BANCA D'ITALIA
EUROSISTEMA

Global value chains: new evidence and implications

Seminari e convegni
Workshops and Conferences

March 2016

number 21

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EUROSISTEMA

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This volume brings together the papers presented at the Bank of Italy's workshop entitled 'Global Value Chains: new evidence and implications', held in Rome on 22 June 2015.

The workshop and the volume have been organised and edited by Rita Cappariello, assisted by Alessandra Piccinini and Roberto Marano. The editor wishes to thank Antonio Accetturo, Alessandro Borin, Stefano Federico, Alberto Felettigh, Sara Formai and Michele Mancini for the valuable scientific contribution; Carlo Altomonte, Anna Giunta, Frauke Skudenly, Lucia Tajoli and Julia Wörz for the useful comments and suggestions as discussants of the papers.

ISSN 2281-4337 (print)

ISSN 2281-4345 (online)

The publication is available online at www.bancaditalia.it

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FOREWORD

Luigi Cannari* and Rita Cappariello*

The international fragmentation of production and the expansion of multinational corporations have profoundly changed the way goods and services are produced and exchanged. Exports are now less important as a gauge of both a country's global competitive position and its access to outlet markets. An increase in exports may in fact generate only a small change in domestic value added if exports contain a growing amount of imported value added. Moreover, intermediate goods cross a country's national borders several times, artificially swelling foreign trade flows due to double counting. As a result of this international fragmentation of production, exports may also be stimulated by the final demand of a different country from that of first destination of the goods and services sold abroad. Lastly, foreign markets are served increasingly by multinationals whose production is carried out locally through subsidiaries.

These shifts in the global economy have brought about changes in both economic analysis and its tools. The development of a new analytical framework and the construction of the global input-output tables have greatly changed the way empirical analysis is conducted. This now provides researchers and policy makers with measures of trade in value-added.

The Bank of Italy has actively participated in the debate, providing original contributions to the research in this area. The Bank held a workshop entitled 'Global Value Chains: new evidence and implications', in Rome on June 22, 2015.

The papers in the first session focused on the structure of global value chains and how they function in the euro area economies. The first paper measures and compares the participation in global value chains of the largest euro area countries by using a new methodology developed by Koopman et al. (2014). The second paper takes a broader approach by mapping the value added flows of the Eurozone. It first looks at the euro area as a whole and compares it with other major world economies, such as the U.S., Japan and China. Then, the paper analyses the euro area's regional linkages.

The second session contained two papers that deal with the implications of global value chains on competitiveness. They propose alternative indicators of a country's competiveness and take into account the different ways through which firms participate in global value chains. The first paper calculates the shares in global value added of various countries and compares them with traditional market shares in global gross exports. The second paper develops measures of competitiveness taking into account the activity of multinational companies, key players in global value chains. These competiveness measures are based on the firm's ownership structures rather than on the production location.

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The third session tackled the impact of global value chains on economic performance. The first paper uses a measure of GVC-related trade to examine the role played by the international fragmentation of production on the changes to the long-term relationship between trade and income. The second paper analyses the relationship between the international fragmentation of production, labour productivity and total factor productivity. Moreover, the authors study the impact of offshoring on employment.

The fourth session examined specific countries, regions and firms. The first paper provides interesting insights into China, whose demand plays a big role as final absorber of value added originating from the euro area. The role of the Chinese market for the Italian economy can be better evaluated by using measurements that are based on value added flow rather than statistics that are based on gross trade. The second paper integrates regional input-output tables for Italy with data from the World Input-Output Database to investigate whether employment patterns in Italian macro-regions are linked to their participation in value chains. The last two papers are based on micro-data: the third paper describes the effects of the crisis on Italian and German firms based on the way these firms are connected to Global Value Chains while the last paper studies how institutional quality at the local level, measured by the efficiency of civil courts, influences the ability of firms to become international subcontractors.

This volume contains all the papers presented in the workshop: some papers are still provisional with a view to stimulating discussion on the work in progress. We take this opportunity to thank the authors who contributed to the success of this initiative with their research papers, the discussants for their insightful comments, and the participants for their helpful discussion.

How does foreign demand activate domestic value added? A comparison among the largest euro-area economies

Rita Cappariello* and Alberto Felettigh*

January 2015

Abstract

We propose an analysis for the largest euro-area countries (France, Germany, Italy and Spain), based on the framework developed by Koopman et al. (2014) for tracing value added in a country's exports by source and use. We integrate their approach by introducing an additional dimension: the domestic-sector origin of value added embodied in exports. While providing an accurate picture of these countries' participation in global value chains, we estimate the impact on their GDP of a shock to foreign demand and disentangle individual contributions along a geographical dimension in a period running from the introduction of the euro to the beginning of the sovereign debt crisis.

Keywords: global value chains, final internal demand, domestic value added activation.

JEL classification: F14, F15.

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We wish to thank Stefano Federico, Arne Nagengast, Roberto Tedeschi, two anonymous referees and seminar participants at the Lisbon CompNet Workshop (September 2014) for comments and suggestions. The views expressed herein are those of the authors and do not necessarily reflect those of Bank of Italy.

1. Introduction

The diffusion of global value chains has deeply changed the way production and trade of goods and services take place. As sequential stages of production ("tasks") are performed at several locations all over the world before assembly into the final product, traditional indicators based on *gross* exports *alone* are no longer reliable as a gauge of the contribution of external final demand to GDP growth in a given country, whether the focus is on global demand or on demand originating from a specific foreign country. The reason is two-fold. On the one hand, as economies engage in processing trade, the domestic-value-added content of a country's exports declines, mirroring an increase in the foreign-value-added content. However, trade statistics record the gross value of goods at each border-crossing rather than the (net) value added between border-crossings. On the other hand, multi-country production networks imply that intermediate goods can travel to their final destination by an indirect route ("triangular" production sharing) making it harder to associate a country's production with the geographical origin of the *final* demand that activated it. For instance, when Italian intermediates are assembled in Germany into final goods to be exported to the US, it is final internal demand in the US that is activating Italian exports (to Germany) of these intermediates and the related content of Italian value added.[1] For all these reasons, global value chains pose intriguing measurement challenges to a full evaluation of an economy's exposure to foreign shocks, both aggregate and idiosyncratic.

Although there is a growing interest in these issues, comparative studies are relatively limited. This paper contributes to filling this gap by focussing on the largest euro-area countries (France, Germany, Italy and Spain); we re-cast the economic international relations of these four countries in value added terms rather than in gross terms. Discrepancies between gross and value added trade flows depend on several characteristics of international production networks; in order to measure them, we apply to WIOD global input-output tables the mathematical framework developed by Koopman, Wang and Wei (2014, henceforth KWW), which traces the value added embodied in a country's exports by source (domestic *vs* foreign) and by geographical origin of the final demand that activated them. WIOD tables match national input-output (supply and use) tables so that the foreign sector in each national table is broken down among partner countries both on the export (use) and on the import (supply) side.

Hummels, Ishii and Yi (2001) was the pioneering attempt at dealing with the measurement issues related to the development of global value chains. They introduced the concept of 'vertical specialisation' proposing to measure it with the foreign content of a country's exports based on national Input-Output tables. However, a country can participate in global value chains not only by using imported inputs to produce exports (international outsourcing), but also by exporting intermediates that are used as inputs by other countries to produce goods for their own exports. Outsourcing is limited to the supply side, whereas globalisation of production is also related to the demand side facing a country's economy. Based on this reasoning, as global input-output tables started being constructed, a later line of research aimed at analysing value added flows from a different perspective, i.e. by considering the origin of the final demand that activates them in a global inter-country input-output framework. Johnson and Noguera (2012) and Stehrer, Foster, and de Vries (2012) are two seminal contributions of this "trade in value added" strand of research.

KWW have managed to integrate the literature on vertical specialisation with the literature on trade in value added. They have provided a unified methodology thanks to an accounting identity that dissects a country's gross exports into different components such as exports of domestic value added, re-imported domestic value added, foreign value added and double-counting terms. In particular, the issue of double-counting in gross trade statistics had received little or no attention in the previous literature. KWW have shown that all metrics proposed by the literature on vertical specialisation and

[1] Pursuing this line of reasoning, the deduction follows that part of the exports of a country (participating in global value chains) is activated by its own internal demand!

the literature on trade in value added can be derived from the KWW framework, in a few instances as special cases of the KWW generalised measures.

In broad terms, our main contribution is to provide a detailed and coherent picture of international production sharing and trade links for the largest euro-area countries in a period spanning from the introduction of the euro to the beginning of the "sovereign debt crisis" in 2011. In particular, we describe the structural features characterising the participation of the main euro-area countries to global value chains, based on a more founded methodology than the ones utilised in previous studies on specific areas or countries (among others Amador et al., 2015, and Iossifov, 2014). More in detail, we break down gross export flows between value added activated by final internal demand around the world and intermediate trade activated by international production sharing processes. We thus provide an estimate of the upward bias that arises when gauging, on the basis of traditional bilateral trade statistics, the impulse of final internal demand within the EU (or the monetary union) on the GDP of the four largest euro-area countries. The strengthening of regional supply chains within Europe explains this bias. Our paper is the first one, to our knowledge, to evaluate euro-area countries' exposure to shocks hitting individual foreign countries by taking into account the interconnectedness of the domestic economy in global value chains.[2]

Rahman and Zhao (2013) was among the first papers to use (a preliminary version of) the KWW methodology; relative to ours, their work focuses on a wider set of countries yet has a narrower scope: to describe supply links and investigate them within a gravity-equation approach. Our work is less analytic but tries to take full advantage of the rich information set that emerges from looking at WIOD tables through the lenses of the KWW decomposition. In fact, tractability requires to restrict attention to a subset of origin countries out of the forty available in WIOD tables. We have chosen the largest four euro area-countries on the grounds that the structural similarities among them should yield comparable results; in particular, for these countries the manufacturing sector, the one mainly interested by the process of international fragmentation of production, still has a relevant weight on the overall economy.

The diffusion of global value chains and international production networks is one reason why the domestic value added content of exports has been moving along a declining trend in the four economies under examination. A competing explanation, which has been widely disregarded in the literature, rests on the adverse terms-of-trade effect stemming from increasing (imported) commodity prices. In this regard, we embark on a preliminary attempt at assessing the bias of an indicator of "international outsourcing", commonly measured as foreign value added in exports at current prices, when the role of commodity inputs is neglected. In the case of Spain the bias appears to be rather important.

Finally, a further contribution of our paper is that we integrate the KWW approach by introducing an additional dimension: the domestic-sector origin of value added embodied in exports. Since manufacturing firms use services as inputs, exports of manufacturing goods include value added that in fact originated in the domestic services sector. Our decomposition strips this domestic value added out of manufacturing exports and reassigns it to the services sector,[3] so that we are able to provide more detailed evidence, for the euro-area countries under examination, on how larger services trade is when measured in value-added terms (Johnson, 2014). Only for France do our results point to a mounting use, in manufacturing firms' selection of production inputs, of services from the *domestic* supply chain. On the contrary, for all four economies it emerges quite clearly that the reduction of the value added generated in the domestic manufacturing sector has been associated with an increased use of imported inputs.

[2] In essence, we will be estimating the (static) elasticity of GDP in France, Germany, Italy and Spain to final internal demand around the world.

[3] Preliminary attempts in this direction include Timmer et al. (2013), and Cappariello (2014, relying on national input-output tables).

By design, ours is an accounting exercise aimed at “getting stylized facts straight” that is unfit for analysing the causes and consequences of euro-area countries’ participation in global value chains. By extending our initial contribution on the Italian economy (Cappariello and Felettigh, 2013), the present work is however a useful step towards a better understanding of the opportunities and the challenges, for the main euro-area countries, of economic integration both at a global and at a regional level.

The paper is organized as follows. The conceptual framework proposed by KWW is presented in Section 2 and is implemented in Section 3, where euro-area countries’ exports are broken down into domestic value added, foreign value added and a residual component associated with double-counting. This decomposition enables us to describe the main structural features and trends of the participation of the four economies in global value chains. In the rest of the paper, we focus exclusively on the domestic value added component of exports. In Section 4, the impact on the euro area countries’ exports and GDP of a shock to foreign demand is estimated. We start with a shock to world demand (global shock) and, in section 5, we analyse geographical effects, i.e. what happens when final internal demand increases in each country around the world in turn (country shocks). Final internal demand around the world activates exports by each sector of the domestic economy; in turn, exports of any given sector contain domestic value added that has been created, directly or indirectly, in all domestic sectors. In section 6 we analyse the domestic-sector origin of the domestic value added embodied in exports, briefly commenting on these inter-sectoral domestic linkages. Section 7 summarises our main findings and concludes.

2. Conceptual framework and data

We use the framework proposed by KWW, who were the first to develop a fully coherent accounting identity that breaks up a country’s gross exports into value-added components by source. The authors’ methodology, an improvement upon the seminal idea of Johnson and Noguera (2012), decomposes a country’s gross exports into three main terms: domestic value added, foreign value added, double-counted value added. We label the first item GDPX, namely the country’s GDP embodied in its gross exports. The second component consists of foreign value added embodied (via imports of intermediate inputs) in the country’s gross exports. The last component is connected with goods that cross borders multiple times and it consists of value added, domestic or foreign, that is embodied in the country’s gross exports and has already been recorded by its trade statistics despite it contributes only once to its GDP.[4,5]

KWW further decompose each of these three components into categories depending on the use (final *vs* intermediate) of the exported goods and services and on the geographical origin (foreign *vs* domestic) of the final demand that activated them. A total of nine sub-components is obtained (see the Appendix for the algebraic details). In this paper we focus on domestic value added and follow the

[4] A simple example can clarify. Suppose that Italy exports an intermediate good (“good A”) to Germany worth €100 and embodying, for simplicity, only Italian domestic value added. The intermediate good is assembled by a German firm, together with €20 of German value added, into a second intermediate good that is exported to Italy. Italy imports the good (“good B”) for €120 and assembles it, together with €10 of domestic value added, into a final product (“good C”) that is exported for €130. Italian gross exports are thus recorded as €100+€130=€230. The Italian value added contained therein is €100+€10=€110, whereas the German value added content is €20. The difference between Italian gross exports (€230) and the sum of Italian and German value added (€110+€20=€130) is indeed the value of good A, which has been exported twice by Italy: after the initial shipping to Germany, it returns home embodied into good B and is exported again embodied into good C. Koopman et al. (2014) correctly identify the value of good A (€100) as value added that is double-counted by Italian trade statistics.

[5] Trade statistics all over the world record flows on a gross basis, hence including double-counting.

author's decomposition of GDPX into the first five sub-components as indicated in Figure 1,[6] which clarifies that a country's GDP is embodied into exports of:

1. Final goods and services.

2. Intermediates that are absorbed by the direct importer, i.e. that are used by the direct importer to produce final goods and services to be consumed in the country itself. The sum of components 1 and 2 is labelled "absorption" to indicate domestic value added that is absorbed abroad by the direct (first) importer.

3. Intermediates that the direct (initial) importer embodies into other goods and services (final or intermediate), which then are exported to third countries. This component is labelled "redirection" to indicate domestic value added that is absorbed abroad by countries other than the direct (initial) importer.

4. Intermediates that are ultimately absorbed at home, embodied in imports of final goods and services.

5. Intermediates that are ultimately absorbed at home, embodied in imports of intermediate goods and services (used to produce final goods and services for domestic consumption). The sum of components 4 and 5 is labelled "reflection" to indicate domestic value added that is exported but is ultimately absorbed at home. Another label would be "export content of imports", mirroring the more familiar phrase "import content of exports". Whatever the name, this component measures the contribution of a country's internal demand to the activation of its own exports.[7]

It should be noted that the KWW decomposition as presented in Koopman et al. (2014) only applies to the overall exports of a given country. A detailed decomposition of either bilateral flows or of sectoral exports entails a more complicated algebraic derivation, which is the subject of the work by Wang, Wei and Zhu (2013).

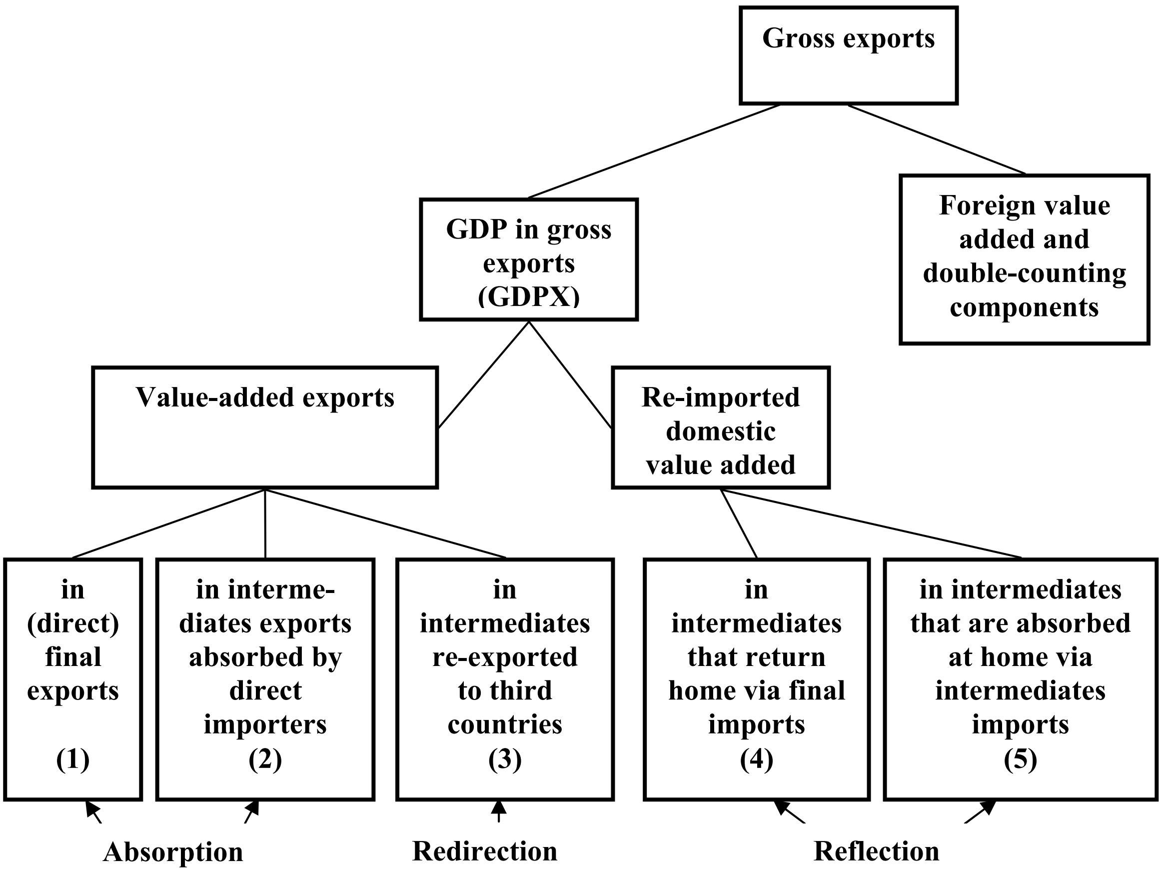
In interpreting the results from the KWW decomposition, one has to keep in mind that this strand of literature measures value added on a domestic rather than a national basis. A domestic firm that off-shores its entire production and sales would contribute to national income via profit repatriation but not to the home country's GDP.

We embrace the metric proposed by Rahman and Zhao (2013) whereby sub-components 1 and 2 (absorption) tell us "how much of a country's exports is created as stand-alone exports, i.e. outside any supply chain". The remainder, which consists of domestic value added sub-components 3 to 5 together with foreign value added and the double-counting component (Fig. 1), measures exports generated due to the participation in global value chains ('international fragmentation of production' hereafter).

[6] The figure is a simplified version of Figure 1 in Koopman et al. (2014); the labels "absorption", "redirection" and "reflection" are taken from Johnson and Noguera (2012).

[7] We do not address the import side in this paper, but it may be useful to point out that (i) the "export content of imports" contributes to double-counted value added in import trade statistics; (ii) internal demand is clearly more effective in activating imports than exports.

Figure 1. Main components of value added in gross exports: concepts



KWW and Rahman and Zhao (2013) entertain the notion that countries for which the share in gross exports of sub-components 3, 4 and 5 (intermediates that are further processed abroad for ultimate absorption in a country rather than the first importer) is relatively large tend to be specialized in upstream activities. Vice-versa, a relatively large share of foreign value added in gross exports tends to signal that the country is specialized in downstream (or assembling) activities. As we shall make some reference to these categories, it is important to keep in mind that they refer to sequential production stages, not to the allocation of value added among the players in a global value chain. For instance, oil extraction and water bottling are upstream activities, respectively, relative to gasoline sale at the pump and running a restaurant (downstream activities). One would expect the value-added-intense activities to be the upstream one in the gasoline case, the downstream one in the water case.

We start our analysis from 1999, the year when the exchange rates among the first 11 members of the Monetary Union were fixed, in order to eliminate any bias due to currency movements with respect to the other countries that eventually joined the euro area. In particular, we exclude the period 1995-1998, when also within our sample of countries sharp *relative* exchange rate movements occurred.

WIOD tables are input-output tables for the global economy, disaggregated into 40 countries (plus a “rest of the world” aggregate) and 35 sectors. All data collected from national sources are converted into US dollars. For a more detailed presentation of the WIOD database, see Timmer (2012). It is important to point out that exports of goods and services connected to international tourism are absent from our analysis since these flows are recorded in WIOD tables as a separate entry (“Purchases on the domestic territory by non-residents”), a sort of memo item that cannot be treated as a separate 36th sector due to missing pieces of information.

3. Participation of euro-area countries in global value chains: similarities and differences

This paragraph describes structural features and trends of the participation by the main euro-area countries in global value chains. While the complete time series can be found in the Appendix, here we identify three sub-periods, covering many relevant developments in euro-area integration and, more generally, in world trade. The first one, from 1999 to 2007, namely the period of the introduction and the strengthening of euro, includes the opening up of the Chinese economy to world trade, especially after joining the WTO in 2001. The same time span also covers a period of increasing trade and investment flows into Eastern Europe, started in the early '90 and culminated in the accession of 12 new EU members by 2007. The second period of analysis, between 2007 and 2009, focuses on the "global financial crisis" and the "Great Trade Collapse". The last period, from 2009 and 2011, includes the rebound of international trade but also the beginning of the "sovereign debt crisis" in the euro area.

Table 1 presents the breakdown of the value-added content of exports of goods and services for the major euro-area economies, as obtained from the KWW decomposition. In order to focus on the three sub-periods described above, we present results for four key years, 1999, 2007, 2009 and 2011.[8] By looking at the different components of each country' exports, we can assess similarities and differences among the major euro-area countries in the characteristics of their participation in global value chains.

Firstly, in the overall period of analysis the ability of exports to activate value added in the domestic economies, as measured by the GDPX share (column 6 of table 1), declined sensibly in all four countries, dropping the fastest in Italy. Its development reflects the increasing trend of the two complementary components: the share of foreign value added and of double-counting. Another feature worth emphasizing is that the GDPX share presents a counter-cyclical pattern: it decreased in the pre-crisis period, rebounded during the Great Trade Collapse and resumed declining afterwards.

Secondly, the increasing share of foreign value added in exports (column 7), akin to the indicator of "vertical specialisation" developed by Hummels et al. (2001) and largely used in this literature,[9] signals a growing use of intermediate inputs sourced abroad by euro-area producers and a strengthening of their position as assemblers in downstream activities. The pattern of foreign value added in exports provides clear evidence of the growing backward integration of the production processes, as firms operating in these four economies took advantage of differences in technologies, factor endowments and factor prices across countries.[10] By comparing this indicator in levels, we do not observe any major differences among the four economies as of 2011, although a deeper analysis is postponed to section 3.1. Foreign value added in exports is, however, a poor measure of a country's participation in global value chains, a point we shall come back later when addressing international fragmentation of production and when discussing the role of fluctuations in imported commodity prices.

[8] For the complete time series, see Tables A1 in the Appendix.

[9] Koopman et al. (2014) show that the original measure of the foreign content of imports by Hummels et al. (2001) is a special case of their measure of foreign value added, since it implicitly assumes that imported intermediates only embody foreign value added.

[10] The analysis of the geographical origin of foreign value added in euro-area countries' exports shows an increasing share of imported inputs from both technologically advanced economies and low-labour-cost countries, thus suggesting a variety of motivations for the increase of this indicator (Amador et al., 2015).

