often still smaller than RFVA shares as they still rely predominantly on regional networks with a large neighbouring country.

#### **4 The global fragmentation trend continued during the Great Recession**

At least two important questions remain to be answered. First, did VCs steadily become more global between 1995 and 2008, or did prominent jumps occur? Second, what happened in the early part of the Great Recession? In this period, the popular press frequently referred to protectionist policies aimed at supporting employment in domestic industries. Answers to both questions are provided by Figure 5, which depicts output-weighted averages of RFVA and GFVA shares for all 27 EU countries (all current EU members minus Croatia). These shares are measured along the left vertical axis, while their ratio is depicted by the solid green line and measured along the logarithmic right vertical axis.

**Figure 5** Trends in regional and global fragmentation of value chains of final manufactures (27 countries-of-completion in the EU)



Source: Los et al. (2015), based on the World Input-Output Database (November 2013 release).

The importance of value added generation outside the EU started to grow steadily after 2003, after a sudden jump around 2000. As is well known (see, for example, Bems et al. 2011 and Ferrantino and Taglioni 2014), international trade collapsed after the Crisis, partly as a consequence of international supply chain trade. Firms reacted to the uncertainty they faced by first depleting inventories, before ordering new supplies of materials and components. Our results show that global foreign value added shares were hit more strongly than regional foreign value added shares. The considerably larger growth of GFVA shares after 2009 provides preliminary evidence that the trend towards further global fragmentation has not come to a halt since the Crisis. Figure 5 even shows that global foreign value added shares had almost returned to their pre-Crisis levels by 2011, while regional foreign value added shares were still at lower levels and did not show much sign of a recovery.

## **5 Conclusion**

Our analysis shows that value chains have become considerably more global in nature since 2003. Increasing shares of the value of a product are added outside the region to which the country-of-completion belongs. Regional blocs like ‘Factory Europe’ are still important, but the construction of ‘Factory World’ is progressing rapidly. This has an important implication for policymakers – enhancing the performance of value chains (i.e. producing final products more efficiently) requires the removal of barriers to trade beyond what is achieved by regional trade agreements.

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# Factor specialisation within global value chains

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*Advanced countries are increasingly specialising in skill- and capital-intensive activities within global value chains. This chapter examines how far this process has progressed, whether there are relevant differences across countries in the speed of the process, and what is driving it. In most global value chains, there is a strong shift towards value being added by capital and high-skilled labour. The authors find this pattern for advanced nations and, surprisingly, also for emerging countries.*

## **1 Introduction**

The opening up of China, India and other emerging economies provided an enduring increase in the global supply of low-skilled labour. And anecdotal evidence suggests that advanced countries are increasingly specialising in skill- and capital-intensive activities within global value chains, more popularly described as a process of turning into ‘headquarter economies’. How far has this specialisation process progressed? Are there relevant differences across countries in the speed of the process? And what is driving it? These questions are central to this chapter and answers will be provided through an analysis of the factor content of global value chains (GVCs) as given in Timmer et al. (2014).

First, some concepts and definitions are in order. We define a global value chain of a final product as the value added of all activities that are directly and indirectly needed to produce it. A GVC is identified by the country-industry where the last stage of production takes place before delivery to the final user, for example, the GVC of products from Chinese electrical equipment manufacturing.<sup>1</sup> In this chapter, we will focus on the GVCs of final manufacturing products, which we refer to as ‘manufactures’.<sup>2</sup> Of course, these contain activities not only in the manufacturing sector, but also in other sectors – such as agriculture, utilities and business services – that provide inputs at any stage of the production process of manufactures. These indirect contributions are sizeable and will be explicitly accounted for through the modelling of input-output linkages across industries, using the so-called ‘GVC approach’ on data from the World Input-Output Database. The Appendix at the back of this book and Timmer et al. (2015) provide more detail on method and data.

## **2 The increasing income shares of capital and high-skilled workers in GVCs**

The value of final manufacturing goods is decomposed into value added by four factors: low-, medium- and high-skilled labour (identified on the basis of the level of educational attainment of workers) and capital.<sup>3</sup> In our approach, ‘value added’ and ‘income of factors’ are equivalent, so these terms will be used interchangeably. We have in total 560 value chains – 14 manufacturing product groups with 40 possible countries of completion. In 64% of the chains, the share of value added by capital has increased.

1 It is important to note that the fact that a product is ‘completed’ in a particular country does not necessarily mean that domestic firms are governing the value chain. For example, Apple governs the production network of iPods, although they are completed in China. A useful starting point for more on governance in global value chain production is Gereffi (1999).

2 The value added in manufactures chains accounted for about 23% of global GDP in 1995. A similar analysis of the global production of final services is possible in principle, but the current data are not detailed enough to do so.

3 Workers are identified on the basis of educational attainment levels as defined in the International Standard Classification of Education (ISCED). Low skilled (ISCED categories 0, 1 and 2) roughly corresponds to less than secondary schooling. Medium skilled (3 and 4) means secondary schooling and above, including professional qualifications, but below a college degree. High skilled (5 and 6) includes those with a college degree and above. Capital income is derived as a residual and defined as gross value added minus labour income. It represents remuneration for capital in the broadest sense, including physical capital (such as machinery and buildings), land (including mineral resources), intangible capital (such as patents and trademarks), and financial capital.

The share was particularly strong in chains for transport equipment and machinery with China, Germany or the US as the country of completion. The increase in income shares for high-skilled workers was particularly pervasive and positive in 92% of the chains. The unweighted average was about 4 percentage points, with a much lower variance than for capital. On the flip side, the income shares for medium- and low-skilled labour dropped in many value chains. The medium-skilled share declined in 56% of cases, by an average of 1 percentage point. The decline has been particularly severe in major chains, such as those for machinery and transport equipment with Germany or the US as the country of completion. The clearest trend is found for low-skilled shares, which declined in 91% of cases. The average decline was five percentage points, with occasional declines of more than ten percentage points, in particular in European food chains, for example, with France, Italy or Spain as the country of completion.

What are the macroeconomic effects? In the analysis above, each product chain was considered irrespective of its size. But bigger chains have a larger impact on the global economy than smaller ones. Chains for products like food, transport equipment and machinery typically have a larger final output, and end in bigger economies. To account for this, we take the final output of all manufactures together (by simply summing over 560 manufactures chains) and provide a similar decomposition of value added. In effect, the factor shares are now weighted by the final output of their chain. The results are given in Table 1. Global expenditure on manufactures increased by almost one third, from \$6,586 billion in 1995 to \$8,684 billion in 2008 (in constant 1995 prices). We find that the shares of value added by capital and high-skilled workers increased at this aggregate level. This confirms that the patterns found above are not driven by developments in small chains only, but are economically significant. The share of value added by capital increased by more than 6 percentage points, as this shift was most pronounced in bigger chains. The share of high-skilled workers also increased but not as quickly, by 1.5 percentage points. The shares of low- and medium-skilled workers declined both by about four percentage points. Medium-skilled workers lost out in particular in ‘major’ value chains. This finding is consistent with the model of Rodrik

(1997). He argues that the opening up of international capital markets increased the opportunities for quick relocation of capital. This supposedly led to a decline in the bargaining power of labour around the world, limiting the share of labour in value added vis-à-vis capital.

**Table 1** Factor shares in global value chains of all manufactures

	1995	2008	2008 minus 1995
<b>Total value added (US\$ billion) by</b>	<b>6,586</b>	<b>8,684</b>	<b>2,098</b>
capital (%)	40.9	47.4	6.5
high-skilled labour (%)	13.8	15.4	1.5
medium-skilled labour (%)	28.7	24.4	-4.2
low-skilled labour (%)	16.6	12.8	-3.8

*Note:* Shares of production factors in total value added, based on all global value chains of manufactures. Shares add up to 100%. Value added is at basic prices (hence excludes net taxes, trade and transport margins on output). It is converted to US\$ using official exchange rates and deflated to 1995 prices using the US CPI. Figures may not add up due to rounding.

*Source:* Table 1 from Timmer et al. (2014).

### 3 Factor specialisation at the country level<sup>4</sup>

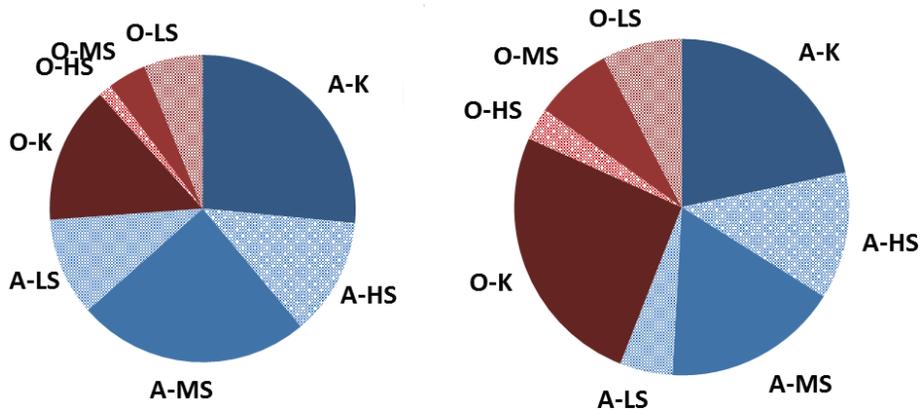
What happened to the location of value added in GVCs? And did specialisation patterns vary between regions? In the traditional Heckscher-Ohlin model of trade, countries will focus on producing goods that are intensive in those factors that are relatively abundant. As a production chain fragments across countries, one might expect the standard Heckscher-Ohlin predictions to still hold, i.e. advanced countries will focus more on activities that require high-skilled labour and capital, and other countries will specialise in less-skilled activities.

To test these predictions, we group Australia, Canada, Japan, South Korea, Taiwan, the US and the 15 pre-2004 members of the European Union in one group, and place all other countries in the world in another group. Roughly speaking, this can be viewed as

<sup>4</sup> This section relies heavily on Timmer et al. (2014).

a comparison of the high-income countries of the world and other countries that play an active role in international trade. The results are shown in Figure 1. The share of high-income countries in total value added generated in all manufactures chains declined from 74% in 1995 to 56% in 2008.<sup>5</sup> At the same time, the factor content delivered by high-income countries shifted: the shares of capital and of high-skilled workers increased by three and five percentage points, respectively, while the combined share of medium- and low-skilled workers declined by eight percentage points. The direction of this change is in line with the Heckscher-Ohlin intuition.

**Figure 1** Factor shares in global value chains of manufactures, by region



*Note:* Shares of production factors in total value added in a region, based on all global value chains of manufactures. Value added by a region is the sum of value added by labour – low- (LS), medium- (MS), and high-skilled (HS) workers – and capital (K) on the domestic territory. Advanced countries (A) include Australia, Canada, the US, Japan, South Korea, Taiwan and all 15 countries that joined the European Union before 2004. O indicates value added in all other countries in the world.

*Source:* Based on Table 2 from Timmer et al. (2014).

In Table 2 we provide similar decompositions for individual countries. Capital income shares increased in most countries, except in the UK and Italy, with the largest increases found in Germany and South Korea (seven and nine percentage points, respectively). The share of value added by high-skilled workers increased everywhere, ranging from around three percentage points in Australia, Germany and Japan, to 4 in the US, to more

<sup>5</sup> Given sizeable flows of foreign investment, part of the value added in emerging regions will accrue as income to multinational firms headquartered in advanced regions. However, analysing capital income on a national rather than a domestic basis is notoriously difficult. To establish the full link from production value added to national factor incomes, one would additionally need data on the actual ownership of firms (Lipsy 2010).

than eight in France, The Netherlands, South Korea and the UK. The income shares of other labour declined all around. In Canada, Germany and the US, medium-skilled labour shares declined faster than low-skilled shares. In other countries, such as France, the UK, Italy and Spain, as well as in South Korea and Australia, low-skilled worker income shares suffered the most, sometimes falling by more than ten percentage points.

**Table 2** Changes in factor shares in global value chains of manufactures, by country

	Capital	Low-skilled labour	Medium-skilled labour	High-skilled labour
United States	3.9	-1.9	-5.9	4.0
Japan	4.5	-5.4	-2.1	3.1
Germany	6.8	-2.8	-7.4	3.4
France	0.2	-8.7	0.1	8.4
United Kingdom	-3.4	-8.0	1.2	10.2
Italy	-1.1	-14.8	10.4	5.5
Spain	0.1	-12.9	4.7	8.1
Canada	1.8	-2.0	-4.6	4.8
Australia	6.0	-8.4	-0.9	3.3
South Korea	9.3	-11.6	-5.6	8.0
Netherlands	5.5	-7.3	-7.1	8.9
<b>Total all high-income</b>	<b>2.9</b>	<b>-4.9</b>	<b>-3.0</b>	<b>5.0</b>
China	9.3	-9.3	-2.1	2.0
Russian Federation	1.1	-1.6	-2.4	2.8
Brazil	-6.7	-4.8	7.5	4.0
India	4.5	-5.9	-1.7	3.1
Mexico	6.4	-4.2	-0.5	-1.7
Turkey	-12.7	4.5	5.2	3.1
Indonesia	5.3	-8.1	1.3	1.6
<b>World minus all high-income</b>	<b>3.2</b>	<b>-6.3</b>	<b>1.4</b>	<b>1.7</b>
<b>World</b>	<b>6.5</b>	<b>-3.8</b>	<b>-4.2</b>	<b>1.5</b>

*Note:* Shares of production factors in total value added in a country, based on all global value chains of manufactures. The percentage point changes in factor shares over the period 1995-2008 are given. Changes in four factors for each country add up to zero by definition, but may not due to rounding. Countries within a region are ranked by GDP.

*Source:* Calculations based on World Input-Output Database, as shown in Timmer et al. (2014).

What might account for this? In traditional models of production, factor shares are determined by the interplay of relative prices of factors, their elasticities of substitution,

and the nature of technical change. For example, the opening up of Asian economies led to a shock in the global supply of unskilled workers. Whether this leads to an increase in its factor share depends on the elasticity of substitution between unskilled workers in Asia and elsewhere, but also on the substitution possibilities between unskilled and skilled workers, as well as between unskilled workers and capital. Another important element is the rapid advances in the information and communication technology industry, driving down the relative price of information technology capital. Again, the effects on the share of capital income will crucially depend on the substitution possibilities between information technology capital on the one hand, and various types of labour on the other.

Substitution possibilities are hard to model and measure. Archetypal models of growth and international trade rely on production functions where elasticities of substitution are rather restricted. In these models, the production process is conceived of as a mapping from factor inputs to output, as if taking place in one stage. With fragmentation, however, it is more insightful to model the generation of output as a result of a set of ‘tasks’ that are to be completed by various combinations of production factors. So rather than a direct mapping from labour and capital inputs to output, factors map into tasks, which subsequently map into output. This framework allows for a much richer modelling of complementarities and substitution possibilities between various factors of production, both domestic and foreign.<sup>6</sup> For example, according to the ‘routinisation hypothesis’ put forward by Autor et al. (2003), information technology capital complements highly educated workers engaged in abstract tasks, substitutes for moderately educated workers performing routine tasks, and has little effect on less-skilled workers performing manual tasks and tasks that require personal interactions, such as those in many services. The latter tasks are less important in manufacturing GVCs, which is consistent with our observation that income shares for both low- and medium-skilled workers in manufactures are declining.

6 See the new set of models of labour demand discussed in Acemoglu and Autor (2011).

At the same time, the increasing importance of intangible capital provides another potential explanation for the increasing value added shares of capital and high-skilled workers. Recent investment in advanced countries is increasingly directed towards intangibles such as intellectual capital (including software and databases, R&D and design), brand names and organisational firm-specific capital (Corrado et al. 2012). To the extent that the build-up of intangibles requires high-skilled labour, this will increase demand for the latter.

#### **4 Concluding remarks and policy implications**

In this chapter, we have provided a new perspective on the effects of international production fragmentation and showed that the patterns of specialisation found in case studies like the iPod have a macroeconomic equivalent. The findings fit a broad story in which firms in mature economies relocate their unskilled labour-intensive production activities to lower-wage countries, while keeping high value added functions concentrated at home where the skilled workers and intangible capital they need are available. But this shift of activities was decidedly non-neutral – capital shares in value added increased in both high-income and emerging economies. Squaring these facts would be an interesting challenge for further research. One possible explanation is a shift in manufacturing technologies that possibly led to a worldwide decline in the demand for unskilled workers. This can only be investigated from a global value chain perspective, as a focus on industries will not be able to distinguish between offshoring and technological change. Another interesting analysis concerns the specialisation of countries in tasks or functions – such as R&D, back-office tasks, production, logistics and marketing – in international production. This work is ongoing, as in Timmer and de Vries (2015).

Declining incomes and jobs for less-skilled workers are major policy concerns, mostly framed in terms of a ‘manufacturing decline’, and have prompted various initiatives for ‘re-industrialisation’ in a number of former industrial strongholds. Setting aside

the merits of such proposals, it is important to note that with fragmented production, a sectoral (such as ‘manufacturing’) approach is becoming the wrong way to evaluate economic performance and to frame public policies. Competitiveness is no longer solely determined by domestic clusters of manufacturing firms, but increasingly also relies on the successful integration of other tasks in the chain, both domestic and foreign. In today’s world what you export matters much less than what you do within a chain. Trade, labour and industrial policies would do well to take this new fact into account.

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# A basic network perspective<sup>1</sup>

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Banco de Portugal

*The evolution of global value chains over time can be examined with basic network analysis tools. In each moment, the chain can be represented as a directed network of nodes (countries) and edges (value added flows between them). This chapter uses data on the bilateral foreign value added in exports from the WIOD and graph visualisation techniques to illustrate the network properties of value added flows from 1995 to 2011.*

## **1 Introduction**

The analysis of global value chains (GVCs) has focused on the computation of indicators that break down gross trade flows along sources and destinations of value added. One of the simplest measures of participation in GVCs is the foreign value added embodied in exports (FVAiX) (see the Appendix of this book for a discussion of this measure). Given the specific nature of GVCs, these flows can be interpreted as the result of complex linkages established between sectors in different countries over time. In this context, since exports increasingly embody a sizeable share of foreign value added, important questions about the interdependence of economies arise, notably in relation to the impact and propagation of economic shocks. In addition, the importance of specific players in the functioning of an entire GVC and the impact of their potential removal direct the discussion towards the resilience of the world trade system.

<sup>1</sup> The views expressed in the chapter are those of the authors and do not necessarily correspond to those of Banco de Portugal or the Eurosystem.

In order to study interconnections between economic agents, economic research has made progressive use of network analysis tools. The appeal of using network analysis in the study of economic relations comes from the ability to identify the whole structure of interactions, assuming the interdependence of observations, and to explore the entire pattern of connections in their multilateral aspects, instead of focusing on the isolated characteristics of each individual element. The visualisation of the network structure, using graphs that contain the architecture of nodes linked by edges, is a useful and informative tool to facilitate the interpretation of network data.

Economic research resorting to social network analysis already covers a wide set of issues. In the area of econophysics, a number of articles have focused on the empirical analysis of international trade from the perspective of complex networks. In the so-called ‘world trade web’ (WTW), each country is a node and the bilateral trade flow between two countries constitutes an edge between them. Several aspects of the structural and topological properties of the WTW were studied by Serrano and Boguñá (2003), Garlaschelli and Loffredo (2005), Kali and Reyes (2007) and Fagiolo et al. (2010), among others. In addition, international trade economists have also applied network metrics to examine the evolution of total world trade (De Benedictis and Tajoli 2011), and of trade in specific sectors (Akerman and Seim (2014) for arms trade; Amighini and Gorgoni (2014) for auto parts trade).

This chapter makes use of basic network visualisation tools to describe the characteristics of GVCs, using the WIOD for the period 1995-2011 and differentiating between manufacturing and services exports.<sup>2</sup> It is important to clarify the nature of the exercise performed. The flows of value added in a GVC tend to occur in a sequential way, with firms incorporating external value added as they use intermediate goods in production that is subsequently exported for final consumption or integrated into other products or services. Therefore, the path made by each unit of value added in the world economy before it reaches the final consumer may be extremely complex and long.

2 All valued added decompositions in this chapter were made using the R package *decomp* (Quast and Kummritz 2015).

In conceptual terms, this path could be identified stepwise in the global input-output matrix. However, given the structure of the matrix, the number of iterations would be huge and the resulting network virtually impossible to represent. Instead, economic theory has focused on the inverse Leontief matrix as the total impact of this iterative process. This is also the approach adopted in this chapter, i.e. the network represents the final foreign value added flows and not individual flows in successive stages of the chain, which makes it compatible with the discussion in Chapter 1 by Amador, Cappariello and Stehrer. A similar approach, but taking the entire set of country-product linkages, is presented by Cerina et al. (2014).

## **2 What can we learn from the networks of value added trade?**

The construction of a network requires the identification of a set of nodes, or vertices, and edges that represent the interactions between them. In this chapter, the nodes are the 40 individual countries that are present in the WIOD. The criteria for the existence of an edge is set to reflect the importance of a country as a supplier of value added for other countries' exports. A threshold is chosen for this purpose. The choice of the threshold is made in such a way that the resulting network is simple enough to interpret and visualise, while capturing the main interrelations. The threshold was set at 1% of total gross exports of the user country, but the main results remain qualitatively unchanged for alternative values. In addition, the analysis below disregards the strength of the edges identified, i.e. the values of the foreign value added shares in exports. Hence, we only use the binary information contained in the data (unweighted network) and focus on the extensive margin of value added trade among countries.

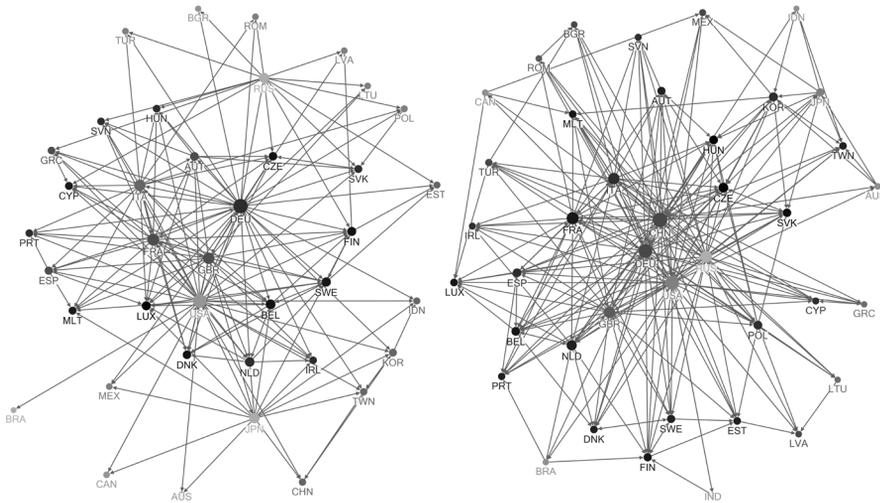
A very simple but powerful notion in network analysis is the 'degree' of a node. This is simply the number of connections or edges that a node has with other nodes. If the network is directed, every node has two different degrees: indegree and outdegree. The indegree is the number of incoming edges, and the outdegree is the number of outgoing edges. In our case, the existence of a clear interpretation for the orientation of the edge,

i.e. directed from a country whose value added share in another country's exports is larger than the threshold, makes this network directed. Hence, the edges pointing towards a country identify its main suppliers and, conversely, the edges originating from a country reveal its importance as supplier in the GVC.

## 2.1 Network visualisation

Figure 1 displays the network representations of foreign value added in gross trade in 1995 and 2011. Each country is represented by a circle, with arrows pointing from supplier to receiver of value added. The economic size of the countries interacts with their integration in GVCs in order to establish their location and importance within the network. In the figure, the size of each node is proportional to its total degree (sum of indegree and outdegree) and the colour of the node is mapped to its indegree, with darker shades indicating higher values. In general, bigger countries tend to have bigger nodes and appear in the centre of the network, mostly because they are important suppliers of value added in the network. Smaller economies tend to appear in the outer layers of the network. These countries are usually placed in intermediate stages of the GVC and act as clients of other countries either at the beginning of the chain (e.g. focused on R&D and engineering or raw materials) or at the last stages (as assemblers). In addition, some small countries have the darkest nodes in the graph as they use value added from several sources, signalling a strong integration in the network.

**Figure 1** Network graphs of foreign value added flows, 1995 and 2011  
(a) 1995 (b) 2011



Notes: The network graphs are based on the Harel-Koren Fast Multiscale algorithm and are drawn with the use of NodeXL (see Hansen et al. 2010 for details), an open-source template for Excel for analysing complex networks (<http://nodexl.codeplex.com/>).

The increase in the density of the network from 1995 to 2011, due to a larger number of edges linking the 40 countries in the database, stands out in Figure 1. The flows of foreign value added that are embodied in gross exports became larger, increasing the number of cases where the threshold is surpassed and the respective edges are represented. The position of the nodes takes into consideration their relative importance in the network. In 1995, the countries standing in the core are the large European countries – like Germany, France and the UK – and the US. Secondary relations are seen in Asia – centred in Japan as a supplier and linking countries like China, Korea and Taiwan – and in central and eastern Europe, with Russia supplying several other countries in the region.

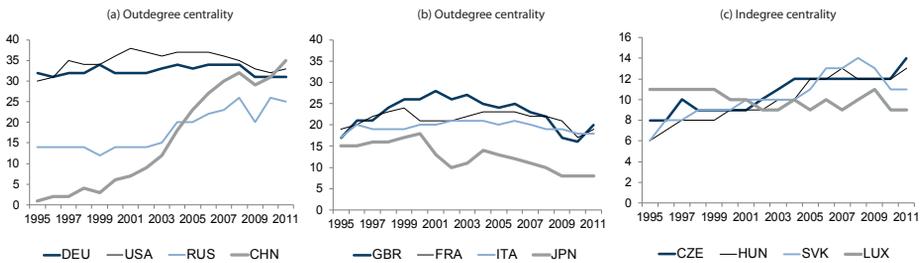
In 2011, the network is denser with China joining the inner core. In this period, a closer inspection reveals also that the UK and France moved slightly away from the inner core. This is also the case for Japan, while Germany and the US maintained their central position. A more subtle difference between these two central countries – Germany and

the US – is visible when considering the shade of their nodes. Even though their nodes are almost the same size (i.e. a similar total degree), Germany's node is darker than that of the US in both periods. This means that the role of the US is mostly as a supplier of foreign valued added to other countries, while Germany also has some relevance as a client of value added to be embodied in German exports. Finally, Russia gained importance as a supplier to other countries. This is evident from its bigger but still light-shaded node in 2011, which mostly reflects the country's role as a major exporter of energy products. These facts are in line with the results of Chapter 2 in this book by Los, Timmer and de Vries, which highlight the progressive transformation of GVCs, evolving from a regional into a truly global network, on other words, the emergence of 'Factory World' (see Chapter 2 for a complementary analysis).

Node degree is also called 'degree centrality', and it is the simplest form of centrality. Centrality indicators are used to determine how important nodes are in a network. Figure 2 displays the evolution of indegree and outdegree centralities for some of the main countries in the GVC network from 1995 to 2011, and reinforces some of the major features already observable in the network graphs described above. The most important suppliers of valued added throughout the whole period are the US and Germany, as their value added is used in the exports of more than 30 other countries. Panel (a) also shows the sharp rise of China since the beginning of the 2000s, accelerating after 2003 and standing as the most important supplier in 2011 – 35 other countries used Chinese value added in their exports in 2011. Moreover, the role of Russia has also slowly increased since the mid 2000s. Panel (b) focuses on other relevant economies, which seem to have lost some of their importance as suppliers in the network. The contraction of Japan is clear, while the UK shows an upturn in the latest years of the sample, though not compensating for the decline after the beginning of the 2000s. Panel (c) looks at the role of smaller European countries that are identified as the most important receivers of foreign valued added in the GVC network. The Czech Republic, Hungary and Slovakia have progressively become more important clients of foreign valued added

to be incorporated in exports, as they increased their role in the intermediate stages of European production chains.

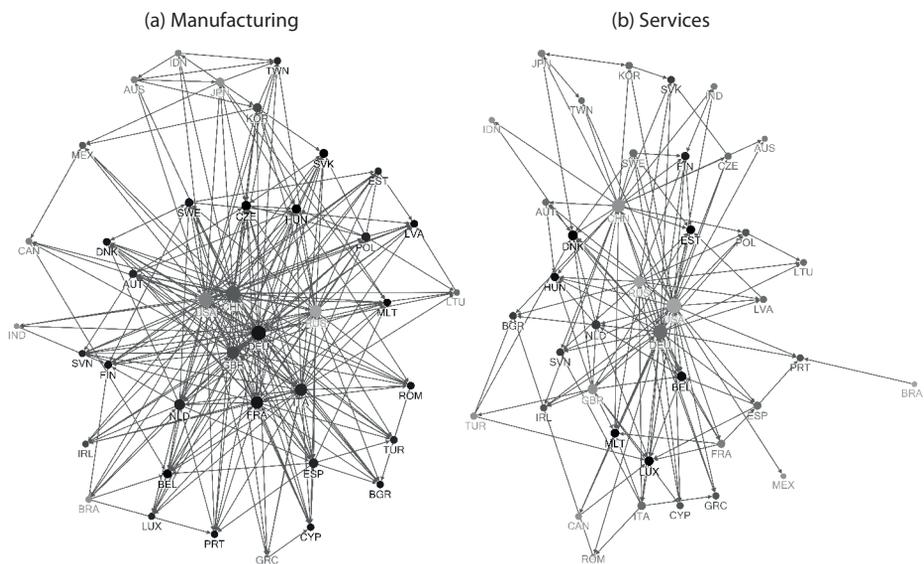
**Figure 2** Main suppliers and users of foreign value added in exports over time



Notes: The outdegree centrality of a country reflects its relevance as a supplier of foreign value added, while the indegree centrality of a country reveals its importance as a user of foreign value added.