Table 1. Decomposition of gross exports of goods and services for the main euro-area economies
(as a percentage of total gross exports, except otherwise indicated)

		Gross exports								Memo item: "International fragmentation of production"
		GDP in gross exports (GDPX)						Foreign value added	Double counting	
		Value added exports			Re-imported domestic					
Year	Gross exports (in millions of dollars)	in direct final exports	in intermediates exports absorbed by direct importers	in intermediates re-exported to third countries	in intermediates that return home via final imports	in intermediates that are absorbed abroad via intermediates imports				
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
					France					
1999	351,545	33.9	34.7	8.3	0.8	0.5	78.2	16.7	5.0	31.4
2007	636,359	30.8	31.9	8.9	0.8	0.5	72.9	19.8	7.3	37.3
2009	564,579	31.9	34.1	8.2	0.7	0.5	75.3	18.9	5.9	34.1
2011	691,460	29.1	32.8	8.0	0.7	0.5	71.0	21.4	7.6	38.1
					Germany					
1999	600,303	34.3	34.5	8.0	1.6	1.0	79.3	15.4	5.3	31.2
2007	1,510,356	29.0	32.5	8.3	1.3	0.8	71.9	19.4	8.7	38.5
2009	1,265,888	31.2	34.2	7.8	1.3	0.8	75.2	18.0	6.8	34.7
2011	1,602,979	28.1	33.6	7.6	1.2	0.8	71.4	20.2	8.4	38.2
					Italy					
1999	267,446	39.7	33.2	8.2	0.6	0.4	82.1	14.3	3.6	27.1
2007	574,778	33.2	31.4	9.0	0.5	0.4	74.6	18.8	6.6	35.4
2009	467,639	37.6	31.8	8.2	0.5	0.4	78.4	16.8	4.7	30.6
2011	596,637	32.7	31.0	8.2	0.4	0.3	72.7	20.5	6.8	36.3
					Spain					
1999	134,698	35.4	32.2	8.0	0.5	0.3	76.3	18.9	4.8	32.4
2007	334,953	29.0	31.6	8.9	0.5	0.5	70.5	22.0	7.5	39.4
2009	293,688	32.8	34.1	8.1	0.4	0.4	75.7	18.9	5.3	33.1
2011	386,534	28.1	33.3	7.9	0.3	0.3	70.1	22.6	7.3	38.5

Source: authors' calculations on WIOD data.
Notes: columns (1) to (5) correspond to terms (1) to (5) in Figure 1; column (6) is the sum of columns (1) to (5); columns (6), (7) and (8) add up to 100, consistently with Figure 1; international fragmentation of production in column (9) is measured as the sum of columns (3), (4), (5), (7) and (8).

Thirdly, the double counting component of gross exports presents an increasing trend, much steeper than that of the foreign value added component, testifying an increasingly complex participation of the four economies in international production chains, with intermediates and components crossing the domestic borders multiple times (column 8). Table 1 reveals that in 2011 the double counting component inflated gross exports of the four countries in a range between 6.8 and 8.4 per cent, preventing the foreign value added in exports to be the mirror image of GDPX. Although small in absolute terms, this component represented about one fourth of the gross exports not accounted for by their domestic value added. The role of double-counting is even bigger in dynamic terms: it was the counterpart of between one third (for Italy) and 40 per cent (for Spain and Germany) of the drop in GDPX between 1999 and 2011. A pro-cyclical behaviour of both the foreign value added and the double counting components can be observed in the period under examination.

Fourthly, the component related to the four countries' specialisation in upstream activities (sum of columns 3, 4 and 5) remained quite flat between 1999 and 2011, at around 9 to 10 percentage points. Focusing on columns 4 and 5, virtually all GDPX produced in the four economies was absorbed abroad; a slightly higher level of re-imported domestic value added for Germany (about 2 percentage points) is probably explained by the larger size of this economy.

Finally, international fragmentation of production increased significantly as of 1999 in all four economies (last column of Table 1)[11]; in 2011 almost 40 per cent of gross exports involved the participation in global value chains. Italy is the country for which the indicator of international fragmentation of production started at the lowest level and grew at the fastest pace, although in 2011 it was still slightly below the average of the remaining countries. While this suggests that Italy is still lagging behind in the participation to global value chains, the result is mainly driven by a lower share of the double-counting component for the Italian economy, at least with respect to Germany.

A word of caution is necessary on the role of fluctuations in the exchange rate of the euro for the results presented in Table 1. It is fair to assume that a large fraction of French, German, Italian and Spanish exports and imports are quite independent of the exchange rate of the euro vis-à-vis the US dollar; for instance, all trade with euro-area partners. This being the case, these transactions fluctuate with the exchange rate as WIOD tables convert them from euros to US dollars for international comparison. In general, we do not expect our results to be greatly affected by exchange-rate fluctuations, as we express value added contents in percentage of exports. More specifically, the sensitivity to the exchange rate affects both exports and imports, in different proportions depending on composition, and consequently, in loose terms, also the split of exports between domestic and (imported) foreign value added is affected. The role of imported raw materials, which are the main cause of composition mismatch between exports and imports for our four economies, is addressed in the next section.

3.1. A digression on foreign value added in exports: the impact of fluctuations in commodity prices

One might expect that the sharp increase in commodities prices between 1999 and 2011, in particular energy raw materials, introduced an upward bias in the foreign value added content of the main euro area economies' exports measured, as we and the vast majority of the literature do, at current prices. Since these resources are mainly acquired through imports, a change in the terms of trade is likely to drive up the foreign value added in exports, another reason why this indicator is a poor measure of vertical integration.[12]

A big step towards the use of foreign value added as an indicator of "international outsourcing" would be to isolate the role of commodity prices. We fall short of this ambitious target and focus here, for each of the four countries under analysis, on the portion of the foreign value embodied in its exports that originated, both directly and indirectly, in the commodities sector of foreign countries.[13] That is, we look at the value of imported commodities, not just at their price. For this reason, our estimates are only indicative of the above-mentioned terms-of-trade effect, since commodity-price fluctuations may be counteracted or reinforced by independent fluctuations in the degree to which exports depend on imported commodities (due for example to export composition, or to energy-friendly technological improvements).

We report our results in Table 2, where the foreign value added in exports - already presented in column (7) of Table 1 - is compared with the measure net of commodity inputs. Beginning with the

[11] Nagengast and Stehrer (2014) propose a revised version of the KWW decomposition. In their methodology, the domestic value added in intermediates re-exported to third countries is larger and consequently so is international fragmentation of production.

[12] Notice that also indirect imports matter, as cost pressures on commodities are passed through to final and intermediate products (gasoline and basic metal products are a prominent example).

[13] After experimenting with a definition of "commodities" that includes both agriculture and mining and quarrying, we have restricted our focus on the latter, since the share of foreign value added originated in the agriculture sector abroad tends to be stable over time for all countries under examination.

overall foreign-value-added content of exports, in 2011 the level of this indicator is very similar across our four economies, standing at around 20-22 per cent. Italy and Spain started off in 1999, respectively, from the lowest level (14.3 per cent) and the highest level (18.9 per cent).

Looking at the foreign-value-added content of exports net of the component originated in the commodities sector abroad (for each country, the third column in Table 2), the growth experienced in Italy shrinks in absolute terms to a magnitude that is very similar to that recorded in France and Germany (around 3 percentage points), although the finding that Italy started from the lowest level in 1999 (13.2 per cent, against an average of 15 for the other two countries) is still confirmed. For Spain, commodities account for the entire increase in foreign value added: net of this component, the finding that Spain started from the highest level in 1999 (17.1 per cent) still holds, whereas the 2011 level is no longer the highest; it is in fact close to the minimum recorded by Italy (16.9 and 16.0 per cent, respectively).

Not surprisingly, for each of the four euro-area countries, the overall foreign-value-added content of exports net of the component originated in the commodities sector abroad is driven by the component embodied in manufacturing exports.[14] More interestingly, the finding that foreign value added dropped with the international crisis in 2009 holds even after controlling for imported commodities.

In conclusion, for France, Germany and Italy we can safely assess that the increase in foreign value added shares is not just driven by the hike in resource prices. For Spain, the value of imported commodities, including indirect imports, seems to account for the entire increase in the overall foreign-value-added content of exports, although we are not able to disentangle price effects from quantity effects.

Table 2. Foreign-value-added content of overall exports, including and excluding commodity inputs

(as a percentage of total gross exports)

Year	France			Germany			Italy			Spain		
	Foreign-value-added content of exports (FVAX)	FVAX originated in commodities sector abroad (FVAXcomm)	FVAX net of FVAXcomm	Foreign-value-added content of exports (FVAX)	FVAX originated in commodities sector abroad (FVAXcomm)	FVAX net of FVAXcomm	Foreign-value-added content of exports (FVAX)	FVAX originated in commodities sector abroad (FVAXcomm)	FVAX net of FVAXcomm	Foreign-value-added content of exports (FVAX)	FVAX originated in commodities sector abroad (FVAXcomm)	FVAX net of FVAXcomm
1999	16.7	1.1	15.6	15.4	0.9	14.5	14.3	1.1	13.2	18.9	1.8	17.1
2000	18.7	1.8	16.9	16.8	1.5	15.4	16.4	2.0	14.4	21.5	2.9	18.6
2001	18.4	1.7	16.7	16.8	1.4	15.4	16.0	1.8	14.2	20.1	2.5	17.6
2002	17.9	1.6	16.3	16.0	1.3	14.7	15.3	1.7	13.7	19.3	2.2	17.1
2003	17.4	1.5	15.9	16.3	1.4	14.9	15.4	1.7	13.6	19.0	2.1	16.9
2004	18.1	1.8	16.2	16.9	1.6	15.3	15.9	2.0	13.9	19.8	2.6	17.2
2005	18.8	2.5	16.3	17.9	2.1	15.8	16.9	2.8	14.1	20.4	3.5	16.8
2006	19.6	2.9	16.7	19.0	2.7	16.3	18.5	3.4	15.1	21.9	4.5	17.4
2007	19.8	2.7	17.1	19.4	2.4	16.9	18.8	3.3	15.5	22.0	4.2	17.8
2008	20.7	3.6	17.1	20.0	3.0	16.9	19.4	4.0	15.3	22.2	5.4	16.7
2009	18.9	2.4	16.5	18.0	1.9	16.1	16.8	3.4	13.4	18.9	3.8	15.1
2010	20.5	2.5	17.9	19.5	2.1	17.3	19.7	4.4	15.3	21.0	4.6	16.3
2011	21.4	2.8	18.6	20.2	2.1	18.0	20.5	4.5	16.0	22.6	5.7	16.9

Source: authors calculations on WIOD data.
Notes: “commodities” are identified with the “mining and quarrying” sector.

[14] Tables A2.a and A2.b in the Appendix report results for manufacturing and services exports, respectively.

4. The impact of world demand on gross exports and GDPX

The KWW methodology enables us to trace back export flows, and the domestic-value-added content they generate, to the final internal demand that activated them. In this paragraph, we set off to estimate the (static) elasticity of a country's GDP to final internal demand around the world (including the country itself so as to capture the reflection component) by relying uniquely on data taken from WIOD input-output tables. These provide a fixed set of "structural" parameters (technical production coefficients, market shares and so on) which indeed change from one year to the other, but are held constant when a positive shock to foreign demand is considered and all else expands in proportion.

In particular, we assume a unit elasticity of exports to world GDP; recent studies focussing on world trade have estimated its elasticity to world GDP to be either around 2.0-2.5 (Cheung and Guichard, 2009) or larger than 3 (Freund, 2009).

It is important to stress that we estimate the effect of external final demand on nominal GDP neglecting exports of travel services associated with tourism. In 2011 exports of travel services amounted to about 13 per cent of total Spanish exports of goods and services; the percentage was more than 6 per cent for France and Italy, and 2 per cent for the German economy. Our measure of the impact of external demand on domestic GDP may therefore be considered a lower bound for Spain and, to a lesser extent, Italy and France.

Figure 2 presents, for each year between 1999 and 2011, the impact on the domestic value added of the main euro-area countries of a 10 per cent positive shock to world final demand in that year. By using such impact as an indicator of the role of foreign final demand for the generation of domestic value added, Figure 2 reveals that the reliance of France, Italy and Spain on foreign demand remained broadly flat over the period, whereas it increased markedly for Germany.

The impact of external demand on domestic GDP is driven by two factors: the impact on gross exports (trade openness) on the one side, and the domestic-value-added content of each dollar-worth of exports on the other side (we label the latter magnitude "GDPX-intensity", which is simply obtained by dividing column 6 in Table 1 by 100). The dynamics of these two driving forces are presented in Figures 3 and 4 respectively.

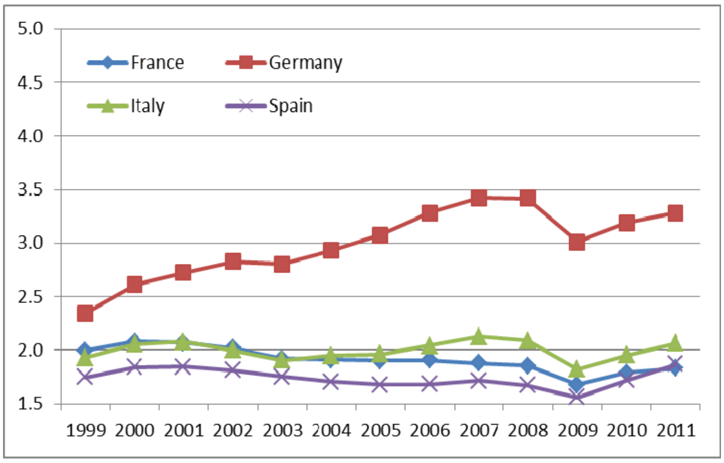
As already mentioned, GDPX-intensities display a decreasing trend in all countries, with Italy and Spain tracing the upper and the lower bound, respectively. Of the two driving forces, trade openness is the prevailing one: it remained broadly stable in France, Italy and Spain, while German exports as a share of GDP rose from roughly 30 per cent in 1999 to over 45 in 2011 (Fig. 3).[15]

A visual analysis suggests that, in general, the relevance of foreign final demand for the creation of domestic value added evolved in a pro-cyclical fashion. For the ease of exposition, we consider the German case: the indicator grew between 1999 and 2007, with a slowdown around the recession in 2002-2003, it fell sharply in 2009 with the Great Trade Collapse and it rebounded afterwards. This is again the net effect of two factors: a volatile pro-cyclical trade openness more than compensates for a moderately counter-cyclical GDPX-intensity. The latter is a mirror image of the pro-cyclical pattern of the use of imported inputs, driven by firms' attempt at reducing variable costs common to the majority of European countries (Amador et al., 2015), and of the double-counting component.

A noticeable result is that Germany is the only country in our analysis that increasingly benefitted from external demand in order to generate GDP: the higher and steeper degree of openness of the German economy is reflected in the upward sloping trend of the sensitivity of GDP to external demand, which is only partially smoothed by the reduction in the GDP-intensity of exports. As seen in the previous paragraph, the latter reflects not only the increasing use of imported inputs but also the mounting relevance of multilateral ("triangular") production sharing, through double-counting.

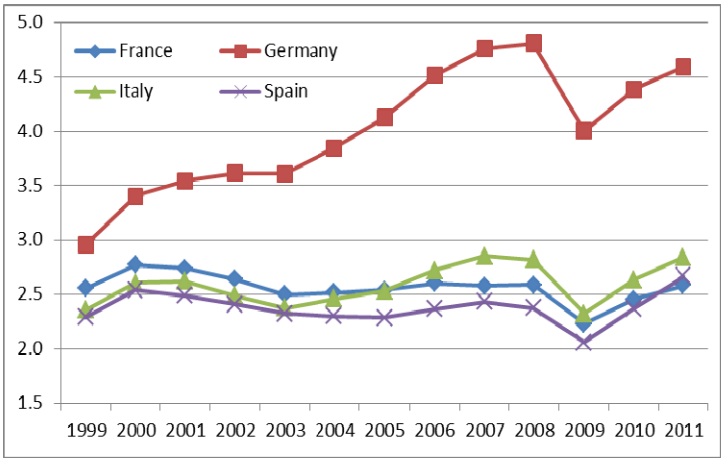
[15] It should be obvious that in our comparative statics exercise, the share of exports in GDP coincides with the impact on gross exports of a 100 per cent increase in world demand.

Figure 2. Impact on GDPX of a 10% increase in world final internal demand
(as a percentage of GDP)



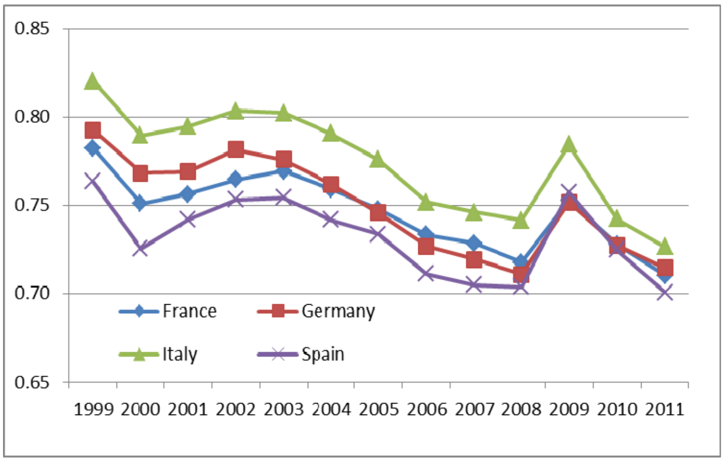
Source: authors' elaborations on WIOD data.

Figure 3. Impact on gross exports of a 10% increase in world final internal demand
(as a percentage of GDP)



Source: authors' elaborations on WIOD data.

Figure 4. GDPX-intensities



Source: authors' elaborations on WIOD data.

5. Bilateral results

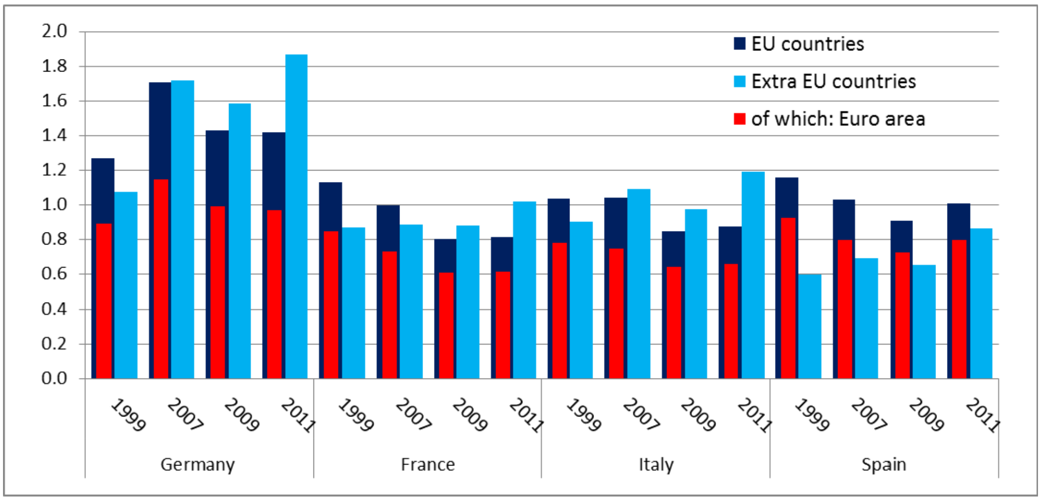
In order to focus on the relevance of different areas and countries for the creation of GDP in the four economies under analysis, we address the following question: how does final internal demand in the various countries around the world contribute, via the exports they activate, to the generation of GDP in France, Italy, Germany and Spain? For instance, we are about to shock final internal demand in the US and measure the impact on Italian exports, both directly and indirectly (that is, Italian intermediate exports to third countries, where they are assembled into final goods to be ultimately exported to the US).

In fact, we present the results of a comparative statics exercise that estimates the impact of a 10 per cent increase in final internal demand in country *j* on the GDP of France, Germany, Italy and Spain, given the technical coefficients and international organisation of production as represented by the WIOD matrix in a given year and everything else equal. In this exercise no second-round effects are considered: final demand increases in country *j*, global value chains are activated around the world in order to meet that demand, but final demand in all other countries remains unchanged.

We start with an analysis by macro-regions: the EU (with the detail of the monetary union) on the one side and the bulk of countries outside the EU on the other side; Figure 5 considers a 10 per cent increase in final demand in each macro-region in turn and tracks the response of domestic value added in the four economies under analysis. Results are reported as a share of GDP.

Figure 5. Impact on GDPX of a 10% increase in the EU and the extra-EU components of global final internal demand

(as a percentage of GDP)

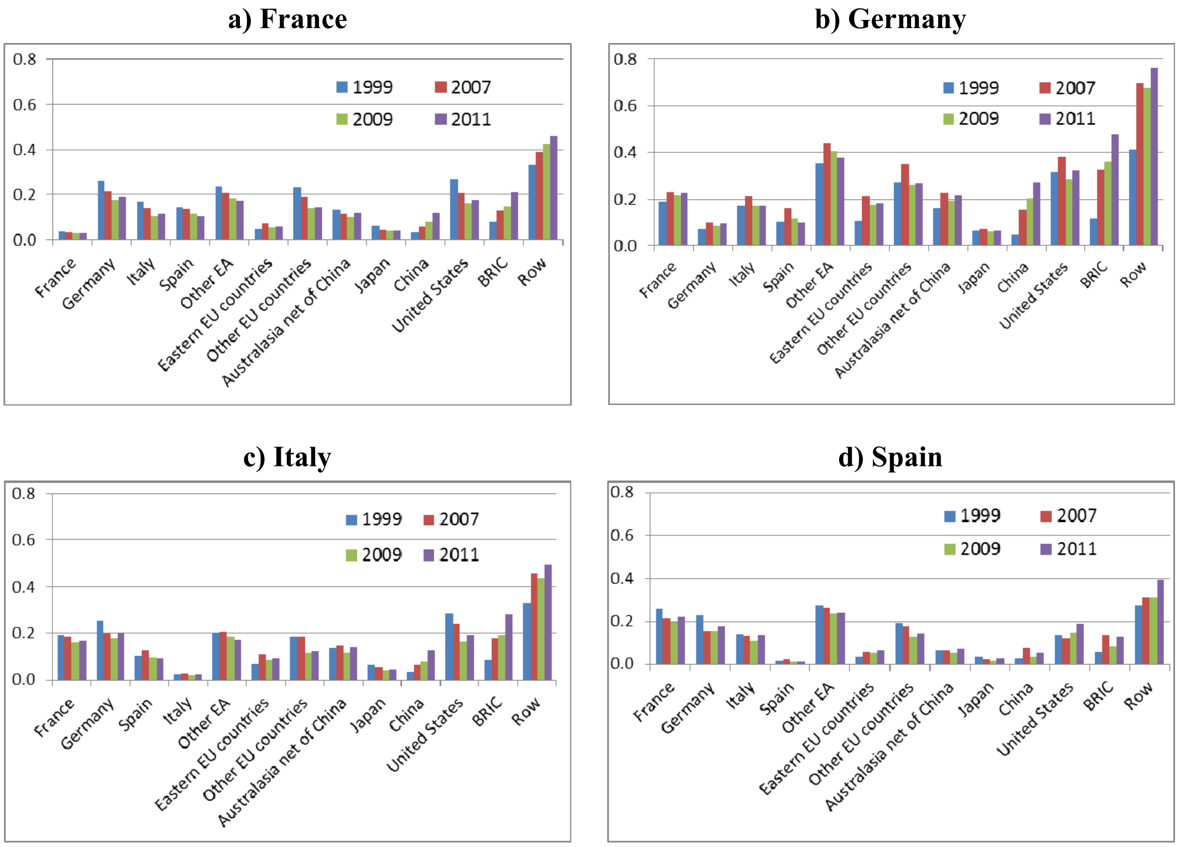


Source: authors' elaborations on WIOD data.

Germany is the only economy for which the dependence on final internal demand originated in the euro area and in the EU rose between the introduction of the euro and 2011. In the pre-crisis period, activation by both components of external demand, from the EU and from extra-EU countries, grew significantly for the German economy, although only the latter strongly rebounded after the Great Trade Collapse. The overall increasing dependence on final internal demand originated outside the EU is a common feature of the four economies. Only in Spain the EU component of external final demand remained the most relevant in activating GDP throughout the period; in Germany and Italy it lost its primacy already in 2007, in France only in 2009.

Figures 6a - 6d provide further details on our geographical analysis by presenting the response of GDPX in the four euro-area economies to the same 10 per cent increase in final internal demand in some selected countries.[16]

Figure 6. Impact on GDPX of a 10% increase in selected partners' final internal demand
(as a percentage of GDP)



Source: authors' elaborations on WIOD data.
Notes: see the Appendix for a detailed definition of the geographical entities on the x-axis.

Between 1999 and 2007, German GDP became more and more reactive to final external demand from euro-area countries testifying that, with the introduction and the strengthening of the euro, the German economy reinforced its relative position within the euro area. The same pattern can be observed for the activation of German GDPX by the rest of the EU, which is split in the figure between Eastern EU countries and the non-euro EU countries (Denmark, Sweden and UK). After the crisis, the picture partially changed: the activation of German exports and GDP from the other euro-area countries contracted. The reduction was determined by the fall in final demand from the economies hit by the sovereign debt crisis (among them, Italy and Spain). On the contrary, extra-EU countries continued to gain weight in activating German exports and GDPX. This result was driven essentially by China and, to a lesser extent, by some emerging economies such as Russia and Turkey, at the expenses of large advanced economies such as the US and Japan.

For the other three countries, in general the elasticity of GDPX to final internal demand originated in the euro-area countries, in particular Germany, decreased as of 1999, with only a minor rebound after 2009. Activation from Eastern EU countries, China and the rest of BRICs tended to increase over time.

[16] The underlying data are presented in Tables A3 in the Appendix.

Between 1999 and 2007, the impact of final internal demand in euro-area countries on Italian GDPX slightly weakened. In fact, the result is entirely due to the reduction of the impulse driven by German final demand; net of this country, activation of Italian GDP by final internal demand from the euro area slightly increased in the period.

Figure 6 also shows a delay of the Italian, French, and especially Spanish producers with respect to their German competitors in taking advantage of the enormous growth potential of the Chinese market.[17] The corresponding elasticity was almost identical for all four countries in 1999 (and tiny, between 0.03 and 0.05); by 2011 it only doubled in Spain, it increased almost four-fold in France and Italy and it rose six-fold in Germany.

As mentioned in the introduction, multi-country production networks imply that intermediate goods can travel to their final destination by an indirect route ("triangular" production sharing). For instance, when Italian intermediates are assembled in Germany into final goods to be exported to the US, it is final internal demand in the US that is activating Italian exports (to Germany). This requires a distinction, for a country's exports, between the initial destination (as recorder by trade statistics) and the "ultimate" destination (as detected by WIOD tables), i.e. the partner country whose final internal demand activated the original export flow.

Switching from a "destination" perspective to an "activation" perspective leads to a reassessment of the drivers behind export-led GDP growth, as Figure 7 clarifies by considering the same macro-regions of Figure 5 (EU, euro-area, extra-EU). The blue bars in the four panels report the percentage of the corresponding country's gross exports in 2011 that was shipped to each macro-region, while the red bars depict the percentage of the country's gross exports that was activated by final demand internal to each macro- region. Similarly, the green bars represent the percentage of the country's GDPX that was activated by final demand in each macro-region.

In the figure, for a given reporting country and a given macro-region, the red and the green bars tend to be very similar, while they differ from the blue bar. That is, what makes a difference is the "destination" perspective as opposed to the "activation" perspective (blue *vs* red and green), whereas within the "activation" perspective it is quite immaterial whether we focus on gross exports (red bars) or on the their GDP content (green bars). The main message of Figure 7 is that trade statistics overestimate the role of the EU (or the monetary union) in driving gross exports and GDP of the four main euro-area countries. Clearly, the opposite holds for the role of partner countries outside the EU. The main reason behind this finding is the strengthening of regional supply chains within Europe: taking Germany and Poland as an example, a significant portion of German exports to Poland consists of intermediates that are assembled in Poland into final products that are shipped abroad to be consumed (or invested) in third countries outside the EU.

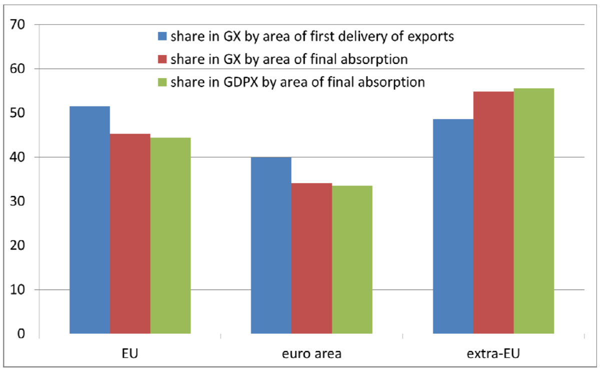
For each of our four countries, the difference between the blue bar for the EU and the red bar for the EU tends to be explained almost entirely by the corresponding difference for the euro-area bars. Germany is the only exception, signalling that the regional supply chains for this economy tend to be stronger with EU countries outside the euro area than with countries inside the monetary union.

[17] Nevertheless, Germany, France and Italy do not show a significantly different pattern in the strengthening of the backward linkages with the Chinese economy, as measured by the growth of imported inputs (Amador et al., 2015).

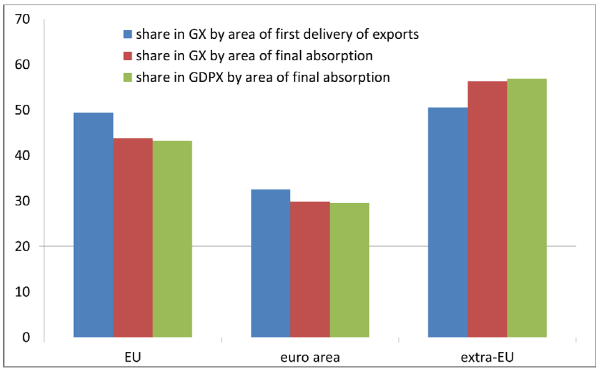
Figure 7. Gross exports and GDPX of the main euro-area countries in 2011: shares by area of first delivery of exports and shares by final absorption

(percentage points)

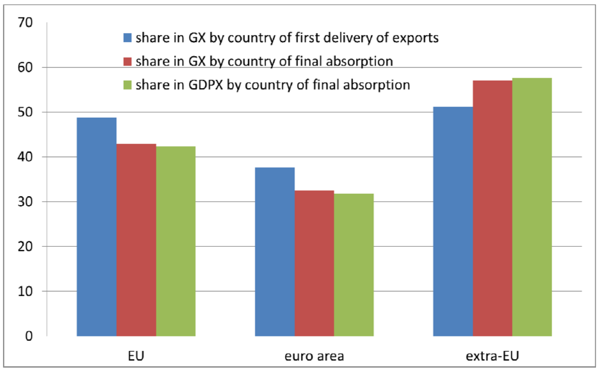
a) France



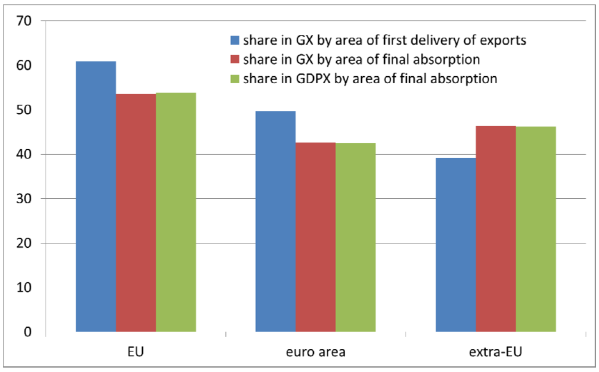
b) Germany



c) Italy



d) Spain



Source: authors' elaborations on WIOD data.

6. Sectoral analysis of exports and GDPX

Final internal demand around the world activates exports by each sector of the euro-area economies under analysis. In turn, exports of any given sector contain domestic value added that has been created, directly or indirectly, in all domestic sectors along "intra-national value chains". Figure 8 presents, for the domestic value added content of overall exports of goods and services, the percentages that originated in domestic manufacturing, in services and in other sectors. It also shows the share of exports originated in global value chains, that is, the sum of foreign value added and the double-counting component. These enable us to comment on the contribution of the domestic macro-sectors to the creation of value added through exports.[18]

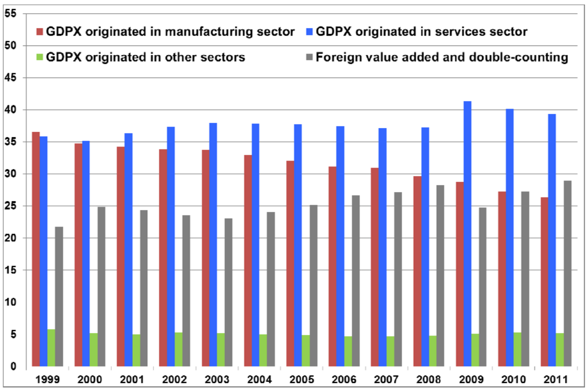
A visual analysis of Figure 8 reveals that, for all four countries, the reduction of the value-added share generated in the domestic manufacturing sector was mainly associated with an increase of the value-added share that originated in international supply chains. However, both the level of these shares and the pace of their change over time differed across the four economies.

[18] As previously mentioned, tourism is absent from WIOD tables, despite it represents a relevant portion of exports of services for some of the countries under examination (in 2011, 13.5 per cent for Germany, 23.2 per cent for France, 40.6 per cent for Italy, 42.3 per cent for Spain; calculations on balance of payments data from Eurostat, BPM5).

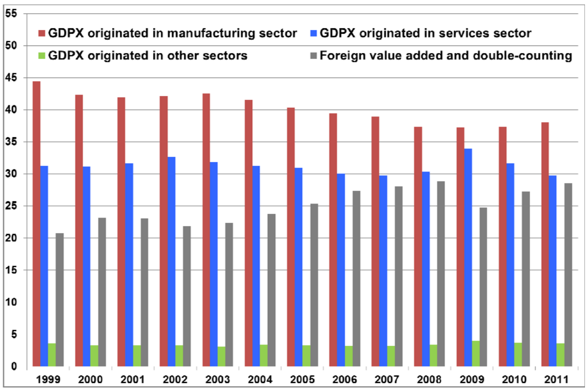
Figure 8. Overall exports of goods and services: shares of value added by origin

(percentage composition)

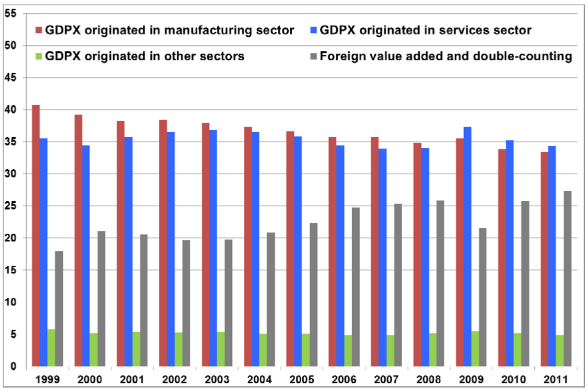
a) France



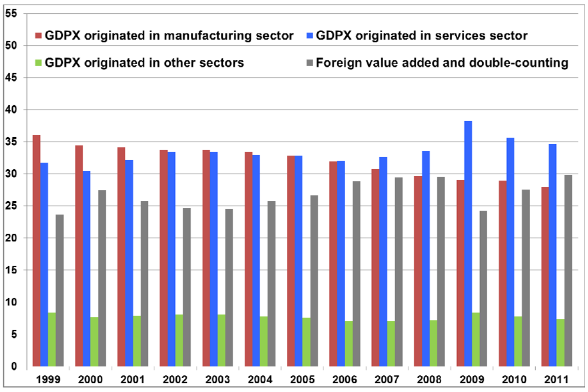
b) Germany



c) Italy



d) Spain



Source: authors' elaborations on WIOD data.
Notes: in every year, the four bars add up to one hundred.

France is the country with the largest and fastest-growing relevance of the services sector, whose weight in GDPX surpassed that of manufacturing already in 2000. By 2011, almost 40 per cent of overall gross exports was value added originated in the domestic services sector, whereas gross exports of services accounted for just 15 per cent of French sales abroad. The increasing role of services for the French economy is both due to "direct" services exports growing faster[19] and to the growing activation of services by manufacturing exports. This point is clarified in Figure 9, which displays the same decomposition as Figure 8 for exports of manufactures only: while the substitution between domestic and foreign inputs remain a common feature among the four economies, a pattern emerges of an increasing use, by French manufacturing firms, of services from the *domestic* supply chain.

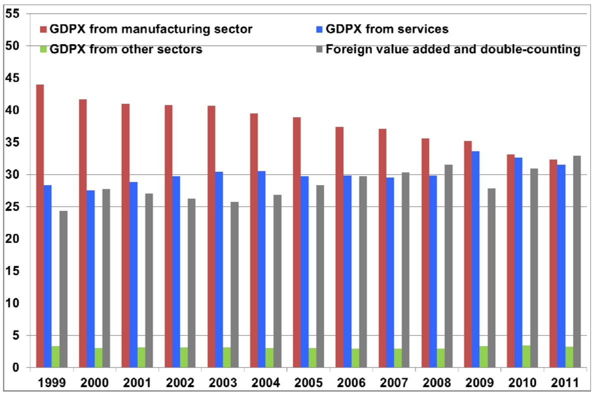
This contribution mostly came from trade services (both retail and wholesale) and from domestic providers of services ancillary to production and marketing of manufactures ("Renting and other business activities"; see Table A4 in the Appendix), which is a black box including such a large range of activities that it is hard to distinguish among competing explanations for the domestic activation of services. On the one hand, French manufacturing firms could have focused on their core competencies by outsourcing their non-core service activities; on the other hand, manufacturing firms could have turned to external service suppliers in order to acquire knowledge-intensive business services and new business solutions that are unlikely to be generated in-house (Beyers, 2005).

[19] The composition of French exports slowly moved from manufacturing towards services between 1999 and 2011: the share of manufacturing declined from 81.5 to 80.2 per cent while the share of services increased by 1.4 percentage points (from 13.7 to 15.1 per cent).

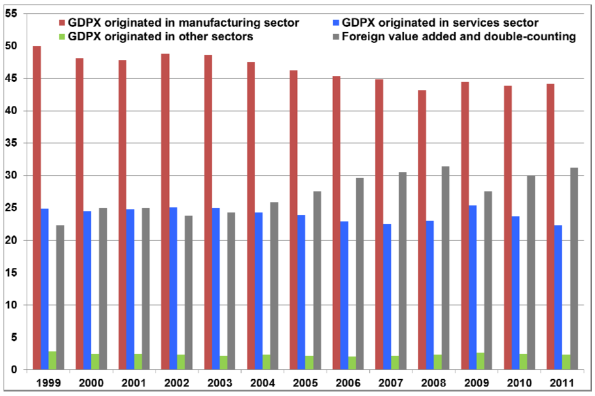
Figure 9. Exports of manufactures: shares of value added by origin

(percentage composition)

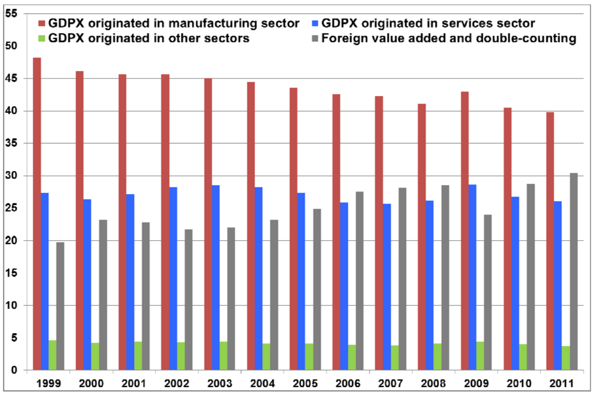
a) France



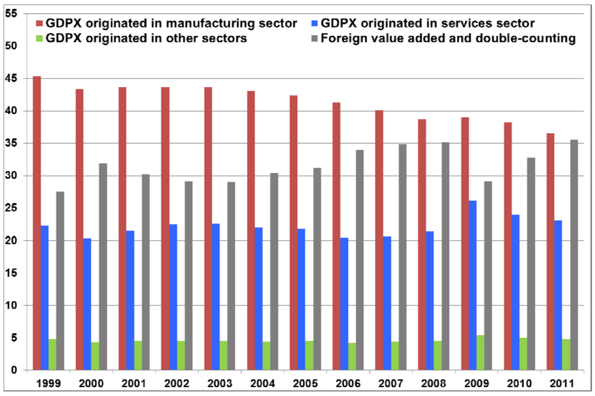
b) Germany



c) Italy



d) Spain



Source: authors' elaborations on WIOD data.

In Spain the weight of services as a source of domestic value added embodied in exports of goods and services grew somewhat less rapidly than in France, surpassing the weight of manufacturing in 2006 (Fig. 8). In this case, the result was mainly driven by a stronger re-composition of gross exports towards services.[20]

In Italy the relative weight of services as a source of domestic value added embodied in total exports remained flat. The reduction of the domestic value added originated in manufacturing entirely reflected a decreasing use of inputs sourced from domestic manufacturing chains, which were substituted with imported inputs.

Despite the strong substitution of value added generated in the domestic manufacturing sectors with value added sourced from abroad, Germany is the only country where manufacturing remained the predominant source of GDPX throughout the period. Germany stands out in the present context for two more reasons: on the one side, despite a mild re-composition of German gross exports towards services, the manufacturing share of exports remained relatively high with respect to the other economies; on the other hand, the contribution in terms of value added of the domestic suppliers operating in the services sector to the exports of manufactures slightly decreased. This result may be explained by the fact that German manufacturing firms tend to be larger than their euro-area competitors, and for bigger units it is easier to undertake multiple tasks "in house" rather than outsourcing them to other economic units in upstream domestic sectors.

[20] Their share in overall foreign sales increased by 4.4 percentage points, from 16.6 to 21.0 per cent.

7. Conclusions

As production has become increasingly organised along global value chains, sequential stages of production are performed at several locations all over the world before assembly into the final product. As a result, traditional indicators based on *gross* exports *alone* are becoming less informative in assessing the contribution to GDP growth (in a given country) of the various sources of final external demand. The reason is two-fold. On the one hand, as economies engage in processing trade, the domestic-value-added content of a country's exports (GDPX) declines, mirroring an increase in the foreign-value-added and in the double-counting components. Such developments are not captured by trade statistics, whose mandate is to record the gross value of goods at each border-crossing rather than the (net) value added between border-crossings. On the other hand, as intermediates travel to their final destination by an indirect, possibly multi-country route, it becomes more complex to associate a country's exports (and their domestic-value-added content) with the final demand that activated them.

The availability of global input-output tables has increasingly allowed the analysis of trade in value added, rather than gross, terms. This paper contributes to this strand of the literature by providing a methodologically sound description of the economic relations that underlie international trade by the largest euro-area countries (France, Germany, Italy and Spain), based on a novel methodology, developed by Koopman et al. (2014), aimed at tracing value added in exports by source and by geographical origin of the final demand that activated them. We also propose (i) an exercise to isolate the role of commodity inputs when calculating a very common indicator of "international outsourcing", the foreign-value-added content of exports (at current prices), and (ii) a decomposition of the domestic-value-added content of exports by domestic sector of origin.

Although we do not claim to analyse the causes and consequences of euro-area countries' participation in global value chains, our accounting exercise provides a useful dashboard towards a better understanding of the opportunities and the challenges that global value chains offer, as well as new tools for policy evaluation.

We focus on the years between 1999 and 2011, covering many relevant developments in euro-area integration and, more generally, in world trade. The time span includes the "Great Trade Collapse", the subsequent rebound of international trade and also the beginning of the "sovereign debt crisis" in the euro area. Our main conclusions can be summarized as follows.

Firstly, the growing participation of the euro-area economies in global value chains is indeed a common structural feature, displaying both a trend and a sensitivity to business cycles. Between 1999 and 2011, the GDPX-intensity, namely the ability of one euro-worth of exports to activate value added in the domestic economies, declined sensibly in all four countries. Its development reflected the increasing trend of the two complementary components: foreign value added and double-counting. The pattern of the former, the classical indicator of "vertical specialisation", provides clear evidence of the growing backward integration of production processes, as firms operating in these four economies took advantage of differences in technologies, factor endowments and factor prices across countries. The steep trend of commodity prices played a role in shaping the mounting relevance of the foreign value-added component, but did not entirely determine it, according to our preliminary assessment. The increasing trend of the double-counting component testifies instead a growing complexity for the participation in international production chains, with intermediate inputs crossing multiple times the domestic borders.

Secondly, we find that the reliance of France, Italy and Spain on foreign final demand in order to generate GDP remained broadly flat over the period, whereas it increased sensibly for Germany. The higher and faster-growing degree of openness of the German economy, only partially smoothed by the reduction in the GDP-intensity of exports, explains this result. We find that an upward bias arises when gauging, on the basis of traditional bilateral trade statistics, the impulse of final internal demand within the EU (or the monetary union) on the GDP of the four major euro area countries. The main reason behind this finding is the strengthening of regional supply chains within Europe: taking

Germany and Poland as an example, a significant portion of German exports to Poland consists of intermediates that are assembled in Poland into final products that are shipped abroad to be consumed (or invested) in third countries outside the EU.

Thirdly, the overall increasing dependence on final internal demand originated outside the EU is a common feature for the four economies in the pre-crisis period; instead, activation by the EU-component of final internal demand grew significantly only for the German economy. In particular, with the introduction and the strengthening of the euro, Germany reinforced its relative position within the euro area, with an increasing activation of GDP by final internal demand from the monetary union. On the contrary, for France, Italy and Spain the impact on their GDP of final internal demand originated in the euro area slightly weakened, a result entirely due to the reduction of the impulse driven by German final demand. The picture changed after the crisis: the activation of German exports and GDP by the other euro-area countries contracted, driven by the fall in final demand from the economies hit by the sovereign debt crisis. On the contrary, extra-EU countries continued to gain weight in activating German exports and GDPX, a pattern common to the other three economies. In particular, between 1999 and 2011 the sensitivity of the German economy to final internal demand in China increased much more than for the other countries, in what we interpret as a delay of the Italian, French, and especially Spanish producers in taking advantage of the enormous growth potential of the Chinese market.

Finally, value added that is embodied in manufacturing exports often originates in a different sector, typically services. Our analysis of the domestic-sector origin of value added embodied in exports reveals that the weight of services as a source of domestic value added embodied in overall gross exports considerably grew over time only for the French and the Spanish economies. The corresponding weight for Italy and for Germany was in 2011 almost unchanged from 1999. France is the country with the largest relevance of the service sector, whose weight in GDPX surpassed the weight of manufacturing already in 2000. This pattern is especially due to the growing activation of services by manufacturing exports and only in part to “direct” service exports growing faster. In Spain the weight of value added originated in domestic services embodied in overall exports grew somewhat less rapidly than in France, surpassing the weight of manufacturing in 2006. In this case, the result was driven by a stronger re-composition of gross exports towards services.