Another dimension that can be examined relates to the structure of the value added networks for different sectors. Here, we consider the broad sectors of manufacturing and services. For a given sector, the edges in the binary network are set by taking pairs of countries where the supplier's value added share in the user country's exports of the selected sector is above the threshold. Hence, the reading of sectoral networks must always take into consideration that the importance of foreign suppliers of value added is set relative to the user countries' gross exports of the manufacturing and services, respectively. In addition, the importance of foreign suppliers includes all value added and not just that originated in the selected sectors. It should be noted that the distinct shapes of the sectoral networks reflect not only the organisation of GVCs but also the technological differences included in the global input-output matrix, i.e. the different number and type of inputs used in manufacturing and services. Figure 3 represents the networks of manufacturing and services foreign value added in exports in 2011.

**Figure 3** Network graphs of foreign value added flows in manufacturing and services, 2011



*Notes:* The network graphs are based on the Harel-Koren Fast Multiscale algorithm and are drawn with the use of NodeXL (see Hansen et al. 2010 for details), an open-source template for Excel for analysing complex networks (<http://nodexl.codeplex.com/>).

It is clear from the visualisation of these networks that GVCs are more developed and integrated in the manufacturing industry than in services, comprising more interactions among countries. In fact, the representation of the manufacturing network in 2011 strongly resembles that for overall trade, with China, the US and Germany standing in the inner core as the top three suppliers of value added, respectively. In addition, German manufacturing exports also use foreign value added from more sources than the other two main suppliers. The main users of foreign value added in manufacturing exports are, again, the Czech Republic, Hungary and Slovakia.

As for the services network in 2011, the US stands out as the main supplier of foreign value added to be embodied in the services exports of other countries, followed by Germany and then China. Moreover, these three countries are less important as users of foreign value added in their services exports than in their manufacturing exports. In

2011, the country whose services exports used valued added from the most sources was Denmark, with an indegree of 11.

### **3 Final remarks**

The analysis of the networks of foreign value added in exports is a complementary tool for understanding GVCs in Europe and in the world. Not surprisingly, several results of the network visualisation of value added trade confirm the mapping of GVCs discussed in Chapters 1 and 2 of this book. Larger countries play a vital role, the regional dimension of GVCs is still dominant but it is progressively giving way to a more global network, and manufacturing GVCs outpace those of services. At the country level, the robust role of Germany and the US and the rising importance of China are non-surprising results arising from the analysis in this chapter. All in all, there is still room to extend and deepen the network of value added trade in the global economy, both through the stronger integration of peripheral economies and the expansion of linkages in the services sector.

The relevance of using network analysis to understand GVCs is great, and existing research is still in its infancy. The complexity of measures in network theory and the ability to build models that incorporate these features is promising. The utilisation of network metrics computed at the country level (for each node) in regressions to assess the structural integration in GVCs is just one example (see Chapter 5 in this book by Santoni and Taglioni).

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# Networks and structural integration in global value chains<sup>1</sup>

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*Network analysis and metrics can help capture the complexity and heterogeneity of actors and trade links in global value chains, including the different patterns embedded in a supply (demand) perspective. Measures of eigenvector centrality are preferable to openness measures, as the former account not only for direct linkages but also for indirect linkages. An investigation of the network of trade in value added reveals interesting stylised facts that are useful to guide both research and policy analysis. While the tri-polar structure of the world economy, clustered around a Factory Asia, a Factory North America and a Factory Europe, is confirmed, two interesting new facts also emerge. First, emerging markets have gained centrality as buyers of value added in these sectors, but not so much as sellers. The main suppliers of value added in technology-intensive sectors, such as the automotive and ICT sectors, continue to be the US, Japan and Germany. The second important fact is that being well integrated with the supplier network is what matters most. Being close to the demand is also relevant, but to a lesser extent.*

## **1 At a glance**

Network analysis is a useful tool to assess global value chains (GVCs) and countries' participation in them. It allows direct and indirect links and the full heterogeneity of

<sup>1</sup> The findings, interpretations, and conclusions expressed in this chapter are entirely those of the authors. They do not necessarily represent the views of the World Bank Group, or those of the Executive Directors of the World Bank or of the governments they represent.

both actors and links to be accounted for. It also provides new insights. For example, results from the input diffusion model of Carvalho and Voigtländer (2015) show that a relatively central position of an input in the production network (i.e. it is used by already central technologies) makes a wide diffusion of the input more likely. Moreover, input-output linkages can generate a cascade effect induced by the propagation of micro-shocks through the production network (Acemoglu et al. 2012, 2015 and Carvalho 2014). The size of the impact depends on the network structure, i.e. the properties of the matrix corresponding to the underlying production relations.

To analyse the network structure of global GVC flows, this chapter takes an exploratory approach to value added in bilateral trade flows, as measured by the OECD-WTO TiVA database. Section 2 describes the network representation of value added trade for countries, with country-by-sector observations, and for selected sectors. Section 3 reports the results of the empirical analysis, quantifying correlation between measures of integration in the value added trade and country (country-by-sector) economic outcomes. The key insights are summarised in the next paragraphs.

GVCs are regionally clustered. Network visualisations of gross trade and value added trade confirm the existence of three main clusters: Factory Asia, Factory North America and Factory Europe. Meanwhile, most large countries in Africa, South America and South Asia remain marginal to the global trade network of value added, a measure associated with the distribution of value generated by GVCs. Looking at country-sector specific nodes, it is possible to map not only geographical interdependence but also industrial interdependence. Not surprisingly, US industries are at the core of the network of global trade, but German business services, China's retail and Russian mining are also well integrated. Meanwhile, the countries and industries in the Eurozone are the most clustered, with German industries such as chemicals, business services and retail being the most connected to the other industries in the region.

Analysing the direction of bilateral flows reveals interesting sector-specific patterns beyond regional clusters. Visualisations of the network of value added of technology

intensive sectors, such as the ICT and automotive sectors, suggest that the increasing centrality of emerging economies in GVCs is most prominent on the demand side. While these countries are important buyers in technology-intensive GVCs, the supply of value added still predominantly originates from three countries – the US, Japan and Germany.

Discussions of the benefits from GVC participation often revolve around the share of overall value added that individual countries post, and whether this has increased or decreased over time. Econometric evidence, however, suggests that export growth benefits all participants in a GVC network by boosting their value added. Being more integrated in a GVC network is associated with both higher domestic value added and higher exports. An interesting question is whether being integrated upstream (with suppliers of value added) or downstream (with buyers of value added) matters most. Contrary to common assumptions that proximity to final demand is what matters most, this chapter shows that there is a premium in terms of export growth to being well connected to the sources of value added (presumably a proxy for technology and skills).

According to our results, integration on the supply side is far more important than integration on the demand side. This is true both for the domestic value added content of exports and for gross exports. The elasticity of gross exports to supply-side integration is more than twice the elasticity to demand-side integration. When measured in value added terms, the premium from supply side integration is 80%. Nevertheless, there is significant cross-sectoral heterogeneity in the magnitude of the effect. In manufacturing, more than in services, there is scope for demand-side spillovers to export growth, especially in value added terms.

These results demonstrate the interconnectedness of countries and industries, particularly at the regional level. They also suggest that facilitating access to imports, particularly from the GVC hubs and from countries and industries closely integrated with them, is not only as important as facilitating exports, but perhaps should even be

the priority, given the export premium associated with good connectivity to the sources of value added.

## **2 Structural integration in GVCs**

The polarisation of the value added network around the US and Germany, along with the rising relevance of China, is fully consistent with the evidence from Johnson and Noguera (2012) showing that distance and contiguity matter greatly in shaping bilateral value added flows, driving the emergence of a clear regional structure, i.e. Factory Asia, Factory North America and Factory Europe (Baldwin and Lopez-Gonzalez 2013).

Analysing the direction of bilateral flows reveals interesting sector-specific patterns beyond regional clusters. In a GVCs/trade web, there are two main perspectives from which to analyse a country's relative position: the foreign value content, i.e. the value added 'imported' from abroad and embedded in the country's own exports; and the domestic value added 'exported' to be processed in third countries and embedded in their exports.

The two measures convey different information. In the first case, for the 'buying' (demand) country, the origin of foreign value used in domestic production (for exports as well as for final consumption) helps in identifying potential sources of technology and productivity spillovers (through intra-firm and arm's-length transfers). In the latter case, for the 'selling' (supply) country, the final destination of domestic value added is crucial to evaluate the structural position of the country with respect to final demand.<sup>2</sup> In what follows, we present a sectoral example, based on network representations of trade in value added, which emphasises intra-sectoral interaction patterns between countries.<sup>3</sup> Each sectoral network is characterised by an  $N \times N$  input-output (IO) matrix,

2 Conditional on the detail of the data, the cross-country value added trade structure could also be useful to assess the degree of a country's exposure to foreign demand shocks.

3 Note that sectoral graphs consider only flows occurring within the same sector, e.g. automotive firms in Poland importing value added from automotive firms in US (and the other way around). Those linkages are particularly relevant since technological and productivity spillovers are most likely to materialise along intra-sectoral connections.

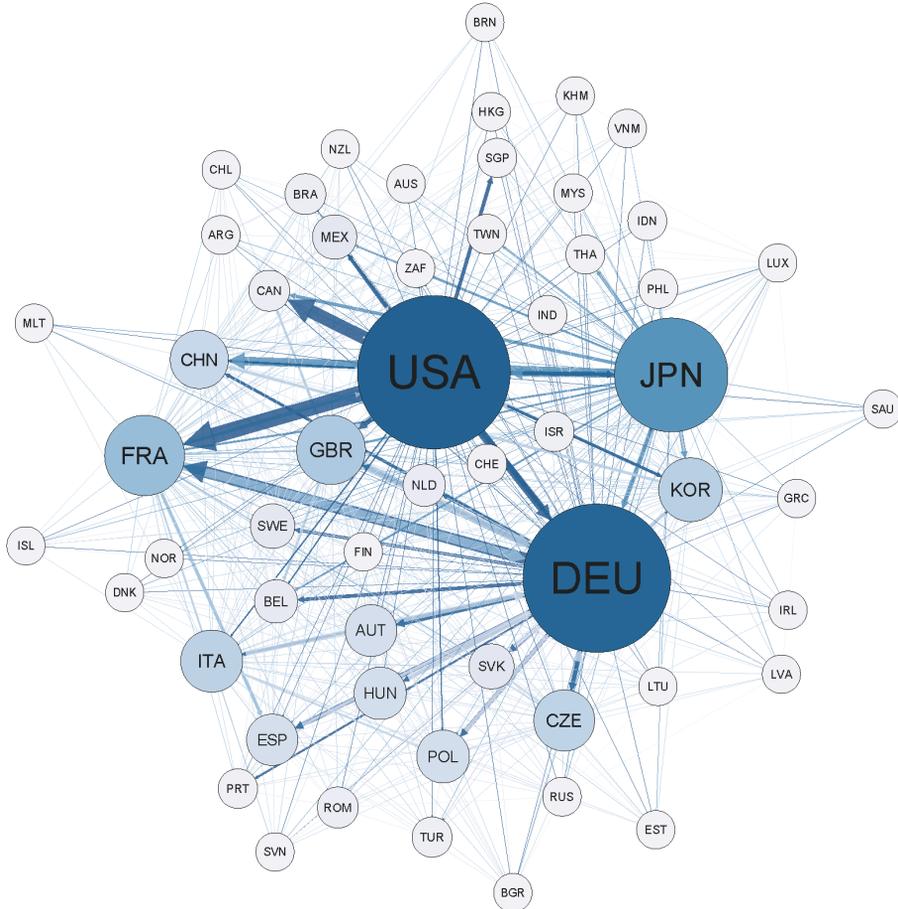
W, where the general entry  $w_{ijis}$  the flow of value added from country  $i$  to country  $j$  within the same sector, with N equal to 56 (the number of countries in the TiVA-OECD database). We relax this assumption later on.

From a supply-side perspective, in most high-tech sectors the majority of countries still depend heavily on a small number of technological hubs. This is despite a sharp increase in international integration. Figure 1 shows that three countries – Germany, Japan and the US – still provide most of the foreign value added generated in the automotive sector and embedded in third countries' gross exports. The world biggest flow of value added is from the US to France (possibly associated with the fact that France, through Airbus, sources high value aeronautical components from the US).

- Moving to the buyer side, it is possible to track the source of the demand for foreign value added in the automotive sector. Figure 2 shows that the highest share of value added flows in the automotive sector is absorbed by Germany.
- Similar results to those for the automotive sector hold for the ICT sector (visualisations not reported here).

Note that Figure 1 and Figure 2 report the exact same network structure, with the only difference being the size of the nodes. In the former they are proportional to the weighted out-degree (VA export market share), while in the latter to the in-degree (VA import market share).

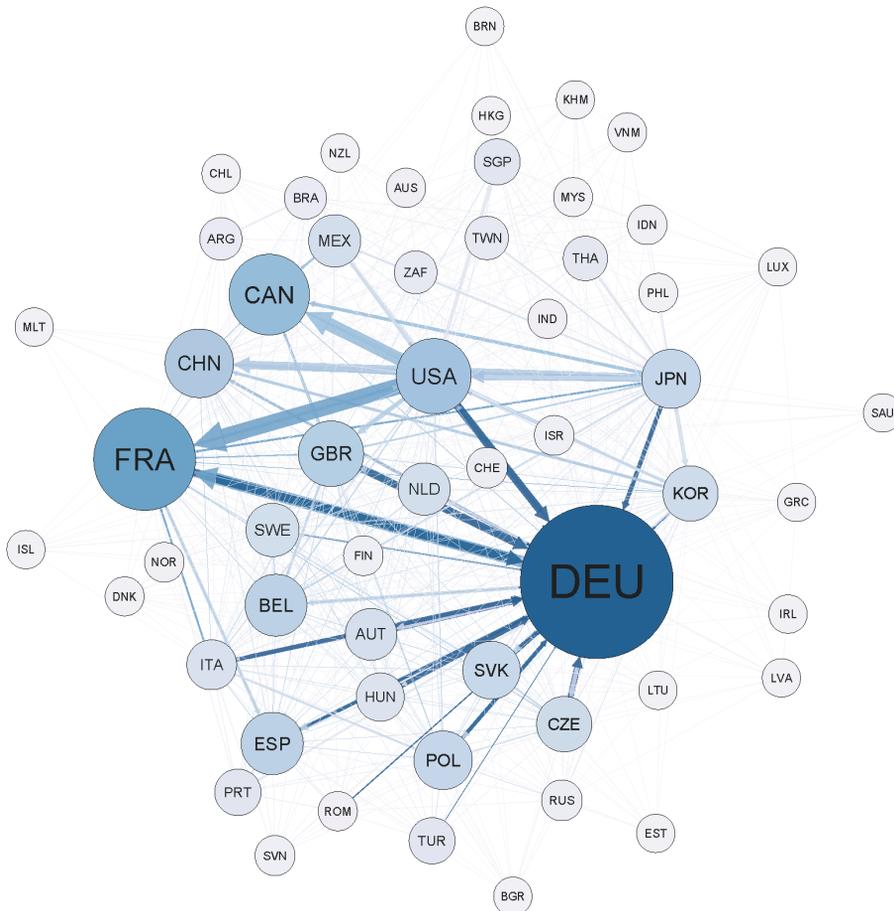
**Figure 1** Intra-sector automotive value added network, main suppliers, 2009



*Notes:* Only flows representing at least 1% of foreign value added out-flows are shown. Nodes are proportional to country market share (as origin of value added flows). The thickness of the links reflects the share of the individual flow in the global value added trade in the sector.

*Source:* OECD TiVa database, intra-industry flows.

**Figure 2** Intra-sectoral automotive value added network, main buyers, 2009



*Notes:* Only flows representing at least 1% of foreign value added in-flows are shown. Nodes are proportional to country market share (as destination of value added flows). The thickness of the links reflects the share of the individual flow in the global value added trade in the sector.

*Source:* OECD TiVa database, intra-industry flows.

In Figure 3 we relax the assumption of inter-sectoral independence. The network in this case shows foreign value added flows by country and sector in 2009. The overall number of nodes is  $N=1008$ , being equal to the number of countries (56) times the available sectors (18). The node size is given by an out-degree, country weighted. Given that the matrix is column normalised, the out-degree measure captures the role of a given country-sector-specific supply of value added. In order to improve readability,

we report only those flows that represent at least 1% of each country-sector imports. Countries are identified by colour: dark grey for China, Hong Kong and Taiwan; dark orange for the US; and blue for the Eurozone.

Not surprisingly, US industries are at the core of the network of global trade, but German business services, China's retail and Russian mining are also well integrated. The Eurozone's industrial structure is very tightly clustered, with business services, retail and chemicals in Germany the biggest suppliers of value added for the other industries in the region. It is worth noting the relative importance of Russian mining and chemical products for the European region. This is depicted by the position of the node in the network and its relative size.



facts, empirical analysis based on network measures can provide further insights on determinants and impacts. Section 3 uses the eigenvector centrality of Bonacich (1987) and Katz (1953) as an indicator of node integration in the network. More formally, we define our structural integration measure (Katz-Bonacich) as:

$$Network_{cst} = \eta(I - \alpha W)^{-1} \mathbf{1}.$$

where  $W$  is the matrix representation of the international input-output network,  $\eta$  is a normalisation factor set equal to 1, and  $\alpha$  is the relative weight of higher order interactions and is set to be equal to 0.5 (as in Acemoglu et al. 2012 and Carvalho 2014).<sup>4</sup> The underlying idea is that in evaluating the integration of a given country  $i$  (i.e. its structural position within the network), what matters is not just direct links (country  $i$ 's import and export relations) but the overall structure of the network, i.e. including higher order linkages. The centrality of a given country  $i$  is then the result of the centrality of its partners and, recursively, of their partners.

Traditional openness measures implicitly assume that, for example, value added flows from the US to France in a given sector are orthogonal to those from Japan to China. The main advantage of using network centrality measures instead is that they account for both direct interactions with partner countries and the interactions of these countries with their partners, in an iterative process that covers the entire network. According to the social interaction model of Duernecker and Vega-Redondo (2012), sustained economic growth is possible only if a country achieves a globalised pattern in which local opportunities for collaboration (or investment) are balanced with those emerging on a global scale. Local opportunities are easy to find (and are usually measured by openness indicators), but they have limited reach. Global opportunities, supplied by very distant nodes, are a powerful way to channel and sustain growth. The working hypothesis of Fagiolo and Santoni (2015), for example, is that local spillovers (measured by country

4 Note that the average share of domestic indirect plus foreign (direct and indirect) value added content of gross exports was 0.47 in 2009. Note that when  $\alpha=0$ , the measures collapse to the degree centrality (only first order connections matter).

openness of business and leisure tourist flows) do not fully characterise the ability of a country to benefit from exposure to foreign ideas and investment opportunities. Their empirical findings show that for any given level of local openness, being more globally integrated in the network is associated with stronger income- or productivity-enhancing spillovers. Other things equal, sharing small flows of people with influential countries can be more income- and productivity-enhancing than interacting with larger numbers of people in less central nodes. Measures of network centrality are therefore preferred here to openness.

In what follows, we measure the correlation between gross exports, EXGR (Exp), and the evolution of the direct (intra-sector) domestic value added, EXGRDDC (Dir), the indirect (upstream) domestic value added, EXGRIDC (Ind), and the foreign value added embodied in gross exports, EXGRFVA (For). All correlations control for country-sector and year fixed effects.<sup>5</sup> The data are from the OECD-WTO TiVA database, covering 56 OECD and non-OECD countries and 18 sectors (two primary sectors, nine manufacturing sectors, and seven services sectors).<sup>6</sup>

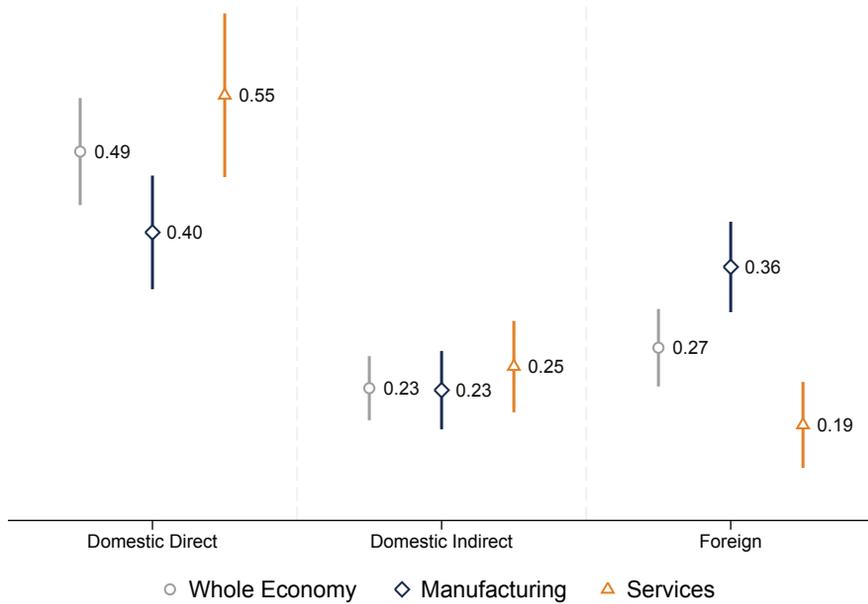
5 Correlations are computed by a linear regression with fixed effect on first differenced variables using a random trend model. This class of model was originally proposed by Heckman and Hotz (1989); Wooldridge (2005) provides a theoretical discussion. The main advantage of this approach is that it allows individual specific time-varying trends along with time-invariant unobserved heterogeneity to be controlled for. Taking the first differences of our baseline equation allows us to remove the additive individual (country-by-sector) specific fixed effect; we can now estimate differenced data using fixed effects to eliminate conditioning of individual-specific trends. The estimated equation is defined as follows:

$$\Delta \ln(Exp_{cst}) = \alpha + \beta_1 \Delta \ln(Dir_{cst}) + \beta_2 \Delta \ln(Ind_{cst}) + \beta_3 \Delta \ln(For_{cst}) + \delta_{cs} + \delta_t + \epsilon_{cst}$$

where  $\Delta$  designates log differences:  $[\ln(Exp_{cst,t}) - \ln(Exp_{cst,t-1})]$ . Re-imported domestic value added is not included, since in many cases its value is 0 and taking natural logarithms would significantly reduce the number of observations.

6 In the empirical application we exclude 'Mining and Quarrying' and 'Construction' from the analysis. The dataset covers the years 1995, 2000, 2005, 2008 and 2009.

**Figure 4** Decomposition of gross export growth (estimated coefficients)



Notes: The graph reports the estimated coefficients of the regression detailed in footnote 5.

Source: Own computations using OECD-WTO TiVA data

The results are reported in Figure 4 and confirm that all value added components are positively correlated with gross exports, suggesting that export growth benefits all participants by expanding their value added.<sup>7</sup> When considering all sectors pooled, the domestic value added embodied in gross exports shows the highest correlation with gross export growth (0.49). For the manufacturing sector as a whole, domestic and foreign value added shows about the same order of magnitude, 0.40 and 0.36. Interestingly, the correlation between exports and domestic direct value added is highest for services industries (0.55), while the association of gross exports with foreign value added seems to be weaker for this sector.

As pointed out above, our preferred measure of a country's structural integration in GVCs is the Katz-Bonacich centrality score ( $Network_{cst}$ ), which measures the centrality

<sup>7</sup> The regression results are reported in Table A3.

of country  $c$  using the whole structure of the network (including third-country effects). The measure can be computed from both the buyer's ( $Network_{cst}^{IN}$ ) and the seller's ( $Network_{cst}^{OUT}$ ) network perspective. In the first set of regressions (Table 1) we assume that sectoral networks are independent; the degree of integration of each country is then evaluated separately for each sector using only the intra-industry cross-country value added flows.<sup>8</sup> The estimated model is given by the following equation:

$$\Delta \ln(y_{cst}) = \alpha + \beta_1 \Delta \ln(Network_{cst}) + \beta_2 \Delta \ln(DomVA_{cst}) + \delta_{cs} + \delta_t + \varepsilon_{cst} \quad (1)$$

where  $\Delta$  designates log differences:  $[\ln(y_{cst}) - \ln(y_{(cst-1)})]$  and  $y_{cst}$  is either the domestic value added content of gross exports ( $Dom_{cst}$ ) or gross exports ( $Exp_{cst}$ ). In the latter case, we also include as a control the share of direct domestic value added,  $DVA_{cst}$ . All correlations control for country-sector and year fixed effects,  $\delta_{cs}$  and  $\delta_t$ . To ease comparability of the effects across specifications, network variables have been standardised (to a zero mean and standard deviation equal to 1) after taking logs.

Table 1 shows the results for the baseline estimation of Equation 1, for both domestic value added content of exports and gross exports. In columns (1) and (3), the integration variable,  $Network_{cst}$ , is built considering only bilateral flows, discarding the directionality of the value added (i.e. setting  $w_{ij} = w_{ji}$ ). The results show that being more integrated in the GVC network is associated with higher domestic value added and exports.

In columns (2) and (4), we consider two different perspectives: the supply side,  $Network_{cst}^{IN}$ , if the country is sourcing value added from other central countries (its suppliers are themselves central); and the demand side,  $Network_{cst}^{OUT}$ , if the country is selling its value added to other central markets (its buyers are themselves central).

Decomposing the integration measure provides useful insights on the possible economic channels through which global value chain externalities diffuse. The magnitude of the estimated coefficients in columns (2) and (4) is evidence of the greater magnitude and

<sup>8</sup> To ease comparability of the effects across specifications and directed centrality measures (inward vs. outward), network variables are standardised (to a zero mean and standard deviation equal to 1) after taking logs.

statistical precision of the estimated effect of supply-side integration ( $Network_{cst}^{IN}$ ). The elasticity of gross exports to supply-side integration is more than twice that for demand (for domestic value added it is 80% higher).

Next we relax the assumption of inter-sectoral independence and compute the Katz-Bonacich centrality scores for the entire country-sector structure of the networks (i.e. the number of nodes is  $N=1008$ ). Table 2 reports the coefficient estimated for the whole sample, and separately for manufacturing and services. The results confirm that the supply side is more strongly correlated with both gross exports and domestic value added. Nevertheless there is a significant cross-sectoral heterogeneity in the magnitude of the effect. In manufacturing, there is greater scope for demand-side spillovers, especially when export growth is measured in terms of domestic value added content of exports ( $Dom_{cst}$ ).

**Table 1** Structural integration in the GVC network, full sample, intra-sectoral IO

Dep Variable:	$\Delta \ln(Dom_{cst})$		$\Delta \ln(Exp_{cst})$	
	(1)	(2)	(3)	(4)
$\Delta Network_{cst}$	0.984*** (0.079)		1.017*** (0.077)	
$\Delta Network_{cst}^{IN}$		0.997*** (0.073)		1.046*** (0.071)
$\Delta Network_{cst}^{OUT}$		0.355*** (0.065)		0.263*** (0.063)
$\Delta \ln(DomVShare_{cst})$			-0.025 (0.096)	-0.043 (0.090)
Constant	0.163*** (0.018)	0.168*** (0.015)	0.204*** (0.018)	0.208*** (0.015)
Observations	3,533	3,533	3,530	3,530
R-squared	0.520	0.606	0.546	0.635

Notes: In parentheses, standard errors clustered at the country-by-sector level. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ . Year and country-by-sector dummies, not reported, are included in all regressions. 'Mining' and 'Construction' are excluded from the estimation sample.

**Table 2** Structural integration in the GVC network, full sample and macro-sectors, inter-sectoral IO

	All	Manuf	Services	All	Manuf	Services
Dep Variable:	$\Delta \ln(Dom_{cst})$			$\Delta \ln(Exp_{cst})$		
$\Delta Network_{cst}^{IN}$	0.997*** (0.073)	0.738*** (0.068)	1.447*** (0.146)	1.046*** (0.071)	0.810*** (0.067)	1.451*** (0.146)
$\Delta Network_{cst}^{OUT}$	0.355*** (0.065)	0.433*** (0.069)	0.331*** (0.079)	0.263*** (0.063)	0.254*** (0.078)	0.310*** (0.072)
$\Delta \ln(DVA_{cst})$				-0.043 (0.090)	0.001 (0.101)	-0.344 (0.235)
Constant	0.168*** (0.015)	0.140*** (0.018)	0.237*** (0.028)	0.208*** (0.015)	0.191*** (0.018)	0.250*** (0.028)
Observations						
R-squared	3,533	2,005	1,304	3,530	2,005	1,301

Notes: In parentheses, standard errors clustered at the country-by-sector level. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. Year and country-by-sector dummies, not reported, are included in all regressions. 'Mining' and 'Construction' are excluded from the estimation sample.

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## Appendix A: Additional regression tables

**Table A3** Decomposition of gross export growth, full sample, various years

Dep Var: Gross Export (EXGR)	All	Manuf	Services	Traditional	Business
EXGRDDC (Dir)	0.489*** (0.030)	0.400*** (0.032)	0.550*** (0.046)	0.639*** (0.018)	0.567*** (0.021)
EXGRIDC (Ind)	0.229*** (0.018)	0.227*** (0.022)	0.253*** (0.026)	0.215*** (0.025)	0.240*** (0.019)
EXGRFVA (For)	0.273*** (0.022)	0.362*** (0.025)	0.189*** (0.024)	0.149*** (0.020)	0.187*** (0.016)
Constant	-0.008** (0.003)	-0.007* (0.004)	-0.009 a	-0.006 (0.004)	0.003 (0.004)
Observations	3,587	2,041	1,314	674	456
R-squared	0.989	0.989	0.994	0.997	0.997

Notes: In parentheses, standard errors clustered at the country-by-sector level. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. All variables are in logs. Year and country-by-sector dummies, not reported, are included in all regressions.