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Appendix

The algebra of the KWW decomposition

In this section we briefly describe the decomposition of gross exports developed by Koopman et al. (2014). We focus on a source country *s* which produces and exports *N* products to *G* countries. Gross exports of country *s* are used as an intermediate or final good abroad, according the following definition:

$$E_{s*} = \sum_{r \neq s}^{G} E_{sr} = \sum_{r \neq s}^{G} \left(A_{sr} X_r + Y_{sr} \right) \tag{A.1}$$

where:

- E_{s*} is the *GN-by-1* vector of exports by country *s* to its *G* partner countries*;*
- E_{sr} is the *N-by-1* vector of gross exports from country *s* to country *r, r=1,…,*G*;*
- A_{sr} is the *N-by-N* input-output coefficient matrix, with typical element a_{sr}^{ij} representing the coefficient for input i in country *s* used in the production of sector *j* in country *r;*
- X_s is the *N-by-1* vector of gross output of country *s;*
- Y_{sr} is the *N–by-1* vector of final demand in country *r* for final goods and services produced in *s.*

By pre-multiplying E_{s*} by the unit vector *u* one obtains aggregate exports (a scalar), which can be decomposed into various value-added and double-counted components as follows:

$$\begin{aligned} uE_{s*} = & \left[V_s \sum_{r \neq s}^{G} B_{ss} Y_{sr} \right] + \left[V_s \sum_{r \neq s}^{G} B_{sr} Y_{rr} \right] + \left[V_s \sum_{r \neq s}^{G} \sum_{t \neq s,r}^{G} B_{sr} Y_{rt} \right] + \\ & + \left[V_s \sum_{r \neq s}^{G} B_{sr} Y_{rs} \right] + \left[V_s \sum_{r \neq s}^{G} B_{sr} A_{rs} \left(I - A_{ss} \right)^{-1} Y_{ss} \right] + \left[V_s \sum_{r \neq s}^{G} B_{sr} A_{rs} \left(I - A_{ss} \right)^{-1} E_{s*} \right] + \\ & + \left[\sum_{t \neq s}^{G} \sum_{r \neq s}^{G} V_t B_{ts} Y_{sr} \right] + \left[\sum_{t \neq s}^{G} \sum_{r \neq s}^{G} V_t B_{ts} A_{sr} \left(I - A_{rr} \right)^{-1} Y_{rr} \right] + \left[\sum_{t \neq s}^{G} V_t B_{ts} \sum_{r \neq s}^{G} A_{sr} \left(I - A_{rr} \right)^{-1} E_{r*} \right] \end{aligned} \tag{A.2}$$

where:

- V_s is the *GN-by-1* row vector of direct value-added coefficients*;*
- B_{sr} is the *N-by-N* block Leontief inverse matrix, which is the total requirement matrix that gives the amount of gross output in producing country *s* required for a one-unit increase in final demand in destination country *r,* with typical element b_{sr}^{ij} representing the coefficient of inputs from sector *i* in country *s* to sector *j* in country *r;*
- X_{sr} is the *N-by-1* vector of gross output produced in *s* and absorbed in *r.*

While the algebra to obtain equation (A.2) may be a bit tedious, expressing a country's gross exports as the sum of these nine terms is very useful. We try to explain briefly their economic interpretations.

The first two terms in square brackets are the direct value added exports, i.e., the source-country value added absorbed by the direct importer, country *r*, in the form of final (first term) and intermediate (second term) imports. The 3rd term is value added of country *s* exported to country *r* and, after some processing in *r*, finally absorbed in a third country *t*.

The 4th and the 5th terms are source value added of country *s* which is initially exported but then returns home in either final (4th term) or intermediate (5th term) imports to be consumed by country *s*.

The 7th and 8th terms represent foreign value added in source country's exports, including foreign value added embodied in both final and intermediate products.

The 6th and 9th terms are the two "pure double-counted terms" that sum up the double-counted share of two-way intermediate trade from all bilateral routes.

Definition of geographical entities

We re-organize the 41 geographical entities considered in WIOD matrices as follows:

1. European Union (EU, 27 countries), broken down in: Euro area (17 members) and countries belonging to the EU27 but outside the Eurozone.
   - The former aggregate is further split as: France, Germany, Italy, Spain, the remaining 13 countries belonging to the Euro area;
   - the latter aggregate is further split between "Eastern" countries[21] and "other" countries (Denmark, Great Britain, Sweden).
2. All countries outside the EU27, further broken down in:
   - Australasia net of China: Australia plus the Asian countries considered in WIOD matrices.[22] The aggregate includes Japan, whose detail appears in some figures/tables.
   - China.
   - Americas (American countries considered in WIOD matrices).[23] The aggregate includes the US, whose detail appears in some figures/tables.
   - Russia and Turkey.
   - All other countries.

In some figures and tables a memo item for BRIC appears.

[21] Bulgaria, Czech Republic, Hungary, Latvia, Lithuania, Poland and Romania.
[22] India, Indonesia, Japan, South Korea, Taiwan.
[23] Brazil and the NAFTA countries (Canada, Mexico, USA).

Table A1.a

Decomposition of French exports of goods and services

(as a percentage of total gross exports, except otherwise indicated)

Year	Gross exports (in millions of dollars)	Gross exports								Memo item: Interna-tional fragmenta-tion of production"
		GDP in gross exports (GDPX)						Foreign value added	Double counting	
		Value added exports			Re-imported domestic					
		in direct final exports	in inter-mediates exports absorbed by direct importers	in inter-mediates re-exported to third countries	in inter-mediates that return home via final imports	in inter-mediates that are absorbed abroad via inter-mediates imports				
1995	334642	33.6	37.4	7.7	0.8	0.6	80.1	15.5	4.4	29.0
1996	339102	34.1	36.4	7.6	0.8	0.6	79.5	16.0	4.5	29.5
1997	338362	33.5	36.2	7.6	0.7	0.5	78.6	16.6	4.8	30.2
1998	356010	34.2	34.7	7.8	0.8	0.5	78.0	17.2	4.9	31.1
1999	351545	33.9	34.7	8.3	0.8	0.5	78.2	16.7	5.0	31.4
2000	349817	31.3	33.9	8.6	0.8	0.5	75.1	18.7	6.2	34.8
2001	348540	32.7	32.9	8.7	0.8	0.5	75.6	18.4	6.0	34.3
2002	366869	33.1	33.2	8.8	0.8	0.5	76.4	17.9	5.7	33.7
2003	427267	33.4	33.4	8.8	0.8	0.5	76.9	17.4	5.6	33.2
2004	492932	32.8	33.0	8.7	0.8	0.5	75.9	18.1	6.0	34.2
2005	517610	32.0	32.8	8.6	0.8	0.5	74.8	18.8	6.4	35.1
2006	559843	31.4	31.9	8.7	0.8	0.5	73.3	19.6	7.0	36.7
2007	636359	30.8	31.9	8.9	0.8	0.5	72.9	19.8	7.3	37.3
2008	704819	30.3	31.5	8.7	0.7	0.5	71.8	20.7	7.5	38.1
2009	564579	31.9	34.1	8.2	0.7	0.5	75.3	18.9	5.9	34.1
2010	609074	30.8	32.9	8.0	0.7	0.5	72.8	20.5	6.7	36.4
2011	691460	29.1	32.8	8.0	0.7	0.5	71.0	21.4	7.6	38.1

Source: authors' calculations on WIOD data.

Table A1.b

Decomposition of German exports of goods and services

(as a percentage of total gross exports, except otherwise indicated)

Year	Gross exports (in millions of dollars)	Gross exports								Memo item: Interna-tional fragmenta-tion of production"
		GDP in gross exports (GDPX)						Foreign value added	Double counting	
		Value added exports			Re-imported domestic					
		in direct final exports	in inter-mediates exports absorbed by direct importers	in inter-mediates re-exported to third countries	in inter-mediates that return home via final imports	in inter-mediates that are absorbed abroad via inter-mediates imports				
1995	577907	34.5	37.2	7.6	1.6	1.1	82.1	13.4	4.5	28.3
1996	581114	34.0	37.4	7.8	1.5	1.0	81.8	13.6	4.6	28.6
1997	569373	33.2	37.6	7.5	1.4	0.9	80.7	14.6	4.8	29.2
1998	600858	34.3	35.4	7.8	1.6	1.0	80.1	14.8	5.1	30.3
1999	600303	34.3	34.5	8.0	1.6	1.0	79.3	15.4	5.3	31.2
2000	614537	32.1	33.9	8.3	1.6	0.9	76.8	16.8	6.4	34.0
2001	636044	33.0	33.2	8.3	1.5	0.9	76.9	16.8	6.3	33.8
2002	695201	33.8	33.8	8.2	1.5	0.8	78.1	16.0	5.8	32.4
2003	839066	33.5	33.5	8.2	1.6	0.9	77.6	16.3	6.1	33.1
2004	1007507	31.5	33.9	8.4	1.5	0.9	76.2	16.9	6.9	34.6
2005	1096000	30.7	33.3	8.4	1.4	0.8	74.6	17.9	7.5	36.0
2006	1258715	29.6	32.6	8.3	1.4	0.8	72.7	19.0	8.4	37.8
2007	1510356	29.0	32.5	8.3	1.3	0.8	71.9	19.4	8.7	38.5
2008	1671980	28.8	32.0	8.2	1.3	0.8	71.1	20.0	8.9	39.2
2009	1265888	31.2	34.2	7.8	1.3	0.8	75.2	18.0	6.8	34.7
2010	1391739	29.8	33.2	7.8	1.2	0.8	72.7	19.5	7.8	37.0
2011	1602979	28.1	33.6	7.6	1.2	0.8	71.4	20.2	8.4	38.2

Source: authors' calculations on WIOD data.

Table A1.c

Decomposition of Italian exports of goods and services

(as a percentage of total gross exports, except otherwise indicated)

		Gross exports								Memo item: Interna-tional fragme nta-tion of producti on"
Year	Gross exports (in millions of dollars)	GDP in gross exports (GDPX)						Foreign value added	Double counting	
		Value added exports			Re-imported domestic					
		in direct final exports	in inter-mediates exports absorbed by direct importers	in inter-mediates re-exported to third countries	in inter-mediates that return home via final imports	in inter-mediates that are absorbed abroad via inter-mediates imports				
1995	264094	39.8	33.6	6.9	0.4	0.4	81.1	15.4	3.5	26.7
1996	284159	40.3	34.7	7.2	0.4	0.4	82.9	13.9	3.2	25.1
1997	273709	38.7	35.4	7.3	0.5	0.4	82.2	14.4	3.4	25.9
1998	279200	39.8	33.6	7.8	0.5	0.4	82.0	14.4	3.5	26.7
1999	267446	39.7	33.2	8.2	0.6	0.4	82.1	14.3	3.6	27.1
2000	271817	37.4	32.0	8.5	0.6	0.4	78.9	16.4	4.6	30.5
2001	278623	38.1	31.6	8.8	0.6	0.4	79.5	16.0	4.6	30.3
2002	289677	38.9	31.6	8.8	0.6	0.4	80.3	15.3	4.3	29.5
2003	341425	38.8	31.5	8.9	0.6	0.4	80.2	15.4	4.4	29.7
2004	405297	36.2	32.6	9.2	0.6	0.4	79.1	15.9	5.0	31.2
2005	428302	35.1	32.3	9.1	0.6	0.4	77.6	16.9	5.5	32.6
2006	481657	33.4	31.7	9.0	0.6	0.4	75.2	18.5	6.3	34.8
2007	574778	33.2	31.4	9.0	0.5	0.4	74.6	18.8	6.6	35.4
2008	620446	34.0	30.6	8.7	0.5	0.4	74.1	19.4	6.5	35.4
2009	467639	37.6	31.8	8.2	0.5	0.4	78.4	16.8	4.7	30.6
2010	514168	35.0	30.3	8.1	0.4	0.3	74.2	19.7	6.1	34.7
2011	596637	32.7	31.0	8.2	0.4	0.3	72.7	20.5	6.8	36.3

Source: authors' calculations on WIOD data.

Table A1.d

Decomposition of Spanish exports of goods and services

(as a percentage of total gross exports, except otherwise indicated)

		Gross exports								Memo item: Interna-tional fragme nta-tion of producti on"
Year	Gross exports (in millions of dollars)	GDP in gross exports (GDPX)						Foreign value added	Double counting	
		Value added exports			Re-imported domestic					
		in direct final exports	in inter-mediates exports absorbed by direct importers	in inter-mediates re-exported to third countries	in inter-mediates that return home via final imports	in inter-mediates that are absorbed abroad via inter-mediates imports				
1995	109520	37.7	33.7	7.4	0.3	0.3	79.3	16.9	3.8	28.7
1996	121020	37.0	34.2	7.6	0.3	0.3	79.4	16.7	3.9	28.8
1997	125441	35.5	34.3	7.7	0.4	0.3	78.1	17.6	4.3	30.2
1998	132596	37.0	31.9	7.8	0.4	0.3	77.4	18.3	4.4	31.1
1999	134698	35.4	32.2	8.0	0.5	0.3	76.3	18.9	4.8	32.4
2000	140904	32.8	31.0	8.0	0.4	0.4	72.5	21.5	5.9	36.2
2001	144887	32.9	31.9	8.6	0.4	0.4	74.2	20.1	5.7	35.2
2002	158477	34.3	31.8	8.5	0.4	0.3	75.3	19.3	5.4	34.0
2003	195988	33.6	32.3	8.7	0.5	0.4	75.4	19.0	5.6	34.1
2004	229314	32.4	32.2	8.7	0.5	0.4	74.2	19.8	6.1	35.4
2005	245986	31.8	32.1	8.6	0.5	0.4	73.4	20.4	6.3	36.1
2006	278285	29.7	31.9	8.6	0.5	0.4	71.1	21.9	7.0	38.4
2007	334953	29.0	31.6	8.9	0.5	0.5	70.5	22.0	7.5	39.4
2008	366573	28.8	32.3	8.4	0.4	0.4	70.4	22.2	7.5	38.9
2009	293688	32.8	34.1	8.1	0.4	0.4	75.7	18.9	5.3	33.1
2010	322167	30.2	33.5	8.1	0.4	0.3	72.5	21.0	6.6	36.4
2011	386534	28.1	33.3	7.9	0.3	0.3	70.1	22.6	7.3	38.5

Source: authors' calculations on WIOD data.

Table A2.a

Manufacturing exports: foreign-value-added content, including and excluding commodities inputs

(as a percentage of manufacturing gross exports)

Year	France			Germany			Italy			Spain		
	Foreign-value-added content of exports (FVAX)	FVAX originated in commodities sector abroad (FVAXcomm)	FVAX net of FVAXcomm	Foreign-value-added content of exports (FVAX)	FVAX originated in commodities sector abroad (FVAXcomm)	FVAX net of FVAXcomm	Foreign-value-added content of exports (FVAX)	FVAX originated in commodities sector abroad (FVAXcomm)	FVAX net of FVAXcomm	Foreign-value-added content of exports (FVAX)	FVAX originated in commodities sector abroad (FVAXcomm)	FVAX net of FVAXcomm
1995	17.5	1.1	16.4	14.4	0.9	13.5	17.1	1.3	15.7	19.5	1.7	17.9
1996	17.9	1.2	16.7	14.7	1.0	13.7	15.4	1.4	14.0	19.2	1.9	17.3
1997	18.5	1.1	17.4	15.7	1.0	14.7	15.9	1.3	14.6	20.3	2.0	18.3
1998	19.3	0.9	18.3	15.9	0.8	15.1	15.9	1.0	14.9	21.2	1.5	19.7
1999	18.7	1.2	17.5	16.6	1.0	15.7	15.8	1.3	14.5	22.0	2.1	20.0
2000	20.8	2.0	18.8	18.1	1.6	16.6	18.1	2.2	15.9	25.1	3.3	21.8
2001	20.4	1.8	18.6	18.2	1.5	16.7	17.8	2.0	15.8	23.6	2.9	20.7
2002	19.9	1.7	18.2	17.5	1.4	16.0	17.1	1.9	15.2	22.9	2.5	20.3
2003	19.4	1.7	17.8	17.6	1.4	16.2	17.1	1.9	15.2	22.6	2.5	20.1
2004	20.1	2.0	18.2	18.3	1.7	16.7	17.7	2.2	15.5	23.4	3.0	20.4
2005	21.1	2.8	18.4	19.5	2.3	17.2	18.8	3.1	15.7	24.0	4.1	19.9
2006	21.9	3.2	18.7	20.6	2.9	17.7	20.6	3.8	16.7	25.8	5.3	20.5
2007	22.2	3.0	19.2	21.0	2.6	18.4	20.9	3.7	17.2	26.2	5.1	21.1
2008	23.2	4.0	19.2	21.7	3.3	18.5	21.4	4.5	16.9	26.3	6.6	19.7
2009	21.3	2.7	18.6	20.0	2.1	17.9	18.8	3.8	15.0	22.8	4.7	18.1
2010	23.2	2.8	20.4	21.4	2.3	19.1	21.9	4.9	17.0	24.9	5.6	19.3
2011	24.3	3.1	21.2	22.0	2.3	19.7	22.7	5.0	17.7	26.8	6.9	19.9

Source: authors calculations on WIOD data.
Notes: “commodities” are identified with the “mining and quarrying” sector.

Table A2.b

Exports of services: foreign-value-added content, including and excluding commodities inputs

(as a percentage of gross exports of services)

Year	France			Germany			Italy			Spain		
	Foreign-value-added content of exports (FVAX)	FVAX originated in commodities sector abroad (FVAXcomm)	FVAX net of FVAXcomm	Foreign-value-added content of exports (FVAX)	FVAX originated in commodities sector abroad (FVAXcomm)	FVAX net of FVAXcomm	Foreign-value-added content of exports (FVAX)	FVAX originated in commodities sector abroad (FVAXcomm)	FVAX net of FVAXcomm	Foreign-value-added content of exports (FVAX)	FVAX originated in commodities sector abroad (FVAXcomm)	FVAX net of FVAXcomm
1995	8.2	0.5	7.7	5.2	0.3	4.9	7.5	0.5	7.0	7.0	0.8	6.3
1996	8.5	0.5	7.9	5.3	0.3	5.0	6.8	0.5	6.3	7.5	1.0	6.6
1997	8.7	0.5	8.2	5.9	0.4	5.6	7.0	0.5	6.5	7.7	0.9	6.8
1998	7.9	0.4	7.5	6.0	0.3	5.8	7.2	0.4	6.9	7.8	0.6	7.2
1999	7.4	0.5	6.8	6.1	0.3	5.7	7.1	0.4	6.7	8.1	0.8	7.3
2000	9.0	1.0	8.0	7.3	0.7	6.6	7.9	0.8	7.1	9.8	1.6	8.2
2001	8.9	0.8	8.1	7.2	0.6	6.6	7.7	0.7	7.0	9.1	1.3	7.9
2002	8.4	0.8	7.6	7.1	0.5	6.6	7.1	0.6	6.5	8.7	1.1	7.6
2003	7.8	0.7	7.1	6.9	0.6	6.3	6.9	0.6	6.3	8.2	1.0	7.2
2004	7.7	0.9	6.8	7.0	0.7	6.3	7.5	0.8	6.8	8.6	1.3	7.4
2005	8.1	1.1	7.0	7.4	0.9	6.5	8.1	1.1	7.0	9.6	1.9	7.8
2006	8.4	1.3	7.1	8.2	1.1	7.0	8.9	1.4	7.4	10.1	2.1	8.1
2007	8.4	1.2	7.2	8.4	1.0	7.3	8.7	1.3	7.4	9.6	1.7	8.0
2008	8.5	1.5	7.0	8.6	1.4	7.2	9.0	1.6	7.4	10.3	2.0	8.2
2009	8.1	1.1	7.1	8.0	0.9	7.1	7.9	1.3	6.6	8.8	1.5	7.3
2010	7.7	1.0	6.7	8.9	1.0	7.9	9.4	1.8	7.6	10.1	1.9	8.2
2011	8.3	1.2	7.1	9.1	1.0	8.1	9.7	1.9	7.8	10.3	2.1	8.3

Source: authors calculations on WIOD data.
Notes: “commodities” are identified with the “mining and quarrying” sector.

Table A3.a

Impact on French exports and GDPX of a 10 % increase in selected areas' final internal demand

(as a percentage of GDP, except for GDPX-intensities)

Countries and areas:	1995			1999			2007			2011		
	Exports	GDPX	GDPX-intensity	Exports	GDPX	GDPX-intensity	Exports	GDPX	GDPX-intensity	Exports	GDPX	GDPX-intensity
EU countries	**1.20**	**0.95**	**0.795**	**1.46**	**1.13**	**0.777**	**1.37**	**0.99**	**0.725**	**1.17**	**0.82**	**0.698**
Euro area	0.95	0.75	0.795	1.09	0.85	0.777	1.01	0.73	0.725	0.88	0.61	0.698
of which: *France*	*0.04*	*0.03*	*0.791*	*0.04*	*0.03*	*0.776*	*0.05*	*0.03*	*0.716*	*0.04*	*0.03*	*0.687*
Germany	*0.33*	*0.26*	*0.785*	*0.34*	*0.26*	*0.770*	*0.30*	*0.21*	*0.704*	*0.28*	*0.19*	*0.677*
Italy	*0.19*	*0.15*	*0.799*	*0.22*	*0.17*	*0.782*	*0.19*	*0.14*	*0.737*	*0.16*	*0.11*	*0.703*
Spain	*0.12*	*0.10*	*0.793*	*0.19*	*0.14*	*0.765*	*0.19*	*0.14*	*0.724*	*0.15*	*0.11*	*0.721*
EU not belonging to the Euro area	0.25	0.20	0.796	0.37	0.28	0.778	0.36	0.26	0.726	0.29	0.20	0.698
Eastern EU countries	*0.03*	*0.03*	*0.808*	*0.06*	*0.05*	*0.785*	*0.10*	*0.07*	*0.721*	*0.08*	*0.06*	*0.695*
Other EU countries	*0.22*	*0.17*	*0.794*	*0.30*	*0.23*	*0.776*	*0.26*	*0.19*	*0.728*	*0.20*	*0.14*	*0.700*
Extra EU countries	**1.08**	**0.87**	**0.807**	**1.10**	**0.87**	**0.790**	**1.21**	**0.89**	**0.732**	**1.42**	**1.02**	**0.720**
Australasia net of China	0.17	0.14	0.811	0.16	0.13	0.799	0.15	0.11	0.742	0.16	0.12	0.717
of which: *Japan*	*0.09*	*0.07*	*0.815*	*0.08*	*0.06*	*0.797*	*0.06*	*0.04*	*0.744*	*0.06*	*0.04*	*0.708*
China	0.03	0.03	0.787	0.04	0.03	0.772	0.08	0.06	0.722	0.16	0.12	0.728
Americas	0.32	0.27	0.826	0.42	0.34	0.801	0.36	0.27	0.740	0.36	0.26	0.727
of which: *United States*	*0.26*	*0.22*	*0.828*	*0.34*	*0.27*	*0.801*	*0.28*	*0.21*	*0.740*	*0.25*	*0.18*	*0.722*
Russia and Turkey	0.04	0.03	0.797	0.05	0.04	0.768	0.08	0.06	0.712	0.10	0.07	0.703
Row	0.51	0.41	0.796	0.43	0.33	0.779	0.53	0.39	0.728	0.64	0.46	0.718
Total	**2.28**	**1.83**	**0.801**	**2.55**	**2.00**	**0.782**	**2.58**	**1.88**	**0.729**	**2.58**	**1.83**	**0.710**
Memo item: BRIC	0.09	0.07	0.804	0.10	0.08	0.791	0.18	0.13	0.729	0.29	0.21	0.729

Source: authors' calculations on WIOD data.

Table A3.b

Impact on German exports and GDPX of a 10 % increase in selected areas' final internal demand

(as a percentage of GDP, except for GDPX-intensities)

Countries and areas:	1995			1999			2007			2011		
	Exports	GDPX	GDPX-intensity	Exports	GDPX	GDPX-intensity	Exports	GDPX	GDPX-intensity	Exports	GDPX	GDPX-intensity
EU countries	**1.29**	**1.06**	**0.821**	**1.60**	**1.27**	**0.789**	**2.39**	**1.71**	**0.714**	**2.01**	**1.42**	**0.706**
Euro area	0.93	0.77	0.821	1.12	0.89	0.790	1.60	1.14	0.714	1.37	0.97	0.706
of which: *France*	*0.21*	*0.17*	*0.819*	*0.24*	*0.19*	*0.788*	*0.33*	*0.23*	*0.708*	*0.33*	*0.23*	*0.696*
Germany	*0.08*	*0.07*	*0.817*	*0.09*	*0.07*	*0.789*	*0.14*	*0.10*	*0.706*	*0.14*	*0.09*	*0.698*
Italy	*0.17*	*0.14*	*0.820*	*0.22*	*0.17*	*0.786*	*0.30*	*0.21*	*0.714*	*0.24*	*0.17*	*0.702*
Spain	*0.08*	*0.07*	*0.822*	*0.13*	*0.10*	*0.790*	*0.23*	*0.16*	*0.709*	*0.14*	*0.10*	*0.717*
EU not belonging to the Euro area	0.36	0.29	0.819	0.48	0.38	0.788	0.79	0.56	0.716	0.64	0.45	0.704
Eastern EU countries	*0.08*	*0.07*	*0.825*	*0.14*	*0.11*	*0.790*	*0.30*	*0.21*	*0.712*	*0.26*	*0.18*	*0.704*
Other EU countries	*0.27*	*0.22*	*0.817*	*0.34*	*0.27*	*0.787*	*0.49*	*0.35*	*0.718*	*0.38*	*0.27*	*0.703*
Extra EU countries	**1.13**	**0.93**	**0.821**	**1.35**	**1.08**	**0.797**	**2.37**	**1.71**	**0.724**	**2.59**	**1.87**	**0.721**
Australasia net of China	0.22	0.18	0.830	0.20	0.16	0.802	0.31	0.23	0.730	0.30	0.22	0.715
of which: *Japan*	*0.09*	*0.07*	*0.821*	*0.08*	*0.07*	*0.788*	*0.10*	*0.07*	*0.725*	*0.09*	*0.07*	*0.710*
China	0.04	0.03	0.818	0.06	0.05	0.796	0.21	0.15	0.721	0.38	0.27	0.710
Americas	0.32	0.26	0.823	0.51	0.40	0.787	0.69	0.50	0.722	0.65	0.47	0.723
of which: *United States*	*0.24*	*0.20*	*0.820*	*0.40*	*0.31*	*0.784*	*0.53*	*0.38*	*0.721*	*0.45*	*0.32*	*0.722*
Russia and Turkey	0.07	0.06	0.819	0.07	0.05	0.788	0.20	0.14	0.705	0.22	0.15	0.689
Row	0.48	0.39	0.817	0.51	0.41	0.806	0.96	0.70	0.729	1.04	0.76	0.734
Total	**2.42**	**1.99**	**0.821**	**2.95**	**2.34**	**0.793**	**4.76**	**3.42**	**0.719**	**4.59**	**3.28**	**0.714**
Memo item: BRIC	0.14	0.12	0.829	0.15	0.12	0.801	0.45	0.33	0.721	0.67	0.48	0.711

Source: authors' calculations on WIOD data.