**Table A4** Decomposition of gross export growth by sectors, various years (full sample)

Dep Var:								
Gross Export	Agr	Food	Text	Chem	Met	Mac	Elect	Auto
EXGRDDC (Dir)	0.576*** (0.092)	0.230*** (0.040)	0.461*** (0.043)	0.429*** (0.039)	0.370*** (0.044)	0.443*** (0.026)	0.518*** (0.070)	0.463*** (0.050)
EXGRIDC (Ind)	0.340*** (0.067)	0.497*** (0.073)	0.231*** (0.031)	0.192*** (0.043)	0.238*** (0.042)	0.221*** (0.022)	0.092 (0.068)	0.173*** (0.034)
EXGRFVA (For)	0.108* (0.064)	0.269*** (0.047)	0.290*** (0.034)	0.361*** (0.034)	0.370*** (0.051)	0.333*** (0.026)	0.392*** (0.082)	0.377*** (0.033)
Constant	0.003 (0.014)	0.002 (0.012)	0.001 (0.007)	0.003 (0.009)	-0.007 (0.010)	-0.010** (0.005)	-0.002 (0.015)	-0.018* (0.010)
Observations	224	224	224	224	223	217	224	223
R-squared	0.989	0.989	0.989	0.989	0.989	0.989	0.989	0.989

Notes: In parentheses, standard errors clustered at the country level. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. All variables are in logs. Year and country dummies, not reported, are included in all regressions.

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# Global value networks<sup>1</sup>

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*We study, at the industry level, the patterns of correlation between value added trade flows and the presence of multinational business groups (MBGs) across countries and industries. Value added trade flows are computed from WIOD data through the methodology developed by Wang et al. (2013). Data on the presence of MBGs are obtained as in Altomonte and Rungi (2013), using data from ORBIS and the Ownership Database by Bureau van Dijk. We run gravity estimations augmented with measures of MBGs presence across “triplets”, defined as “home country - home industry - partner country”. We employ as dependent variables both gross exports and the four main value added components of exports (e.g. domestic and foreign value added). We find evidence of a rich pattern of positive correlations between value added trade and the presence of MBGs.*

## **1 Introduction**

There is broad evidence that the development of global value chains (GVCs) is strongly linked to the increasing presence of multinational business groups (MBGs) across countries. And yet, scant evidence exists at the micro level on the characteristics of these MBG-related production networks, and on their relationship with bilateral trade flows. This chapter aims at deepening our understanding of this phenomenon. In particular,

<sup>1</sup> We thank Afrola Plaku for excellent research assistance. We are very grateful to Zhi Wang, Shang-Jin Wei, and Kunfu Zhu for having shared their data on the decomposition of exports with us.

we provide the first micro-based evidence on the patterns of correlation between the joint presence of multinational business groups across countries and industries and the corresponding bilateral flows of trade in value added.

We construct a dataset mapping more than 50,000 multinational business groups globally in the year 2010 (using ORBIS data). We develop several measures of MBG-based linkages across countries and industries, as stemming from the joint presence of the same business groups through their affiliates. We then study how these indicators correlate with bilateral trade flows within a gravity framework, focusing both on gross export flows and, separately, on the different value added components of the same flows. Figures on trade in value added are obtained through the gross export accounting methodology recently developed by Wang et al. (2013), using WIOD data.

Our work is the first to propose a gravity approach to studying the patterns of these bilateral value added trade flows, rather than simple gross measures of exports. To the best of our knowledge, it is also the first to augment gravity equations with a bilateral country-industry variation in terms of business groups' linkages.

Our results are consistent with the standard findings of the gravity literature on gross export flows, for example with respect to the negative role played by distance between countries. In addition, we show that such findings keep holding when considering each value added component separately. This is a novel finding, suggesting that a properly specified gravity approach may remain valuable when studying value added trade flows rather than gross flows. When we augment the gravity equations with indicators for the bilateral joint presence of MBGs across countries, we find evidence of a rich pattern of correlations with value added trade flows.

Section 2 of this chapter describes the methodology of Wang et al. (2013) for decomposing trade flows. Section 3 discusses our data on MBGs. Section 4 presents our econometric analysis, while Section 5 concludes.

## **2 Bilateral value added trade measures and stylised facts**

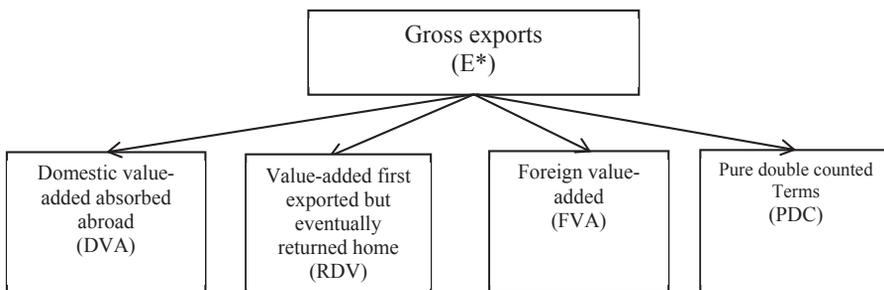
The ability to decompose gross export flows into their different value added components is key to our analysis. To do this, we rely on the methodology recently developed by Wang et al. (2013), which generalises the country-level decomposition by Koopman et al. (2014). Essentially, given a gross export flow equal to 100 from the home country A, in the home industry X, to the partner country B, the methodology by Wang et al. (2013) allows us to uncover which share of the total gross flow corresponds to domestic value added, to foreign value added, and so on, with the shares summing up exactly to 1. Just as in the latter example, the observational units of our analysis are then ‘triplets’, defined as home country (HC) - home industry (HI) - partner country (PC). Having decomposed each gross trade flow at the triplet level, we will focus on four main value added components, as reported in Figure 1, whose sum is always equal to the corresponding gross flow:

- Domestic value added (DVA) is the value added generated in the exporting home country (HC), which is embodied in exported goods of the home industry (HI) and is finally absorbed abroad (not necessarily in the partner country PC). It is important to note that this is a ‘backward linkage’-based measure of value added exports. This means that it takes into account the domestic value added embodied in the exports of a given industry, no matter in which domestic industry such value added has been generated. Thus, it considers the creation of domestic value added along all the vertically related industries, finally embodied in the exports of the industry considered in the triplet (HI).<sup>2</sup>
- Domestic value added first exported but eventually returned home (RDV) is the domestic value added embodied in the export flows which returns home. It includes the export of intermediates that are processed abroad and return home, both as final and intermediate goods.

2 For a discussion of why forward linkage-based measures of value added exports are problematic when working at the industry level, see Wang et al. (2013).

- Foreign value added (FVA) is the foreign value added embodied in domestic exports, both in final goods and in intermediates.
- Pure double counting (PDC) is the portion of gross exports accounted for by intermediates crossing borders several times before being finally absorbed. PDC may include value added generated both in the home country (HC) and abroad, and can be considered a sort of indicator for the extent of production sharing across countries (Wang et al. 2013).

**Figure 1** Gross exports accounting: Major categories



Wang et al. (2013) performed the decomposition of export flows for the 40 countries and 35 industries covered by the WIOD database, as described in the Appendix at the end of this book, over the period 1995-2011. For the purposes of our analysis, we will focus on the year 2010, for which we have been able to retrieve information on the joint presence of MBGs across countries and industries. In particular, we will relate gross exports and their four components to the underlying distribution of business groups, at the triplet level. For example, considering Germany as the home country (HC) and the automotive industry as the home industry (HI), how do trade flows vary as we consider different partner countries (i.e. different PCs and so different triplets)? Are these changes related to the underlying distribution of multinational groups across the different triplets? A practical example, clarifying the concept of triplets and the decomposition of bilateral exports is presented in Appendix A.

Table 1 reports instead some descriptive statistics, across triplets, on the relative importance of the four value added components, taken as shares of gross export flows. As can be seen in the table, DVA accounts for the largest share, about 77% on average, followed by FVA with about 17%, and PDC with an average share of 6.1%. RDV is much less relevant, accounting on average for only 0.4% of gross exports. However, these figures mask substantial heterogeneity across triplets, as suggested by the high standard deviations. In what follows, we investigate how such heterogeneity relates to the presence of multinational business groups across countries and industries.

**Table 1** Shares of value added components across triplets

Variable	Obs.	Mean	Std. Dev.	Min	Max
Share DVA	49411	0.7667	0.1424	0.1294	0.9908
Share RDV	49411	0.0040	0.0092	0.0000	0.3033
Share FVA	49411	0.1678	0.1130	0.0004	0.8025
Share PDC	49411	0.0615	0.0621	0.0000	0.6074

### 3 Business group metrics

In order to build the dataset on multinational groups operating at the triplet level, we combine two sources of data: the Ownership database, containing worldwide proprietary linkages, and the Orbis database, containing firm-level financial accounts. Both databases are produced by the Bureau Van Dijk, and cover the same 40 countries and 35 industries covered by the WIOD data, from which we have obtained value added trade flows. Proprietary linkages data for the year 2010 are employed in order to identify firms that belong to the same business group, both within and across countries. The identification of business groups is performed using the methodology developed by Altomonte and Rungi (2013), considering both direct and indirect control through majority ownership.<sup>3</sup>

<sup>3</sup> Group affiliation is identified through a direct or indirect control above 50.01%; see Altomonte and Rungi (2013) for additional technical details.

Having identified all of the business groups in the data (270,454), given the focus of our study we then restrict our analysis to 50,016 multinational business groups (MBGs), i.e. business groups controlling at least one subsidiary in a country different from the country of origin of the parent company. These 50,016 multinational groups account for a total of 758,696 ‘nodes’, where a node is a firm belonging to a group, be it an affiliate or the parent company. Table 2 shows the distribution of nodes across the 40 WIOD countries. The majority of nodes are located in OECD countries, with the US and the UK being the two major hosts of multinational firms.<sup>4</sup>

Starting from the retrieved information on MBGs, we develop a number of metrics on the number and the characteristics of multinational business groups operating in each triplet. In particular, given the triplet home country (HC) - home industry (HI) - partner country (PC), we have the following:

- H\_Nodes is the number of nodes located in home country (HC) - home industry (HI), belonging to MBGs that are also present with at least one node in the partner country (PC).
- P\_Nodes is the number of nodes located in the partner country (PC), in any industry, belonging to MBGs that are also present with at least one node in the home country (HC) – home industry (HI). P\_Nodes can be further split in two components:
  - P\_Nodes\_HI is the number of nodes operating in the partner country (PC) in the same home industry (HI).
  - P\_Nodes\_noHI is the number of nodes operating in the partner country (PC) in any other industry.

As a clarifying example, let us consider France as the home country (HC), food as the home industry (HI), and Italy as the partner country (PC). A value of H\_Nodes = 145 means that, in the French food industry, there are 145 nodes owned by MBGs (no matter where they are originated) which are also present in Italy. P\_Nodes = 230 means

<sup>4</sup> The very large number of nodes in the UK partly reflects the fact that we are including MBGs of a financial nature.

that the MBGs operating in the French food industry control 230 nodes in Italy, across all industries. We can further decompose this figure into two components: P\_Nodes\_HI = 110 (nodes owned in the Italian food industry); and P\_Nodes\_noHI = 120 (nodes owned in any other Italian industry but food).

**Table 2** Number of nodes by country

Country	Country Identifier	Total Nodes	Country	Country Identifier	Total Nodes
Australia	AUS	24,141	Italy	ITA	33,216
Austria	AUT	12,335	Japan	JPN	31,796
Belgium	BEL	12,493	South Korea	KOR	3,122
Bulgaria	BGR	7,795	Lithuania	LTU	1,300
Brazil	BRA	8,378	Luxembourg	LUX	6,741
Canada	CAN	15,493	Latvia	LVA	1,097
China	CHN	23,970	Mexico	MEX	10,062
Cyprus	CYP	2,915	Malta	MLT	872
Czech Republic	CZE	5,269	Netherlands	NLD	30,473
Germany	DEU	67,132	Poland	POL	11,719
Denmark	DNK	11,403	Portugal	PRT	7,091
Spain	ESP	34,076	Romania	ROM	2,541
Estonia	EST	1,663	Russia	RUS	17,492
Finland	FIN	5,324	Slovakia	SVK	2,233
France	FRA	48,432	Slovenia	SVN	1,294
United Kingdom	GBR	134,159	Sweden	SWE	14,500
Greece	GRC	3,245	Turkey	TUR	3,413
Hungary	HUN	3,094	Taiwan	TWN	3,710
Indonesia	IDN	2,370	United States	USA	130,200
India	IND	7,034			
Ireland	IRL	15,103			<b>Total 758,696</b>

In addition to the quantitative metrics presented above, we also compute four additional variables capturing some characteristics of the MBGs that are active in each triplet, i.e. that control at least one node in home country (HC) - home industry (HI), and one node in the partner-country (PC) in any industry. In particular, we retrieve two measures of size and two indicators of diversification:

- Average Total Sales is the average global sales of the MBGs operating in the triplet.
- Average Total Affiliates is the average number of affiliates of the MBGs operating in the triplet.
- Geographical Diversification is the average number of countries in which the MBGs operating in the triplet are active.
- Industrial Diversification is the average number of industries (NACE 2-digits) in which the MBGs operating in the triplet are active.

It is important to bear in mind that the same MBG can operate in several different triplets; in that case, its characteristics will be considered for the averages of each relevant triplet. Table 3 presents the median values for the MBG indicators by country. These figures are computed for each country C across all the triplets having country C as the home country (HC).

**Table 3** Multinational group indicators: Medians by country across triplets

Country Identifier	H_Nodes	P_Nodes	P_Nodes_HI	P_Nodes_noHI	Average Total Sales	Average Total Nodes	Geographical Diversification	Industrial Diversification
AUS	66	43	19	20	14,674,116	311	24	14
AUT	37	65	13	43	19,082,830	366	24	17
BEL	61	105	19	76	25,073,384	385	25	17
BGR	8	24	8	12	14,835,578	356	26	15
BRA	43	76	18	53	21,200,436	356	25	16
CAN	58	88	20	62	23,137,028	353	25	16
CHN	73	53	23	26	20,230,366	297	23	14
CYP	7	13	5	5	11,558,296	303	22	14
CZE	27	66	16	43	20,231,190	366	25	16
DEU	245	275	33	209	23,826,804	356	24	17
DNK	27	43	12	29	15,485,565	322	25	15
ESP	137	164	23	126	24,593,904	385	24	16
EST	6	17	4	10	13,617,586	349	26	16
FIN	18	38	9	25	16,485,939	306	25	15
FRA	240	202	28	155	29,848,053	403	25	17
GBR	463	278	39	222	24,845,375	349	22	16
GRC	11	27	8	15	22,298,174	364	26	15
HUN	19	49	16	27	20,502,895	372	26	16
IDN	10	22	9	9	18,845,260	338	26	15

Country Identifier	H_Nodes	P_Nodes	P_Nodes_HI	P_Nodes_noHI	Average Total Sales	Average Total Nodes	Geographical Diversification	Industrial Diversification
IND	27	42	19	20	17,665,032	321	25	15
IRL	36	64	14	43	24,330,286	387	25	16
ITA	98	134	23	101	21,642,671	386	24	17
JPN	73	71	12	51	32,429,070	330	23	16
KOR	16	32	12	19	24,269,402	321	26	16
LTU	5	13	3	7	10,800,584	287	24	14
LUX	28	44	16	21	20,940,257	380	25	16
LVA	3	9	3	5	9,787,161	262	24	13
MEX	64	90	19	62	24,098,509	371	26	17
MLT	3	4	1	1	8,803,183	304	23	12
NLD	109	123	24	88	21,146,170	344	24	16
POL	56	112	23	79	22,421,414	367	24	16
PRT	32	58	15	37	22,208,305	392	26	16
ROM	19	52	18	28	21,567,157	404	27	16
RUS	71	98	21	70	25,090,180	357	24	17
SVK	14	37	11	20	20,624,558	371	26	16
SVN	5	14	4	7	13,091,379	325	27	16
SWE	71	85	16	62	19,434,209	353	25	16
TUR	21	30	13	14	18,562,468	333	26	15
TWN	8	16	8	6	15,895,090	321	27	15
USA	507	317	39	266	28,202,264	365	24	16

## 4 Econometric analysis

We investigate the correlation patterns between trade and MBG metrics within a gravity framework. The basic idea behind the gravity analysis is that two countries will trade more or less with each other depending on a number of factors related to geographical, cultural and institutional proximity.

Our analysis proceeds in steps. First, we run a standard gravity estimation (as in Anderson and Van Wincoop 2003) by regressing bilateral gross exports from country to country over the following variables: geographical distance and contiguity, common legal origin and language, and being part of a regional trade agreement involving trade in goods or also in services. We also include dummies for the exporting home country

(HC) and the recipient partner country (PC), to properly account for the multilateral resistance term in our cross-section. Such an approach has been widely adopted in trade studies aiming to identify the drivers of international trade.

Our results (available in Appendix B, Table 5) are in line with earlier studies, i.e. exports are higher towards closer and more similar trading partners. And yet, as suggested by Baldwin and Taglioni (2011), a gravity analysis based on gross exports alone may perform poorly in a world of global value chains, in which parts and components trade is relevant. Therefore, in the second step of our exercise, we repeat the same gravity analysis separately on the four bilateral value added components making up gross exports: DVA, RDV, FVA and PDC. To the best of our knowledge, we are the first to engage in such an analysis, thanks to the availability of precisely estimated bilateral value added flows via the methodology of Wang et al. (2013). By looking at the distance coefficient, the gravity specification seems appropriate also for each of the four value added components, and the results are essentially the same as in the analysis of gross exports. That is, all the value added components of exports tend to grow when considering closer and more similar trading partners. In the case of RDV, proxies for distance play an even stronger role, consistent with the fact that this component refers to domestic value added which is first exported and then re-imported and absorbed at home.

In the third step of our analysis, we replicate the analysis above at the triplet level, i.e. focusing on export flows from each home country (HC) and home industry (HI) towards each partner country (PC). We include in this case home country-home industry effects, as well as partner country effects. The results confirm the above findings obtained for country-to-country exports. In addition, a positive and significant association emerges

between trade flows and joint participation in a regional trade agreement covering trade in goods (Appendix B, Table 6).<sup>5</sup>

In the last step of the analysis, we augment the triplet-level gravity analysis by including our metrics for the presence of multinational business groups, aiming to uncover the correlation patterns between MBGs and (value added) trade. First, we include the variable Total Nodes, capturing the total MBG-based linkages in a triplet. This variable is computed as the sum of H\_Nodes and P\_Nodes, and thus considers both nodes present in the home country-home industry and nodes located in the partner country in any industry (Appendix B, Table 7). We then include separately H\_Nodes and the two components of P\_Nodes, i.e. P\_Nodes\_HI and P\_Nodes\_noHI (Appendix B, Table 8). The results suggest the presence of a robust positive correlation between MBG-based linkages, gross exports, and each of the four value added components. To give an idea of the magnitude of this correlation, a 1% increase in the number of Total Nodes operating in the triplet is associated with an increase in gross exports and DVA flows by 0.38%, an increase in RDV flows by 0.59%, an increase in FVA flows by 0.36%, and an increase in PDC flows by 0.45%. When breaking down the different components of Total Nodes, the highest correlation is always found between trade flows and H\_Nodes, i.e. the number of nodes located in home country (HC) - home industry (HI), belonging to MBGs that are also present with at least one node in the partner country (PC). Considering the nodes in the partner country, the correlation is higher for nodes that are operating in industries different from the home industry (HI) considered in the triplet. The latter finding suggests that vertical integration has a stronger correlation with exports than horizontal integration.

Finally, we enrich our specifications with the four indicators on the average size and diversification of the MBGs operating in each triplet (Appendix B, Table 9). A higher

5 Our analysis focuses only on triplets for which we observe both a positive trade flow and the presence of MBGs. Since we are working with the 40 largest economies in the world, and with relatively aggregated industries, few triplets drop out of the analysis. Robustness checks in which we have considered also the presence of the zero cells have confirmed our results.

average size of MBGs, as proxied by average total sales, is positively associated with gross exports and with each value added component. In contrast, higher diversification, especially at the geographical level, is negatively related to value added trade flows. This suggests that, having controlled for the number of MBG linkages, nodes operating in more dispersed countries and industries *ceteris paribus* will tend to trade relatively less.

All of the above findings mask some degree of heterogeneity across countries. In particular, results from Ramondo et al. (2015) suggest that intra-group trade may be less relevant for US multinational groups than for others. This result is also confirmed in our setting when restricting the analysis to triplets having the US as the home country. Indeed, in that case only  $P\_nodes\_HI$  is found to be associated with higher trade, consistent with the idea that the ‘horizontal’ dimension may be more relevant in the US FDI strategy.

## **5 Conclusion**

Several policy-relevant findings emerge from our analysis.

First, although the nature of the four value added trade flows differs in principle, the economic drivers of these flows are largely similar. Indeed, the same bilateral gravity framework is able to explain each component of the value added trade decomposition, with very similar coefficients to those obtained for the standard aggregate export measure.

Second, the bilateral cross-country linkages established through the presence of business groups, however defined, are positively associated with each type of value added trade flow. This finding is quite unsurprising when considering the share of exported value added sourced from abroad (FVA), ‘double counting’ trade flows (PDC), and outward processing trade (RDV). In fact, in a model of ‘vertical’ FDI, the establishment of affiliates in a partner country (or the presence of local affiliates of foreign groups in

the home country) would generate a higher exchange of intermediates, eventually embodied in domestic exports. Much less obvious is our finding that the same business group linkages are also positively associated with the ability of any home country/industry to export more domestic value added (i.e. the DVA component).

A causal (and non-exclusive) interpretation of the latter finding might suggest that, through the presence of multinational business groups, a country may raise its ability to export domestic value added, for example via access to superior technology, product upgrading, and the like. These channels have not been investigated in our contribution, and may constitute an interesting subject for future studies.

A further promising line of research could be to explore in more depth the cross-country heterogeneity behind our results, especially in light of the recent findings by Ramondo et al. (2015) on the US. This would certainly deepen our understanding of global value networks.

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## Appendix

### A. Decomposition of gross exports: An example

A practical example may help in understanding the concept of triplets and the decomposition of bilateral exports in different value added components. Consider the exports of the automotive industry (code c15 in the WIOD classification) originated in Germany, France and Italy, and directed to the US. Columns 1 and 2 in Table 4 report the exporting home country (HC) and home industry (HI) considered, while Column 3 reports the importing partner country (PC). Column 4 shows the value (in millions of US dollars) of gross exports for each triplet. For example, in 2010 the German automotive industry exported approximately \$26 billion of goods to the US. Columns 5-8 decompose this export flow into the four major value added components: DVA, RDV, FVA and PDC. To ease comparison across triplets, the four components are reported as shares of gross exports. By summing up the four shares in each row, one obtains 100%, as the backward linkage methodology allows us to precisely decompose gross exports at the triplet level.

**Table 4** Example of gross exports decomposition

Home country	Home industry	Partner country	Gross Exports	Share DVA	Share RDV	Share FVA	Share PDC
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DEU	Automotive	USA	26,093	66.15%	0.18%	30.97%	2.70%
FRA	Automotive	USA	7,793	62.04%	0.18%	33.34%	4.45%
ITA	Automotive	USA	2,481	70.10%	0.09%	25.49%	4.31%
DEU	Automotive	CHN	22,794	65.72%	0.38%	30.16%	3.74%
FRA	Automotive	CHN	4,392	62.29%	0.12%	34.37%	3.23%
ITA	Automotive	CHN	5,854	69.94%	0.25%	25.40%	4.41%
DEU	Automotive	POL	7,288	59.81%	0.40%	19.84%	16.34%
FRA	Automotive	POL	1,203	61.32%	0.91%	29.45%	8.32%
ITA	Automotive	POL	1,925	65.95%	3.91%	15.87%	14.27%
DEU	Food	USA	1,353	76.14%	0.07%	23.04%	0.75%
FRA	Food	USA	2,457	82.64%	0.00%	17.30%	0.06%
ITA	Food	USA	2,527	80.54%	0.00%	19.40%	0.06%

Looking at the first row, we observe that 66.15% of the German automotive exports towards the US is accounted for by value added produced at home (in any industry of the home country) and ultimately absorbed by other countries (DVA). Domestic value added initially exported but ultimately returned home and absorbed at home (RDV) accounts for 0.18% of gross exports. The share of foreign value added embedded in German exports (FVA) is equal to 30.97%, while 2.7% is pure double counting (PDC). Comparing the German automotive exports towards the US to those coming from Italy and France, we can observe several differences. In particular, the Italian automotive industry has the highest DVA share (70.1%) and the lowest FVA share (25.49%), while the opposite holds for France. RDV shares are very small for all countries, while PDC is non-negligible, implying a significant extent of international production integration.

Considering a different partner country, China, quite surprisingly we find a very similar decomposition of gross exports, thus suggesting that the same value added structure holds for the automotive exports of Germany, Italy and France towards both China and the US. Different considerations can be made, however, when we repeat the same exercise decomposing the export flows towards Poland. In this case, both DVA and FVA shares are lower than those observed for the US and China. On the other hand, RDV and especially PDC shares are higher. For instance, in the case of Italy, almost 4% of gross exports towards Poland are re-imported and absorbed in the home market, while pure double counting, caused by multiple border crossing of intermediate goods, accounts for around 14% of gross exports. This evidence is in line with the idea that global value chains actually tend to have a stronger 'regional' nature (Baldwin 2014).

Finally, it is interesting to compare the value added structures for the same European exporting countries and the first considered partner country, the US, while focusing on a different home industry, i.e. food (code c03 in the WIOD classification), as reported in the last three rows of Table 4. In particular, we notice that DVA is always more relevant for the food industry than for the automotive industry, with France and Italy having the highest DVA shares. Consistent with this observation, we also find lower FVA shares, while RDV and PDC are negligible. Overall, food production thus seems to rely more

on domestic components and services, with a less internationally segmented value chain.

These simple descriptive statistics show how the value added structures of exports may differ substantially between exporting countries, between industries within each exporting country, and also for the same home country and home industry depending on the partner country towards which exports are directed.

B. Econometric analysis: Results

**Table 5** Gravity country-to-country

	(1)	(2)	(3)	(4)	(5)
Dependent variable:	Gross Exports	DVA	RDV	FVA	PDC
Distance	-1.0821*** [0.050]	-1.0495*** [0.051]	-1.9769*** [0.077]	-1.1194*** [0.049]	-1.2178*** [0.054]
Contiguity	0.3600*** [0.099]	0.3686*** [0.100]	0.7177*** [0.153]	0.3418*** [0.096]	0.3318*** [0.107]
Common Legal Origin	0.2848*** [0.050]	0.2862*** [0.051]	0.4490*** [0.077]	0.2807*** [0.048]	0.2561*** [0.054]
Common Language	0.2538** [0.100]	0.2401** [0.102]	0.4082*** [0.155]	0.2806*** [0.098]	0.2240** [0.108]
RTA Goods	1.2729 [0.141]	1.3056 [0.143]	1.8736 [0.218]	0.2289* [0.137]	1.0944 [0.152]
RTA Services	0.1639 [0.149]	0.2590 [0.151]	0.3590 [0.230]	0.0084 [0.145]	0.6097 [0.161]
Obs.	1560	1560	1560	1560	1560
R2	0.63	0.63	0.63	0.63	0.62

Notes: Depending on the column, the dependent variable is, alternatively: (log of) Gross Exports (1), DVA (2), RDV (3), FVA (4), and PDC (5). These figures refer to bilateral exports country-to-country. Distance is the log of the population-weighted distance (pop-wt, km). Contiguity, Common Legal Origin, and Common Language are dummy variables indicating, respectively, if the two countries are contiguous, have the same legal origin, share the same language. RTA Goods and RTA Services are dummy variables indicating if the two countries have Regional Trade Agreements involving only goods, or both services and goods, respectively. All specifications are estimated by OLS and control for home country and partner country effects. \*\*\*, \*\*, \* = indicate significance at the 1, 5, and 10% level, respectively.

**Table 6** Gravity at the triplet level

	(1)	(2)	(3)	(4)	(5)
Dependent variable:	Gross Exports	DVA	RDV	FVA	PDC
Distance	-1.2205*** [0.023]	-1.2149*** [0.023]	-2.1043*** [0.026]	-1.2105*** [0.023]	-1.2539*** [0.024]
Contiguity	0.4128*** [0.045]	0.4044*** [0.045]	0.7981*** [0.050]	0.4210*** [0.044]	0.4271*** [0.046]
Common Legal Origin	0.4007*** [0.022]	0.4014*** [0.022]	0.5535*** [0.025]	0.4081*** [0.022]	0.3690*** [0.023]
Common Language	0.1452*** [0.046]	0.1408*** [0.046]	0.3480*** [0.051]	0.1426*** [0.045]	0.1701*** [0.047]
RTA Goods	0.3480*** [0.069]	0.3489*** [0.069]	0.2893*** [0.077]	0.3602*** [0.068]	0.2568*** [0.071]
RTA Services	-0.1538** [0.072]	-0.1541** [0.072]	-0.0340 [0.080]	-0.1728** [0.071]	-0.0254 [0.073]
Obs.	49,411	49,411	49,179	49,411	49,179
R2	0.762	0.758	0.818	0.789	0.780

Notes: Depending on the column, the dependent variable is, alternatively: (log of) Gross Exports (1), DVA (2), RDV (3), FVA (4), and PDC (5). These figures refer to bilateral exports at the triplet level. For further explanations see footnote on Table 5. All specifications are estimated by OLS and control for home country - home industry and partner country effects. \*\*\*, \*\*, \* = indicate significance at the 1, 5, and 10% level, respectively.