Table A3.c

Impact on Italian exports and GDPX of a 10 % increase in selected areas' final internal demand

(as a percentage of GDP, except for GDPX-intensities)

Countries and areas:	1995			1999			2007			2011		
	Exports	GDPX	GDPX-intensity	Exports	GDPX	GDPX-intensity	Exports	GDPX	GDPX-intensity	Exports	GDPX	GDPX-intensity
EU countries	**1.27**	**1.03**	**0.806**	**1.26**	**1.03**	**0.817**	**1.40**	**1.04**	**0.744**	**1.22**	**0.87**	**0.716**
Euro area	1.02	0.82	0.805	0.95	0.78	0.816	1.01	0.75	0.739	0.93	0.66	0.710
of which: *France*	*0.25*	*0.20*	*0.803*	*0.24*	*0.19*	*0.815*	*0.25*	*0.18*	*0.742*	*0.24*	*0.17*	*0.713*
Germany	*0.37*	*0.30*	*0.810*	*0.31*	*0.25*	*0.823*	*0.26*	*0.20*	*0.751*	*0.28*	*0.20*	*0.732*
Italy	*0.02*	*0.02*	*0.799*	*0.03*	*0.02*	*0.813*	*0.04*	*0.03*	*0.733*	*0.03*	*0.02*	*0.706*
Spain	*0.11*	*0.08*	*0.794*	*0.13*	*0.10*	*0.804*	*0.18*	*0.13*	*0.707*	*0.14*	*0.09*	*0.646*
EU not belonging to the Euro area	0.25	0.20	0.810	0.31	0.25	0.820	0.39	0.29	0.758	0.30	0.22	0.733
Eastern EU countries	*0.06*	*0.05*	*0.806*	*0.09*	*0.07*	*0.817*	*0.15*	*0.11*	*0.746*	*0.13*	*0.09*	*0.725*
Other EU countries	*0.19*	*0.15*	*0.811*	*0.22*	*0.18*	*0.822*	*0.24*	*0.18*	*0.765*	*0.17*	*0.12*	*0.739*
Extra EU countries	**1.19**	**0.97**	**0.815**	**1.09**	**0.90**	**0.824**	**1.46**	**1.09**	**0.747**	**1.62**	**1.19**	**0.735**
Australasia net of China	0.21	0.17	0.825	0.16	0.14	0.833	0.19	0.15	0.765	0.19	0.14	0.739
of which: *Japan*	*0.10*	*0.08*	*0.823*	*0.08*	*0.07*	*0.831*	*0.07*	*0.05*	*0.768*	*0.06*	*0.05*	*0.739*
China	0.05	0.04	0.809	0.04	0.03	0.818	0.09	0.07	0.750	0.17	0.13	0.755
Americas	0.37	0.30	0.817	0.43	0.36	0.824	0.42	0.32	0.749	0.40	0.29	0.732
of which: *United States*	*0.28*	*0.23*	*0.819*	*0.35*	*0.29*	*0.826*	*0.32*	*0.24*	*0.755*	*0.27*	*0.19*	*0.728*
Russia and Turkey	0.08	0.06	0.800	0.05	0.04	0.808	0.14	0.10	0.750	0.19	0.14	0.739
Row	0.49	0.40	0.813	0.40	0.33	0.824	0.62	0.46	0.740	0.68	0.49	0.729
Total	**2.46**	**1.99**	**0.811**	**2.36**	**1.93**	**0.821**	**2.85**	**2.13**	**0.746**	**2.84**	**2.07**	**0.727**
Memo item: BRIC	0.15	0.12	0.811	0.11	0.09	0.816	0.23	0.18	0.755	0.37	0.28	0.755

Source: authors' calculations on WIOD data.

Table A3.d

Impact on Spanish exports and GDPX of a 10 % increase in selected areas' final internal demand

(as a percentage of GDP, except for GDPX-intensities)

Countries and areas:	1995			1999			2007			2011		
	Exports	GDPX	GDPX-intensity	Exports	GDPX	GDPX-intensity	Exports	GDPX	GDPX-intensity	Exports	GDPX	GDPX-intensity
EU countries	**1.22**	**0.96**	**0.789**	**1.52**	**1.15**	**0.762**	**1.45**	**1.03**	**0.709**	**1.43**	**1.01**	**0.704**
Euro area	1.02	0.81	0.789	1.21	0.93	0.762	1.12	0.79	0.708	1.14	0.79	0.697
of which: *France*	*0.30*	*0.24*	*0.775*	*0.34*	*0.26*	*0.749*	*0.31*	*0.22*	*0.690*	*0.33*	*0.22*	*0.670*
Germany	*0.27*	*0.22*	*0.791*	*0.30*	*0.23*	*0.769*	*0.23*	*0.16*	*0.700*	*0.25*	*0.18*	*0.710*
Italy	*0.15*	*0.12*	*0.782*	*0.19*	*0.14*	*0.756*	*0.18*	*0.13*	*0.716*	*0.19*	*0.14*	*0.714*
Spain	*0.01*	*0.01*	*0.787*	*0.02*	*0.02*	*0.755*	*0.03*	*0.02*	*0.700*	*0.03*	*0.02*	*0.692*
EU not belonging to the Euro area	0.20	0.15	0.790	0.30	0.23	0.760	0.33	0.23	0.713	0.29	0.21	0.729
Eastern EU countries	*0.02*	*0.02*	*0.801*	*0.04*	*0.03*	*0.774*	*0.08*	*0.06*	*0.720*	*0.09*	*0.07*	*0.746*
Other EU countries	*0.17*	*0.14*	*0.789*	*0.26*	*0.19*	*0.757*	*0.25*	*0.18*	*0.711*	*0.20*	*0.15*	*0.722*
Extra EU countries	**0.69**	**0.55**	**0.799**	**0.77**	**0.59**	**0.766**	**0.98**	**0.69**	**0.699**	**1.24**	**0.86**	**0.697**
Australasia net of China	0.09	0.07	0.796	0.09	0.07	0.775	0.09	0.07	0.714	0.11	0.07	0.705
of which: *Japan*	*0.04*	*0.04*	*0.797*	*0.04*	*0.03*	*0.782*	*0.03*	*0.02*	*0.730*	*0.04*	*0.03*	*0.715*
China	0.02	0.02	0.819	0.03	0.03	0.824	0.10	0.08	0.799	0.08	0.06	0.699
Americas	0.18	0.14	0.796	0.25	0.20	0.771	0.27	0.18	0.657	0.38	0.26	0.669
of which: *United States*	*0.13*	*0.10*	*0.800*	*0.18*	*0.14*	*0.777*	*0.19*	*0.12*	*0.658*	*0.28*	*0.19*	*0.672*
Russia and Turkey	0.03	0.02	0.796	0.04	0.03	0.737	0.08	0.05	0.672	0.12	0.08	0.698
Row	0.37	0.30	0.800	0.36	0.28	0.758	0.44	0.31	0.705	0.55	0.39	0.715
Total	**1.91**	**1.51**	**0.793**	**2.29**	**1.75**	**0.763**	**2.43**	**1.72**	**0.705**	**2.67**	**1.87**	**0.701**
Memo item: BRIC	0.06	0.05	0.797	0.08	0.06	0.785	0.18	0.14	0.746	0.19	0.13	0.697

Source: authors' calculations on WIOD data.

Table A4

Domestic value added in exports by sector of origin: 2011

(percentage distribution of GDPX across domestic origin sectors; percentage points)

	Germany			France			Italy			Spain		
Exporting macro-sectors: / Sector of origin of DVA:	All goods and services	Manufac-turing	Services	All goods and services	Manufac-turing	Services	All goods and services	Manufac-turing	Services	All goods and services	Manufac-turing	Services
Raw materials	**4.3**	**2.8**	**1.0**	**6.7**	**4.1**	**0.6**	**5.2**	**4.2**	**1.6**	**9.0**	**6.2**	**1.9**
Refined oil and electricity	0.8	0.9	0.5	1.5	1.8	0.5	0.7	0.9	0.2	2.0	2.7	0.4
Traditional sectors	8.1	9.7	0.6	8.7	11.1	0.9	13.6	16.6	1.8	11.1	15.1	2.1
Chemicals, rubber and plastics	9.2	11.1	0.2	7.0	9.1	0.1	6.3	7.9	0.4	8.1	11.7	0.3
Metal products	8.6	10.4	0.3	5.9	7.7	0.2	9.4	11.7	0.6	7.5	10.7	0.4
Machinery and electrical equipment	17.5	21.2	0.4	8.0	10.4	0.2	13.0	16.2	0.7	5.6	8.1	0.3
Transport equipment	9.1	11.0	0.2	6.0	8.0	0.1	3.1	3.9	0.2	5.7	8.4	0.1
Manufacturing	**53.2**	**64.2**	**2.2**	**37.2**	**48.2**	**2.0**	**46.1**	**57.1**	**4.0**	**40.0**	**56.7**	**3.6**
Construction	**0.8**	**0.6**	**0.6**	**0.7**	**0.7**	**0.6**	**1.4**	**1.2**	**1.6**	**1.5**	**1.3**	**1.7**
Trade	8.3	8.0	10.7	10.9	12.6	4.6	13.0	11.3	21.3	10.6	12.4	6.9
Trasport services	6.1	3.0	24.5	8.7	3.9	29.6	6.8	5.2	14.5	10.0	5.4	23.9
Financial services and real estate	6.4	5.3	13.0	8.1	7.2	12.7	9.5	7.4	19.1	7.9	5.8	14.6
Renting and other business activities	16.4	12.6	38.5	22.1	18.9	38.7	13.0	9.6	28.8	14.2	7.6	34.2
Other private services	1.4	0.7	5.1	2.5	1.8	5.3	2.9	2.3	5.3	2.7	1.9	5.2
Pubblic administration	3.0	2.8	4.5	3.1	2.5	5.9	2.1	1.7	3.9	4.1	2.9	8.1
Services	**41.7**	**32.4**	**96.3**	**55.4**	**47.0**	**96.8**	**47.2**	**37.5**	**92.9**	**49.5**	**35.8**	**92.8**
Gross exports (millions of USD)	*1602979*	*1367700*	*191024*	*691460*	*554565*	*104033*	*596637*	*493166*	*90789*	*386534*	*286247*	*80733*

Source: authors' calculations on WIOD data.

Notes: sectors are defined as follows starting from those considered in WIOD tables:

Raw materials: Agriculture, Hunting, Forestry and Fishing; Mining and Quarrying.

Refined oil and electricity: Coke, Refined Petroleum and Nuclear Fuel; Electricity, Gas and Water Supply.

Traditional sectors: Food, Beverages and Tobacco; Textiles and Textile Products; Leather, Leather and Footwear; Wood and Products of Wood and Cork; Pulp, Paper, Printing and Publishing; Other Non-Metallic Mineral; Manufacturing not elsewhere classified; Recycling.

Chemicals, rubber and plastics: Chemicals and Chemical Products; Rubber and Plastics.

Metal products: Basic Metals and Fabricated Metal.

Machinery and electrical equipment: Machinery not elsewhere classified; Electrical and Optical Equipment.

Transport equipment: Transport Equipment.

Construction: Construction.

Trade: Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel; Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles; Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods.

Transport services: Inland Transport; Water Transport; Air Transport; Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies.

Financial services and real estate: Financial Intermediation; Real Estate Activities.

Renting of machinery and equipment: Renting of Machinery and Equipment and Other Business Activities.

Other private services: Hotels and Restaurants; Post and Telecommunications.

Public administration: Public Administration and Defence; Compulsory Social Security; Education; Health and Social Work; Other Community, Social and Personal Services; Private Households with Employed Persons.

Global Value Chains: a view from the Euro Area

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September 2013

Abstract

This paper describes the main features of Global Value Chains (GVC) between the euro area taken as a whole and other large world trade players like the USA, China and Japan, which also operate as monetary unions. In addition, the individual euro area countries' perspective is considered, with a special focus on intra-area linkages. The analysis is primarily based on the concept of foreign value added in exports, which is suitable to assess the pervasiveness of GVC. The paper uses the World Input-Output Database (WIOD) and covers the period 2000-2011, giving also some information on the sectoral dimension of production linkages. The paper concludes that GVC are important for the euro area as whole and there has been a rebound after the trade collapse in 2009. Moreover, there is a strong relevance of regional production linkages in Europe, with a large role for Germany and Central and Eastern European countries.

Keywords: International trade, Global Value Chains, Euro Area.

JEL Classifications: F1, F14, F15.

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The views expressed in the papers are those of the authors and do not necessarily correspond to those of Banco de Portugal, Banca d'Italia or the Eurosystem. The authors thank for comments from participants in the CompNet-Peterson Institute for International Economics-World Bank Conference (Washington), CESSA-WIIW Joint International Workshop (Wien), EU DG Trade - TEN meeting (Brussels) and CompNet Workshop (Frankfurt). All remaining errors are the responsibility of the authors.

1 Introduction

Global Value Chains (GVC) became omnipresent in production processes around the world, especially in manufacturing sectors. This trend impacts not only on international trade between major blocks like the USA, the European Union (EU), and Asia; but has also increased the importance of regional linkages. As for the European regional production networks, important drivers have been economic integration with Central and Eastern European economies and the creation of the euro area by a subset of EU countries.

The economic literature has been making progress in the measurement and mapping of this phenomenon. In methodological terms, contributions have focused on the proposal of new indicators that measure the pervasiveness and assess the role of GVC. Building on the initial contributions by Feenstra and Hanson (1999) and Hummels *et al.* (2001), broader frameworks for computing the foreign and domestic content in exports have been suggested by Koopman *et al.* (2010, 2014), Johnson and Noguera (2012a) and Stehrer (2012). Although the interpretation of trade in value-added indicators is now essentially established, there is still insufficient analysis on regional trade blocks and individual countries along the time, geographic and sectoral dimensions. Some recent contributions along these lines are Johnson and Noguera (2012b) and Backer and Yamano (2012).

This paper takes a descriptive approach, highlighting the main features of GVC between the euro area taken as a whole and other large world trade players like the USA, China and Japan, which of them also operating as monetary unions. In addition, the perspective of individual euro area countries is considered, with a special focus on intra-area linkages. The focus of the paper on the euro area bases on the notion that its economic adjustment mechanisms and trade ties are closer to those operating inside the USA, China or Japan than to those of EU as a whole, because exchange rates are fixed and other non-monetary integration dimensions are stronger. In short, the analysis of developments in GVC in the context of the economic integration process in the euro area is the main objective of the present study.

The paper computes domestic and foreign value added embodied in a country's exports, making use of the concept of foreign value added content of exports (FVAiX). This concept improves on the measure of "vertical specialization" proposed by Hummels *et al.* (2001) as it takes into account the country of origin of value added contained in imported inputs used to produce goods and services that are subsequently exported, thus providing a deeper understanding of the characteristics of GVC operating outside and inside the euro area. The analysis is based on the World Input-Output Database (WIOD), which links national supply and use tables with bilateral trade data in goods and services to produce a unique global input-output table. This database builds on national official statistics, covers 27 EU countries and 13 other major world economies and comprises 35 industries, corresponding to a broad NACE classification (see Timmer, 2012, and Dietzenbacher *et al.*, 2013). The paper focuses on the years 2000, 2007, 2009 and 2011. Taking into account this final year is very relevant as it provides insights on GVC developments following the global financial and economic crisis period, which started in 2007 and strongly impacted on international trade and on the euro area's overall macroeconomic situation.

The results show that, in 2011, for the euro area taken as a whole, GVC were as important as in China and more important than in the USA and Japan. The high relevance of GVC in the euro area, measured by the percentage of FVAiX, is accompanied by a stronger resilience in the face of the trade collapse. This contrasts with the developments observed in China, which may reflect GVC with different characteristics.

When euro area countries are taken individually, there is substantial heterogeneity in the development of GVC from 2000 to 2011. Nevertheless, FVAiX increased for more than half of euro area countries and for the average (export-weighted) euro area it increased by 4.5 percentage points in this period to 32 percent in 2011. In sectoral terms, the analysis shows that the services sector has increased its importance in GVC operating in most countries. The results obtained for the euro area confirm the notion that GVC have a strong regional dimension. In the period 2000-2011, the share of FVAiX sourced within the euro area is more stable than the total. Taking the average euro area country, the share of value added originated in other euro area countries in gross exports stood at 12 per cent in 2007 (about 17 percent if the all EU countries are considered as sources). Following the trade collapse this share rebounded to about 11 percent in 2011 (about 16 percent if all EU countries are considered as sources).

The paper is organized as follows. Section 2 presents the methodological framework to decompose value added in trade and reviews the interpretation of these measures. Section 3 focuses on the GVC operating between the euro area as a whole and other major trade blocks, while Section 4 looks at intra-area value-added flows. Next, Section 5 looks at individual euro area countries to identify common trends and differences in their supply linkages within and outside the euro area. Section 6 presents some concluding remarks.

2 Methodology

This section briefly reviews the methodology underlying the computation of the measure used in the present study to assess the pervasiveness of GVC: the foreign value-added content in a country's gross exports (FVAiX). In addition, the section presents the measures of domestic value added in exports (DVAiX) and re-exported domestic value added in imports (RDVAiM); that is, the exported domestic value added that returns back home (embedded in imports) and is subsequently exported.

The value of gross exports reported in the trade statistics exceeds the value added actually created in an economy in the production of its exports. The FVAiX belongs to the last generation of indicators that try to take account of this fact, that is, indicators that aim to measure the value added created in foreign countries that was previously imported in the form of intermediates, and after some processing, was embodied in the country's exports. The recently available global input-output matrices, in which country-sector pairs of inputs are disentangled along country-sector pairs of outputs, allow for the calculation of the geographical origin of FVAiX.

We base on Trefler and Zhu (2010) and Foster and Stehrer (2013) for a simple presentation of the indicator. The global Leontief inverse matrix is denoted as $\mathrm{L} = (\mathrm{I} - \mathrm{A})^{-1}$, with dimension NC × NC, where N stands for the number of sectors and C for the number of countries. The vector of value-added coefficients, that is, value added created per unit of gross output in country r, is denoted by v^{r}. This 1 × NC vector contains the value-added coefficients for country r and zeros otherwise. Further, country r's exports are written in a vector e^{r}, which is of dimension NC × 1 and reports the exports for country r as positive elements and zeros otherwise.

The DVAiX basically picks the on-diagonal block in the Leontief inverse for country r, pre-multiplies with the value-added coefficients in each sector and post-multiplies with the values of exports value, that is:

$$\mathrm{DVAiX}^{\mathrm{r}} = \mathrm{v}^{\mathrm{r}}\,\mathrm{L}\,\mathrm{e}^{\mathrm{r}} \qquad (1)$$

The FVAiX provides the value added directly and indirectly created in the country from which intermediates are imported (source country s) for production of country r's exports and is calculated in a similar way. It implies pre-multiplying the Leontief inverse by the vector containing the value-added coefficients for country s and zeros otherwise, denoted as v^{s}, and post-multiplying with country r's exports vector. In other words, the FVAiX basically takes the off-diagonal blocks of the global Leontief inverse for country r, pre-multiplies with country s value-added coefficients and post-multiplies with the vector of country r exports. Formally, this is written as:

$$\mathrm{FVAiX}^{\mathrm{sr}} = \mathrm{v}^{\mathrm{s}}\,\mathrm{L}\,\mathrm{e}^{\mathrm{r}} \qquad (2)$$

Next, summing up over all partner countries, the total foreign value added embodied in country r's exports is:

$$\mathrm{FVAiX}^{\mathrm{r}} = \textstyle\sum_{s,s\neq r} \mathrm{v}^{\mathrm{s}}\,\mathrm{L}\,\mathrm{e}^{\mathrm{r}} \qquad (3)$$

This expression is akin to the one suggested by Hummels *et al.* (2001) to calculate the import content of exports, designated as "vertical specialization". However, in Equation (3) the calculation is based on a value-added concept and uses a global Leontief inverse rather than a basic matrix with the country's import coefficients.

Summing up the domestic and foreign value added in exports, as presented in Equations (1) and (3), provides the value of total exports in gross terms. In fact, through national accounts' identities, the value added created along the supply chain for the production of the exported good must correspond to factor income generated in domestic or foreign countries. It should be noted that the same procedure can be applied when the value-added content of exports of a particular sector is analyzed. In this case, only the exports of the selected sector are included in the export vector e^r.

It should also be noted that the calculations consider a country's total exports, that is, both exports of intermediates and final goods. This is justified because exports, irrespectively of whether these are intermediates or final goods, are classified as final demand from this country's national accounting perspective. In fact, to include only exports of final goods would be misleading. For example, a country exporting only raw materials would show zero value added in exports, in a context where the production of raw materials genuinely creates domestic income. In other words, the consideration of exports of intermediates and final goods leads to double counting in overall trade statistics (which is precisely the motivation for the proposal of value-added measures) but from an individual country's perspective both types of exports have to be considered as sources of value added created there (for detailed discussions, see Koopman *et al.* (2010, 2014), Stehrer (2012) and Foster and Stehrer (2013).).

The imports of a given country can be disentangled by using the same approach described above (Foster and Stehrer, 2013). In order to discuss the characteristics of GVC it is useful to calculate the value added that is embodied in exports but returns back home (embedded in imports) and is later embodied in new exports. This measure provides insights on the existence of GVC where some intermediates are sent abroad for transformation before a final stage of production in the initial country. For example, this would be the case of a country exporting parts and components of an automobile, which are transformed abroad and reimported for final assembly before being exported.

To estimate this re-exported domestic value added in imports (RDVAiM) we proceed in two steps. Firstly, the domestic value added embodied in imports (DVAiM) is obtained. Secondly, the coefficient that results from dividing the level of DVAiM by total imports is multiplied with FVAiX. To compute DVAiM, the strategy is similar to the one presented above and starts by denoting country r's imports from the other countries by m^r. Note that this vector of dimension NC × 1 includes bilateral imports values of country r from other countries as positive entries and zeros otherwise. The domestic value added in a country's imports is then calculated as:

$$\mathrm{DVAiM}^r = v^r \, L \, m^r \qquad (4)$$

Equation (4) picks up the off-diagonal blocks of the rows of country r in the global Leontief inverse, which are pre-multiplied by country r's input coefficients and post-multiplied by country r's bilateral imports. Koopman *et al.* (2010) show that subtracting this reimported domestic value added from the domestic value-added content of exports (i.e. Equation (1) minus Equation 4), yields the "value added in exports" (VAX) as also defined in Johnson and Noguera (2012a) (see Stehrer (2013) for a detailed bilateral assessment). Next, taking ι as 1 × NC vector of ones,

$$\mathrm{RDVAiM}^r = \frac{\mathrm{DVAiM}^r}{\iota \, m^r} \mathrm{FVAiX}^r \qquad (5)$$

yields our proposed measure of the re-exported domestic value added in imports.

3 External euro area linkages

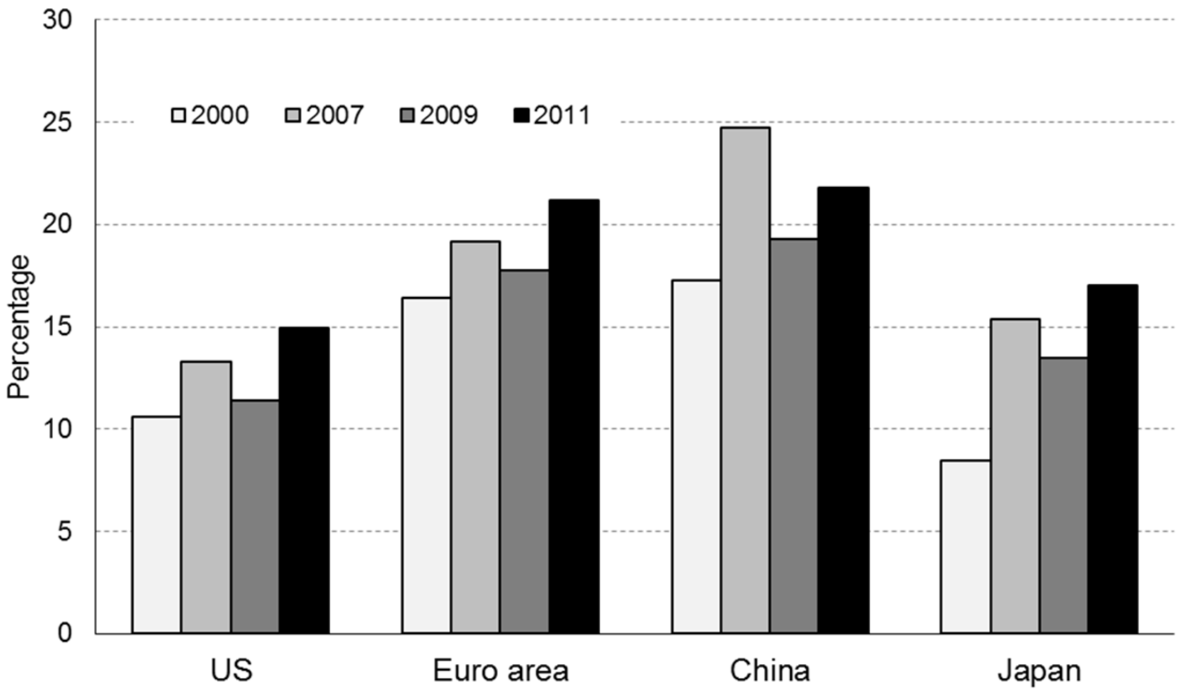
This section presents the patterns of FVAiX when the euro area is considered as a whole, that is, the euro area is taken as the "home country" and its member countries as "regions".[1] As previously discussed, the importance of GVC in the euro area with respect to the rest of the world is gauged by the size of foreign (extra-area) value added embedded in the production of goods and services sold to extra-area countries, thus being comparable with other large countries like the USA, China and Japan trading with smaller neighbouring countries.

The FVAiX is evaluated for years 2000, 2007, 2009 and 2011, based on the WIOD database. This timeframe covers the existence of the euro area and allows for the consideration of three relevant sub-periods; namely the pre-crisis (2000-2007), the great trade collapse (2007-2009) and the rebound of international trade (2009-2011).

Figure 1 shows that GVC have been playing an important role in the euro area (taken as a whole) since its creation and are, at present, virtually as important as in China. The FVAiX for the euro area as a whole stands at 21 percent in 2011, compared with 22 percent in China. The USA and Japan, with figures of 15 and 17 percent, respectively, present significantly lower shares. As the monetary integration matured, euro areas' participation in the global production processes increased substantially. From 2000 to 2011, the FVAiX increased by 5 percentage points. Comparing the developments in the euro area with those of other large economies operating as monetary unions like the USA, China and Japan, some important facts should be mentioned. First, the trade collapse implied a decrease in FVAiX in the four economies from 2007 to 2009, but this drop was particularly strong in the case of China, which had also recorded the strongest increase in the previous period. The higher sensitiveness of Chinese GVC to this shock and the comparatively higher resilience of GVC in the euro area taken as a whole is an important result and it may point towards a different nature of production linkages prevailing in these economies. Second, except in the case of China, there was a rebound of GVC in the recent period as the FVAiX in 2011 surpassed that of 2007.

[1] By the time this paper was produced, the euro area comprised: Austria, Belgium, Cyprus, Germany, Spain, Estonia, Finland, France, Greece, Ireland, Italy, Luxembourg, Malta, Netherlands, Portugal, Slovakia and Slovenia. This definition for the euro area is held constant throughout the paper.

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



In addition to the FVAiX, Table 1 provides figures for the DVAiM and RDVAiM indicators computed for the euro area, China and Japan and for individual euro area countries when only their extra-area trade relations are considered, that is, members are considered as "regions" of the euro area. These indicators can provide some clues on the position of a country in the global value chains. A large share of FVAiX may indicate its position as a downstream processor (near final consumption), while a relatively high share of DVAiM and RDVAiM may suggest a relatively upstream position in the GVC. However, such upstream position can refer to a situation where a country provides raw materials or high-skill activities like design and R&D. An important result that emerges is that the values for the DVAiM and RDVAiM in the euro area as a whole tend to be higher than those for China and Japan. The scale of the euro area economy, the types of products exported and the organizational choices of firms are key determinants of this relevant share of euro area value added re-imported from extra-area countries. A broader discussion of these aspects is taken up in section 5, where the analysis on the individual euro area countries sheds light on the role of the German economy on this result for the euro area. The developments of FVAiX and DVAiM in China from 2000 to 2011 point towards a progressive "upstreamness" of it exports. In fact, in this period Chinese FVAiX increased relatively less than it's DVAiM. Nevertheless, this type of analysis is approximate to more precise and elaborate measures of "upstreamness" exist in the literature (see, e.g., Antràs *et al.*, 2012).

Table 1: Euro area as a whole and members' extra-area trade: Indicators of value added in trade

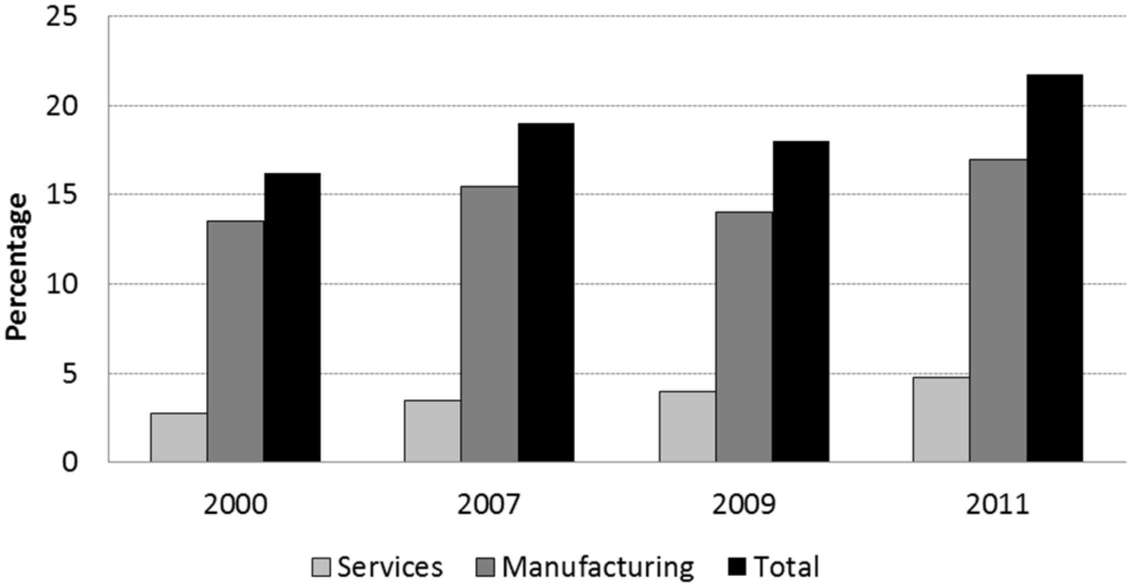
	Share in extra-area exports	Foreign value added in exports (FVAiX) % extra area exports				Domestic value added in imports (DVAiM) % extra area imports				Re-exported value added in imports (RDVAiM) % of extra area exports			
		2000	2007	2009	2011	2000	2007	2009	2011	2000	2007	2009	2011
AUT	4.1	12.8	16.0	14.8	17.6	7.4	8.8	7.6	7.3	0.9	1.4	1.1	1.3
BEL	5.3	20.7	20.7	19.9	24.1	5.6	6.8	5.8	5.1	1.1	1.4	1.2	1.2
CYP	0.1	17.4	13.7	15.2	17.2	5.2	6.7	6.2	5.1	0.9	0.9	0.9	0.9
DEU	36.4	14.4	17.7	15.7	18.7	7.1	8.5	7.5	7.4	1.0	1.5	1.2	1.4
ESP	6.5	14.0	18.6	14.7	19.5	5.3	6.3	5.6	4.9	0.7	1.2	0.8	1.0
EST	0.2	31.0	24.3	21.6	23.7	7.7	8.8	7.2	6.6	2.4	2.1	1.5	1.6
FIN	2.4	19.8	23.8	22.2	26.2	6.2	6.8	5.8	5.3	1.2	1.6	1.3	1.4
FRA	14.4	13.3	15.5	13.9	16.4	5.7	6.8	6.0	5.7	0.8	1.1	0.8	0.9
GRC	1.3	22.1	20.0	16.7	17.2	4.6	6.0	4.9	4.4	1.0	1.2	0.8	0.7
IRL	4.4	34.3	30.6	33.5	36.2	5.1	4.8	3.8	3.5	1.7	1.5	1.3	1.3
ITA	12.7	12.2	15.5	13.5	17.4	5.3	6.9	5.7	5.0	0.7	1.1	0.8	0.9
LUX	1.4	33.9	37.3	40.1	50.5	3.9	3.8	3.0	2.5	1.3	1.4	1.2	1.3
MLT	0.1	31.4	25.4	21.6	23.3	7.1	6.9	6.1	5.4	2.2	1.8	1.3	1.3
NLD	7.7	21.4	23.5	22.4	27.4	4.6	5.0	4.4	3.9	1.0	1.2	1.0	1.1
PRT	0.9	12.6	14.9	13.2	13.7	5.2	5.9	5.4	4.8	0.7	0.9	0.7	0.7
SVK	1.0	26.9	30.3	26.2	27.0	9.5	11.4	10.0	9.3	2.6	3.4	2.6	2.5
SVN	0.8	14.8	17.7	17.0	18.5	8.1	10.5	8.1	7.4	1.2	1.9	1.4	1.4
Euro area	100.0	16.4	19.1	17.7	21.2	6.0	7.1	6.1	5.7	1.0	1.4	1.1	1.2
memo:													
China		*17.3*	*24.7*	*20.8*	*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: Results for euro area member countries' eliminate intra-area trade linkages. Therefore, results for the euro area as a whole are compatible with the aggregation of member's levels.

As for a broad sectoral analysis of GVC in the euro area as a whole, Figure 2 breaks down the FVAiX into manufacturing and services.[2] Unsurprisingly, the largest share corresponds to the manufacturing sector. This is a stylized feature in GVC literature, as manufacturing represents the core of the tradable sector. Nevertheless, the FVAiX contained in services exports has increased its share in extra-euro area exports from 2.6 percent in 2000 to 4.6 percent in 2011, confirming the increasing importance of these activities in the overall functioning of GVC. In addition, it is important to note that the foreign value added in this sector's exports did not reduce its importance from 2007 to 2009, not even in absolute terms.

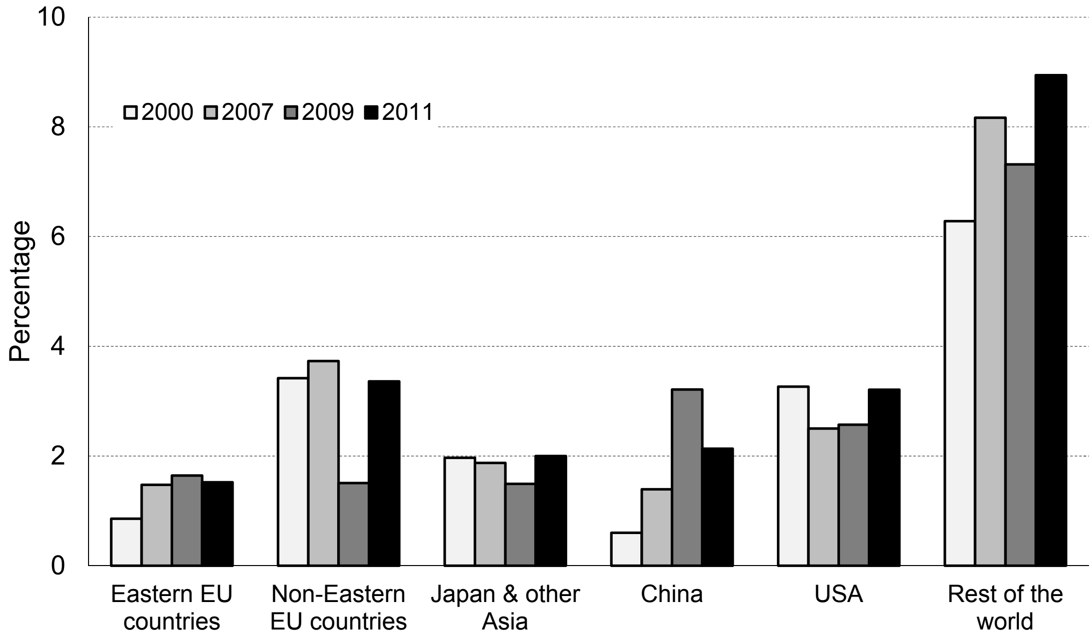
[2] Here manufacturing and services are broadly defined. Manufacturing includes ISIC Rev. 3 1-37 and services include ISIC Rev. 3 40-95.

Figure 2: Foreign value added in exports of manufacturing and services in the euro area, as a percentage of total exports



One important exercise that is made possible by the existence of global input-output matrices like the WIOD is the decomposition of the FVAiX by country of origin. Figure 3 provides information on the production linkages of the euro area with other areas of the world. The relevance of the non-Eastern EU countries (UK, Denmark and Sweden) as a source of value added embodied in the euro area's exports is high, that is, 3 percent in the average of the period 2000-2011. Nevertheless, this percentage decreased to less than half during the trade collapse period, which may interlink with the specific nature of the production linkages and industry specific trade shocks, amplified by important exchange rate shifts. The Eastern EU countries (Bulgaria, Czech Republic, Hungary, Lithuania, Latvia, Poland and Romania) have increased their relevance as origins of value added in euro area exports, reaching 1.5 percent in 2011, and did not record a fall from 2007 to 2009. In addition, Japan and other Asia and the USA show a stable share (averages close to 2 and 3 percent in the period, respectively), while China recorded a very significant increase in the period (from 0.5 percent in 2000 to around 2 percent in 2011), surpassing Eastern EU countries. The largest share of euro area's FVAiX is originated in the block "rest of the world", which includes oil producers. The FVAiX originated in this geographical block increased from nearly 6 per-cent in 2000 to about 9 percent in 2011.

Figure 3: Euro area as whole: foreign value added in exports by origin (as a percentage of exports)



Note: Eastern EU countries: Bulgaria, Czech Republic, Hungary, Lithuania, Latvia, Poland and Romania; Non-Eastern EU countries: United Kingdom, Denmark and Sweden; Japan & other Asia: Japan, Indonesia, India, Korea and Taiwan.

The results for euro area countries considered as "regions" of the monetary union show significant diversity in terms of their FVAiX intensity, ranging from about 14 percent in Portugal in 2011 to 50 percent in Luxembourg. When country results are weighted by their share in euro area's extra exports in 2011, the main contributors to the area's FVAiX are Germany (6.6 percentage points), Netherlands (2.3 percentage points), France (2.2 percentage points), Italy (2.1 percentage points) and Ireland (2.0 percentage points).

4 Internal euro area linkages

This section assesses the supply linkages between euro area countries, thus restricting the analysis to intra-area trade of internally generated value added. It is clear that some of these internal value-added flows would not exist in reality if extra-euro trade were not present. For example, if all energy were produced outside the area, internal trade and even production would be impossible. Therefore, this section must be interpreted as an analysis of production linkages existing inside the euro area made but in a context where the latter is integrated in the world economy. [3]

[3] In this analysis exports of goods and services do not include services related to international tourism. In WIOD tables the latter are recorded as a separate item ("Purchases on the domestic territory by non-residents"). For this reason they cannot be treated as a separate sector due to missing pieces of information. This should be kept in mind since for some countries exports of tourism services amount to a relatively high share of exports.

Table 2: Breakdown of intra euro area value added flows, bilateral linkages 2011 in %

To:	AUT	BEL	CYP	DEU	ESP	EST	FIN	FRA	GRC	IRL	ITA	LUX	MLT	NLD	PRT	SVK	SVN	Euro area
From:																		
AUT	-	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
BEL	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
CYP	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
DEU	4	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
ESP	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
EST	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	0.2
FIN	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
FRA	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
GRC	0.0	0.0	0.1	0.1	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
IRL	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
ITA	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
LUX	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
MLT	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
NLD	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
PRT	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
SVK	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
SVN	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
Euro area	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

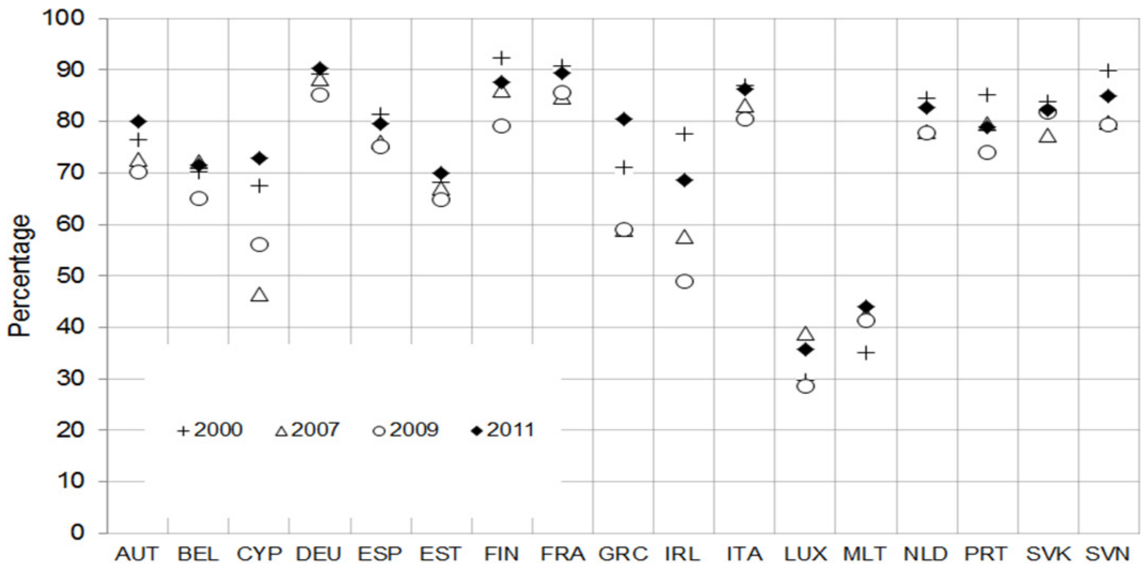
Note: Domestic value added in exports from row country to column country, as percentage of total intra-euro area value added trade. Values above 2 percent are shaded in light grey and above 4 percent in dark grey.

Table 2 provides information on the flows of value added that are traded between country-pairs in 2011. The geographical decomposition of each country's value added exported to the euro area is presented by row. Therefore, the marginal distribution along the row dimension represents the share of a country as supplier of value added, while the marginal distribution on the column dimension represents the share of the country as user of value added. The table shows that Germany plays the largest role in the internal euro area linkages, representing about 29 percent of value added supplied in intra-euro area exports to other euro area economics and 23 percent of value added consumed. Other large suppliers present much lower percentage, namely France (14.8 percent), the Netherlands (12.5 percent) and Italy (12.2 percent). In terms of users the ranking changes, with France (18.0 percent), Italy (13.2 percent) and Spain (10.1 percent) following Germany. Unsurprisingly, the key bilateral linkage lies between Germany and France, each one 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 in the row and column dimensions can be interpreted as the trade in value-added balance relative to the euro area. These differences suggest that Germany runs a surplus in the intra euro area *trade in value added balance*. A similar position is found for Netherlands, whereas France shows a deficit. The similar magnitude of shares in the value added supplied and consumed within the euro area for Spain and Italy suggests for them a position close to balance, with very small deficit for Italy.

The sectoral dimension of intra-area production linkages has changed from 2000 to 2011. Figure 4 presents the share of manufacturing in each country's total supply of value added to the euro area in this period. The most striking feature is that this share decreased from 2000 to 2011 in most countries but it decreased even more from 2007 to 2009. The resilience of services in this period was also observed in the extra-euro area analysis. The countries that rely less on manufacturing are Luxembourg and Malta, with shares around 40 percent, while Germany shows the largest share for manufacturing in its role of euro area supplier (90 percent).

Figure 4: Share of manufacturing in value-added exported to the euro area, 2000-2011 (as a percentage of total value-added exports)



The analysis of the intra-euro area GVC can be detailed in a bilateral way. This makes it possible to identify whether specialization patterns are partner-specific or common across euro area partners. Table 3 presents the share of manufacturing in bilateral intra-area value-added flows; the numbers below 50 percent are shaded in grey. Some countries show consistently show low shares of manufacturing (high shares for services). This is the case for Luxembourg and Malta, and, to a lower extent, Ireland and Greece. Conversely, it is striking that more than half of the value added moving from most euro area countries into Ireland and Luxembourg corresponds to services. The role of Ireland and Luxembourg as users of euro-area services is related with their role as headquarters of multinational corporations and as financial centre, respectively.

Table 3: Share of manufacturing in intra euro area value added flows, bilateral linkages 2011

To: From:	AUT	BEL	CYP	DEU	ESP	EST	FIN	FRA	GRC	IRL	ITA	LUX	MLT	NLD	PRT	SVK	SVN
AUT	-	48	60	85	71	74	67	91	78	36	83	10	21	60	61	63	82
BEL	51	-	71	82	51	61	62	80	72	37	78	31	48	69	61	66	54
CYP	85	83	-	75	61	9	95	91	69	49	94	13	47	77	76	52	30
DEU	92	80	85	-	85	92	92	97	86	55	95	52	75	89	93	96	94
ESP	73	60	93	85	-	72	66	85	91	31	85	7	90	60	85	91	93
EST	32	49	19	86	64	-	73	85	38	13	89	4	6	46	89	86	77
FIN	79	70	77	96	78	77	-	95	94	48	93	26	39	83	76	90	92
FRA	92	89	95	98	80	85	88	-	89	55	97	44	90	79	91	95	87
GRC	68	46	92	87	69	46	90	85	-	19	92	3	64	60	80	89	90
IRL	51	85	90	92	47	58	35	80	76	-	42	8	41	55	51	61	60
ITA	90	70	91	93	80	89	77	91	81	24	-	36	88	75	90	91	89
LUX	23	23	11	49	78	15	33	33	94	6	34	-	55	53	18	42	47
MLT	15	25	54	70	48	1	11	44	67	12	34	7	-	30	51	8	53
NLD	82	85	85	89	57	87	71	88	77	50	90	22	72	-	83	47	90
PRT	70	63	92	90	79	80	89	85	90	16	73	55	76	73	-	92	91
SVK	78	67	63	89	92	75	71	91	88	35	91	10	14	34	71	-	80
SVN	63	30	69	94	85	94	79	94	84	45	88	36	78	76	93	91	-

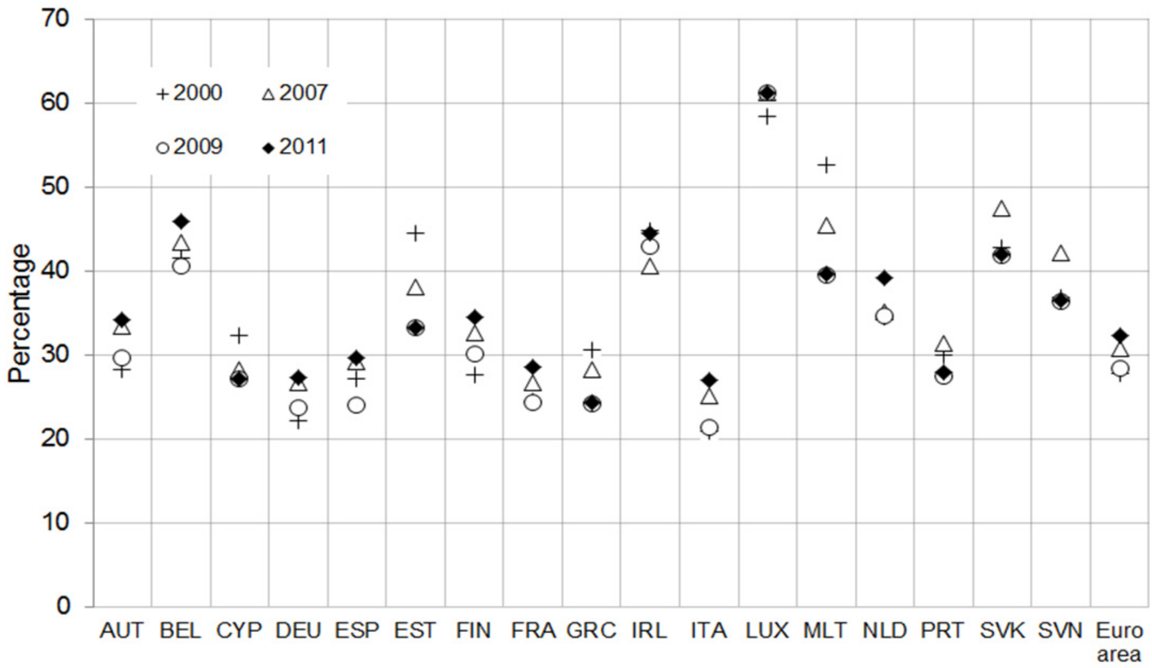
Note: Domestic value added in exports from row country to column country as percentage of total euro area value added exports. values below 50 percent are shaded in grey.