**Table 7** Gravity at the triplet level, augmented (1)

	(1)	(2)	(3)	(4)	(5)
Dependent variable:	Gross Exports	DVA	RDV	FVA	PDC
Total Nodes	0.3827*** [0.017]	0.3823*** [0.017]	0.5890*** [0.018]	0.3554*** [0.016]	0.4460*** [0.017]
Distance	-1.0673*** [0.025]	-1.0615*** [0.025]	-1.8758*** [0.028]	-1.0661*** [0.025]	-1.0773*** [0.026]
Contiguity	0.3628*** [0.047]	0.3541*** [0.047]	0.7204*** [0.052]	0.3737*** [0.046]	0.3777*** [0.048]
Common Legal Origin	0.3830*** [0.024]	0.3837*** [0.024]	0.5371*** [0.027]	0.3910*** [0.024]	0.3590*** [0.025]
Common Language	0.1211** [0.048]	0.1164** [0.048]	0.2860*** [0.054]	0.1215** [0.048]	0.1295*** [0.050]
RTA Goods	0.2646*** [0.073]	0.2655*** [0.073]	0.2142*** [0.081]	0.2761*** [0.072]	0.1704** [0.075]
RTA Services	-0.0424 [0.076]	-0.0427 [0.076]	0.0630 [0.084]	-0.0581 [0.075]	0.0880 [0.078]
Obs.	41,583	41,583	41,448	41,583	41,448
R2	0.759	0.755	0.817	0.787	0.777

Notes: Depending on the column, the dependent variable is, alternatively: (log of) Gross Exports (1), DVA (2), RDV (3), FVA (4), and PDC (5). These figures refer to bilateral exports at the triplet level. Total Nodes is computed as the sum of H\_Nodes and P\_Nodes. For further explanations see footnote on Table 5. All specifications are estimated by OLS and control for home country - home industry and partner country effects. \*\*\* \*\* \* = indicate significance at the 1, 5, and 10% level, respectively.

**Table 8** Gravity at the triplet level, augmented (2)

	(1)	(2)	(3)	(4)	(5)
Dependent variable:	Gross Exports	DVA	RDV	FVA	PDC
H_Nodes	0.3173*** [0.025]	0.3165*** [0.025]	0.4652*** [0.028]	0.3165*** [0.025]	0.3178*** [0.026]
P_Nodes_HI	0.0724*** [0.013]	0.0724*** [0.013]	0.1213*** [0.015]	0.0492*** [0.013]	0.1256*** [0.014]
P_Nodes_noHI	0.2517*** [0.016]	0.2518*** [0.016]	0.3884*** [0.018]	0.2430*** [0.016]	0.2723*** [0.017]
Distance	-0.9961*** [0.026]	-0.9902*** [0.026]	-1.7692*** [0.029]	-0.9948*** [0.026]	-0.9999*** [0.027]
Contiguity	0.3548*** [0.047]	0.3461*** [0.047]	0.6995*** [0.052]	0.3647*** [0.047]	0.3827*** [0.049]
Common Legal Origin	0.3339*** [0.025]	0.3348*** [0.025]	0.4746*** [0.028]	0.3437*** [0.025]	0.3008*** [0.026]
Common Language	0.0946* [0.049]	0.0897* [0.049]	0.2433*** [0.055]	0.0946* [0.049]	0.1125** [0.051]
RTA Goods	0.1365* [0.074]	0.1374* [0.074]	0.0942 [0.083]	0.1533** [0.073]	0.0683 [0.077]
RTA Services	0.0869 [0.077]	0.0866 [0.077]	0.1860** [0.086]	0.0720 [0.076]	0.1917** [0.080]
Obs.	36,963	36,963	36,867	36,963	36,867
R2	0.762	0.758	0.819	0.794	0.781

Notes: Depending on the column, the dependent variable is, alternatively: (log of) Gross Exports (1), DVA (2), RDV (3), FVA (4), and PDC (5). These figures refer to bilateral exports at the triplet level. For further explanations see footnote on Table 5. All specifications are estimated by OLS and control for home country - home industry and partner country effects. \*\*\*, \*\*, \* = indicate significance at the 1, 5, and 10% level, respectively.

**Table 9** Gravity at the triplet level, augmented (3)

	(1)	(2)	(3)	(4)	(5)
Dependent variable:	Gross Exports	DVA	RDV	FVA	PDC
H_Nodes	0.1667*** [0.028]	0.1661*** [0.028]	0.2248*** [0.031]	0.1657*** [0.027]	0.1681*** [0.029]
P_Nodes_HI	0.0482*** [0.013]	0.0482*** [0.013]	0.0824*** [0.015]	0.0249* [0.013]	0.1003*** [0.014]
P_Nodes_noHI	0.2265*** [0.016]	0.2266*** [0.016]	0.3472*** [0.018]	0.2178*** [0.016]	0.2476*** [0.017]
Average Total Sales	0.1389*** [0.039]	0.1387*** [0.039]	0.1448*** [0.044]	0.1368*** [0.039]	0.1050*** [0.041]
Average Total Affiliates	0.0513 [0.103]	0.0505 [0.103]	-0.1475 [0.115]	0.0596 [0.102]	-0.0432 [0.107]
Industrial Diversification	-0.3812** [0.160]	-0.3811** [0.160]	-0.2508 [0.179]	-0.3894** [0.159]	-0.3035* [0.166]
Geographical Diversification	-1.1375*** [0.133]	-1.1345*** [0.133]	-1.7308*** [0.149]	-1.1403*** [0.132]	-1.0528*** [0.138]
Distance	-0.9235*** [0.026]	-0.9177*** [0.026]	-1.6482*** [0.029]	-0.9222*** [0.026]	-0.9252*** [0.027]
Contiguity	0.3073*** [0.047]	0.2987*** [0.047]	0.6237*** [0.052]	0.3171*** [0.047]	0.3353*** [0.049]
Common Legal Origin	0.3043*** [0.025]	0.3052*** [0.025]	0.4253*** [0.028]	0.3141*** [0.025]	0.2697*** [0.026]
Common Language	0.0547 [0.049]	0.0498 [0.049]	0.1807*** [0.055]	0.0545 [0.049]	0.0731 [0.051]
RTA Goods	0.1465** [0.074]	0.1474** [0.074]	0.1109 [0.082]	0.1634** [0.073]	0.0777 [0.077]
RTA Services	0.0768 [0.077]	0.0765 [0.077]	0.1751** [0.086]	0.0618 [0.076]	0.1839** [0.080]
Obs.	36,963	36,963	36,867	36,963	36,867
R2	0.763	0.759	0.821	0.795	0.782

Notes: Depending on the column, the dependent variable is, alternatively: (log of) Gross Exports (1), DVA (2), RDV (3), FVA (4), and PDC (5). These figures refer to bilateral exports at the triplet level. For further explanations see footnote on Table 5. All specifications are estimated by OLS and control for home country - home industry and partner country effects. \*\*\*, \*\*, \* = indicate significance at the 1, 5, and 10% level, respectively.

## Part II

### Impacts of global value chains

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# Global value chains, labour markets and productivity<sup>1</sup>

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*Global value chains (GVCs) have deeply changed the paradigm of world production, strongly affecting labour market and productivity developments. This chapter broadly surveys the empirical research on the impacts of GVCs on employment, wages and productivity. Most papers conclude that the rise of GVCs accounts for a relevant part of the increase in the relative demand for skilled labour in developed countries, but the overall effect on the level of employment is small. As for productivity, the literature suggests a positive impact of participation in GVCs.*

## **1 Introduction**

Numerous empirical studies have focused on the potential adverse effects of offshoring on the labour markets of developed countries, stemming from fears of significant job losses. The media often claims that offshoring of corporate activities to developing countries reduces operations and employment at home (for a discussion, see Mankiw and Swagel 2006). Over the last few decades, most developed countries have witnessed a shift in labour demand towards more-skilled workers, with an increase in wage and employment inequality. Skill-biased technological change and GVCs are commonly seen as the two main factors behind this evolution. In a complementary strand of analysis, the literature has discussed whether and how GVCs affect firm-level

<sup>1</sup> The views expressed in the chapter are those of the authors and do not necessarily correspond to those of Banco de Portugal or the Eurosystem.

productivity. A positive effect is expected, as GVCs allow firms to benefit from gains from specialisation, leading to a more efficient use of production factors. However, the empirical evidence on the relationship between offshoring and productivity is still limited. In this chapter, we briefly survey the literature on these two topics.

## **2 Employment, skills and wages**

International outsourcing tends to have a negative impact on the relative demand for low-skilled labour in developed countries. Studies using industry-level measures of offshoring – sometimes combined with information on individual wages – to evaluate the impact on relative labour demand are numerous and cover a wide range of countries. The seminal works of Feenstra and Hanson (1996, 1999) conclude that the rise of outsourcing accounted for a significant part of the increase in the relative demand for skilled labour in US manufacturing industries in the 1980s. Using a similar approach, Geishecker (2006) finds that the significant growth of international outsourcing in the 1990s was an explanation for the observed decline in relative demand for manual workers in German manufacturing. Also for Germany, Geishecker and Görg (2008) combine information on individual wages with industry-level measures of international outsourcing and find evidence of a significant negative (positive) effect of offshoring on the real wage of low-skilled (high-skilled) workers in the country. For the UK, Hijzen et al. (2005) also find that international outsourcing had a strong negative impact on the demand for unskilled labour, and Hijzen (2007) concludes that while skill-biased technological change is the major driving force of wage inequality, offshoring also contributed significantly (see Chapter 3 of this book by Los, Stehrer, Timmer and de Vries for a contribution to this literature).

Other studies use similar methodologies but focus on the impact of services offshoring. Crinò (2010b) studies the effects of services offshoring on white-collar employment, using an industry-level measure combined with disaggregated occupational data for the US. The paper finds that services offshoring increases employment in more skilled

occupations and concludes that, within each skill group, such offshoring penalises tradeable occupations. Geishecker and Görg (2013) use worker-level data combined with sectoral data to study the impact of services offshoring on individual wages for the UK, finding small but non-negligible effects on wage inequality. The authors conclude that services offshoring negatively affects the real wages of low- and medium-skilled individuals, but has a positive effect on the real wages of skilled workers. For Japan, Agnese (2012) differentiates the effects of services and materials offshoring on the employment shares of seven broad skill groups, concluding that services offshoring has a positive effect on the employment share of highly skilled workers, while materials offshoring tends to benefit production workers.

There are fewer empirical works using firm-level measures of offshoring to assess its impact on the relative labour demand of skilled and unskilled workers. Antonietti and Antonioli (2011) study how the international outsourcing of production impacts the skill structure of employment within Italian manufacturing firms. Their results point to a potential skill-bias effect of production offshoring, driven by a fall in the demand for unskilled workers. Crinò (2010a) studies the effects of services offshoring on the level and skill composition of domestic employment of Italian firms. The paper concludes that services offshoring has no effect on the level of employment but changes its composition in favour of high-skilled workers. The results of Tomiura et al. (2013) for Japan also suggest that offshoring is related with a shift in the composition of employment towards high-level skills, even within non-production workers. Mion and Zhu (2013), using Belgian manufacturing firm-level data, also find evidence that offshoring of both finished and intermediate goods, especially to China, tends to foster skill upgrading. Crinò (2012) examines the effect of imported inputs on the relative demand for high-skill labour using firm-level data for 27 transition countries. The author finds that imported inputs increase the relative demand for high-skill labour, as importing firms engage in high-skill-intensive activities. Hummels et al. (2014) use matched worker-firm data for Denmark to estimate how offshoring and exporting affect

individual wages by skill, concluding that offshoring tends to increase the wages of high-skilled workers and decrease the wages of low-skilled workers.

Following firm-level studies by labour economists on the impact of technological change on skill composition and wage inequality, some papers use the content of tasks to examine the impact of offshoring and find that offshoring tends to shift labour demand towards non-routine tasks. Using plant-level data for German multinationals, Becker et al. (2013) provide evidence that offshoring is related to onshore skill upgrading. They find that offshore employment within multinationals in both manufacturing and services is associated with a shift towards more non-routine and more interactive tasks and towards highly educated workers. Baumgarten et al. (2013) link individual-level data with industry-level offshoring measures for the German manufacturing industry, taking into account the interaction between tasks and skills. They find that within-industry changes in offshoring have only modest negative effects on wages but, allowing for labour mobility across sectors, the cross-industry negative wage effects of offshoring are substantial and depend strongly on the task profile of workers, even within skill groups. A high degree of personal interactivity and, especially, of non-routine content play a mitigating role in the negative wage effect of offshoring. Ebenstein et al. (2014) merge worker-level data on wages with industry-level data on offshoring employment of US multinationals and conclude that the impact of offshoring depends both on the location of the offshore activities and on the routineness of the tasks performed. For instance, the increase of offshore employment in low-income locations is associated with wage reductions for routine workers, but the opposite happens with offshore activity in high-income locations. However, the effects of offshoring are always stronger in occupations classified as more routine.

A less studied issue relates to the overall effect of offshoring on the level of employment. Using industry-level data for 17 OECD countries, Hijzen and Swaim (2007) find that offshoring has no effect, or a slight positive effect, on sectoral employment. Falk and Wolfmayr (2008) use input-output tables for five European countries and find a small negative impact of services outsourcing to low-wage countries on employment in the

non-manufacturing sector. For the manufacturing sector, the outsourcing of intermediate materials to low-wage countries also appears to have a relatively small negative impact on the demand for labour. Cadarso et al. (2008) use detailed input-output tables for the Spanish manufacturing industry and find a negative effect of outsourcing to central and eastern European countries on employment in medium-high-tech sectors, but no clear effect in low-tech sectors. Michel and Rycx (2012), using Belgium industry-level data, find that materials and services offshoring has no significant impact on total employment.

The small magnitude of the effects obtained at the industry level can hide differences in labour demand for different skill categories and differences at the individual firm level. Görg and Hanley (2005b) use plant-level data for the Irish electronics sector to examine the effect of international outsourcing on labour demand of the outsourcing plant, finding that it decreases labour demand in the short run. In addition, they find stronger negative effects from the outsourcing of materials than of services. Lo Turco and Maggioni (2012) use a balanced panel of Italian manufacturing firms and find a negative effect of imports of intermediates from low-income countries on the conditional labour demand of firms, especially in firms involved in traditional activities. Wagner (2011) uses combined data from matched regular surveys and a special purpose survey on relocation to investigate the causal effect of offshoring on the performance of German manufacturing firms. He concludes that offshoring has a small negative impact on employment in offshoring firms, but finds no evidence for a causal effect on wages per employee. The results of Gomez et al. (2013) for Canada also suggest that the offshoring of business services is not likely to have a large negative impact on employment.

Using a sample of German firms, Moser et al. (2015) find a positive effect of an increase in the share of foreign intermediate inputs on the employment level of the offshoring plant. Desai et al. (2009) also find evidence of complementarity between the domestic and foreign operations of US manufacturing firms – an increase in foreign operations is associated with greater domestic investment, wages and employment growth. Wright

(2014) finds that offshoring to China resulted in a small increase in total employment in the US labour market, with a decline in the share of low-skill workers. Harrison and McMillan (2011) use firm-level data on US multinationals to measure the impact of changes in foreign affiliates' wages on domestic employment. They find that the link between offshoring and domestic employment depends on both the type and location of foreign affiliates. In general, offshoring to low-wage countries substitutes for domestic employment, but for firms that export to affiliates located in low-income (high-income) countries for further processing, domestic labour and foreign labour are complements (substitutes).

### **3 Productivity**

Studies that explore the relationship between offshoring and productivity using industry-level data tend to conclude that offshoring positively affects productivity. Amiti and Wei (2009) estimate the effects of offshoring on productivity in US manufacturing industries, concluding that service offshoring has a significant positive effect on productivity. Offshoring of material inputs also has a positive effect on productivity, but the magnitude is smaller. Similar findings were obtained by Winkler (2010) for Germany using input-output data for 1995-2006. Crinò (2008) uses comparable data for nine European countries and finds that service offshoring exerts positive and economically large effects on domestic productivity. Egger and Egger (2006) analyse how offshoring affects the productivity of low-skilled workers in the EU manufacturing sector. They find a negative marginal effect on productivity in the short run, but that the impact becomes positive and significant in the long run. Schwörer (2013) combines industry-level data on offshoring from the WIOD with firm-level data for nine European countries between 1995 and 2008 and finds that offshoring of services and of non-core manufacturing activities contributed to an increase in productivity, whereas no significant effect is found for offshoring of core manufacturing activities. He finds also evidence of additional productivity gains for multinational firms.

Studies using firm-level data to analyse this issue are still scarce and have so far produced mild evidence for the productivity-enhancing effects of offshoring. Görg and Hanley (2005a) examine the effect of offshoring on productivity at the plant-level in the electronics industry in Ireland. They find that total offshoring increases plant-level productivity, but this effect only holds for plants with low export intensities. When distinguishing between offshoring of services and materials, they find that the positive impact on productivity is limited to materials outsourcing. Görg et al. (2008) investigate the impact of offshoring on productivity with plant-level data for Irish manufacturing, finding that being more embedded in international markets leads to larger productivity gains from outsourcing. McCann (2011) also finds that an increase in outsourcing intensity leads to productivity gains for foreign affiliates and for indigenous exporters in Ireland. In contrast, being or becoming an outsourcer matters much more for Irish firms that are not exporting. Using a dataset of Japanese firms, Ito et al. (2011) find productivity gains in the firms offshoring both manufacturing and service tasks, but not in the firms offshoring only one of these tasks. These results suggest that the level of firms' engagement in offshoring is more important for productivity than whether or not they engage in offshoring at all. Hijzen et al. (2010) also use firm-level data for Japanese manufacturing industries and find that intra-firm offshoring generally has a positive effect on the productivity of the offshoring firm, while arm's-length offshoring does not.

Fariñas and Martín-Marcos (2010) find evidence consistent with self-selection of the most productive firms into international outsourcing in a sample of Spanish manufacturing firms. Their results also suggest that foreign outsourcing has a positive impact on total factor productivity growth at the firm level. Jabbour (2010) finds positive effects of offshoring on productivity and profitability of French manufacturing firms, but only in the case of international outsourcing to developing countries. For Germany, Wagner (2011) concludes that offshoring firms were already larger, more productive, more human capital-intensive, and had a higher share of exports in total sales before they started offshoring, which points to self-selection of better firms into offshoring.

However, he finds evidence of only a very small positive causal effect of offshoring on firm-level productivity.

#### **4 Concluding remarks**

The impact of GVCs and offshoring on labour market outcomes will surely continue to fuel public debate. Most papers conclude that the rise of outsourcing accounts for a relevant part of the increase in the relative demand for skilled labour in developed countries. When tasks are analysed, the literature tends to conclude that offshoring tends to shift labour demand towards non-routine tasks. As for the overall effect of offshoring on the level of employment, the numbers seem small but the effects obtained at the industry level can hide differences in labour demand for different skill categories and differences at the individual firm level.

Concerning productivity, studies using industry-level data tend to conclude that offshoring positively affects productivity. However, studies using firm-level data to analyse this issue are still scarce and have so far only found mild evidence for the productivity-enhancing effects of offshoring. In parallel and consistently with the general trade literature, there is empirical evidence of self-selection of the most productive firms into international outsourcing.

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# Global value chains and the great collapse in value added trade<sup>1</sup>

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*The consensus that has emerged in the literature is that the Great Trade Collapse can be mainly attributed to changes in final expenditure, inventory adjustment and adverse credit supply conditions. In this chapter, we provide a nuanced view of the Great Trade Collapse in value added terms and quantify the contribution of the proximate factors that led to changes in value added exports in the last decade. We show that changes in vertical specialisation and a variety of different compositional demand factors contributed substantially to the decline in value added trade. Finally, we highlight that the dichotomy between the services and manufacturing sectors observed in gross exports during the Great Trade Collapse is not apparent in value added trade data.*

## **1 Introduction**

The previous literature attributes the Great Trade Collapse mainly to changes in final expenditure,<sup>2</sup> inventory adjustment<sup>3</sup> and adverse credit supply conditions.<sup>4</sup> Due to data constraints, previous studies suffer from two shortcomings. First, they focus on gross trade instead of value added trade. Second, they assume that the extent of vertical specialisation remained fixed during the crisis. In a recent paper, we fill this gap in the literature by considering value added trade for the years 2000 to 2011 derived from the World Input Output Database (WIOD),<sup>5</sup> which is particularly well suited for analysing changes in the international sourcing structure (Nagengast and Stehrer 2015).

1 This chapter represents the authors' personal opinions and does not necessarily reflect the views of the Deutsche Bundesbank.

2 See Bems et al. (2010, 2011), Eaton et al. (2011) and Bussière et al. (2013).

3 See Alessandria et al. (2011, 2013) and Altomonte et al. (2012).

4 See Bricongne et al. (2012), Chor and Manova (2012) and Behrens et al. (2013).

5 See Dietzenbacher et al. (2013).

## **2 The great collapse in gross and value added trade**

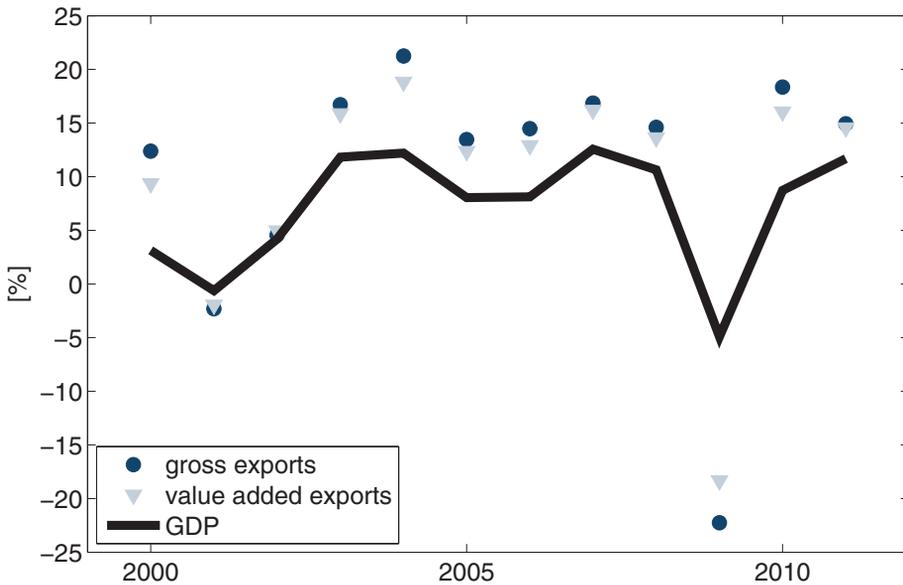
Figure 1 depicts the relation between nominal GDP growth and export growth for gross and value added concepts at the global level (all measured in current US dollars). Prior to the global financial crisis, increases in trade outpaced GDP changes by several percentage points. Overall, the evolution of world value added trade resembles the changes in gross trade figures. The Great Trade Collapse, i.e. the more than proportional decline of trade in comparison to changes in GDP, was a phenomenon not limited to gross trade, but was also apparent in value added trade data. While world GDP declined by 'only' 5.4% in nominal terms, value added trade collapsed by 18.3% in 2009. The contraction of world gross exports by 22.3% was even more pronounced owing to the fact that demand for sectors with a strong degree of cross-border linkages – and hence foreign value added and double counting terms (Koopman et al. 2014) – declined most (Bems et al. 2011). The two years after the crisis saw a cyclical rebound of value added exports, with exceptionally high growth rates in comparison to most pre-crisis years.

## **3 Decomposing the great collapse in value added trade**

In Nagengast and Stehrer (2015), we use a structural decomposition analysis to assess which of the three basic building blocks of value added trade contributed to its overall change over time:  $\Delta v$  captures changes in the value added content of production,  $\Delta L$  represents changes in the structure of international production sharing, and  $\Delta f$  records changes in final demand. Figure 2 shows that in an average year before the crisis, growth in value added trade (11.4%) was to a large extent driven by changes in final demand (9.6 percentage points). Increased international production sharing contributed substantially less (2.6 percentage points), while the decline in the sectoral value added content – corresponding to the outsourcing of value creation to other sectors – put a drag on the growth of value added trade (-0.8 percentage points). In stark contrast, changes in international production sharing explained just under half (-8.5 percentage points) of the decline in value added exports in 2009 (-18.3%). Demand factors were still the most important (-10.8 percentage points), although their relative significance was smaller than

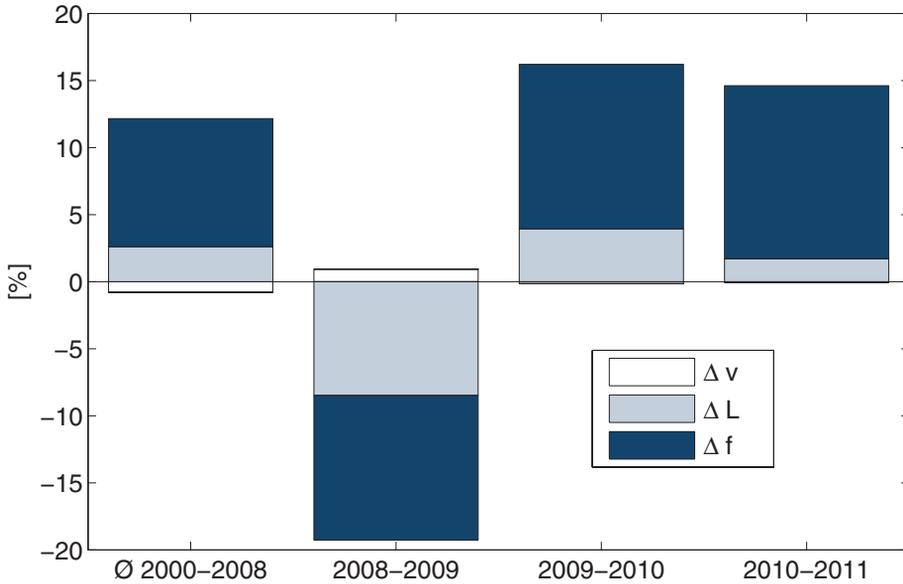
in previous years. During the crisis, the portion of inputs sourced from national suppliers grew to the detriment of those from international suppliers. Additional analyses show that changes in the input mix were a widespread phenomenon not limited to particular sectors or economies (Nagengast and Stehrer, 2015). While the drop in final demand was almost completely compensated for in the first year after the crisis, the degree of international production sharing had still not regained its pre-crisis level by 2011. Our focus on value added trade, which precludes the influence of double counting terms, demonstrates that changes in vertical specialisation played a substantial role during the Great Trade Collapse, even over and above demand effects (as emphasised in Bems et al. 2011).

**Figure 1** Growth rates of world exports and world GDP



Source: Authors' calculations based on WIOD.

**Figure 2** Decomposition of change in world value added exports



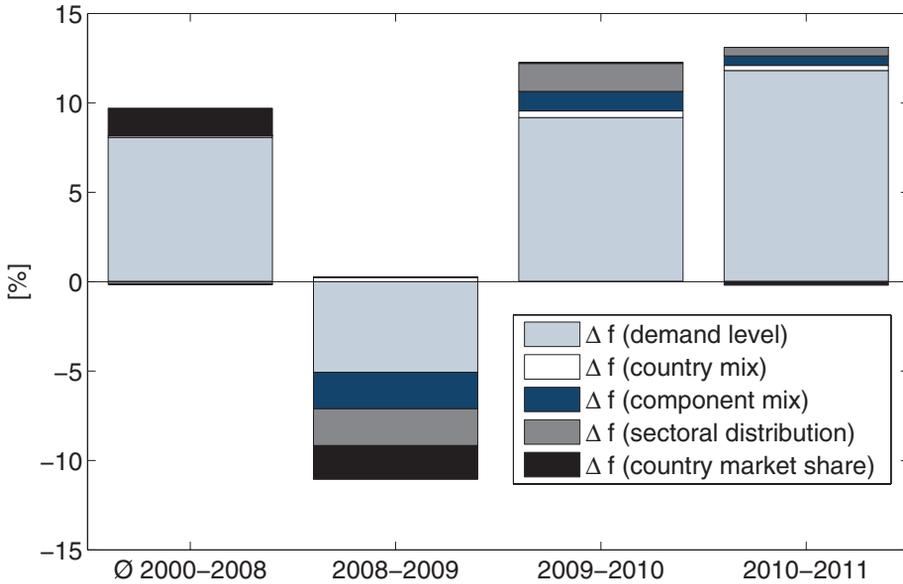
Notes:  $\Delta v$  = changes in the value added content of production;  $\Delta L$  = changes in the structure of international production sharing;  $\Delta f$  = changes in final demand.

Source: Authors' calculations based on WIOD.

#### 4 Quantifying the importance of compositional factors

For gross exports, it has been shown that changes in the composition of final expenditure were an important determinant of the Great Trade Collapse, although their exact contribution has not been quantified so far. Using a global input-output framework allows us to estimate the share of the great collapse in value added trade that was due to changes in the level of final demand and four compositional demand factors.

**Figure 3** Final demand contribution to change in world value added exports



Notes:  $\Delta f$  (demand level) = changes in the overall level of final demand;  $\Delta f$  (country mix) = changes in the mix of countries that contribute to the overall level of demand;  $\Delta f$  (component mix) = changes in the mix of final demand across different demand components, such as investment and private consumption;  $\Delta f$  (sectoral distribution) = changes in the distribution of goods and services across different demand components;  $\Delta f$  (country market share) = changes in the distribution of country market shares by sector.

Source: Authors' calculations based on WIOD.

In an average year before the crisis, almost the entire final demand contribution to growth in value added trade derived from increases in the overall level of final demand in parallel with strong world economic growth (Figure 3). The only other significant contribution came from the country market share distribution (1.5 percentage points), which reflects gains in export market shares of countries such as China and other emerging countries, to the detriment of Japan and the US, which are less strongly integrated in global value chains.<sup>6</sup> During the Great Trade Collapse, the drop in the overall level of demand accounted for roughly a quarter of the decline in value added exports (-5.1 percentage points of the 18.2% decline in overall value added trade), while just under one third (-5.7 percentage points) was due to compositional changes

6 See Chapter 10 in this book by Konstantins Benkovskis and Julia Wörz for a detailed analysis of changes in world market shares.

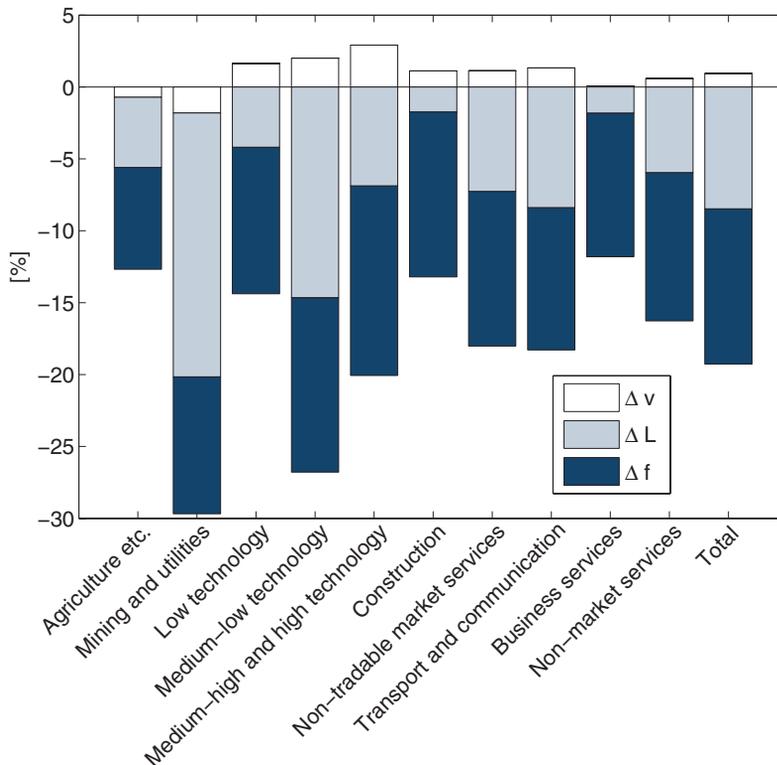
in final demand. Changes in the component mix (-2.0 percentage points) – i.e. a strong decline in investment and inventories – and the sectoral distribution (-2.1 percentage points) – i.e. a large decrease in the demand for durable goods – played an important role, confirming results from the literature on gross trade (Baldwin 2009, Bems et al. 2013). Another important compositional factor that emerges is the country market share distribution, which contributed about one tenth (-1.9 percentage points) to the Great Trade Collapse. This reflects the fact that the crisis particularly affected demand for goods and services of economies that are highly integrated in cross-border production chains, such as EU countries. The year after the crisis saw an immediate rebound in the overall demand level that more than offset the drop during the Great Trade Collapse. The sectoral distribution and component mix recovered much more slowly and by 2011 still had not reached pre-crisis levels, mainly due to weak investment and durables demand. The prolonged crisis, particularly in the Eurozone, was also reflected in the country market share distribution, which did not recuperate in the year after the crisis and even showed a further decline in 2011.

## **5 Trade in services value added: No evidence for crisis resilience**

For gross exports, the consensus that has emerged is that exports of durables were particularly affected while services trade proved very resilient during the Great Trade Collapse (Mattoo and Borchert 2009). In contrast to the findings on gross exports, for value added trade all sectors were hit hard by the crisis, and in no sector did value added exports decline by less than 11.8% (Figure 4). While value added exports fell particularly strongly in the medium-low technology sector (-24.8%), the dichotomy between the services and manufacturing sectors observed in gross exports is not apparent in the value added trade data. Our results are consistent with what we know about the structural differences between gross and value added trade. Johnson and Noguera (2012) show that the share of services value added in total value added exports is substantially higher than the share of direct services exports in the total gross exports

of a country. This is due to the fact that services sectors often provide intermediate inputs to goods exporters, whereas direct services exports are hampered, for example, due to linguistic and legal barriers. As a consequence, services sectors indirectly benefit from and contribute to the export success of goods exporters. On the downside, our findings highlight that demand shocks hitting direct goods exporters are transmitted to service input providers further upstream, in line with theoretical models on the origins of aggregate fluctuations (Horvath 2000, Acemoglu et al. 2012). This highlights that services sectors that are suppliers of inputs to direct exporters are likely to be much more vulnerable to external shocks than is generally acknowledged.

**Figure 4** Decomposition of change in world value added exports between 2008 and 2009, by sector.



Notes:  $\Delta v$  = changes in the value added content of production;  $\Delta L$  = changes in the structure of international production sharing;  $\Delta f$  = changes in final demand.

Source: Authors' calculations based on WIOD.

## **6 Policy implications**

The observed increase in sourcing from international suppliers, to the detriment of national suppliers, provides an amplifying mechanism of the decline in final demand and reduces the volume of international trade for every dollar spent on final goods and services. This is particularly important in the context of the slowdown in global trade growth relative to GDP growth that has been observed in recent years (Ferrantino and Taglioni 2014, Constantinescu et al. 2015.). A decline in international production sharing therefore might have played a role both in explaining the Great Trade Collapse as well as partially accounting for the decrease in global trade elasticities.<sup>7</sup>

What ultimately lies at the heart of the changes in international production sharing is the most pressing question that comes out of our study. In Nagengast and Stehrer (2015), we argue that neither price changes, inventory adjustments, intra-sectoral composition effects or an increase in protectionism were likely to be the main driver for the observed alteration in international production sharing in 2009. A more likely explanation appears to be related to firms' unfavourable financing conditions during the crisis and the ramifications of this on the sourcing of intermediate inputs. For gross trade, it has been shown that adverse credit supply conditions played a significant role in explaining the contraction in trade volumes during the crisis (Bricongne et al. 2012, Chor and Manova 2012, Behrens et al. 2013). The observed persistence of the decline in vertical specialisation is also in accordance with a financial explanation, since the supply of credit remained tight or even continued to decline in the years after the financial crisis, for example in the euro-area, making liquidity management a top priority for firms (Campello et al. 2011). Furthermore, changes in the pre-crisis trend for production relocation and incipient back-shoring activities may also have played a role (Kinkel, 2012). Studies at the firm-level on the international organisation of production in times of crisis provide a promising avenue for future research.

<sup>7</sup> See also Chapter 9 in this book by Alexander Al-Haschimi, Frauke Skudelny, Elena Vaccarino and Julia Wörz.

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# The trade and demand nexus: Do global value chains matter?<sup>1</sup>

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*Unexpectedly weak dynamics in global trade flows in 2012 and 2013 caused a renewed discussion of a potential structural change in global trade drivers in addition to the cyclical weakness related to the Great Recession in 2009. In our econometric model for import demand, we put the focus on the international fragmentation of production and hence the role of global value chains (GVCs) in the global trade-to-income ratio. We combine trade data from UN Comtrade and national accounts data from the IMF's World Economic Outlook with information on global linkages from WIOD for a sample of emerging and advanced economies over the period from 1996 to 2011. Our measure of GVC participation is based on the decomposition of trade flows proposed in Koopman et al. (2014). We find a greater demand elasticity for emerging economies and a reinforcing effect of GVC participation, both in advanced and emerging economies. Recursive estimates suggest a decline in the demand elasticity already before the Global Crisis, suggesting that the process of GVC integration may have reached its peak.*

## **1 Introduction**

In the past decades, world trade growth exceeded global output growth by a margin. Trade as a share of global output has tripled since the 1950s. The impressive increase in

<sup>1</sup> The views expressed in this chapter are those of the authors and do not necessarily reflect the official viewpoints of the European Central Bank or Oesterreichische Nationalbank.

worldwide trade flows was fostered by at least four fundamental structural developments in the global economy. First, multilateral free trade negotiations started in the late 1940s under the GATT and implied a substantial reduction of global tariffs in subsequent decades, leading to an unprecedented degree of trade liberalisation worldwide. Second, new players – in particular, emerging market economies – experienced a rapid integration into the world economy. Third, the majority of countries liberalised their financial accounts in the late 1980s and early 1990s, thus facilitating trade beyond arm’s-length operations through foreign direct investment and trade in services. And finally, coinciding with capital account liberalisation, technological improvements, especially in the information, communication and transportation sectors, lowered trade costs in addition to the dismantling of trade barriers.

Since standard trade models focused mainly on the first factor – trade liberalisation – they could not explain the disproportionate growth of international trade. When the Great Recession led to an unprecedented and unexpectedly sharp drop in world trade in 2009, standard trade models again failed to explain the magnitude of this event much as they had failed before to explain why trade growth outpaced output growth in the decades before. This is possibly due to the fact that these models largely neglected the fundamental structural change that has led to a globally integrated production structure and has given rise to trade in intermediates.

In this chapter, we focus on the empirical importance of vertical specialisation – or global value chains (GVCs) – for the elasticity of global trade to income. It is of utmost importance to understand if and how GVCs have affected global trade patterns and to what extent they are responsible for swings in the trade-to-output ratio. GVC integration is likely to represent an omitted factor in most studies of global trade patterns or in traditional estimates of trade to income elasticities. Given the very recent availability of data sources that allow the calculation of the degree and type of GVC integration for a wide range of countries, we want to put the spotlight on precisely this factor. We estimate a standard import demand function augmented by measures of GVC integration for 14 emerging and advanced economies over the period 1996 to 2011.

The next section presents some stylised facts about global trade and the relationship between trade and income. Section 3 surveys the existing literature on this topic. Section 4 describes our dataset and the empirical method used, and presents our results. Section 5 concludes.

## **2 Stylised facts about global trade and income**

In the second half of the 20th century, the ratio of global trade to GDP was on a rising trend. From at least the mid-1980s onwards, the ratio of trade growth to income growth accelerated strongly, but it started to fall in the late 1990s and dropped to 20-year lows right after the crisis (see Figure 1). While, on average, global imports grew almost twice as quickly as global GDP over the period 1981-2007, this ratio fell to 1.0 for the period 2011-2014. However, Figure 1 also shows that the growth differential had already started to decline some ten years before the Global Crisis hit.

The rising international fragmentation in production and the emergence of global value chains in which intermediate inputs are outsourced to foreign suppliers have certainly been a driving force behind faster trade growth compared to GDP growth in the past decades. In a sense, there were also statistical reasons behind it, as customs statistics increasingly included ‘double-counted’ value added trade by recording flows of intermediate goods which crossed international borders more than once during the production process. Consequently, gross trade flows as recorded by customs statistics exceeded valued added trade flows (i.e. measured net of imported value added) by one third in 1995, while they more than doubled value added trade flows in 2008 (see Figure 2).

We would like to emphasise that global value chains are not a new feature of global economic activity, even though the topic has entered the academic literature on trade only recently thanks to conceptual clarifications by authors such as Koopman et al. (2014) and Stehrer (2012). Simple measures of global supply chains – such as measures of imported intermediate inputs in gross output, or the value added content of a country’s

exports – have been developed from national input-output tables (Hummels et al. 2001). These first attempts to measure vertical integration could not account for the fact that participation in global value chains has both an upstream and a downstream component: the upstream supplier exports intermediate goods to a downstream producer, who uses these intermediates to add value for further export. This can also result in circular or other types of non-linear trade relationships between individual participants of a global value chain.

### **3 Global value chains and the trade-to-income ratio in the literature**

According to Yi (2001), falling tariff barriers could only explain the rise in the trade-to-income ratio if an unrealistically large elasticity of substitution between goods was assumed. Noting further that tariff liberalisation was strongest up until the mid-1980s while trade growth substantially surpassed output growth only after the mid-1980s, he points to vertical specialisation as an explanation for the puzzle. Hummels et al. (2001) postulate that a system of vertically specialised firms that use imported intermediates to produce exports can explain the unknown part of the trade growth. Daudin et al. (2011) claim that in 2004, vertically specialised trade represented 27% of total international trade.

Much as the emergence of GVCs helped to explain the rising trade-to-GDP ratio in the 1980s and 1990s, their presence could also serve as an explanation for the puzzling magnitude of the trade collapse relative to the global income decline in the Great Recession. Gangnes et al. (2014) argue that global value chains help to explain the collapse of trade in 2009 because they led to an increase in the sensitivity of trade to external shocks. From the current academic literature, they identify two possible channels for how global value chains may increase the elasticity of trade to income: the composition effect and the supply chain effect. The composition effect postulates that global value chain trade is concentrated in durable goods industries, which are known to have high income elasticities. As a result, aggregate trade becomes more sensitive to

foreign income shocks when the importance of GVCs in trade rises. The supply chain effect assumes that income elasticities in global value chain trade are higher than in traditionally recorded trade due to structural characteristics of GVCs, such as higher inventory holdings.

Both effects find support in the literature. Eaton et al. (2011) show that a shift away from spending on durable goods during 2008-09 aggravated the downturn, a finding which supports the composition effect hypothesis. Alessandria et al. (2010) mention disproportionately large inventories of imported inputs, which may cause such an increase in income elasticities. In an economic downturn, these inventories are used to continue with the production process while the purchases of new imported inputs are reduced. This puts upstream exporters under pressure within global value chains and hence results in an increased sensitivity of trade to foreign income shocks. In this context, Gangnes et al. (2014) identify the composition effect as being important for China – an important downstream producer – while they found no evidence for the supply chain effect. Altomonte et al. (2012) agree with the adjustment of inventories inside supply chains and refer to it as the ‘bullwhip effect’. They show that trade among related parties (i.e. within GVCs) is characterised by a faster drop followed by a faster recovery than trade among unrelated parties. Also, Bems et al. (2011) conclude that inventory adjustment is likely to have increased the impact of the Crisis on trade. They further found that a lack of credit supply enhanced the decline in trade even more.

Constantinescu et al. (2015) caution against assigning a strong role to GVCs in the explanation of the Crisis-related decline in the trade-to-income ratio. Based on the results of an error correction model, they find evidence for a decline in the trade-to-GDP ratio long before the Crisis. Hence, they conclude that the sharp reduction in demand during the Crisis cannot fully explain the sharp trade contraction, but that international fragmentation had slowed down for structural reasons long before the Crisis. Thus, a longer-term perspective should be adopted when analysing the impact of GVCs on the trade-to-GDP ratio.

## 4 Empirical model and results

We estimate an import demand model similar to Anderton et al. (2007), as described in the following equation:

$$\ln(M_{ijt}) = \alpha_{ij} + \alpha_1 \ln(TFE_{it}) + \alpha_2 \ln\left(\frac{P_{jt}}{P_{it}}\right) + \alpha_3 \ln(ER_{ijt}) + \alpha_4 \ln(TFE_{it}) * \ln(GVC\_part_{it}) + \varepsilon_{ijt}$$

$M_{ijt}$  are bilateral import values of country  $i$  from country  $j$  at time  $t$ , expressed in US dollars and obtained from the UN Comtrade database.  $TFE_{it}$  is total final expenditure, our demand variable, and is obtained by adding a country's imports in gross terms to its gross domestic product.  $P_{it}$  are producer prices and  $ER_{ijt}$  is the bilateral nominal exchange rate. GDP and imports are taken from the IMF's World Economic Outlook, the other variables are taken from the IMF's International Financial Statistics database.  $GVC\_part_{it}$  is an index of GVC participation, which is derived from the export decomposition proposed by Koopman et al. (2014) using the WIOD database (Timmer et al. 2015). In our estimations, we do not use the bilateral version of the index but aggregate all partner countries  $j$  using a year-specific trade-weighted average to minimise a potential endogeneity bias in the estimation.

As we expect emerging economies to have a different income elasticity to advanced economies, we run the estimations for these two groups of countries separately, but we keep the total group of countries as partner countries in each group. More specifically, we include the following importers: Brazil, China, India, Mexico, Turkey and Poland in the group of emerging economies; and Japan, the US, France, Germany, Italy, the UK and Spain in the group of advanced economies. Two different estimation methods are used, a fixed effects model with AR(1) disturbances and a dynamic panel model with fixed effects. The latter corrects for the correlation between the lagged dependent variable and the fixed effects and is estimated by the generalised method of moments (GMM) (Arellano and Bond 1991, Arellano and Bover 1995, Blundell and Bond 1998).

Note that we run the regression on import values instead of import volumes, as we do not have an appropriate import deflator for bilateral imports. As a result, while increases in relative prices and in the bilateral exchange rate (corresponding to a depreciation of the importing country's currency) should have a negative impact on real imports, they increase import prices and therefore can also have a positive impact on import values. The results indeed indicate that the coefficients on these two variables are mostly positive and not always significant (see Table 1).

The nominal demand variable (TFE) has a significant and positive impact as expected in all regressions. In the estimations without GVC participation, the long-run coefficient is between 1.3 and 1.5. While the difference between emerging and advanced economies is minor for the autoregressive regression, the elasticity is smaller for advanced economies when estimating a dynamic panel. Similar results have been found in the literature. For example, Anderton et al. (2007) find income elasticities of around 1 in their different specification of an import demand equation for imports of Eurozone countries from outside the Eurozone. Constantinescu et al. (2015) estimate the income elasticity to be 1.7 for the period 1970-2013, based on annual data. For the period 1986-2000, it is found to be somewhat higher (2.2), while it is estimated to be 1.3 for the period 2000-2013 (which is most similar to our estimation period). Based on quarterly data, they find a demand elasticity of 2.4 for the 1990s, which shrinks to 1.5 for the period 2001Q1 to 2007Q4, and further to 0.7 for 2008Q1 to 2013Q4.

When adding the interaction term of GVC participation with TFE, the impact is positive and significant in all cases. This suggests that importing countries that are strongly interlinked within a GVC tend to have a higher impact of their demand on import values.

We run the estimations recursively, starting in 2000 and adding each year individually. Figure 3 shows that for advanced economies, recursive estimates based on the AR model suggest that the demand elasticity increased somewhat in 2004. This is also reflected in the five-year rolling sample estimation where we estimate 5-year samples

starting with 1996-2000 and moving the sample by one year until the sample 2007-2011. The recursive coefficient of TFE then decreases slightly, and stabilises in the last years of the sample. The rolling sample estimations reveal that this hides an increase in the coefficient in the samples starting in 2005 and in 2006, i.e. the sample which also include the Crisis period. At the same time, the recursive coefficient on the interaction term increased with the Crisis and stabilised afterwards, leading to a decline in the rolling sample coefficient towards the end. Interestingly, the dynamic estimation yields a decline in the recursive coefficient over the whole period, which stabilises somewhat only towards the end of the sample. This is compensated by an interaction term which increases recursively. For emerging economies, the demand elasticity increased up to the sample ending in 2004 and stabilised thereafter in the autoregressive model. When using a dynamic panel, some decline in the long-term coefficient can be observed over the rest of the sample, albeit to a lesser extent than for advanced economies. Unlike the evidence for advanced economies, the impact of GVC participation accompanied by demand growth has declined only since the Crisis for emerging economies.

## **5 Conclusions**

In this chapter, we assess the impact of global value chains on global import demand and hence trade dynamics. Unexpectedly weak dynamics in global trade flows in 2012 and 2013 caused a renewed discussion of a potentially structural change in global trade drivers that has become visible since the Great Recession in 2009 in addition to the cyclical weakness caused by subdued investment. We estimate an import demand model, using a panel data model for bilateral imports of advanced and emerging economies. In addition to the standard demand variables, we add an interaction term between demand and GVC participation. Our results suggest that the demand elasticity tends to be higher for emerging than for advanced economies. In addition, demand reacts more strongly when it is accompanied by stronger GVC participation, both in advanced and emerging economies. This supports the reinforcing effect of GVC integration on the responsiveness of trade to income. Recursive estimates suggest that

there was some decline in the demand elasticity in the middle of the 2000s, while the coefficient has even increased again since the Crisis. Further, GVC integration shows an increasingly positive impact on trade growth beyond the effects of changes in demand, even though this additional trade push has apparently weakened since the mid-2000s, as shown by the rolling window estimations. This suggests that the process of GVC integration may have reached its peak recently. There is evidence that the impact of GVC participation accompanied by demand growth shows a differentiated impact on advanced and emerging economies; while it has increased since the Crisis for advanced economies, it has declined for emerging economies. All of these non-linearities in the trade-to-income ratio have to be taken into account when designing export strategies and, in particular, export-oriented growth policies. Our result is also important for the redesigning of existing forecasting models of trade and GDP growth.

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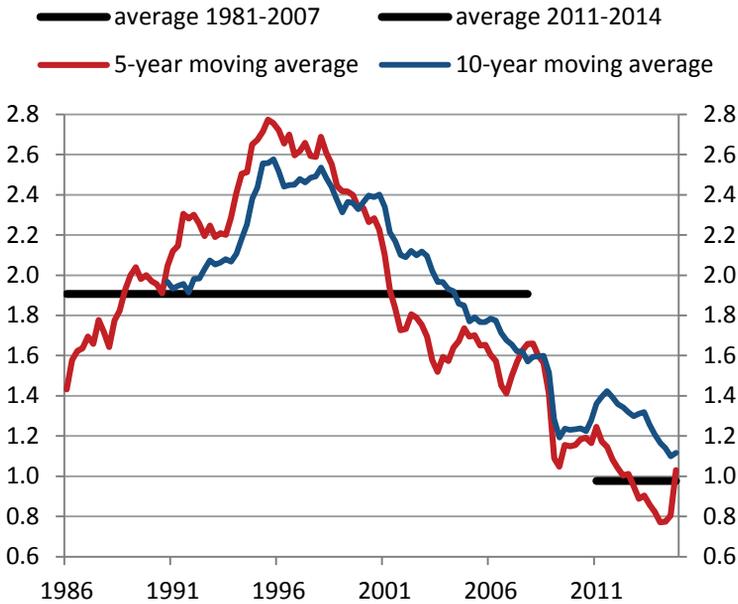
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## Appendix: Tables and charts

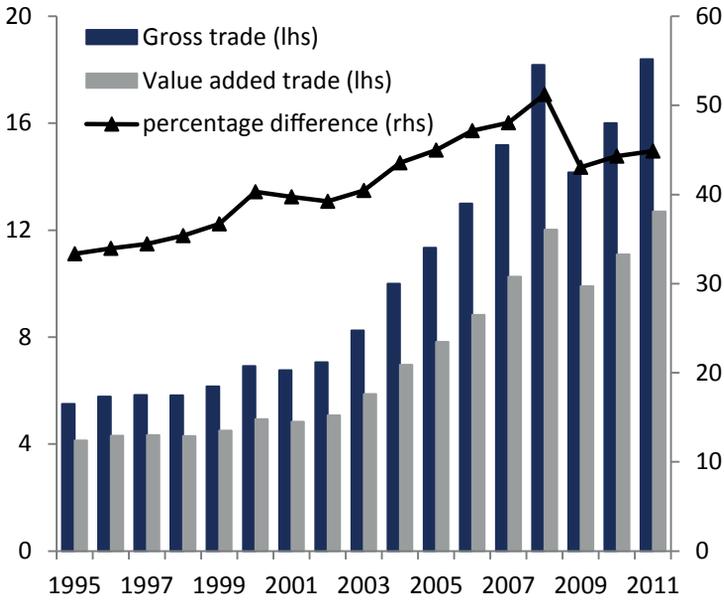
**Figure 1** Ratio of global import growth to GDP growth



Source: ECB staff calculations.

Note: The last observation refers to 2014 Q4. The grey line shows the ratio of average growth rate of global imports of goods and services to global GDP over a rolling five-year window (the blue line is based on a ten-year window).

**Figure 2** Global gross versus value-added trade (lhs: USD trillions, rhs: percent)



Sources: WIOD and ECB calculations.

Note: The black line represents the percentage difference between gross and value added trade.

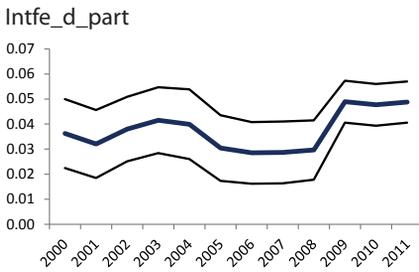
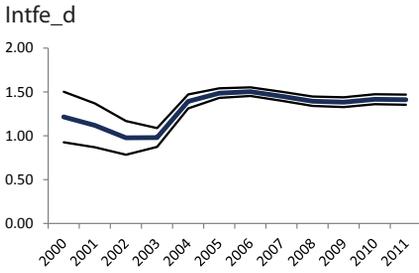
**Table 1** Regression results advanced and emerging economies

	Advanced economies				Emerging economies			
	Fixed effects with AR(1) dist.		Dynamic panel		Fixed effects with AR(1) dist.		Dynamic panel	
Intfe_d	1.509*** (0.027)	1.411*** (0.029)	0.354*** (0.024)	0.255*** (0.025)	1.417*** (0.038)	1.404*** (0.038)	0.476*** (0.027)	0.356*** (0.029)
LT tfe_d			1.273	0.904			1.545	1.163
lnrel_mpr	-0.019 (0.031)	-0.052* (0.029)	0.212*** (0.026)	0.131*** (0.026)	-0.023 (0.0637)	-0.065 (0.0645)	0.146*** (0.0388)	0.075* (0.0381)
LT rel_mpr			0.763	0.465			0.474	0.242
lnfx_bil	0.434*** (0.034)	0.296*** (0.033)	0.128*** (0.027)	0.0601** (0.027)	0.405*** (0.064)	0.377*** (0.064)	0.113*** (0.042)	-0.00988 (0.042)
LT fx_bil			0.460	0.213			0.367	0.000
Intfe_d_part		0.0483*** (0.004)		0.0310*** (0.0031)		0.0309*** (0.0088)		0.065*** (0.006)
LT tfe_d_part				0.110				0.209
Lagged dependent			0.722*** (0.016)	0.718*** (0.016)			0.692*** (0.018)	0.694*** (0.018)
Constant	0.800*** (0.050)	2.733*** (0.043)			1.723*** (0.100)	2.258*** (0.103)		
Observations	1,222	1,222	1,131	1,131	1,034	1,034	957	957
Number of cc_nb	84	84	84	84	72	72	72	72

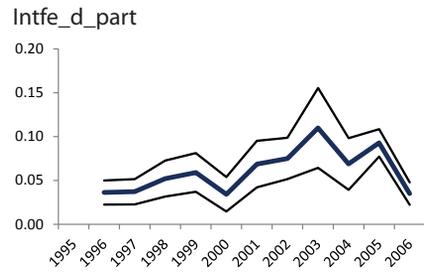
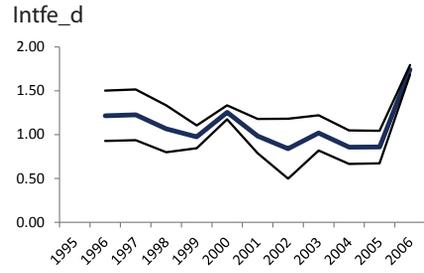
**Figure 3** Recursive and rolling sample results

**Fixed effects with AR, advanced economies**

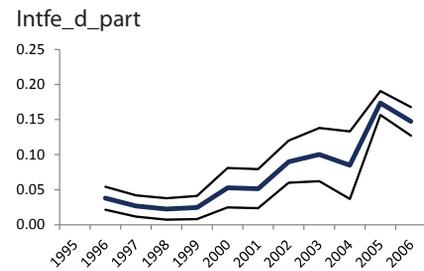
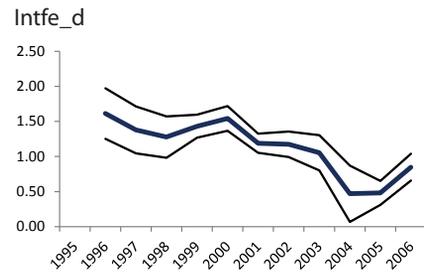
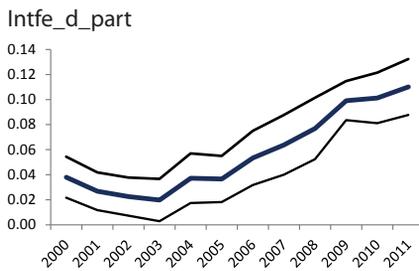
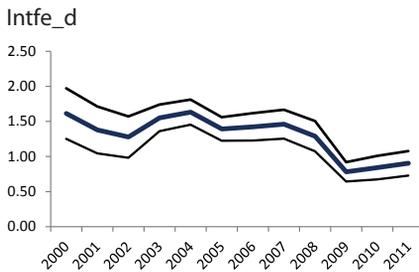
recursive



rolling sample



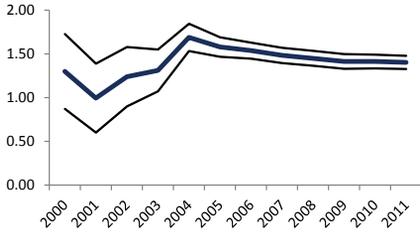
**Dynamic panel, advanced economies**



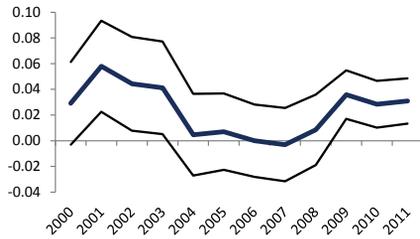
Fixed effects with AR, advanced economies

recursive

Intfe\_d

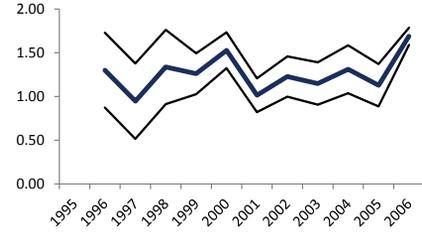


Intfe\_d\_part

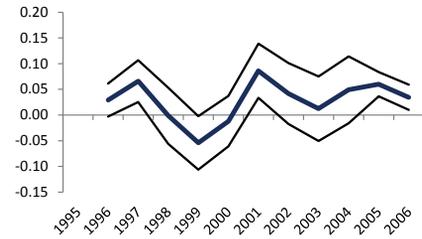


rolling sample

Intfe\_d

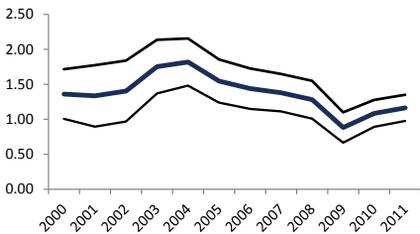


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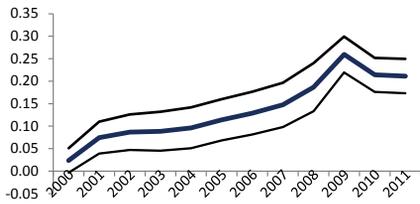


Dynamic panel, advanced economies

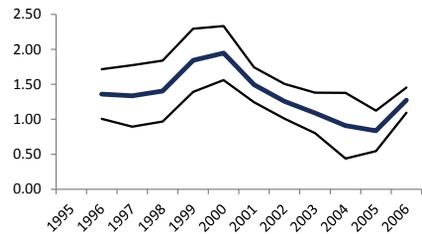
Intfe\_d



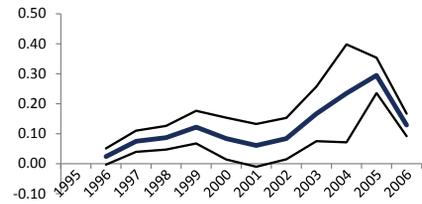
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# The interpretation of changes in global market shares: Adding the global value chain dimension<sup>1</sup>

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**Konstantins Benkovskis and Julia Wörz**

Latvijas Banka; Oesterreichische Nationalbank

*Shifting the focus from traditional gross exports to value added in export market shares does not change the general picture much – new EU countries are gaining market shares at the expense of old EU members. But accounting for GVC participation alters the underlying story. Price factors are more important in explaining changes in global market shares than gross export flows suggest, improvements in the relative quality of exports from the new EU member states often owe to the outsourcing process and the use of higher-quality intermediate inputs from more developed economies. Still, we find evidence of a catching-up in the relative quality of production by the new EU member states.*

## **1 Introduction**

The international fragmentation of production has made the picture of world economics considerably more complex. As mentioned in previous chapters in this book, data on gross export flows are no longer an adequate representation of a country's global market shares, since outsourcing of production greatly diminishes the domestic

<sup>1</sup> The views expressed in this chapter are those of the authors and do not necessarily reflect the official viewpoints of Latvijas Banka or Oesterreichische Nationalbank.

component of exports. Consequently, the traditional measures of competitiveness and their interpretation must change fundamentally.<sup>2</sup>

In this chapter, we uncover the underlying drivers of global market shares taking into account the international fragmentation of production. We claim that changes in global market shares can no longer be explained by simply looking at price and cost factors, it is even not sufficient to control for the changing quality of export goods, since market shares are also affected by a country's ability to integrate and its position in international production chains. Despite some similarities to the methodology proposed by Bems and Johnson (2012), our approach differs from their 'value-added REER'. Most importantly, our decomposition extends beyond price factors, as we evaluate factors such as export growth along the extensive margin, shifts in global demand structure and global production chains, changes in the set of competitors and, finally, residual non-price factors that to a large extent (though not entirely) can be attributed to changes in quality and taste.