5 Global value chains for individual euro area countries

This section studies the role of GVC taking individual euro area countries as they are usually treated; that is, as autonomous countries trading with the rest of the world. This means considering both their intra-euro and extra-euro area value added flows. The analysis proceeds along the aggregate, geographical and sectoral dimensions.

Figure 5 reports FVAiX for each euro area country from 2000 to 2011 and Fgure 6 reports the numbers for the RDVAiM. As expected, substantial differences emerge across countries. In 2000, FVAiX ranged between 21 percent (Italy) and 58 percent (Luxembourg), with lower-end values characterizing the relatively larger countries (Germany, France, Italy and Spain). By 2011, the foreign value-added content of euro area countries’ exports increased, on average, by 4.5 percentage points. Finland, Austria, Italy and Germany experienced strong growth in the foreign content of exports, while Greece, Cyprus and Portugal witnessed an important reduction from 2000 to 2011. Although the figure suggests a quite generalized increase in FVAiX during the overall period, the development of the indicator shows differences across sub-periods. In general, during the 2000s the foreign content of exports grew substantially in the majority of euro area countries, whereas during the great trade collapse, it generally decreased. The developments described above are broadly consistent with those reported by other studies on vertical specialization in European economies until the mid-2000s (e.g. Backer and Yamano, 2012; Breda and Cappariello, 2010; Bravo and Álvarez, 2012). Nevertheless, differences in sectoral classifications, the exclusion of energy products and the degree of disaggregation of the input-output table lead to different results in terms of levels.

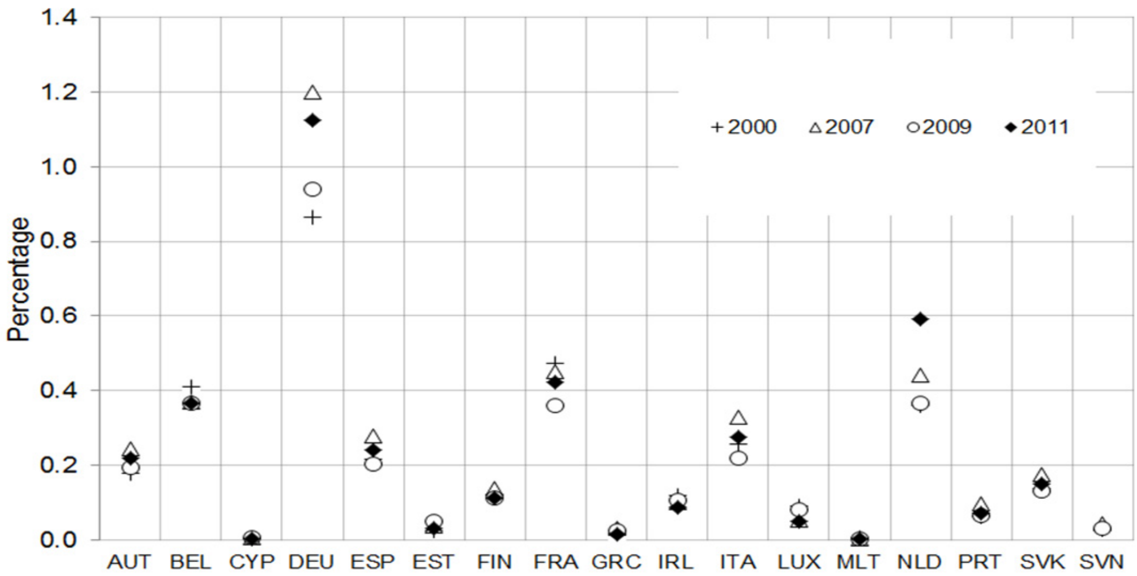
Figure 5: Foreign value added in exports, 2000-2011 (as a percentage of exports)



Another relevant dimension, also discussed in previous sections is the magnitude of the RDVAiM as an indicator of the nature of the GVC (Figure 6). The numbers are generally low in most countries (below 0.4 percent), with the notable exception of Germany and, to a lesser extent, the Netherlands. The comparatively large values presented for Germany (1.1 percent in 2011) are partly explained by its specialization in the production of transport equipment (and machinery) and the inter-link with its intrinsic production process. The technology in the automotive sector has been defined as "spider-shaped", that is, multiple parts and components come together to assemble the final product, in contrast to a "snake-shaped" technology where goods move in a sequential manner from upstream to downstream stages with value being added along the way (Baldwin and Venables, 2013). Such a production process makes it easier to configure the GVC in such a way that both the most upstream stage of the production process (e.g. product design) and the assembly stage remain in the home country, thus turning a high RDVAiM.

Timmer *et al.* (2013) highlights that developments in the German automobile industry partly deviated from those that took place at global level over the last two decades. First, car assembly has largely been kept close to consumption markets, mainly to facilitate penetration and reduce transport costs. Second, there has been a strong global integration in the production process of parts and components. Nevertheless, the delocalization of the final stages of production in Germany's automobile industry is relatively weaker than in other European automobile industries because of its orientation towards high quality segments, which are signalled by the fact that they are "Made in Germany". In fact, the FVAiX in Italy and France is in line with that of Germany, but the RDVAiM is much lower.

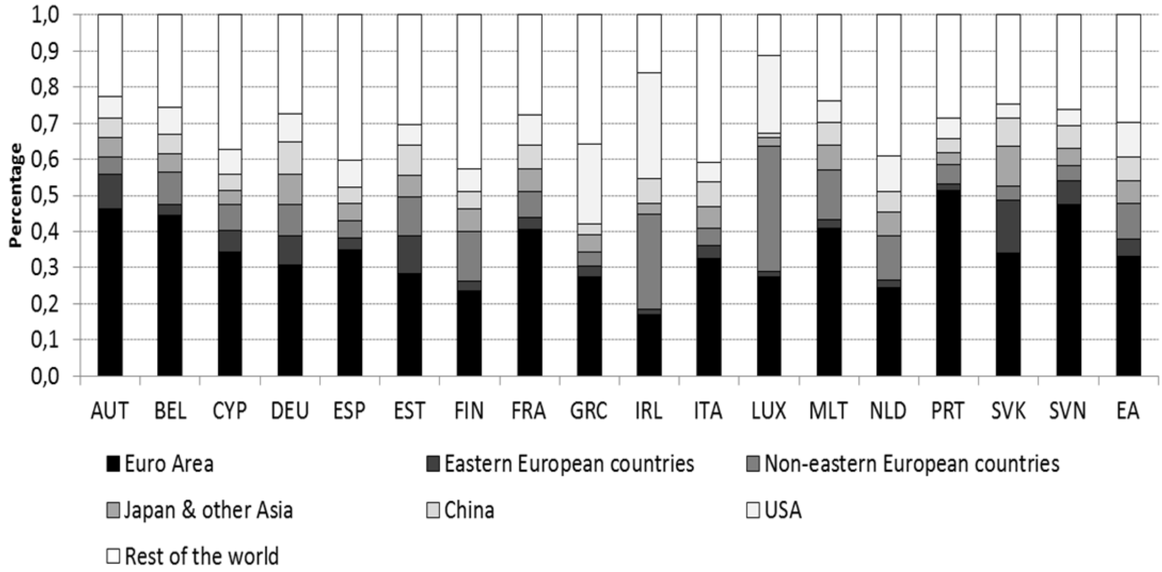
Figure 6: Re-exported value added in imports, 2000-2011 (as a percentage of exports)



The analysis of the DVAiX by source countries adds additional insights to the analysis of GVC in the euro area. Table 4 decomposes the FVAiX for each euro area country along different origins from 2000 to 2011, signalling the importance of the euro area and other international blocks, including other EU countries, the USA and Asia, while Figure 7 presents the geographical structure of this indicator in 2011. Two results emerge from this empirical analysis. First, the share of the (remaining) euro area countries as sources of FVAiX is typically the largest one, that is, the euro area is, in most cases, the dominant part of the GVC for each individual member. In 2000 almost 40 percent of foreign value added embedded in the average euro area country's exports was sourced inside the area and in 2011 this number was 33 percent. Second, this share is more stable than that attached to other sources of foreign value added, that is, the change in total FVAiX is mostly due to changes in value added sourced from other trade blocks.

Figure 7: Decomposition of foreign value added in exports by origin, 2011

(as a percentage of total foreign value-added in exports)



Some countries constitute exceptions to this general pattern. Luxembourg and Ireland present a very large share of non-Eastern EU countries (UK, Denmark and Sweden) as sources of FVAiX. This is partly related with the linkages of Luxembourg with the UK financial centre and Ireland's role as headquarters of Anglo-Saxon and Nordic multinational corporations. In addition, Slovakia shows a strong link with non-euro area Eastern EU countries (notably the Czech Republic), which is related with the strong regional production linkages already in place before its euro area accession. Moreover, Finland and Netherlands present a large share of FVAiX sourced in the "rest of the world". In the case of the Netherlands, this is partly related with its role as a global trade hub and as headquarters of a major oil company. In fact, between 2000 and 2007 an increase of the FVAiX sourced in the "rest of the world" is observed in several countries, which is partly due to the strong increase of oil prices imported from producer countries. Finally, it is important to refer to the role of China as source of FVAiX in euro area countries. Although China is widely referred as a key part of GVC, it represents less than 2 percent of FVAiX for approximately half of euro area countries. Nevertheless, China's relevance as input provider increased rapidly in the overall period under analysis, with a slowdown just in 2009. In 2011, the value added sourced from China and embodied in euro area exports is larger than that coming from the Eastern EU economies, similar to that of Japan and other Asia and lower than that of USA.

Table 4 - Foreign value added in exports by origin (as a percentage of gross exports), 2000-2011

	Euro area				Eastern EU countries				Non eastern EU countries				Japan & other Asia				China				USA				Rest of World			
	2000	2007	2009	2011	2000	2007	2009	2011	2000	2007	2009	2011	2000	2007	2009	2011	2000	2007	2009	2011	2000	2007	2009	2011	2000	2007	2009	2011
AUT	14,7	17,0	14,6	15,8	1,7	2,9	2,7	3,3	2,0	1,9	1,6	1,7	1,7	1,5	1,3	1,8	0,4	1,2	1,2	1,9	1,7	1,5	1,5	2,0	5,9	7,3	6,8	7,7
BEL	20,9	21,9	20,2	20,4	0,8	1,3	1,6	1,4	4,9	4,3	3,5	4,1	2,6	2,3	2,0	2,5	0,7	1,6	1,7	2,4	4,3	2,7	2,7	3,5	7,3	9,4	8,9	11,8
CYP	11,3	13,1	10,9	9,3	0,6	1,1	2,2	1,7	2,4	2,9	2,1	2,0	2,0	1,6	1,2	1,1	0,8	1,3	0,9	1,2	2,7	2,4	1,6	1,9	12,5	5,9	8,2	10,1
DEU	7,7	8,8	7,9	8,4	1,4	2,0	2,1	2,2	2,6	2,8	2,2	2,4	1,9	2,1	1,8	2,3	0,5	1,5	1,7	2,5	2,4	2,0	1,8	2,1	5,7	7,5	6,2	7,5
ESP	13,2	11,8	10,2	10,4	0,4	0,8	0,9	0,9	2,4	1,9	1,4	1,5	1,7	1,4	1,1	1,4	0,4	1,3	0,9	1,4	1,6	1,7	1,5	2,2	7,6	10,1	8,0	11,9
EST	12,6	13,7	11,5	9,4	2,4	3,7	3,8	3,4	4,3	4,0	3,8	3,6	3,8	2,1	1,6	2,0	1,2	2,4	1,9	2,8	3,1	1,6	1,8	1,9	17,2	10,5	8,7	10,1
FIN	8,2	8,8	8,3	8,1	0,7	1,0	1,2	1,0	5,1	5,0	4,2	4,7	2,3	2,6	2,3	2,2	0,6	1,9	1,8	1,6	3,1	1,7	1,9	2,2	7,6	11,6	10,3	14,7
FRA	10,7	11,2	10,4	11,5	0,4	0,9	0,9	0,9	2,7	2,4	1,9	2,0	1,6	1,5	1,3	1,8	0,5	1,1	1,3	1,9	2,9	2,1	2,2	2,4	5,6	7,5	6,5	7,9
GRC	9,7	8,1	7,7	6,7	0,6	1,2	0,9	0,8	1,4	1,7	1,0	1,0	1,4	1,0	0,9	1,1	0,3	0,6	0,5	0,7	7,8	6,0	4,8	5,4	9,4	9,7	8,4	8,7
IRL	10,3	9,7	9,3	7,6	0,5	1,1	1,1	0,6	11,6	12,9	12,3	11,8	3,9	2,2	1,6	1,3	0,7	1,8	2,4	3,1	12,3	8,8	10,6	12,9	5,4	4,0	5,6	7,2
ITA	8,3	9,4	7,8	8,8	0,5	1,1	0,9	1,0	1,8	1,8	1,2	1,3	1,3	1,4	1,0	1,7	0,4	1,1	1,0	1,8	2,0	1,4	1,3	1,5	6,6	8,9	8,0	11,1
LUX	26,8	28,1	26,2	16,8	0,4	0,7	0,9	1,0	22,1	20,2	20,3	21,2	1,7	1,4	1,8	1,5	0,4	1,5	0,5	0,8	4,1	4,3	4,2	13,1	2,9	5,0	7,2	7,0
MLT	24,2	20,1	17,6	16,3	0,6	1,1	0,9	0,9	2,9	5,5	6,0	5,4	3,5	3,0	2,3	2,8	0,9	3,1	1,8	2,5	8,1	3,7	2,3	2,4	12,2	9,0	8,7	9,4
NLD	11,3	10,6	10,8	9,6	0,5	0,7	1,0	0,8	4,6	4,6	3,9	4,8	2,6	2,2	2,2	2,5	1,4	1,6	1,9	2,3	4,2	3,2	3,5	3,9	9,8	12,1	11,5	15,3
PRT	16,7	16,7	15,0	14,3	0,4	0,6	0,6	0,5	2,7	1,9	1,6	1,5	1,5	1,2	0,9	1,0	0,3	0,9	0,8	1,0	1,7	1,2	1,3	1,6	6,7	8,8	7,4	8,0
SVK	18,0	17,2	14,9	14,3	5,2	6,6	5,9	6,1	1,9	2,0	2,0	1,6	1,5	4,5	3,8	4,7	0,5	2,3	2,5	3,2	1,8	1,9	1,7	1,7	13,8	13,1	11,2	10,4
SVN	22,0	24,0	18,9	17,4	2,1	2,8	2,5	2,4	2,1	1,9	1,6	1,5	1,6	1,7	1,6	1,8	0,5	1,1	1,6	2,3	1,7	1,5	1,6	1,6	7,0	9,2	8,7	9,6
EA	11,0	11,6	10,6	10,7	0,9	1,5	1,5	1,5	3,6	3,6	3,1	3,2	2,0	1,9	1,6	2,0	0,6	1,4	1,5	2,1	3,2	2,4	2,5	3,0	6,6	8,5	7,6	9,7

Note: Values above 5 percent are shaded in light grey and above 10 percent in dark grey.

Table 5 presents the geographical decomposition of DVAiX and FVAiX of euro area countries taken individually, breaking down the euro area as a source. Each row presents the share of FVAiX sourced from each column country and the diagonal corresponds to the DVAiX. The results presented are related to those reported in Table 2, for intra-euro area value-added flows. The striking point is the great importance of Germany as an origin of FVAiX for all other euro area countries. This reinforces the conclusion that Germany plays a core role in the euro area GVC, as previously inferred. Although this is also driven by the size of the German economy, it is also a result of its specialisation in manufacturing, notably in the machinery and transport equipment industries. In addition, some other known value chains are identified. France and Netherlands are important sources Belgium's FVAiX and Spain is an important source of Portuguese FVAiX. Finally, Italy is identified as a relevant supplier for Slovenia, and France and Italy are also important suppliers for Malta.

Table 5: Domestic and foreign value added in exports by origin – 2011

From: To:	AUT	BEL	CYP	DEU	ESP	EST	FIN	FRA	GRC	IRL	ITA	LUX	MLT	NLD	PRT	SVK	SVN	Euro area
AUT	**65.8**	0.6	0.0	9.4	0.7	0.0	0.2	1.1	0.0	0.1	1.9	0.1	0.0	0.8	0.1	0.5	0.2	81.6
BEL	0.4	**54.0**	0.0	5.7	1.2	0.0	0.3	3.4	0.1	0.5	1.3	0.4	0.0	6.8	0.2	0.1	0.0	74.5
CYP	0.3	0.6	**72.8**	2.2	0.8	0.2	0.1	1.0	1.6	0.1	1.4	0.1	0.1	0.7	0.1	0.1	0.0	82.1
DEU	0.9	0.9	0.0	**72.7**	0.8	0.0	0.3	1.8	0.0	0.2	1.5	0.1	0.0	1.4	0.1	0.2	0.1	81.1
ESP	0.3	0.6	0.0	3.2	**70.3**	0.0	0.2	2.6	0.0	0.2	1.6	0.0	0.0	1.0	0.5	0.1	0.0	80.7
EST	0.3	0.5	0.0	3.1	0.4	**66.7**	2.5	0.7	0.0	0.2	0.8	0.1	0.0	0.7	0.1	0.1	0.1	76.2
FIN	0.3	0.6	0.0	3.1	0.4	0.4	**65.5**	0.8	0.1	0.2	0.8	0.0	0.0	1.2	0.1	0.1	0.0	73.6
FRA	0.3	1.2	0.0	4.9	1.5	0.0	0.1	**71.5**	0.0	0.2	1.7	0.1	0.0	1.1	0.2	0.1	0.0	83.0
GRC	0.2	0.6	0.1	1.8	0.5	0.0	0.1	0.8	**75.7**	0.1	1.8	0.0	0.0	0.6	0.0	0.0	0.0	82.4
IRL	0.2	0.6	0.0	2.2	0.8	0.0	0.1	1.1	0.0	**55.4**	1.0	0.1	0.0	1.2	0.2	0.0	0.0	63.0
ITA	0.5	0.6	0.0	3.3	1.0	0.0	0.1	1.6	0.1	0.2	**72.9**	0.1	0.0	1.0	0.1	0.1	0.1	81.7
LUX	0.6	3.6	0.0	4.3	2.5	0.0	0.1	2.3	0.0	0.6	0.9	**38.7**	0.0	1.5	0.1	0.2	0.0	55.5
MLT	0.7	0.7	0.1	3.4	0.9	0.1	0.2	4.2	0.1	0.3	4.5	0.0	**60.3**	1.0	0.1	0.1	0.0	76.6
NLD	0.2	1.7	0.0	4.0	0.8	0.0	0.3	1.4	0.0	0.2	0.7	0.1	0.0	**60.8**	0.1	0.1	0.0	70.3
PRT	0.2	0.6	0.0	3.0	6.2	0.0	0.1	1.5	0.0	0.2	1.4	0.1	0.0	0.9	**72.1**	0.1	0.0	86.4
SVK	0.9	0.5	0.0	7.2	0.7	0.0	0.2	1.7	0.0	0.1	1.7	0.1	0.0	0.9	0.1	**58.0**	0.1	72.3
SVN	2.1	0.7	0.0	5.9	0.8	0.0	0.2	1.6	0.1	0.1	4.5	0.1	0.0	0.8	0.1	0.4	**63.5**	80.8

Note: Foreign value added in exports to row country from column country, as percentage of total row country exports. Values above 3 percent are shaded in grey.

6 Conclusions

Global value chains have been changing the organization of production across the world, giving each country the potential to specialize in particular activities within industries. Because of these vertical supply linkages, intermediates move across borders several times before being assembled into a final good. As a result, traditional trade statistics routinely used in assessing a country's production linkages are no longer informative. The present paper takes a descriptive approach and studies the role of GVC in shaping the economic integration of the euro area. The paper also focuses on the differences between the euro area and other large countries in Asia (e.g., Japan and China) and the USA, which can be seen as operating monetary unions, thus providing an appropriate basis for comparisons. By studying production linkages with other non-euro area EU countries the present paper also provides some insights into the effects of monetary integration within a region. This is useful for other regions in the world (like the Asian countries) facing a similar integration process. Furthermore, the present paper provides some evidence of production integration with other major players, notably China, Japan and the USA, arguing that both dimensions (i.e. intra-euro area integration and global integration) need to be considered simultaneously.

In methodological terms, the present study adopts the framework suggested by Koopman *et al.* (2010, 2013) and Foster and Stehrer (2013) to break down gross exports according to their value added sources. The key data source is the WIOD, which provides global product/sector production linkages, and the time period studied is 2000-2011. It is hence possible to cover the years just after the introduction of the euro, the eve of the crisis, the great trade collapse and, finally, the subsequent rebound of international trade.

The present study finds evidence of an increasing trend in the share of foreign value added in exports over the 11-year period for the euro area as a whole, with some cyclical pattern testified by a strong reduction during the crisis. The foreign production linkages of the euro area are comparable in magnitude with those of other important trade blocks, including China, and an increasing participation of services in the value chains is visible. In addition, the bilateral intra-area value-added flows make it clear that Germany plays a core role in intra-area production linkages, notably with France. Moreover, manufacturing retains a dominant role in most of these linkages. The analysis also shows that the euro area is the main source of foreign value added in exports for most member countries and its share is more stable than that of other trade blocks. In other words, the growing relevance of external suppliers does not reflect a weakening of the production links within the union, being instead a substitution of domestic value added by extra-area sourcing.

Furthermore, the present study not only shows that intra-European GVC are very important but also offers some evidence on production integration with other economic blocks. Up to the crisis, the production integration of the euro area with other economic blocks decreased or stagnated, whereas integration with China strongly increased. These patterns have partly been reverted since the crisis as in 2011 the share of China in the foreign content of exports decreased whereas the share of Japan and the other Asian countries slightly increased again, with both groups now showing similar levels of integration with the euro area according to this measure. Finally, the present paper provides evidence on the magnitudes of production integration in other economic blocks, notably in Asia, in a comparative manner. Although not recovering the levels visible before the great trade collapse, in 2011 China shows stronger participation in GVC than the euro area, while Japan and the USA present lower numbers. Evidence also points towards a stronger positioning of the euro area in the upstream stages of the production chain, when compared with China and, mostly, Japan. The indicators presented in the present paper concur with the notion that from 2000 to 2011, China experienced a progressive ‘upstreamness’ of its exports. Examining the effects of this trend and, more generally, the Chinese integration in the world economy and its effect on the Asian integration requires a more detailed account of the Asian region.

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Market shares in manufacturing value added: is the picture different?

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February 2016

Abstract

Using an extension of the methodology proposed by Koopman, Wang and Wei (2014) for quantifying domestic value added in a country's exports of manufactures, this paper provides calculations of countries' market shares in value-added terms and compares them with standard shares in global gross exports. Data show different levels and dynamics between advanced and developing countries, with 2004 apparently marking a watershed. Focusing on the four main euro-area countries, the paper offers a sectorial interpretation for the falling intensity of exported domestic value added.

Keywords: market shares, value added exports, global value chains, competitiveness.