Our approach combines data from two sources. First, we make use of highly disaggregated bilateral trade data from the UN Comtrade database (HS six-digit level, i.e. more than 5,000 products for each possible pair of trading partners). The use of detailed trade data allows us to disentangle price and non-price drivers of export market share changes, since we can interpret unit values as prices of cross-border transactions. However, trade data disregard the international production fragmentation, which may alter the assessment of a country's performance on the global market. Therefore, we also make use of the WIOD database (Timmer et al. 2015). Although available for a considerably smaller set of countries, at a lower level of disaggregation and with a time lag, it still allows us to infer something about the performance of domestic producers (not exporters) on external markets and thus improves our understanding of a country's competitive strengths and weaknesses.

2 See Chapter 8 of this book, by Arne Nagengast and Robert Stehrer, for the implications on bilateral trade balances, Koopman et al. (2014) for the effects on revealed comparative advantages and Bems and Johnson (2012), and Bayoumi et al. (2013) for real effective exchange rates.

## **2 Improving the measure of global market shares**

In order to capture the ongoing fragmentation process, we propose to use market shares of value added in exports of final products, i.e. gross exports of final products corrected for the source of value added.

The measure, 'value added in gross exports', traces gross exports by producer countries (see, for example, Koopman et al. 2010). By combining the information on the country structure of value added with detailed UN Comtrade trade data, we calculate the share of country A in the production of country B's exports of good C, i.e. we focus on market shares of value added in gross exports. The lower level of disaggregation in WIOD compared with UN Comtrade imposes some difficulties, and we need to assume an equal structure of value added for all HS six-digit level products within a broad CPA category. This is a very strong assumption, but we have no alternative for the analysis at the macro level.

An obvious drawback of using value added in gross exports (rather than value added exports per se)<sup>3</sup> is double-counting, which occurs when a country provides value added in exports of intermediate goods that are later contained in exports of final goods. We argue that this problem can be largely eliminated by analysing final use products only. Since we obtain trade data at a very detailed level of disaggregation, we can exclude exports of intermediate products and focus on products for final use (according to the BEC classification).

Thus, our measure of global market share is defined as the (direct and indirect) value added of a country in total world exports of final products, divided by total world exports of final products. While avoiding double-counting, confining ourselves to trade in final goods has two limitations. First, although trade data allow us to analyse final products of foreign origin, they provide no information on domestic products. Therefore, we

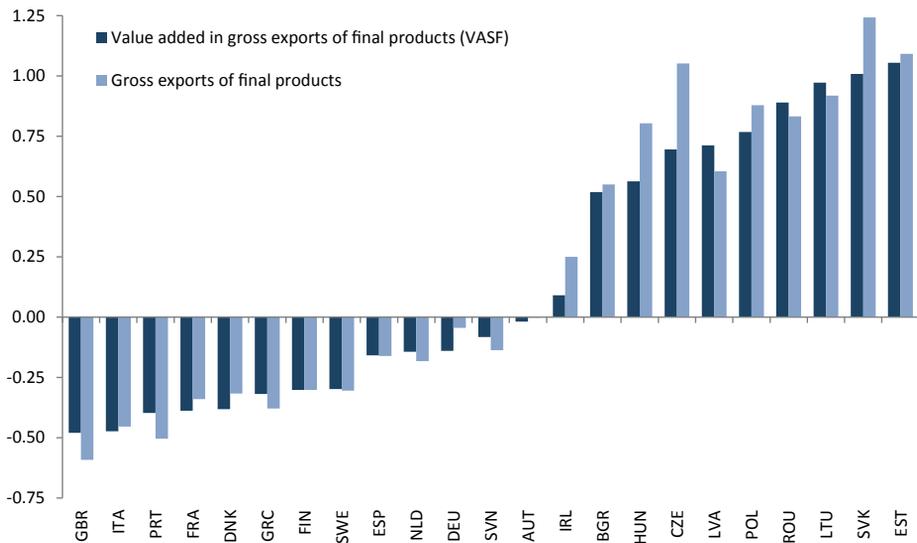
<sup>3</sup> In Chapter 8 of this book, Arne Nagengast and Robert Stehrer compare value added exports per se to gross exports, thus shedding light on the amount of double counting in bilateral gross trade balances.

miss the value added embodied in exports of intermediate products that are further processed and consumed in the same country. Second, since exports of services are not included in UN Comtrade, we miss these, but this does not imply that we totally exclude service sectors from the analysis – we still assess the indirect value added of services sectors for exports of final use commodities.

### 3 Changes in global market shares of EU countries

Let us first compare overall changes in global market shares of EU countries<sup>4</sup> when we switch focus from gross exports of final products to the respective country’s value added in gross exports of final products (VASF). We perform our analysis for the period 1996 to 2011, the last year of data available in WIOD (see Figure 1).

**Figure 1** Changes in global market shares of EU countries between 1996 and 2011



Source: WIOD; UN Comtrade; authors’ calculations.

Notes: Results denote log-changes of global market shares.

4 We have excluded Cyprus and Malta from the analysis due to low importance of goods in overall exports, while Belgium and Luxembourg were excluded due to lack of separately recorded trade data in UN Comtrade before 1999.

Shifting from a conventional analysis of global market shares to one based on value added does not alter the general picture much – old EU member states lost, while new EU member states gained global market shares between 1996 and 2011. Moreover, in most cases changes in global market shares are similar for gross exports and value added concepts.

Yet, we observe several countries – Slovakia, the Czech Republic, Hungary and, to a lesser extent, Ireland – for which market share gains were notably smaller when accounting for GVCs, which suggests a relatively downstream position. In the case of Slovakia, the Czech Republic and Hungary, this was due to the increasing integration into international production chains of motor vehicles, communication equipment and other machinery. A significant share of intermediate inputs for those industries was provided by other countries, primarily by Germany. Ireland, in turn, significantly increased its importance as a final assembly destination for chemical products, office machinery and food products, with intermediate inputs coming from the UK and the US.

We also observe opposite cases, where accounting for fragmentation of production results in smaller market share losses, signalling a more upstream position in GVCs. The most prominent example is the UK, which significantly increased outsourcing not only to Ireland but also to China (office machinery, communication equipment) and Germany (motor vehicles, other machinery).

#### **4 Decomposition of changes in global market shares**

Besides looking only at changes in overall market shares, we can also dig further into the determinants of these changes. Given the detailed information on prices and volumes of trade flows at a highly disaggregated level, we can decompose changes in global market shares further using a methodology developed in Benkovskis and Wörz (2015). First, we distinguish between the extensive and intensive margin of export growth. Intensive margin growth can be decomposed further into shifts in global demand structure and

growth in bilateral trade relationships. Solving the consumer utility maximisation problem, the last effect can further be split into four components:<sup>5</sup>

- *Contribution of shifts in production chains:* An increase in a country's value added contribution in export activities positively affects VASF market share. This can be achieved either by a higher domestic content in a country's own gross exports of final products, or by more active involvement in GVCs leading to a higher value added share in other countries' exports of final use products.
- *Contribution of price factors:* This component is analogous to changes in the real effective exchange rate (although with opposite sign) based on unit values and using value added weights. Unfortunately, we only observe export prices of final products, so we are forced to assume that price changes of the final product are equally distributed at all stages of production.
- *Contribution of changes in the set of competitors:* This influences consumers' choice among various varieties of the final use products.
- *Contribution of residual non-price factors:* This component can be loosely related to factors like the relative quality of the product or consumers' taste. Despite the fact that these characteristics are statistically unobservable, their contribution can be calculated as a residual at the disaggregated level.

## 5 Two case studies: The UK and Slovakia

As an example, we decompose changes in global market shares for two EU countries that can be viewed as opposite cases in terms of market share dynamics and integration into GVCs: the UK and Slovakia.

Figure 2 shows the decomposition of cumulative changes in global market shares for the UK. The left panel is devoted to the decomposition of global VASF market shares using the framework described above. For the comparison, we also report the decomposition

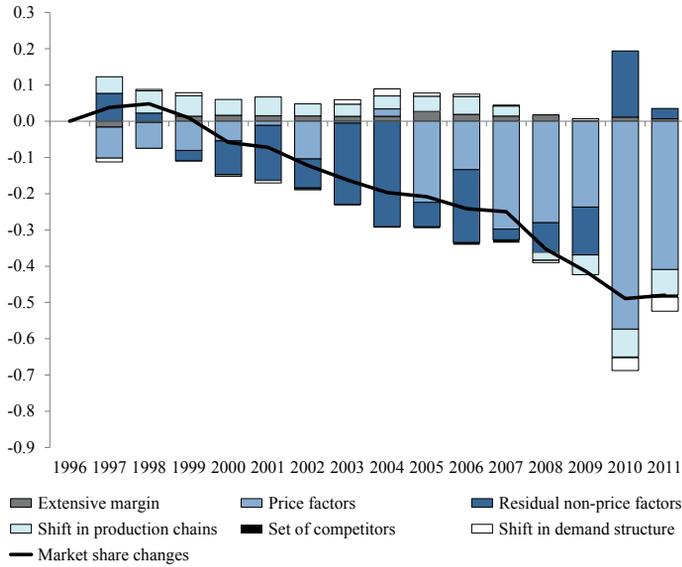
<sup>5</sup> See Benkovskis and Wörz (2015) for technical details.

of market shares for gross export of final products (right panel), which was performed within the same framework but assumes that the producer country always coincides with the exporting country.

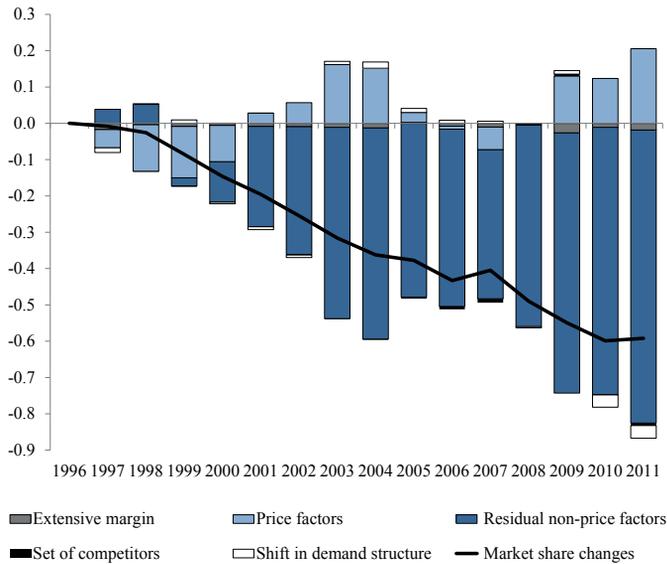
As discussed before, the UK lost global market shares. However, the losses are smaller when accounting for the presence of international fragmentation of production. When focusing on conventional gross export market shares, residual non-price factors are the major driving force behind the UK's market share losses – suggesting a decline in the quality of UK exports relative to other countries – while price factors showed a slightly positive contribution.

**Figure 2** Decomposition of cumulative changes in global market shares for the UK

a. Value added in gross exports of final products (VASF)



b. Gross exports of final products



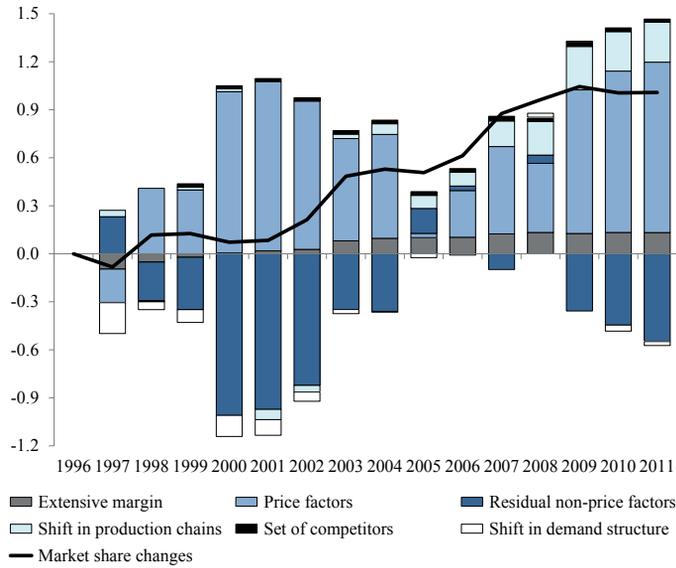
Source: WIOD; UN Comtrade; authors' calculations.

Notes: Results denote cumulative log-changes of global market shares. The sum of contributions is not equal to the total changes in export market shares due to log linearisation and missing unit values data.

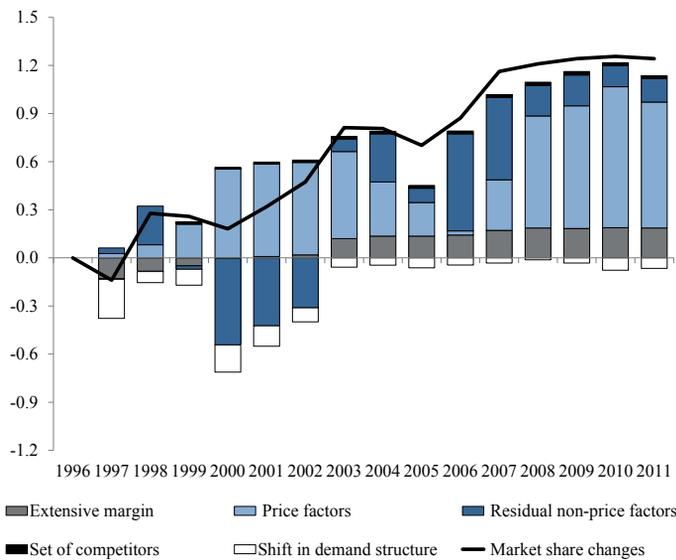
The underlying story alters radically when GVCs enter our analysis. On the one hand, we see that production was gradually outsourced from the UK to other countries (Ireland, China and Germany), which made a direct negative contribution to changes in global market shares. On the other hand, we observe almost no contribution of residual non-price factors to changes in VASF market shares. We can argue that apparent losses in the relative quality of UK exports (in Figure 2b) were due to outsourcing the final assembly of higher-quality products, whereby the relative quality of production in the UK remained unchanged. Finally, our results indicate that price and cost factors almost entirely explain the losses in VASF market shares. This suggests that the UK provides direct and indirect value added for products whose export prices were growing relatively fast. These findings, however, are based on the assumption that price changes of the final product are equally distributed at all stages in the international production chain, and thus should be taken with some caution.

The case of Slovakia (Figure 3) mirrors that of the UK in many respects. Slovakia was one of the most pronounced winners in terms of global market shares within the EU, and outsourcing of production to Slovakia provided a significant direct contribution to this success. On the other hand, while Figure 3b reports relative improvements in the quality of Slovakia's gross exports, accounting for international fragmentation reveals that this improvement was due to the imports of high-quality intermediate inputs.

**Figure 3** Decomposition of cumulative changes in global market shares for Slovakia  
 a. Value added in gross exports of final products (VASF)



b. Gross exports of final products



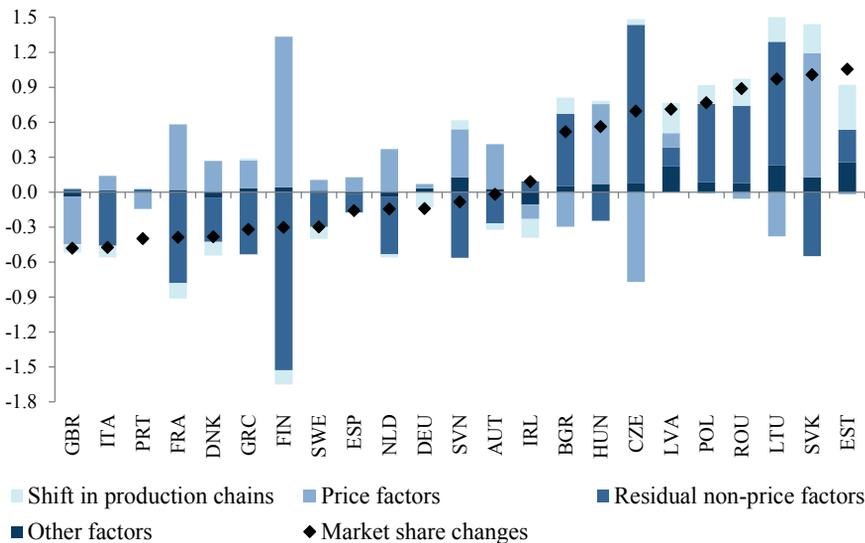
Source: WIOD; UN Comtrade; authors' calculations.

Notes: Results denote cumulative log-changes of global market shares. The sum of contributions is not equal to the total changes in export market shares due to log linearisation and missing unit values data.

## 6 Overview of EU countries

To give a broader picture, in Figure 4 we provide the decomposition of the changes in VASF market shares for 23 EU countries. In order to show further how a focus on GVCs changes our conclusions concerning the drivers of global market shares, we decompose the difference between gross exports and VASF market share changes in Figure 5.

**Figure 4** Decomposition of changes in VASF market shares of EU countries between 1996 and 2011

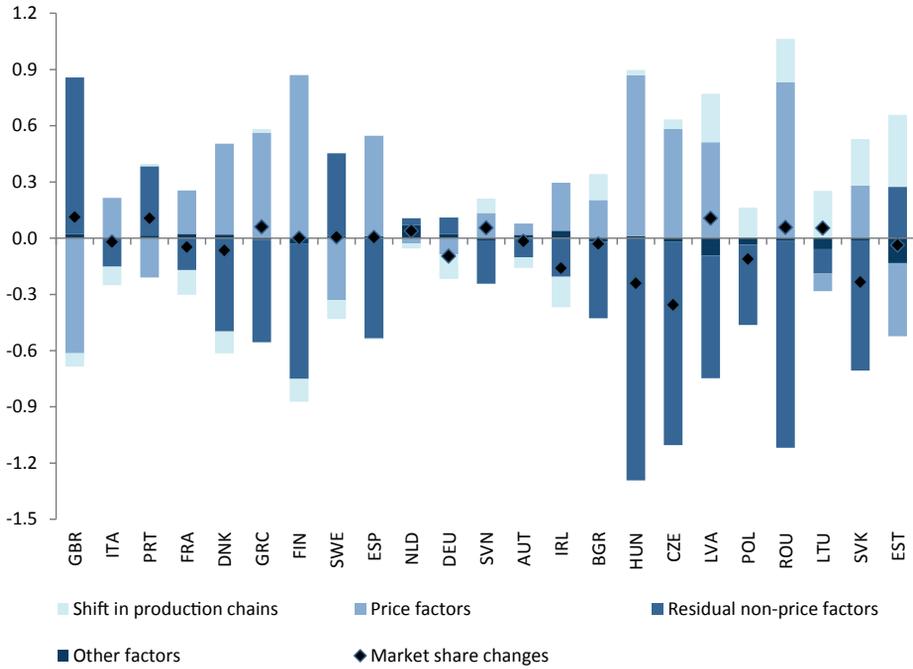


Source: WIOD; UN Comtrade; authors' calculations.

Notes: Results denote log-changes of global market shares. The sum of contributions is not equal to the total changes in export market shares due to log linearisation and missing unit values data.

Outsourcing production to other countries directly implies losses of global market shares for old EU member states. This outsourcing was mainly directed towards developing countries outside the EU (China, Turkey) and new EU member states (Czech Republic, Poland). However, we also observe opposite movements. For example, the production of motor vehicles was shifted to Germany from other old EU members and the US, while Ireland was a popular outsourcing destination for the US and the UK.

**Figure 5** Decomposition of differences between gross exports market share changes and VASF market share changes between 1996 and 2011



Source: WIOD; UN Comtrade; authors' calculations.

Notes: Results denote log-changes of global market shares. The sum of contributions is not equal to the total changes in export market shares due to log linearisation and missing unit values data.

At the same time, shifts in production chains added directly and noticeably to global market share gains by new EU members. The Czech Republic, Slovakia, Hungary and Poland insourced the production of motor vehicles and other machinery, and the same was observed for the production of clothing in Romania.

Figure 4 claims that residual non-price factors are another important driver of changes in global market shares for the EU countries. We usually observe positive contributions for new EU member states and negative contributions for old EU member states. This can be loosely interpreted as evidence of catching-up by new EU members in terms of production quality, although the factors behind this process require further investigation.

Figure 5 shows that for the new EU member states, gains in the relative quality of exports are stronger than improvements in the relative quality of production. Thus, outsourcing of high-quality products from developed countries to the new EU member countries improved the relative quality of the latter's exports and provided a positive contribution to their gross export market shares. We do not find a clear pattern for the old EU member states. Positive red bars in Figure 5 suggest that high-quality intermediate inputs from the UK, Sweden and Portugal were intensively used in production processes abroad, thus cushioning the losses in VASF market shares.

Finally, we observe that price and cost factors positively affected VASF global market shares of old EU member states (with the exception of the UK), while results are mixed for new EU member states (Figure 4). It is important to note that switching from gross exports to the value added concept resulted in a more positive contribution of relative price and cost factors for the majority of the EU countries, meaning that EU countries were indirectly involved in the production of final use goods with overall falling relative prices, and hence gains in price competitiveness. Again, we acknowledge that these findings should be taken with some caution, since we do not observe prices at different stages of production.

## **7 Concluding remarks**

Shifting the focus from traditional gross exports to value added in export market shares does not change the general picture much – new EU countries are gaining market shares at the expense of old EU members. But the inclusion of international fragmentation alters the underlying story, which carries important policy implications. Our results show that the global production process is gradually shifting toward new member states. This affects global market shares directly but also indirectly, changing our understanding of the driving forces behind market share changes. For example, improvements in the relative quality of exports from the new EU member states often owe to the outsourcing process and the use of higher-quality intermediate inputs sourced from more developed

economics. We also observe that price factors are important in explaining changes in global market shares. Putting these two observations together, we can conclude that GVC integration increases the efficient use of locally available resources. Nevertheless, it should be noted that even after controlling for the effects from GVC integration, we observe catching-up in the relative quality of production by the new EU member states.

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# On the interpretation of trade imbalances<sup>1</sup>

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*One of the main stylised facts that has emerged from the recent literature on global value chains is that bilateral trade imbalances in gross terms can differ substantially from those measured in value added terms. In this chapter, we present the results of a novel decomposition framework that distinguishes between (foreign) value added exports that are due to demand of the direct trading partner, and (domestic and foreign) value added exports that are due to demand in third countries. We apply our decomposition framework to the development of intra-EU27 gross trade balances over the last two decades and show that a sizeable and increasing share of intra-EU gross bilateral trade balances was due to demand in countries other than the two trading partners.*

## **1 Introduction**

One of the main stylised facts that emerged from the recent literature on global value chains is that bilateral trade balances in gross terms can differ substantially from those measured in value added terms, while aggregate trade balances are the same in both cases (Johnson and Noguera 2012). For example, in 2011 the trade deficit of the US with China was approximately 17% smaller when measured on a value added basis, while the US trade deficit with Japan was 39% larger (Figure 1). Value added balances capture the difference between any two countries' domestically produced value added

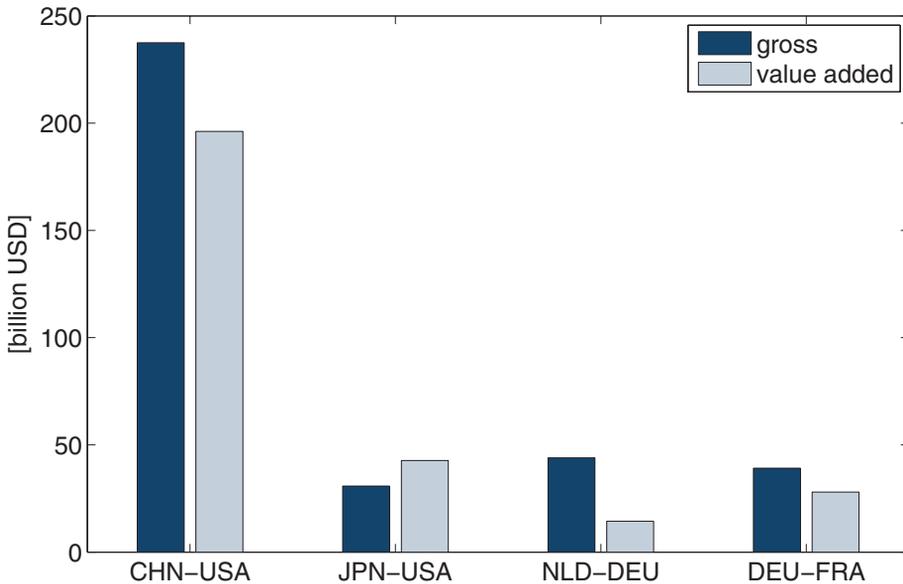
<sup>1</sup> This chapter represents the authors' personal opinions and does not necessarily reflect the views of the Deutsche Bundesbank.

that is absorbed in final demand by their respective trading partner. In contrast to gross trade balances, they discount the part of trade flows that is double-counted in official trade statistics (Koopman et al. 2014).

## 2 On the difference between gross and value added balances

In the absence of trade in intermediate inputs, bilateral gross and value added balances would be identical, so vertical specialisation is the ultimate factor that accounts for the difference between the two concepts. Nevertheless, several distinct value added components can be identified that account for the differences between gross and value added balances (Nagengast and Stehrer 2014), which are a reflection of the relative position of countries in international production networks (Antras et al. 2012).

**Figure 1** Bilateral trade balances in 2011



Note: First country in the pair denotes the surplus country.

Source: Authors' calculations based on WIOD.

Foreign value added absorbed by the respective trading partner (Column 5 in Table 1) accounts for a substantial share of the difference between the gross and value added concepts for most of the trade balances considered in Table 1. For example, about one quarter of the Chinese trade surplus with the US in 2011 was made up of non-Chinese value added, reflecting China's importance as a processing hub of imported intermediates from other countries. Another important factor that emerges for some trade balances is demand in countries other than the two trade partners, which, for example, constitutes a sizeable portion (14%) of the gross trade surplus of Germany with France. This is the result of German intermediates exports to France, such as aircraft components, which are eventually delivered to their final costumers in third countries. The fact that domestic value added often appears in the gross trade balances with other countries also explains why the Japanese value added surplus with the US is larger than its respective gross trade surplus, since Japanese value added often enters the US indirectly via third countries.<sup>2</sup> The residual, which is composed of value added that is double-counted and domestic value added that is reflected back via third countries for domestic consumption, does not play a significant role in any of the four bilateral trade balances under consideration.

**Table 1** Decomposition of selected bilateral trade balances in 2011

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	gross trade balance: (3)+(5)+ (6)+(7)	value added trade balance	value added in gross trade balance	value added in other trade balances: (3)-(2)	foreign value added (trade partner demand)	domestic and foreign value added (3rd country demand)	residual
<i>in million USD</i>							
CHN-USA	237,503	196,173	173,979	-22,194	60,102	-520	3,942
JPN-USA	30,808	42,690	23,786	-18,904	5,481	1,783	-241
NLD-DEU	43,969	14,374	11,131	-3,243	20,098	12,514	226
DEU-FRA	39,098	27,961	22,461	-5,500	9,946	5,599	1,092

2 For most country pairs, the value added contained in the gross bilateral balance (column 3) is smaller than the value added balance (column 2), while the remainder appears in the gross bilateral balances of other countries (column 4).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	gross trade balance: (3)+(5)+ (6)+(7)	value added trade balance	value added in gross trade balance	value added in other trade balances: (3)-(2)	foreign value added (trade partner demand)	domestic and foreign value added (3rd country demand)	residual
<i>in % of gross trade balance</i>							
CHN-USA	100	83	73	-9	25	0	2
JPN-USA	100	139	77	-61	18	6	-1
NLD-DEU	100	33	25	-7	46	28	1
DEU-FRA	100	72	57	-14	25	14	3

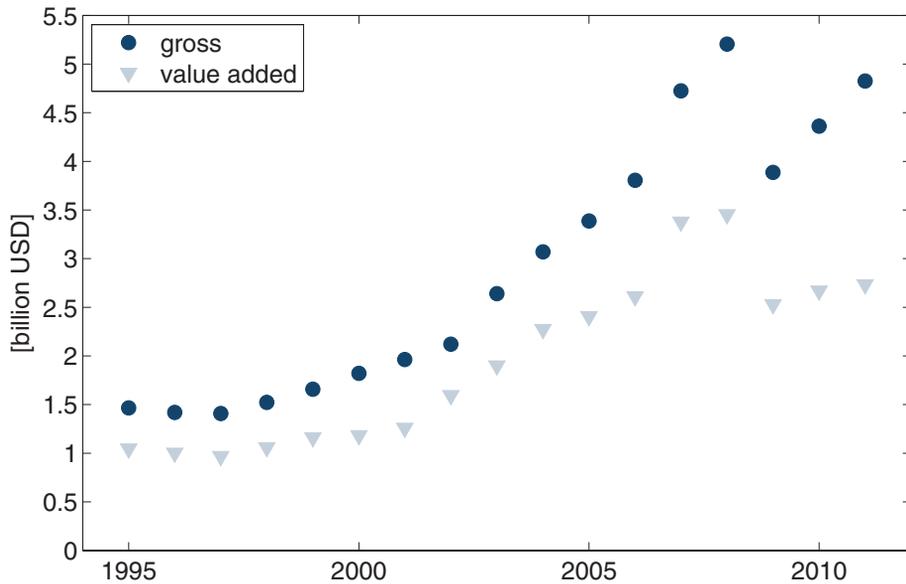
*Note:* First country in the pair denotes the surplus country.

*Source:* Authors' calculations based on WIOD.

### 3 Growing divergence between gross and value added balances

The period prior to the financial crisis saw a substantial build-up of global trade imbalances. Particular attention has been paid to intra-EU imbalances and especially to those countries with large current account deficits that were heavily affected by the financial crisis and the ensuing sovereign debt crisis (Berger and Nitsch 2010, European Commission, 2010). In gross terms, intra-EU27 trade imbalances increased substantially between 1995 and 2008 (Figure 2) as measured by the standard deviation of the bilateral trade balances between all EU27 countries. The Great Trade Collapse led to a substantial reduction in the imbalance measure in 2009, while bilateral imbalances have rebounded since and almost reached their pre-crisis level in 2011. A similar pattern is observed when considering imbalances in value added terms. However, in the past decade there has been a growing divergence between the measure in gross and value added terms, with the increase in the latter being much weaker.

**Figure 2** Standard deviation of intra-EU27 bilateral trade imbalances



Source: Authors' calculations based on WIOD.

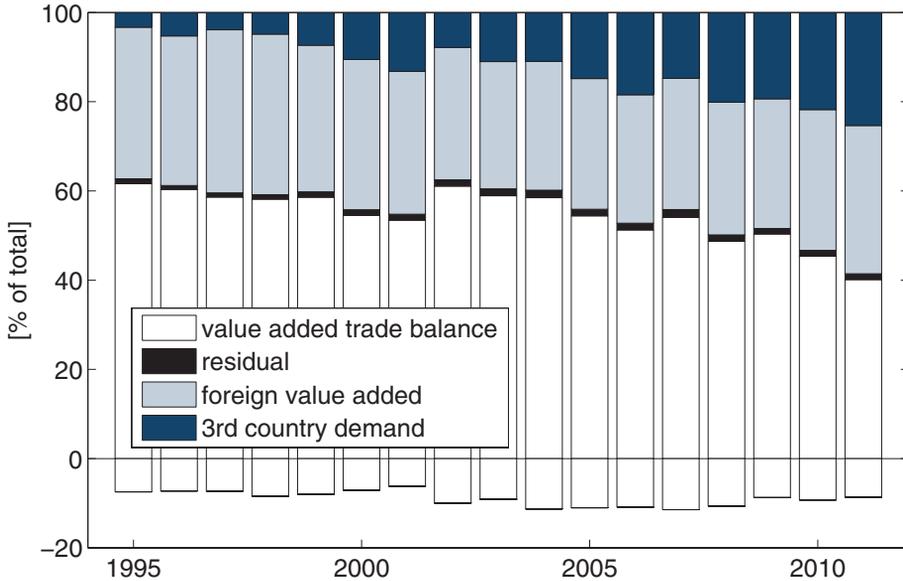
#### 4 Demand in third countries accounts for increasing divergence

In order to assess which factors account for the divergent development of gross and value added balances over time, we performed a variance decomposition of intra-EU bilateral gross trade balances. Figure 3 shows that in 1995, the trade balance in value added terms accounted for 69% of the gross trade balance, while in 2011 its share was down to only 49%.<sup>3</sup> Foreign value added directly absorbed by one of the two trading partners determined the major part of the difference between the gross and value added concepts, although its importance has remained relatively constant, accounting for an average of 32% of the variance in the period under consideration. The divergence between gross and value added balances was mainly due to the rising

<sup>3</sup> Technically, the value added trade balance and gross trade balance between two countries only partially overlap, i.e. a part of the value added trade balance appears in the gross trade balances with other countries (for technical details, see Nagengast and Stehrer 2014). Note that the latter corresponds to the part of the value added balance below the horizontal axis in Figure 3.

importance of demand in third countries, which increased from 3% in 1995 to 25% in 2011. This means that a sizeable portion of gross bilateral trade balances can no longer be influenced directly by demand conditions in the two respective trading partners. The overall conclusions remain unchanged when considering the sample of Eurozone countries, i.e. EMU17 instead of EU27 countries.

**Figure 3** Variance decomposition of intra-EU27 bilateral gross trade balances



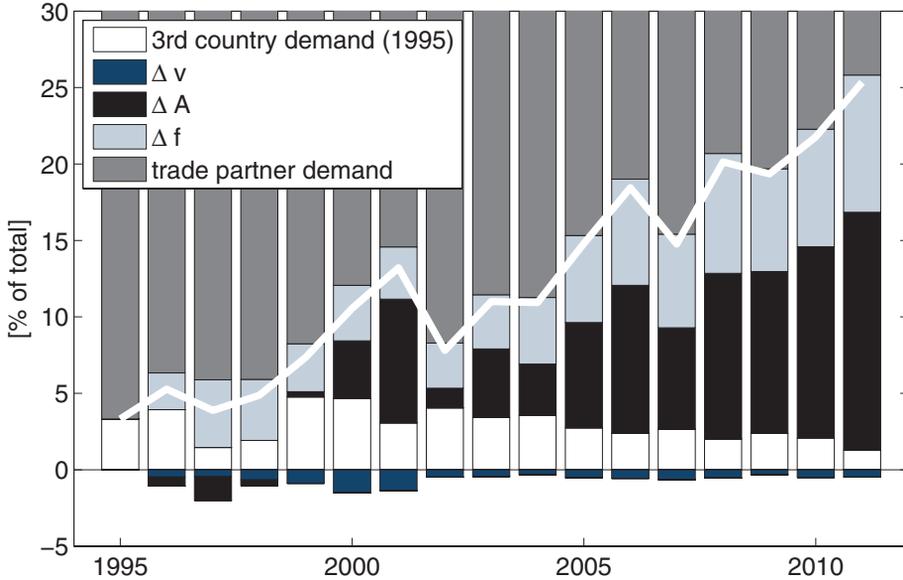
Source: Authors' calculations based on WIOD.

## 5 Vertical specialisation contributes to the increase in intra-European imbalances

The increasing importance of demand in third countries for intra-European trade imbalances could in principle be due to two main developments. A first possibility is that the demand for goods and services for which international production sharing is particularly pronounced could have expanded disproportionately in comparison to demand for other goods and services. Alternatively, the lengthening of global value chains as a result of a further intensification of international production sharing could

also be behind the increase. A structural decomposition analysis (Dietzenbacher and Los 1998, Miller and Blair 2009) of the third-country demand effect provides a breakdown of the shift in this effect into changes of final demand, international production sharing and value added content. Figure 4 indicates that relative to the reference year 1995, intensified international production sharing contributed roughly two thirds (+15.5 percentage points) to the larger prominence of the third-country demand effect, while changes in final demand were responsible for most of the remainder (+9 percentage points). The sectoral value added content of exports – which, for example, is reduced when firms outsource their production to other sectors – had a negligible impact (–0.5 percentage points). This suggests that the expansion of intra-European production networks, together with the incorporation of central European countries into intra-European value chains after the fall of the Iron Curtain, were the main factors driving a wedge between gross and value added trade balances between European countries.

**Figure 4** Structural decomposition analysis of change in the third-country demand effect



Notes:  $\Delta v$  = changes in the value added content of production;  $\Delta L$  = changes in the structure of international production sharing;  $\Delta f$  = changes in final demand.

Source: Authors' calculations based on WIOD.

## 6 Non-EU demand explains part of the trade imbalances

Further insights into intra-European imbalances can be gained by considering a regional breakdown of the third-country demand effect. Figure 5 splits intra-EU27 bilateral trade balances into demand for both domestic and foreign value added in different countries and regions. EU countries other than the two direct trading partners were – on average over the sample period – responsible for 2% of bilateral imbalances. In 2011, countries in the Americas accounted for 5% of the variance, while the US with 3% was the single most important country. The share of Asian countries stood at 2% in 2011, to which China contributed about half. The remainder of 13% was due to demand

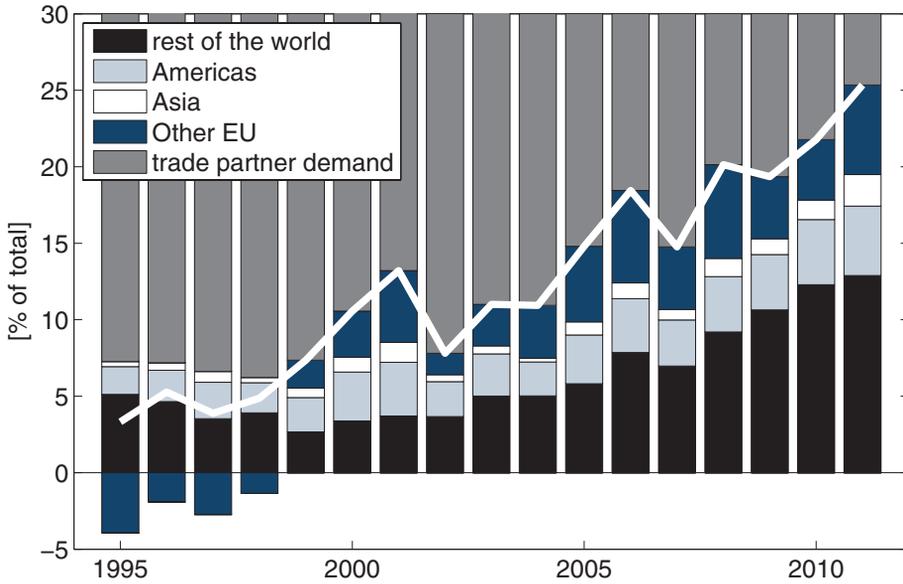
in the rest of the world.<sup>4</sup> Considering changes in contributions over time, demand in other EU countries and the rest of the world had a substantially larger impact on intra-EU imbalances in 2011 than in 1995, whereas the significance of direct trade partners declined sharply. Demand in other regions only marginally increased in importance. It is worth emphasising that due to the changes that occurred in the past decade, about one fifth of intra-EU27 trade balances in 2011 was due to demand in non-EU countries.

## **7 Value added balances vis-à-vis EU/EMU mostly smaller than in gross terms**

The preceding analyses suggest that intra-European trade imbalances were overstated while those with countries outside the EU were slightly underestimated. Indeed, in 2011 the value added trade balance vis-à-vis the EU as a whole was smaller (and therefore that with non-EU countries larger) than the gross trade balance for 21 of the 27 countries. A similar result holds for the Eurozone, for which the value added trade balance of individual countries with the EMU aggregate was smaller than the gross trade balance for 15 out of 17 countries. This finding makes it undesirable to assess intra-EU (intra-EMU) imbalances in terms of gross trade flows, since a sizeable share of these are in fact trade imbalances with countries outside of the EU (Eurozone) and they will by definition be unaffected by adjustment of domestic demand within the EU (Eurozone).

4 WIOD differentiates between 40 individual countries and a model capturing all remaining countries. The “rest of the world” in Figure 5 includes this residual as well as countries neither belonging to Asia, nor the Americas nor the EU.

**Figure 5** Contributions of individual countries to intra-European imbalances



Source: Authors' calculations based on WIOD.

## 8 Policy implications

In a world of international production sharing, the bilateral trade balance between two countries is to some degree a function of demand in the rest of the world. A decrease in domestic demand leads to an adjustment of the portion of the trade balance capturing value added absorbed by the two trade partners, whereas by definition it will have no effect on the part of the trade balance which is due to demand in third countries. Therefore, a completely balanced bilateral gross trade position is unlikely to be a good benchmark for assessing demand or price adjustments.

Our results matter for policy as, particularly in a currency union, it is important to establish with whom trade imbalances exist, since the burden of adjustment may differ between trade deficits vis-à-vis member countries and third parties (di Mauro and Pappada 2014). Even though their limitations are widely acknowledged, gross bilateral trade balances still figure widely in the literature and policy debates (Bahmani-

Oskooee and Brooks 1999, Davis and Weinstein 2002). This provides a strong case for considering value added instead of gross bilateral trade balances, since a sizeable portion of gross bilateral trade balances is no longer under the influence of the direct trading partners themselves. Looking to the future, this highlights the importance of making global input-output tables for current years available to researchers and political decision-makers in a timely manner.

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# Part III

## The firm-level dimension

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# Firms' engagement in global value chains<sup>1</sup>

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*This chapter focuses on the extent and determinants of firms' engagement in global value chains. We begin with a brief discussion of stylised facts on international trade and investment patterns highlighted by the most recent theoretical and empirical evidence. Next, we provide novel empirical evidence about the extent and determinants of European firms' engagement in outward international activities. This evidence indicates that exporting represents the first stage of firms' internationalisation, followed by international sourcing and foreign direct investment. Only a small number of firms engage in more complex international strategies associated with global value chains. Firms' engagement in internationalisation strategies is positively linked to age, size, productivity and product innovation performance.*

## **1 Introduction**

Over the past two decades there has been an increased fragmentation and integration of production and innovation within and across national borders driven by technological change and trade liberalisation. The performance of firms and countries is increasingly linked to the performance of international production and innovation networks. Understanding firms' internationalisation and their organisational choices is key

<sup>1</sup> The views expressed here are purely those of the authors and may not in any circumstances be regarded as stating an official position of the Department of Finance, with which Gavin Murphy is affiliated.

to informed policies aimed at competitiveness and growth at the firm, country and European levels.

Within-industry firm heterogeneity is at the centre of the most recent theoretical models explaining the emergence of global value chains. However, most existing empirical evidence related to global value chains is based on the analysis of industry and country data.<sup>2</sup> To uncover the behaviour and performance of firms in regional and global value chains, cross-country comparable firm-level datasets are needed. Unfortunately, to date these datasets have been very scarce.

This chapter aims to contribute to filling this gap. It begins with a discussion of stylised facts from the underlying theoretical and empirical literature on international production and innovation networks. Next, it summarises key findings from an analysis of European firms' engagement in outward international activities. While most existing studies consider single internationalisation modes, our analysis contributes novel evidence on firms' engagement in a broad range of international activities, including exporting, foreign direct investment (FDI), international sourcing and combinations of these international activities.

## **2 Firms' engagement in global value chains: Stylised facts**

Recent theoretical and empirical evidence has established that firms engaged in international activities such as exporting and FDI differ systematically from firms serving only home markets (Melitz 2003, Helpman et al. 2004, Yeaple 2013). Exporters are larger and more productive than non-exporters (Eaton et al. 2004), and the small fraction of firms that engage in FDI are larger and more productive than exporters. The distribution of firms by size and productivity varies across industries. Multinationals have more complex international integration strategies (Yeaple 2003, Grossman et al. 2005, Feinberg and Keane 2006).

<sup>2</sup> Most recent contributions to this literature are summarised elsewhere in this book.

Helpman (2006) highlights that productivity differences across firms within industries are linked to different choices in the organisation of production and distribution. In this context, trade and FDI patterns are jointly determined with organisational structures such as sourcing and integration strategies. Empirical evidence provided by Tomiura (2007) indicates that firms engaged in FDI are more productive than exporters and firms engaged in foreign outsourcing. Furthermore, the evidence shows that firms engaged in international outsourcing are less capital intensive than other firms with international activities.

Grossman and Helpman (2002) examine firms' choice between outsourcing and firm integration. In determining their organisational mode, firms – assumed to be equally productive – are faced with the trade-off between the costs of running a large and less specialised organisation and the search and monitoring costs of an input supplier. The authors show that outsourcing is likely to be more prevalent in some industries than in others, and that outsourcing is more likely to be viable in large firms and in large economies. Also, in competitive markets, outsourcing requires a high per unit cost advantage for specialised input producers relative to integrated firms, while in markets with less competition, outsourcing depends on the comparison of the fixed costs between specialised producers and integrated firms.

Incomplete contracts help to explain why some firms source inputs abroad via FDI, while others source them via outsourcing (Antràs 2003). Combined with productivity differences across firms within industries, this approach predicts the relative prevalence of alternative forms of the international organisation of production as a function of sectoral characteristics and differences in features of the trading partners. Antràs and Helpman (2004) formalise theoretically the decision of firms to engage in international markets either through foreign sourcing or FDI. Their model predicts that in a vertically integrated industry, the most productive firms source their intermediates from an owned affiliate while less productive firms outsource them from arm's-length suppliers.

Product-cycle models of international trade predict that exports in industrialised countries are driven by innovation (Vernon 1966, Krugman 1979). This theoretical prediction has been supported by empirical evidence obtained using firm-level data from different countries.<sup>3</sup>

Another literature strand brings financial frictions into models of international trade and investment.<sup>4</sup> Existing evidence suggests that financial factors interact with firm heterogeneity (firm characteristics) in determining the choice and performance of firms' international activities. The presence of fixed upfront costs (searching for customers or suppliers, customising products for foreign markets), management and monitoring costs, contract enforceability related to international activities as well as risks associated with exchange rate changes imply that access to external financing conditions the internationalisation choices of firms (Manova 2013, Foley and Manova 2014, Schiavo 2014).

The bulk of available empirical evidence focuses on financial constraints and exporting (Greenaway et al. 2007, Bellone et al. 2010, Berman and Héricourt 2010, Cagesse and Cuñat 2013) and, to a lesser extent, multinational activity (Manova et al. 2015). Under imperfect financial markets, increased access to external financing amplifies the effect of productivity on the self-selection of firms into exporting. To the extent that financial constraints also affect variable trade costs, they also condition export sales (Manova et al. 2015).

Multinational firms are less likely to be financially constrained because they have access to international capital markets and internal funds. This confers on them a comparative advantage over domestic firms and leads them to self-select into more financially vulnerable industries where they face less competition from domestic firms. Manova et

3 Wakelin (1998) and Bleaney and Wakelin (2002) for the UK; Caldera (2010) and Cassiman and Golovko (2011) for Spain; Halpern and Muraközi (2012) for Hungary; and Becker and Egger (2013) for Germany.

4 A more detailed discussion of this literature is provided in Chapter 13 of this book by Kalina Manova.

al. (2015) show that multinational firms in China have a better export performance in more financially dependent industries.

### **3 Firms' engagement in global value chains: Evidence from the EU**

This section summarises key findings from an analysis of outward international activities of firms located in four large economies in the EU: France, Germany, Italy, and Spain. The examined outward internationalisation activities include exporting, FDI, international sourcing as well as combinations of these internationalisation activities.

This analysis uses micro data available from the EFIGE dataset.<sup>5</sup> As shown in Table 1, in the four countries analysed, about 59% of all firms were engaged in internationalisation, while 41% had no international engagement. Italy had the largest share of firms engaged in international activities (68%), followed by Germany (65%), France (56%) and Spain (51%).

Exporting appears to be the first stage of enterprises' internationalisation strategy – 51% of all firms were exporters, while the share of firms engaged in other internationalisation activities was much smaller. Just 1% of all firms were engaged in FDI only, and another 1% were only active international sourcers. Finally, 4% of firms engaged in exporting combined with FDI, 3% were exporters and also engaged in international sourcing, while only 1% engaged simultaneously in all three international activities considered.

5 A detailed description of the EFIGE dataset is available in Altomonte and Aquilante (2012).

**Table 1** Firms' engagement in international activities (% of all firms)

Engagement in international activities	All firms	France	Germany	Italy	Spain
Firms with no engagement in international activities	41	44	35	32	49
Exporting	51	43	43	61	46
FDI	1	1	7	0	0
International sourcing	1	1	2	1	1
Exporting and FDI	4	4	11	3	3
Exporting and international sourcing	3	5	2	3	1
Exporting, FDI and international sourcing	1	1	1	0	0

Source: Own calculations based on the EFIGE dataset. The grouping of firms in different internationalisation modes is mutually exclusive.

The review of the theoretical and empirical literature discussed above suggests that firms' engagement in international activities varies across firms and industries depending on firm and industry characteristics. To uncover this structural firm and industry heterogeneity, this section reports results from a multivariate analysis of determinants of firm's engagement in outward international activities using data for the sample of firms described in the previous section.<sup>6</sup>

A number of key messages emerge from this analysis. More mature firms are more likely to be exporters, to engage in exporting combined with FDI, and to engage in exporting, FDI and international sourcing simultaneously. Engagement in international sourcing only is more likely for firms younger than 20 years. Larger firms are more

<sup>6</sup> These results are obtained from a multinomial model that explains the propensity of firms to engage in different internationalisation activities. The variables used in the regression analysis are described in Table A1 and the estimates are reported in Table A2 in the Appendix.

likely to engage in: exporting; FDI; exporting combined with FDI; exporting combined with international sourcing; and all three international activities simultaneously. Higher productivity increases the propensity of firms to engage in: exporting; exporting combined with FDI; exporting combined with international sourcing; international sourcing only; and all three internationalisation modes simultaneously. While tangible capital intensity does not matter significantly for engagement in exporting, firms engaged in the other internationalisation activities are likely to be less intensive in tangible capital. Product innovation is very important for the engagement of firms in internationalisation activities, and is positively linked to engagement in: exporting; exporting and FDI; exporting and international sourcing; and all three internationalisation modes simultaneously. The largest product innovation effect is for engagement in exporting. Process innovation is positively linked to engagement in exporting, but does not seem to matter significantly for the other internationalisation strategies. Foreign-owned firms are more likely to be exporters, whereas ownership does not significantly influence engagement in the other internationalisation activities.

Given the cross-sectional nature of the available information on outward internationalisation activities, the relationships identified by this analysis could be best interpreted as structural rather than causal links. Understanding these structural links is useful, however, to inform policies aimed at enabling the engagement of firms in international activities. To the extent that firm-level data over time will become available, further analysis could identify causal relationships between firm performance and internationalisation strategies.

#### **4 Concluding remarks**

Firms' engagement in global value chains is linked to a range of outward internationalisation choices such as exporting, FDI and international sourcing, as well as combinations of these international activities. A large number of firms with international activities are exporters only, while a small number of firms engage in

international sourcing only or in FDI only. Also, only a small number of firms engage in combinations of these outward international activities. The results of our empirical analysis indicate that the propensity of firms to engage in international activities is positively linked to their age, size, productivity and product innovation performance. Firms engaged simultaneously in more than one type of international activity are more mature, larger, more productive, and have higher product innovation rates than those engaged in only one international activity.

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## Appendix

**Table A1** Definitions of variables

Age	Dummy variable equal to 1 if firm older than 20 years, 0 otherwise
Size	Log of number of employees
Labour productivity	Log of turnover per employee
Capital intensity	Log of tangible fixed assets per employee
Human capital	Log of labour compensation per employee
Product innovator	Dummy variable equal to 1 if firm carried out product innovation, 0 otherwise
Process innovator	Dummy variable equal to 1 if firm carried out process innovation, 0 otherwise
Access to external finance	Dummy variable equal to 1 if firm resorted to external finance, 0 otherwise
Sales growth at firm level	Growth in firm turnover
Industry sales growth	Growth in industry turnover (industry growth within country that firm is resident, firm turnover excluded from industry turnover calculation)

**Table A2** Determinants of firms' engagement in international activities

	Exporter	FDI	Int. Sourc.	Export/FDI	Exporter / Int. Sourc.	FDI/ Export/ Int. Sourc.
Age	0.067*** (0.014)	0.003 (0.002)	-0.007** (0.003)	0.007* (0.004)	-0.004 (0.005)	0.003** (0.001)
Size (lagged)	0.051*** (0.009)	0.004*** (0.001)	-0.000 (0.002)	0.021*** (0.002)	0.008*** (0.002)	0.003*** (0.001)
Labour productivity (lagged)	0.068*** (0.013)	0.002 (0.001)	0.004** (0.002)	0.019*** (0.004)	0.016*** (0.003)	0.004** (0.001)
Capital intensity (lagged)	0.008 (0.006)	-0.002* (0.001)	-0.002** (0.001)	-0.006*** (0.002)	-0.005*** (0.001)	-0.001*** (0.000)
Human capital (lagged)	0.004 (0.025)	-0.001 (0.003)	-0.004 (0.004)	-0.014** (0.007)	-0.017*** (0.006)	0.004 (0.003)
Product innovator	0.137*** (0.014)	0.001 (0.002)	0.001 (0.003)	0.015*** (0.004)	0.012*** (0.004)	0.005*** (0.002)
Process innovator	0.030** (0.014)	-0.001 (0.002)	0.001 (0.003)	0.001 (0.004)	-0.001 (0.004)	-0.001 (0.002)
External finance	-0.005 (0.014)	-0.005** (0.002)	-0.000 (0.003)	0.009** (0.004)	0.008* (0.005)	0.003* (0.002)
Domestic owned	-0.135*** (0.025)	-0.006 (0.004)	0.000 (0.004)	0.003 (0.005)	-0.015 (0.010)	0.001 (0.002)
Sales growth	-0.013 (0.020)	-0.001 (0.003)	0.000 (0.002)	-0.019** (0.008)	0.007 (0.005)	-0.005 (0.004)
Industry sales growth	-0.105 (0.157)	0.014 (0.010)	-0.038** (0.018)	0.015 (0.035)	0.044 (0.039)	0.018 (0.011)
Observations						5798
Pseudo R <sup>2</sup>						0.149

Notes: This analysis is based on the EFIGE data set. Marginal effects are based on estimates obtained with multinomial model. The grouping of firms in various internationalisation modes is mutually exclusive. Robust standard errors are in parentheses. \*, \*\* and \*\*\* denote 10%, 5%, 1% significance levels, respectively. Country, sector-specific effects not shown. Test statistics based on regression output. Country coverage: France, Germany, Spain, and Italy. The lagged variables are their corresponding values for 2007.

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# Global value chains and multinational activity with financial frictions

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*The increasing fragmentation of production across firm and country boundaries has transformed international trade over the last few decades. At the same time, cumulating evidence indicates that financial frictions severely impede export and multinational activity. This chapter discusses the effect of financial frictions on firms' position in the global value chain and on the pattern of multinational activity, drawing on recent findings in the literature.*

## **1 Introduction**

Two major phenomena have transformed the landscape of international trade over the last few decades: the rise of global value chains (GVCs) and the growth of multinational activity. Production is increasingly fragmented across borders, with trade in intermediate inputs for further processing and re-exporting expanding faster than trade in final goods. The International Labor Organization estimates that 60 million people worldwide work in 3,500 processing zones, located in 130 mostly developing countries. At the same time, multinational companies (MNCs) are of tremendous importance to international trade. Approximately one third of global trade is intra-firm, between subsidiaries of the same multinational enterprise, while another third occurs between a multinational and an unaffiliated party.

The splicing of supply chains across firm and country boundaries raises new policy questions of first-order importance. How should trade policy be designed in the presence of global production networks and multinational activity? How do these phenomena alter the aggregate gains from trade and its distributional effects? What are the implications for firm growth, technology transfer to emerging economies, and the transmission of shocks across borders? While these are largely open questions for future research, their answers depend on understanding the factors that shape the patterns of GVC and MNC activity.

A growing literature finds that financial market imperfections significantly affect international trade. Foley and Manova (2015) provide a detailed overview of this work. The evidence indicates that financial frictions restrict firms' entry into exporting, the scale of their operations conditional on exporting, and their position in global value chains. These distortions impede aggregate trade, especially during financial crises. Moreover, credit constraints disrupt cross-border trade significantly more than general production because of the larger financing needs of foreign transactions: Overall, 75-80% of the total reduction in trade due to financial sector underdevelopment is above and beyond any associated decline in total output. One third of the trade-specific effect can be attributed to limited firm entry into exporting, while two thirds reflect reduced firm-level exports (Manova 2013).

One strand of the trade and finance literature explores the implications of financial frictions particularly for firms' multinational activity and participation in global value chains. This chapter highlights three main insights emerging from this research. First, multinational companies are less credit constrained than domestic firms because they can use internal capital markets to arbitrage cross-country differences in external capital markets to some degree. Second, financial frictions restrict firms to performing lower value added, less profitable segments of global production. Third, credit constraints influence the organisation of production across firm and country boundaries.

## **2 No finance, no trade**

### 2.1 International trade requires external finance

Firms routinely rely on external capital to cover upfront costs that cannot be financed out of retained earnings or cash flows from operations. These upfront costs may be fixed – such as R&D, marketing and capital investments – or variable – such as input purchases, salary payments, and land and equipment rental fees. Exporters are more likely to face credit constraints than non-exporters because they require more external funding. First, exporting involves additional costs. Fixed trade costs include gauging market profitability; investing in market-specific capacity, product customisation and regulatory compliance; and maintaining foreign distribution networks. Variable trade costs comprise transportation, duties and freight insurance. Second, cross-border shipping and delivery typically takes 60 days longer than domestic orders, further aggravating exporters' working capital needs. Third, transnational operations entail increased risks due to currency fluctuations and difficulties in resolving contractual breaches arising from different laws and practices across jurisdictions.

An active market exists for the financing and insurance of international trade, estimated to be worth \$10-\$12 trillion in 2008, or 90% of world trade (Auboin 2009). Exporters and importers decide the financing terms of each transaction, i.e. whether exporters are paid upfront (cash in advance) or after delivery (open account). Trade partners each meet their liquidity needs with financing from commercial banks, specialised export-import banks, or state-backed export credit agencies. They may alternatively use letters of credit jointly issued by their representative banks.

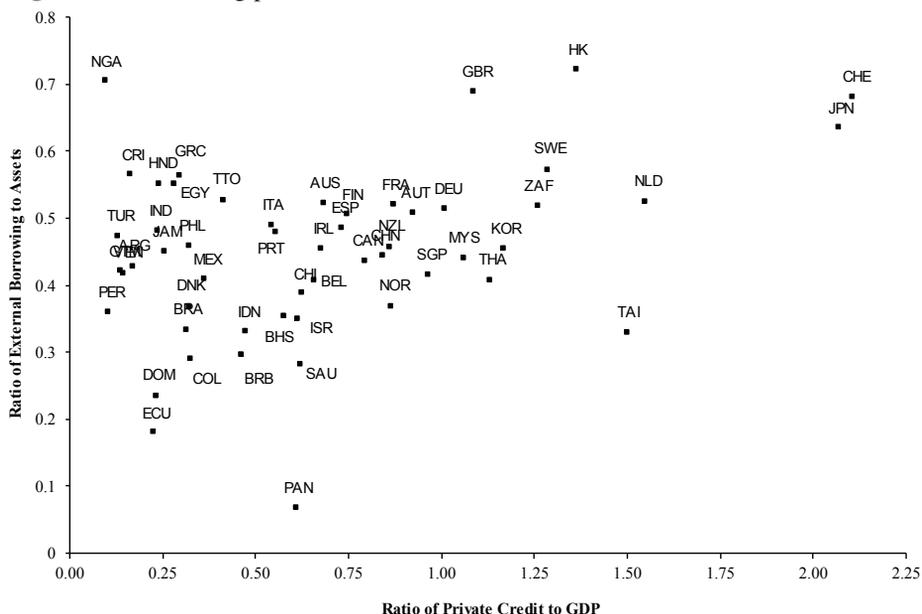
### 2.2 Multinational companies are less constrained than domestic firms

There are important differences between the financing practices of domestic firms and affiliates of multinational corporations. In terms of internal finance, both can use

retained earnings and cash flows from operations, but foreign-owned affiliates can also receive funding from parent companies. In terms of external finance, both can access local capital markets and buyer-supplier trade credit, but MNC subsidiaries can also tap foreign capital markets (directly or through their parent company) and indirectly benefit from buyer-supplier trade credits extended to related parties abroad. Compared to domestic firms, MNC affiliates thus have additional sources of financing.

Research shows that multinationals use internal capital markets opportunistically to overcome frictions in external capital markets. They raise more external finance and use less parent funding in countries with lower costs of capital. Desai et al. (2004) document that the affiliates of US-based multinationals raise less external finance in host countries with less developed capital markets or weaker protection of creditor rights. Figure 1 demonstrates the strong positive relationship across countries between affiliates' ratio of external borrowing to assets and the ratio of private credit to GDP. Bank credit to the private sector as a share of GDP is a standard measure of the availability of external financing in an economy, while creditor rights reflect how well formal institutions can support financial contracting.

**Figure 1** Financing practices of US-based MNC affiliates



Source: Desai et al. (2004).

Evidence indicates that multinationals' use of internal capital markets makes them less financially constrained than domestic firms, especially when limited access to external financing is more likely to bind. Manova et al. (2014) find that the affiliates of foreign enterprises in China have a comparative advantage in sectors more dependent on the financial system relative to local enterprises. Foreign subsidiaries export relatively more than private domestic firms in sectors that require more external finance for long-term investment, sectors that need more liquidity for short-term working capital (i.e. with high inventory-to-sales ratios), sectors with fewer tangible assets that can serve as collateral in raising outside funds, and sectors with less access to buyer-supplier trade credit that can substitute formal borrowing. Table 1 illustrates this with a breakdown of Chinese exports by type of firm ownership for sectors with financial vulnerability above versus below the median. Joint ventures (foreign ownership typically around 50%) lie between domestic and fully foreign-owned affiliates, consistent with parent companies offering more internal financing at higher levels of control.

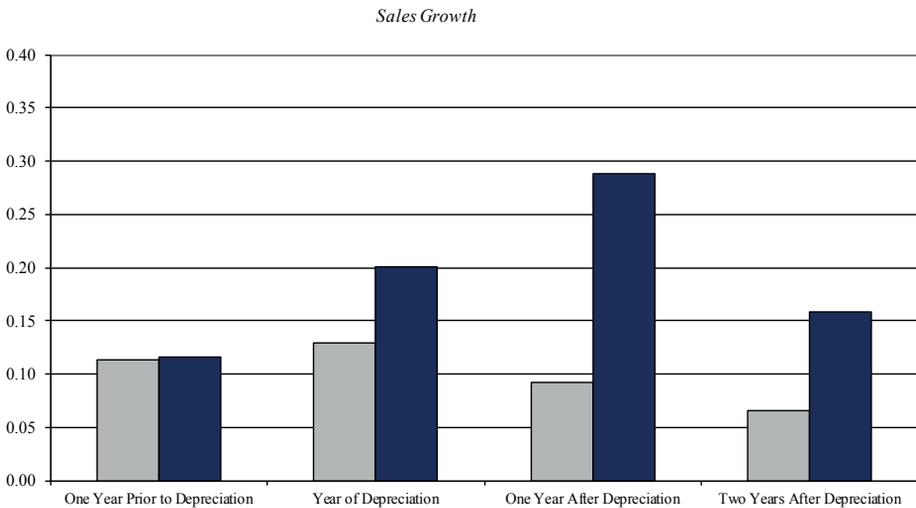
**Table 1** Composition of Chinese exports by firm ownership and sector financial vulnerability

Firm Type:	All Firms	State Owned	Private Domestic	Joint Ventures	Foreign Owned
	(1)	(2)	(3)	(4)	(5)
Total Exports	531.36	9.8%	12.9%	26.3%	51.0%
<b>Panel A. Classifying sectors by external finance dependence</b>					
Low	173.47	14.9%	23.4%	29.4%	32.3%
High	357.89	7.3%	7.8%	24.8%	60.1%
<b>Panel B. Classifying sectors by inventories ratio</b>					
Low	94.01	19.9%	18.8%	32.1%	29.2%
High	437.35	7.6%	11.6%	25.1%	55.7%
<b>Panel C. Classifying sectors by asset tangibility</b>					
Low	423.04	6.2%	9.9%	25.9%	58.0%
High	108.32	23.8%	24.4%	28.1%	23.7%
<b>Panel D. Classifying sectors by trade credit intensity</b>					
Low	285.63	4.9%	7.5%	24.8%	62.8%
High	245.73	15.5%	19.1%	28.1%	37.3%

Source: Manova et al. (2014).

MNCs’ superior access to financing also enables them to respond more to export growth opportunities relative to domestic firms. Desai et al. (2008) examine the impact of large real exchange rate devaluations in a host country on the operations of local firms and US-owned affiliates. Although depreciations reduce relative export prices and boost foreign demand, they are frequently accompanied by negative economic shocks including financial crises, which can prevent producers from scaling up exports. Data reveal that MNC subsidiaries increase sales and investment following devaluations, while domestic companies contract or exit. Moreover, the expansion of subsidiaries is often funded by the parent company. Figure 2 reports the differential sales growth for domestic and foreign enterprises in the years after large real exchange rate depreciations.

**Figure 2** Sales growth of local firms and US multinational affiliates after currency crises



Source: Desai et al. (2008).

While MNC affiliates may be less financially constrained than domestic firms, they are not unconstrained and insensitive to the availability of external capital in the country where they operate. Desai et al. (2004) conclude that lending from the parent company compensates 75% of the reduced external debt of affiliates based in economies with underdeveloped financial markets. This suggests that multinationals cannot fully arbitrage away differences in the cost of capital across countries. A plausible explanation is that financiers hesitate to fund all foreign activities because of asymmetric information or weak enforcement of collateral claims in international lending.

### 3 Organising and financing global value chains

Developing economies often rely on exporting to large, rich destinations for economic growth. Consumers in developed countries, however, typically demand quality products whose production requires skill-intensive design and specialised inputs. Firms in developing economies with limited technological knowhow, skilled labour and quality inputs may be unable to make high-quality products without foreign inputs or

blueprints. Global supply chains enable such firms to participate in international trade by performing only manufacturing stages in which they have a comparative advantage.

From the perspective of developed nations, offshoring production can reduce certain costs, but poses challenges in monitoring and incentivising foreign suppliers to ensure quality control and timely delivery. Multiple factors govern companies' decision whether, where and how to offshore – in-house or at arm's length. Multinational enterprises arise when it is optimal to own and operate production facilities abroad, rather than to subcontract to independent suppliers.

### 3.1 Financial frictions determine firms' GVC position

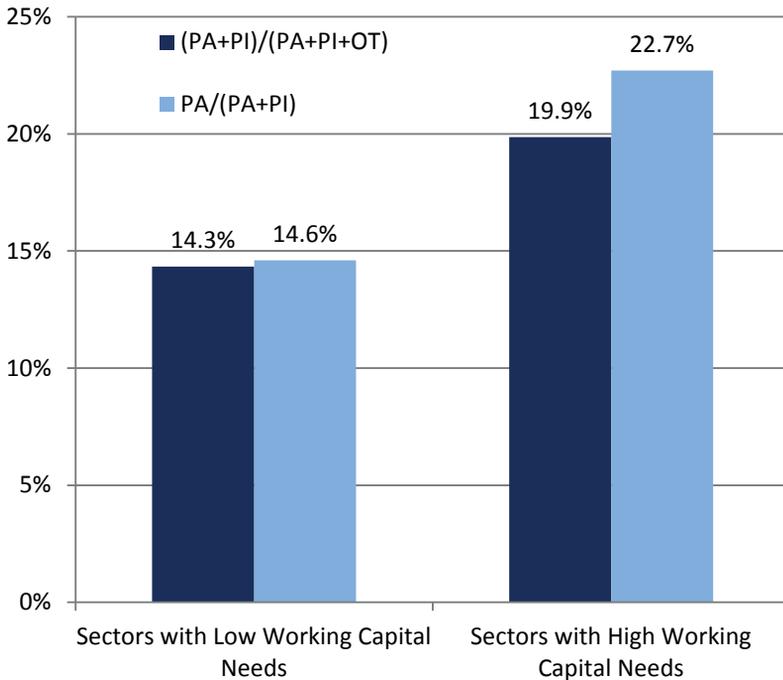
Financial factors can significantly affect the organisation of global value chains across firm and country boundaries. Different organisational structures may prevail depending on country, sector and firm characteristics. For example, Intel assembles microchips in wholly owned subsidiaries in China, Costa Rica, Malaysia and the Philippines, while Nike subcontracts to unaffiliated producers in Thailand, Indonesia, Cambodia and Vietnam. Even though both Apple and Ralph Lauren offshore production to independent parties in China, they employ different input and financing strategies. When outsourcing assembly to FoxConn, Apple provides customised inputs at no cost to FoxConn. By contrast, when manufacturing for Ralph Lauren, Youngor pays for foreign materials and retains ownership rights over them.

Spanning wider segments of production entails greater costs and requires more financing. Manova and Yu (2011) show that credit constraints restrict Chinese firms to lower value added, less profitable stages of global supply chains. In China, under ordinary trade (OT), companies design a product, pay for domestic and foreign inputs, incur import tariffs, assemble and distribute final goods abroad. Under processing trade, Chinese firms can import inputs duty-free to assemble them on behalf of a foreign buyer who handles product design and final distribution. While Chinese firms pay for foreign inputs under processing with imports (PI), the foreign buyer provides these for

free under pure-assembly processing (PA). Working capital needs thus rise from PA to PI to OT.

Financially healthier Chinese firms with more liquidity and less leverage have higher shares of ordinary exports in total exports and of processing with imports in processing exports. Both trade shares are strongly positively correlated with firm profits. Within firms across sectors, both shares fall with sectors' reliance on external finance. Figure 3 decomposes aggregate Chinese exports by trade regime for sectors with high and low liquidity needs (i.e. inventory-to-sales ratio).

**Figure 3** Composition of Chinese exports by trade regime and sector



Source: Manova and Yu (2012).

The choice of export regime depends on the financial conditions of both trade partners. The impact of Chinese firms' financial health and sectors' financial vulnerability on trade shares is bigger in Chinese provinces with weaker financial systems, where liquidity constraints are more likely to bind for the Chinese exporter. By contrast, this

impact is stronger for financially more developed export destinations, where the foreign party is less constrained.

OT implies more segments of the supply chain being performed and financed by a single Chinese firm, while PT means shared financing and profits across the border. GVCs may thus enable credit-constrained firms that could not become ordinary exporters to share in the gains from trade by engaging in processing activities.

### 3.2 Financial frictions affect multinational operations

Multinational enterprises make three key decisions: the host countries for manufacturing facilities (location decision), the ownership of production abroad or offshoring at arm's length (integration decision), and the interaction among affiliates within the firm's global network of production chains and consumer markets (network decision).

An earlier trade literature focused on the location decision, and distinguished between horizontal, vertical and export-platform FDI. In practice, multinationals adopt complex global strategies and use foreign affiliates for multiple purposes. The average US-owned subsidiary abroad directs 75% of its sales to the host country, 7% back to the US and 18% to third markets. A later trade literature examined multinationals' integration decision, and highlighted the importance of imperfect contractibility and relationship-specific investments. Most recently, research has explored the interlinkages among the production, import and export activities of multiple affiliates belonging to the same multinational company. This work emphasises the optimisation difficulties that arise in network structures.

Financial frictions can also significantly affect MNCs' location, integration and network decisions. Bilir et al. (2014) show that host-country financial development relaxes credit constraints for both domestic firms and foreign-owned affiliates, but relatively more for the former. This generates a competition effect that reduces affiliate revenues in the host market due to increased entry by domestic firms, and a financing effect that encourages

affiliate entry by easing their borrowing constraints. Data on US MNCs confirm that economies with stronger financial institutions attract more multinational subsidiaries. Stronger financial institutions in the host nation also raise aggregate affiliate sales to the local market, to the parent country (the US), and to third destinations. At the level of the individual affiliate, exports to the US and other markets are increased, but host-country sales are reduced. Both in the aggregate and at the affiliate level, however, the share of local sales in total sales declines with host-country financial development, while the shares of return sales to the US and export-platform sales to other countries rise.

These findings suggest that financial considerations govern the location and network decisions of MNCs. Stronger financial institutions in the host economy lower the incentives to pursue FDI for horizontal motives in favour of vertical and export-platform motives.

Antràs et al. (2009) establish that capital market imperfections also influence multinationals' integration decisions. They examine how firms headquartered in a developed country offshore production to foreign suppliers who require external finance to make relationship-specific investments. Because of moral hazard, financiers are unwilling to fund suppliers located in economies with weak protection of creditor rights. Foreign headquarters then have an incentive to integrate the supplier and monitor its operations, which in turn encourages local lenders to finance it. The parent company may provide additional funding as well. Empirical results indicate that US multinationals are more likely to deploy technology through foreign affiliates rather than arm's-length licensing in host countries with worse investor protection. They also hold higher equity stakes in the subsidiary and finance more of its activity in such environments. Related to this, Javorcik and Spatareanu (2009) document that less credit-constrained Czech firms self-select into becoming arm's-length suppliers to foreign multinationals.

## **4 Open questions**

Much scope remains for further work on the interactions among financial frictions, global value chains and multinational activity. Such research would inform policy by elucidating underlying economic mechanisms. Of interest is better understanding the organisation of international supply chains and the distribution of profits across firms and countries, especially in the presence of institutional and market frictions. Alleviating such frictions might be an important prerequisite for (firms in) developing countries to move into higher value added, more profitable GVC stages (Manova and Yu 2011).

Also relevant are the effects of GVCs and MNCs on knowledge transfer across borders. Emerging economies can benefit from technological spillovers from multinational activity to firms in the same sector, as well as to upstream and downstream firms (Javorcik 2004). Likewise, the extent of learning from exporting can depend on the GVC segment that firms occupy and their engagement with processing trade (Bai et al. 2013).

Equally important is how GVCs and MNCs influence the transmission of local and global supply and demand shocks across countries. This speaks to macroeconomic concerns about contagion, sudden stops and reversals in international capital flows. For instance, the effect of the 2008-09 financial crisis on a country's credit conditions and trade activity did not depend on its total foreign capital inflows, but was alleviated by a higher pre-crisis share of FDI in foreign capital inflows (Tong and Wei 2010). Indeed, multinational affiliates maintained higher sales during the crisis than domestic establishments, especially affiliates with stronger production and financial linkages to their parent company (Alfaro and Chen 2012).

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# Appendix

## Analysis of global production networks: Approaches, concepts and data

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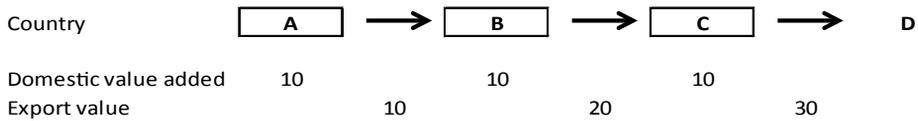
*The analysis of international production networks is blossoming and many new concepts, indicators and datasets have been introduced recently. In this Appendix we briefly outline two popular approaches: the vertical specialisation approach and the global value chain approach. This is followed by a short introduction to input-output tables, which feature prominently in all approaches, as well as a brief overview of the World Input-Output Database, which underlies much of the empirical work to date, including many chapters in this book.*

### **1 Analyses of global production networks: VS and GVC approaches**

There are two main approaches to analysing global production networks. The first is the vertical specialisation (VS) approach rooted in the seminal work by Hummels et al. (2001), which focuses on the measurement of domestic or foreign value added in a country's exports. This ratio is used as an indicator for vertical specialisation in international trade (see, for example, Chapters 1, 4 and 5 of this book). The second perspective is the global value chain (GVC) approach introduced by Timmer et al. (2013a), as used in Chapters 2 and 3, for example. In this approach, the full value added distribution of the GVC of a particular final product is identified, to measure the

contribution of countries to the value of the product. The difference between the two approaches is best illustrated through a simple example given in Figure 1.

**Figure 1** A simple GVC



Suppose the production process of a particular final product (say a car) requires three stages of production carried out in countries A, B and C. The product is consumed in D. In the VS approach, one determines the domestic value added content of a country's exports. Assume 10 units of value are added in each activity. Then this ratio will be 1 for country A, 0.5 ( $=10/20$ ) for B and 0.33 ( $=10/30$ ) for C. A low ratio suggests that a country is vertically specialised, in the sense that it does not add much value in producing its exports. The example shows that a low ratio can also be suggestive of a 'downstream' position in the global production network. Loosely speaking, decreases in the domestic value added in export ratios across a large number of countries indicate that production processes have become more internationally fragmented.

By adding additional information on the origin of a country's imports and the destination of its exports, flows of value added from one country to the next can also be analysed (see Hummels et al. 2001). Johnson and Noguera (2012) noted that value added generated in countries A and B is not consumed in the countries to which they export (B and C, respectively) but in D. They introduced the concept of value-added exports (VAX), which indicates the value added of a country finally absorbed in another country. VAX measures are particularly useful in tracing the effects of final demand shocks (Johnson 2014). Koopman et al. (2014) provide a general decomposition of gross exports encompassing both the VS and VAX measures. An intuitive and accessible interpretation of this decomposition is given in Los et al. (2015).

In the VS approach, the composition of a country's exports is considered. The GVC approach, however, is more general and uncovers the whole distribution of value added in production across all countries. Each global value chain is identified by the industry and country where the last stage of production takes place (the car manufacturing industry in country C). This country is called the country-of-completion. In this approach, it does not matter whether the final product is sold on domestic markets or exported. The approach traces the contributions of every country that participates in the production process. It builds upon the simple accounting identity that the sum of value added in each activity must be equal to the value of the final product that is consumed. In this case, the product value consumed by D (30) is found to be made up of value added in A, B and C (10 each).

The GVC approach allows for a rich analysis of international production, based on tracing changes in the regional and functional distribution of value added in production chains. In particular, one can analyse the degree of fragmentation in the production of a particular set of products (see Chapter 2), or the substitution of domestic for foreign production factors, or capital for labour (see Chapter 3). Changes in the value added by a country in one or more value chains can also be viewed as an indication of its competitiveness in these chains. Extending this idea, Timmer et al. (2013b) suggested using the label 'GVC income' for the value added generated by a country in the production of all final manufactured products completed anywhere in the world.

## **2 Input-output tables**

Both approaches rely on so-called input-output (IO) analysis. IO analysis was developed by Wassily Leontief as a standard tool for inter-industry analysis (Miller and Blair 2009). Leontief's seminal insight is rather straightforward and intuitive: to produce output, one needs labour, capital and intermediate inputs. These intermediates themselves need to be produced, again involving production factors and intermediates,

and so on until all intermediates are accounted for. Leontief provided a mathematical model that allows one to trace the inputs needed in all the stages of production.

In the Leontief framework, each industry produces output that may be used as inputs by other industries, or for final consumption or export purposes. The use and supply of products throughout the economy is described by a national input-output table (IOT) like the one shown in Figure 2.

**Figure 2** National input-output table

	Industry 1	Industry 2	Industry 3	Final Consumption	Gross Capital Formation	Exports	Total
Industry 1	use of intermediate inputs			final uses			Total use of output
Industry 2	use of imported inputs			imported final uses			
Industry 3	use of primary inputs						
Imports							
Value Added							
Gross Output	Total supply of output						

Source: Di Mauro et al. (2013).

To analyse production systems that cross national borders, more information is needed about the origin of a country's imports and the destination of its exports. This type of information can be found in a so-called inter-country input-output table, depicted in Figure 3. If all regions in the world are covered, it is called a global or world input-output table (WIOT).

**Figure 3** Inter-country input-output table

		Inter-industry Transaction/Intermediate Demand						Final Demand			Total
		Country 1			Country 2			Country 1	Country 2	...	
		Ind 1	Ind 2	...	Ind 1	Ind 2	...	...			
Country 1	Industry 1	use of domestic input			use of foreign input						
	Industry 2	use of domestic input			use of foreign input						
Country 2	Industry 1	use of foreign input			use of domestic input						
	Industry 2	use of foreign input			use of domestic input						
...	...	use of foreign input			use of foreign input						
Value Added											
Gross output											

Source: Di Mauro et al. (2013).

A WIOT provides a comprehensive summary of all transactions in the global economy between industries and final users across countries. The columns in the WIOT contain information on production processes, and the cells in a column provide information on the shares of inputs in total costs. Such a vector of cost shares is often referred to as a production technology. Products can be used as intermediates by other industries, or as final products by households and governments (consumption) or firms (stocks and gross fixed capital formation). The distribution of the output of industries over user categories is indicated in the rows of the table. An important accounting identity ensured by the table is that gross output of each industry (given in the last cell of each column) is equal to the sum of all uses of the output from that industry (given in the last cell of each row). Furthermore, it provides information on the use of, and payment for, primary production factors. This value added is recorded on a territorial basis and not according to ownership. Thus, analyses based on an IOT enable tracking of domestic rather than national value added.

### **3 The World Input-Output Database (WIOD)**

The World Input-Output Database, which is freely available at [www.wiod.org](http://www.wiod.org), has been specifically constructed for these types of analyses (Timmer et al. 2015). The second release of the WIOD, from November 2013, provides a time-series of WIOTs from 1995 to 2011. It covers 40 countries, including all 27 members of the European Union (as of 1 January 2007) and 13 other major economies: Australia, Brazil, Canada, China, India, Indonesia, Japan, Mexico, Russia, South Korea, Taiwan, Turkey and the US. Together, the countries cover more than 85% of world GDP in 2008. In addition, a model for the remaining non-covered part of the world economy is estimated, called the 'rest of the world' region. The database contains data for 35 industries covering the entire economy, including agriculture, mining, construction, utilities, 14 manufacturing industries and 17 services industries. WIOD also contains data on factor inputs. It contains numbers and incomes of workers of three types, identified on the basis of educational attainment levels. Capital income is derived as a residual and defined as gross value added minus labour income. It represents the remuneration for all types of capital goods, including intangibles such as patents (for more detail, see Timmer et al. 2015).

While national tables are routinely produced by national statistical institutes, WIOTs are not, as they require integration of national account statistics across countries. One can readily derive the use of products by industries and final consumers from national input-output statistics. But typically the country-of-origin of these products is unknown. Therefore one has to breakdown product import statistics by category of use in the construction of a WIOT. Typically, national statistical institutes and researchers rely on the so-called import proportionality assumption, applying a product's economy-wide import share for all use categories. To improve upon this standard proportionality assumption, the WIOD starts with imports as given in the supply tables and uses bilateral trade statistics to derive import shares for three end-use categories. This is clearly a second-best solution and improvements await further systematic data collection on the sourcing and use of products by statistical institutes.

More in general, as with any database, prudent use of the WIOD requires researchers to familiarise themselves with particular measurement issues. A WIOT is a synthetic database and constructed by combining various primary databases. Several assumptions in the construction process had to be made and various weaknesses in the data remain. Timmer et al. (2015) discuss the most important of these to serve as health warnings for users of the WIOD, or for that matter, any international input-output table that currently exists. Besides use-category classification, these include the treatment of the ‘rest of the world’ region and trade mirror-flows, quality and coverage issues of services trade and possible heterogeneity in production technologies of exporting and non-exporting firms. When production for exports is more intensive in the use of imported intermediates than production for domestic demand, the use of an input-output table that does not explicitly model the export sector might overestimate the domestic value added content of exports.

As a final note, we believe that the future development of this type of data should ideally be shouldered by its incorporation in regular statistical programs. Given the international nature of these tables, this must involve coordination within the international statistical community. Therefore we welcome the current OECD-WTO initiative (<http://oe.cd/tiva>) taking this work forward and hope that underlying sources and materials will become publicly available.

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Global value chains (GVCs) became the paradigm for the production of most goods and services around the world. Production is nowadays fragmented across different countries, i.e., parts and components are produced in distinct locations and are assembled either sequentially along the supply chain or in a final location.

It is widely acknowledged that GVCs are crucial for the operation of firms and have a bearing on macroeconomic developments and policy-decisions. In this context, the book aims to contribute to the policy and academic debate both in terms of mapping GVCs and assessing their implications. The book discusses:

- The path and characteristics of GVCs in the Eurozone, also making use of simple network visualization techniques and indicators, notably to discuss entry of countries and upgrading decisions.
- The evolution of GVCs from a regional dimension towards an increasingly global dimension and the role of multinational corporations and international business groups.
- The implications of GVCs from the perspective of inputs used and their cost, notably in what concerns labour market variables.
- The impact of GVCs on the transmission of macroeconomic shocks, trade elasticities, market shares and on the interpretation of trade imbalances.
- The role of financial considerations on the location and network decisions of multinational companies.

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