JEL Classifications: F12, F14, F15.

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While retaining full responsibility for any errors and omissions, the authors wish to thank Rita Cappariello, Silvia Fabiani, Roberto Tedeschi, Andrea Brandolini (Bank of Italy) and Frauke Skudelny (European Central Bank) for useful comments and suggestions on earlier drafts of this paper. The views expressed here are solely those of the authors and do not necessarily reflect the opinions of the Bank of Italy.

Introduction

The market share in world exports is often used to synthetically assess a country's trade performance and competitive stance. It has ascended to a normative status within the European debate since the European Commission included it in the Scoreboard for the Macroeconomic Imbalance Procedure. However, it is an indicator notoriously unable to grasp all multiple dimensions of competitiveness (Krugman 1994, 1996).

One of the major flaws of shares in world exports is that they are not in a direct and stable relation with GDP growth. The main conceptual reason is that trade statistics record revenues from exporting activity, not value added, and that the ratio between these two magnitudes evolves with the diffusion of global value chains (GVCs). International fragmentation of production and the growing exchanges of intermediate goods have made indicators based on gross exports alone (that is, without the simultaneous analysis of imports) less and less informative on the effective contribution of exports to GDP. In this paper, we set off to look at market shares shifting the focus from gross exports to their domestic-value-added content.

Gross exports can be decomposed into three main components: domestic value added, foreign value added and a residual double-counting term. The first component reflects the use of domestic inputs in producing exports and thus captures the contribution of gross exports to GDP (we label it GDP in exports or GDPX in short[1]). The second component reflects the use of foreign inputs in producing exports; it is a refinement of the concept of "import content of exports", which does not control for the fact that a country's imports may in fact contain a (small) contribution of domestic inputs. Lastly, the double-counting component arises from intermediates that cross the national border back and forth as they get processed in successive stages of production and thus get recorded multiple times in aggregate and bilateral trade statistics.

Relying on the World Input Output Database and on the tools developed by Cappariello and Felettigh (2015), this paper investigates to what extent countries' share in world merchandise (gross) exports differs from its value-added-exports counterpart (that is the share in world GDPX), both in levels and in dynamics, for the period 1995-2011.

Our estimates imply a number of measurement assumptions that are sketched in the next section. Our main conclusion is that in general there is an overall consistency both in terms of levels and medium-term dynamics between the market share based on gross exports and the market share based on value added, especially for developed economies.

Yet, there are differences: the "mismatch" between the two metrics tends to decrease over time for all large advanced exporters, whereas it is increasing for China and some emerging economies. A common narrative interpretation of emerging economies' involvement in GVCs holds that these countries have been moving away from the central through of the "smile curve" [2] (low-value-added manufacture and assembly) towards pre- and post-manufacturing high-value-added services activities. We find some evidence supporting this interpretation: the growth of emerging economies as surmised from market shares was stronger in gross-exports terms than in value-added terms until 2004, while the opposite held afterwards. Commodity prices may however have played a role towards such trend reversion (the steep increase in oil prices started around 2004 and natural resources are concentrated in developing countries).

Differences arise also when restricting attention to the four largest euro-area economies: while levels and dynamics are similar for either notion of market share in each of these countries, the performance of Germany is less outstanding, relative to France and especially Italy, when looked at in value-added terms. In particular, from 1995 up until the Great Trade Collapse in 2009 the Italian market share recorded a cumulative drop, relative to Germany, by around 15 percentage points in gross-exports terms, but by less than 10 points in value-added terms.

The ability of aggregate gross exports at activating domestic value added is a key driver of the relation between a country's market share in gross exports and its share in world GDPX. In our focus on the four largest euro-area economies we offer a sectorial analysis of such pivotal variable. We document that the fall in the ability of aggregate gross exports at activating domestic value added is largely due to the fact that increasing participation in GVCs is widespread across sectors. Secondly, we find some evidence that that the

[1] The terminology is borrowed from Cappariello and Felettigh (2015).

[2] ACER Computer's CEO Stan Shih was the first one to put forth the idea that GVCs develop along a U-shaped curve (that is, a smile) where the centre of value creation in the manufacture or assembly of product is flanked on either side by higher value added services activities (concept development, design, engineering, R&D on the pre-manufacturing side; logistics, sales, marketing, branding, after-sale services on the post-production side). See for instance Baldwin (2012) for an academic presentation of the smile curve.

diffusion of GVCs - and the ensuing improvements in competitiveness due to outsourcing of intermediates inputs from abroad at cheaper prices (or of better quality) - seems to impose a trade-off between favorable market shares dynamics and the ability of gross exports in contributing to domestic value added, which weakens the causal link between "external competitiveness" developments and GDP growth.

The question then arises of whether an excessive emphasis is being put on the evolution of export market shares when assessing "external competitiveness". Monitoring shares in world GDPX helps better understanding the phenomena behind the evolution of shares in gross exports and may soon become essential if the diffusion of GVCs continues at the current speed: in five years' time, the GDP of the average country experiencing an expansion in exports worth 100 US dollars will only increase by 40 dollars, according to a simple linear time trend projection.

The paper is organized as follows: Section 2 outlines the methodology we implement in Section3, which considers the forty countries included in the WIOD dataset and offers an overview on market shares in gross exports and in value added, comparing them across countries and across time. Section 4 narrows the focus to the four main euro-area countries and widens the analysis by deepening into the sectorial dimension. A final section draws conclusions.

2. An outline of the methodology

After the pioneering work of Hummels et al. (2001), the biggest leap forward towards a deeper understanding of GVCs has probably been made with the estimation of Inter-Country Input-Output (ICIO) tables, and in particular with the publication of the TiVA database by the OECD and of the World Input Output Database (WIOD) by Timmer et al. (2012). WIOD tables match national IO (supply and use) tables, breaking down the foreign sector among the various partner countries, both on the export (use) and on the import (supply) side. This new ground-breaking empirical basis has allowed a new stream of analysis, mainly aimed at decomposing the domestic value added embodied in exports into "source" countries and sectors and "user" countries and sectors.

While Johnson and Noguera (2012) is the seminal contribution of this "trade in value added" strand of research, a fully coherent analytical (and algebraic) framework was only developed by Koopman, Wang and Wei (2014, KWW henceforth), who offered a methodological approach for decomposing gross exports into various details of three main components: domestic value added, foreign value added and a double-counting term.

Focusing on the first component, the domestic value added embodied in exports (GDPX) tends to grow less than gross exports (GX) when trade in intermediate goods and the complexity of GVCs increase. We will refer to the ratio between GDPX and GX as "GDPX-intensity", since it represents the amount of GDP that is embodied in one unit (one dollar-worth) of exports.

Cappariello and Felettigh (2015) integrate the KWW framework by introducing an additional dimension: the domestic sector where the value added embodied in exports originated, in order to keep track of the domestic value added exported by one sector (manufacturing, for instance) but created in a different sector (services, for example). With this KWW-enhanced framework, Cappariello and Felettigh calculate GDPX for each of the forty countries included in the WIOD database, broken down by exporting-sector and by origin-sector.

Their approach is especially useful for the purposes of this paper as we need to restrict goods trade, since we rely on WIOD tables in USD dollars at current prices and exchange rates (available years are 1995 to 2011). Ideally, one would like to exclude commodities and raw materials: these sectors are characterised by wide price fluctuations, which make it almost impossible to distinguish changes in value added due to actual GVC developments from changes in value added due to price fluctuations alone (terms-of-trade effects).[3] To clarify, when all goods and services are considered a surge in oil prices tends to mechanically decrease the GDPX-intensity of oil-importing countries, as the foreign value added embodied in exports increases, independently of any development in GVCs or the way production is organized. Vice-versa, spikes in oil prices tend to benefit both exports and the GDPX of countries rich in natural resources. In summary, inflation in raw materials tends to increase both shares in world exports and in world GDPX for countries

[3] Cappariello and Felettigh (2015) experiment with a preliminary and incomplete assessment.

rich in natural resources, and vice-versa for the remaining countries. This is one of the reasons why looking at a country's market share can be misleading unless the analysis is conducted in comparative terms, relative to akin competitors, and covers a sufficiently long time span.

In order to address measurement issues related to commodity prices, we choose to focus on exports of manufacturing goods and on their domestic value added content, irrespective of the sector where it originated. That is, we exclude raw materials entirely from exports but only partially from GDPX, since we still consider the domestic value added that is embodied in manufacturing exports while originating in the (domestic) mining and quarrying sector. Excluding also the latter component is part of our future research agenda.

We claimed earlier that the ability of aggregate gross exports at activating domestic value added (the GDPX-intensity) is a key driver of the relation between a country's market share in gross exports (GX-share hereafter, denoted as s_i) and its share in world GDPX (GDPX-share hereafter, denoted as σ_i). More precisely, if the GDPX-share of a given country i is larger (smaller) than its GX-share, then its GDPX-intensity γ_i is higher (lower) than the global average GDPX-intensity γ_w (and vice-versa). In formulas, if we define (a subscript w indicating world averages)

$$\gamma_i \equiv \frac{GDPX_i}{GX_i}, \quad s_i \equiv \frac{GX_i}{GX_w} \quad \text{and} \quad \sigma_i \equiv \frac{GDPX_i}{GDPX_w}, \tag{1}$$

then it can be algebraically verified that:

$$\sigma_i > s_i \Leftrightarrow \gamma_i > \gamma_w \tag{2}$$

The following identity also holds:

$$\frac{\sigma_i}{s_i} = \frac{\gamma_i}{\gamma_w}. \tag{3}$$

Equation 2 implies that looking at countries' *relative* position with respect to the global average GDPX-intensity is a shorthand way of looking at the difference[4] between countries' own shares σ_i and s_i. We will often use this representation (relative position in GDPX-intensity) for comparing shares s and σ throughout the paper.

Notice in particular from equation (3) that simply comparing s_i and σ_i is not sufficient for determining country i's GDPX-intensity, since GX-shares and GDPX-shares differ in the denominator: world gross exports are larger than world GDPX since the same holds at the individual country level (due to the foreign-value-added and the double-counting components of gross exports).

We conclude this section with two caveats about our analysis, which rests on the assumption that GDPX-intensities can be accurately measured from the WIOD database. In fact, this may be a poor postulate, especially for countries that engage heavily in "processing trade",[5] as documented in the literature. According to Dean, Fung and Wang (2011), from 1995 to 2007 over 50% of Chinese exports were classified as processing exports; they split the official Chinese IO tables into normal and processing imports of intermediate goods to find that the domestic value added of normal exports in 1997 and in 2002 was respectively around five-fold and three-fold that of processing exports. Chen et al. (2012) build an IO table for China containing separate technical coefficients for processing exports and normal exports, also finding that domestic value added is much lower in the first case. Koopman, Wang and Wei (2014) calculate on their ICIO table that the domestic value added content of processing exports from China and Mexico in 2004 was around 40%, which is roughly half the value registered in normal exports. Ahmad et al. (2012) use Turkish firm-level data to estimate technical coefficients for firms by distinguishing their primary market between domestic and foreign; they find that the share of foreign content in Turkish exports in 2005 was higher than estimates based on data that do not distinguish between main outlet markets.

In summary, the literature pointed out that properly considering foreign value added absorbed via processing trade would lead to downsized GDPX-intensities for some emerging countries. In order to sense how much such a correction can affect also world aggregates, we have experimented with using adjusted GDPX-

[4] More precisely, the ratio, as equation (3) shows.

[5] That is exports of goods processed in the country using intermediates that were imported under the strict condition of being used only in export-oriented production.

intensities for China and Mexico, as estimated by Koopman, Wang and Wei, and correcting world GDPX accordingly: the GDPX-shares of the two countries are indeed reduced, with no significant change, however, for the other main exporters in the world (see the Methodological Appendix). No definite conclusion is however warranted, since a thorough assessment would require correcting estimates for all the countries in the dataset (including advanced economies). Still, we would expect some rebalancing in favour of advanced countries to occur if global IO tables were improved to distinguish between processing and "normal" trade or between relevant enterprise characteristics (the OECD has ongoing projects in this direction).

Finally, a second measurement issue worth recalling is that our definition of GDPX includes the domestic value added embodied in exports of manufactures while originating in the (domestic) mining and quarrying sector, which leads to an overestimation of GDPX-shares for countries rich in natural resources.

3. Shares in gross exports and shares in value added

3.1. Comparing shares across countries

Figure 1 shows, for each country in the WIOD database, its average share in world gross exports, its average share in world GDPX and the *percentage* difference between the two, which shows the impact of moving to the GDPX metric better than the absolute difference for small economies. Averages are taken over the available period (1995-2011) and countries are ordered according to their GX-share.[6]

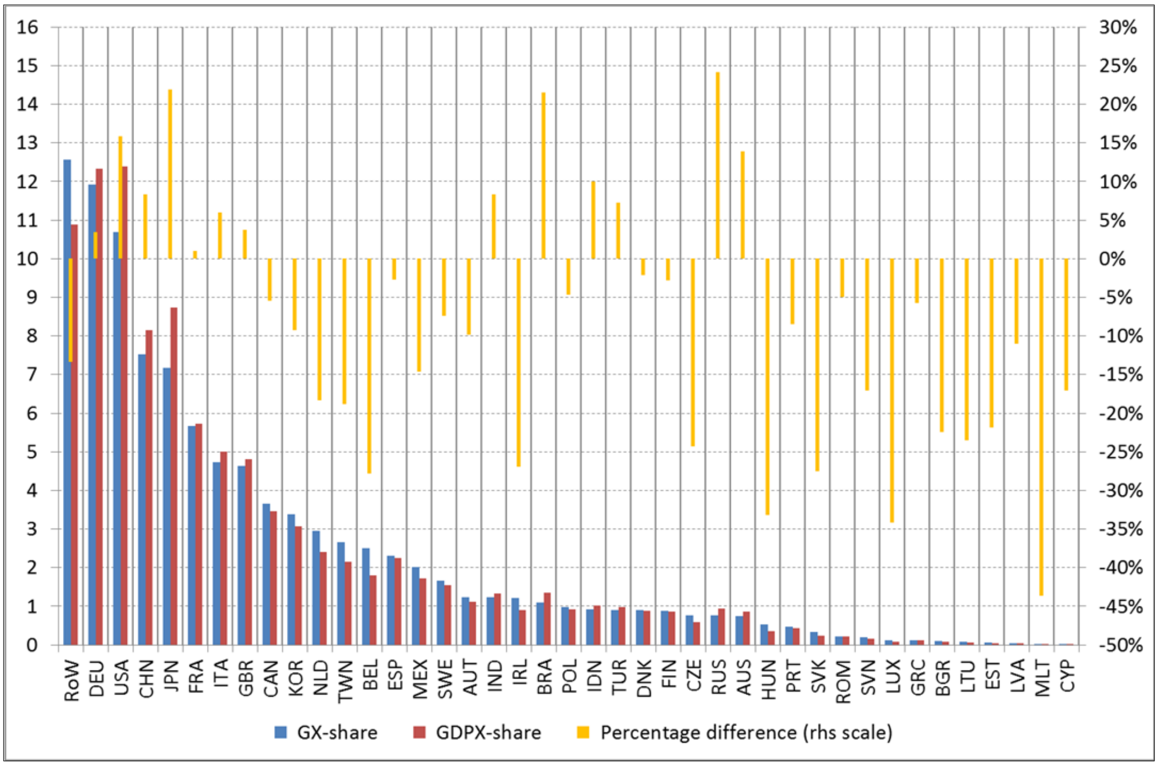
Looking at global market shares "through the lenses of value added" does not seem to convey a radical different ranking of world economies from what can be surmised from nominal export data. We can observe some empirical regularities:

1. A cluster of "big exporters" with both shares above 4% emerges: Germany, the US, China, Japan, France, Italy, Great Britain (disregarding the residual area "Rest of the World").[7] Each country in this group has a share in value added that is larger than the share in gross exports by less than 10 per cent, except for Japan and the US;

2. in remaining countries, the GX-share tends to be larger than the corresponding GDPX-share; the exceptions include economies that are relatively rich in natural resources (Brazil, Indonesia and especially Russia).

[6] Figures A1 and A2 in the Appendix replicate Figure 1 for the initial (1995-96) and the final biennium (2010-11).
[7] In WIOD tables it is defined as the difference between world aggregates and the sum of the forty countries in the database.

Figure 1. Market shares in gross exports and market shares in value added (1)
(percentage points)



Source: authors' calculations on WIOD data.
(1) Average shares in 1995-2011. Countries are ordered in terms of decreasing GX-share. The percentage difference is between countries' GDPX-share and GX-share. Only exports of manufactures are considered.

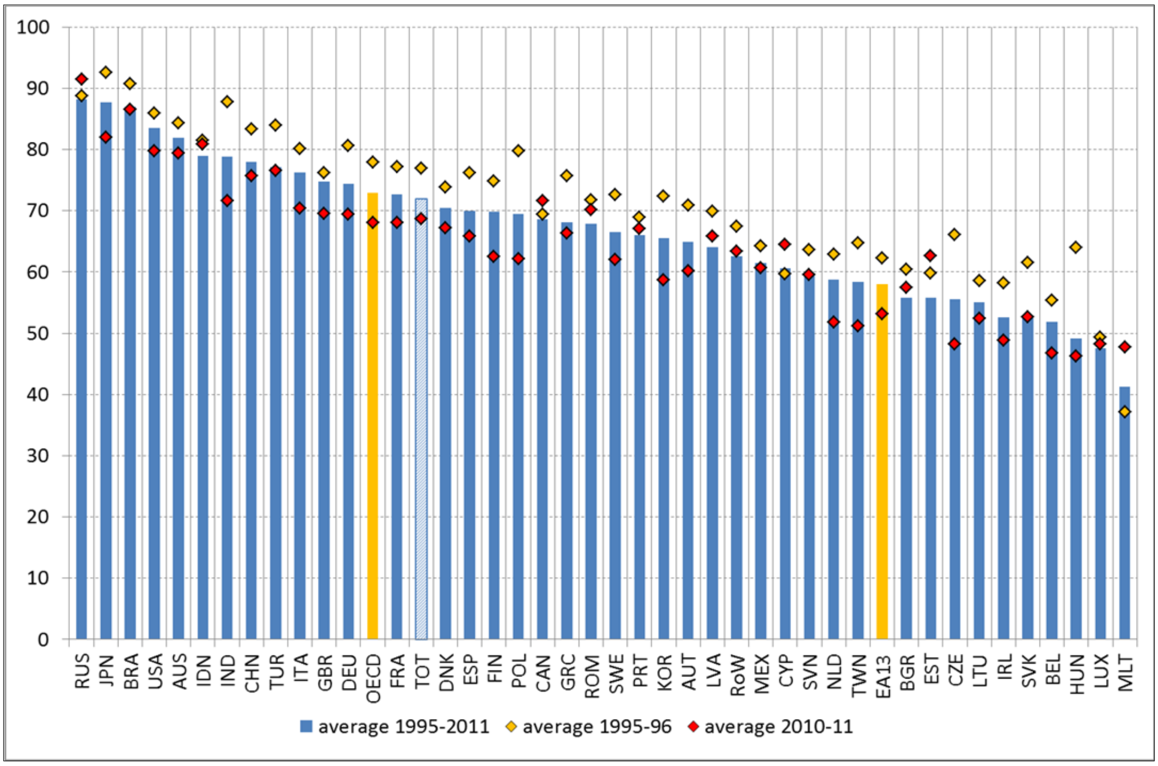
Figure 2 exploits equation (2) above for re-casting Figure 1 in terms of GDPX-intensities: for countries on the left of the "world" shaded bar (namely, for countries with a GDPX-intensity higher than 72%), the share in value added is larger than the share in gross exports.

GDPX-intensity varies a lot across countries, ranging from 88% for Russia and Japan down to 41% for Malta. At the very top of the ranking (intensities above 75% in the 1995-2011 average) we find the BRICs group, Japan, the US, Australia, Indonesia, Turkey and Italy. High GDPX-intensities are due either to limited participation in GVCs or to specialization in the value-added intensive stages of the smile curve, so that the amount of imported foreign value added is relatively small, or to the availability of raw materials and natural resources, as already mentioned. As it might be expected a priori, advanced countries (as approximated by the set of OECD members within WIOD countries, yellow bar in the figure) display a higher-than-average GDPX-intensity; we will come back on this issue when addressing dynamics.

Italy and Germany stand out as the European countries with the highest GDPX-intensity, 3.3 and 1.5 percentage points above the OECD average, respectively. GDPX-intensities around or below 60% are found for emerging (Mexico, Taiwan) and many Eastern European countries, which are often suppliers of intermediate goods to more advanced economies; low GDPX-intensities are registered also in small open economies or countries with a comparative advantage in services and a less relevant manufacturing sector (often the two sets overlap, as it is the case for Luxembourg or Ireland).

The average GDPX-intensity in the period 1995-2011 for the world economy was about 72%; it shrank from 77% in 1995-96 to just below 69% in 2010-11, reflecting the diffusion of GVCs and the ensuing increase in intermediate-goods trade. The fall was a common feature for all countries except Russia, Canada, Cyprus, Estonia and Malta. The next section addresses dynamics more in detail.

Figure 2. GDPX-intensity by country (1)
(percentage points)



Source: authors' calculation on WIOD data.
(1) Yellow bars indicate the areas we derived by aggregating individual countries. The shaded bar represents the global average. Countries are ordered in terms of decreasing GDPX-intensity. Only exports of manufactures are considered.
Notes: RoW is the residual area "Rest of the world"; EA13 is the euro area with 17 members less France, Germany, Italy and Spain.

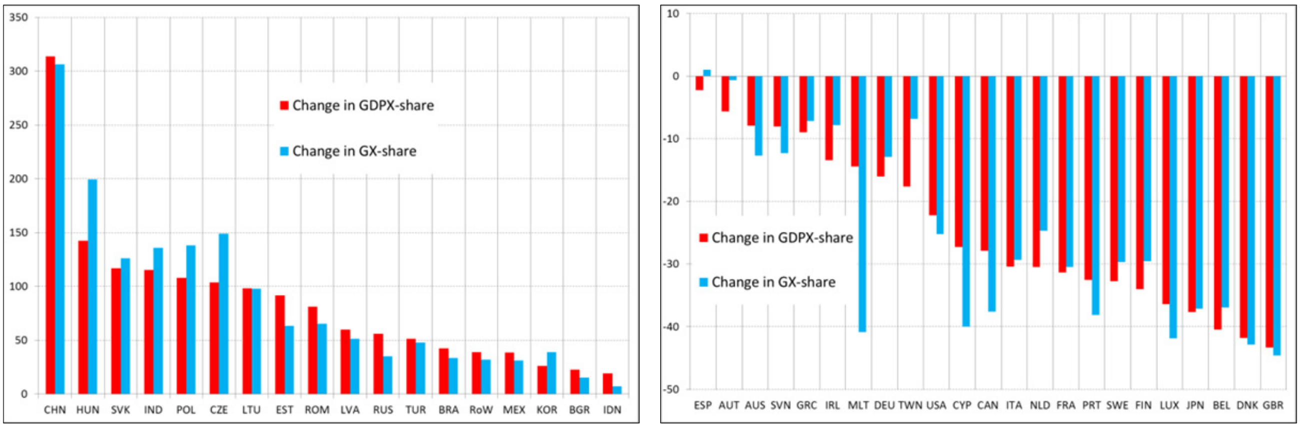
3.2. Shares in time: trends and patterns

Figure 3 compares the variations that the two shares registered in each country between the beginning and the end of the period under examination. As also found by Benkovskis and Wörz (2015), for a vast majority of countries both market shares exhibit very similar dynamics[8]; in particular, both shares lead to the same partition between "gainers" (left panel of Figure 3) and "losers" (right panel), the only exception being Spain. China stands out for the very large increase in both dimensions: Chinese shares surged from 3.7 to 15.2% in value-added terms and from 3.4 to 13.8% in gross-exports terms, a result that mirrors a fall in GDPX-intensity in line with the world average.

Figure 4 reports how, for each country, the difference (s–σ) between the two shares evolved through time, comparing the mismatch at the beginning with that at the end of the period under consideration. As another sign of convergence in the information conveyed by the two metrics, for a large number of advanced countries (which are also large exporters) the difference between the two shares, in absolute value, either shrank markedly or remained virtually steady. Germany and Japan are two remarkable examples; Italy also registered a reduction of its (modest) difference between the two shares. The US, France, the UK and the Netherlands had their respective gaps confirmed.

[8] Although the levels of a country's GDPX-share and GX-share may differ.

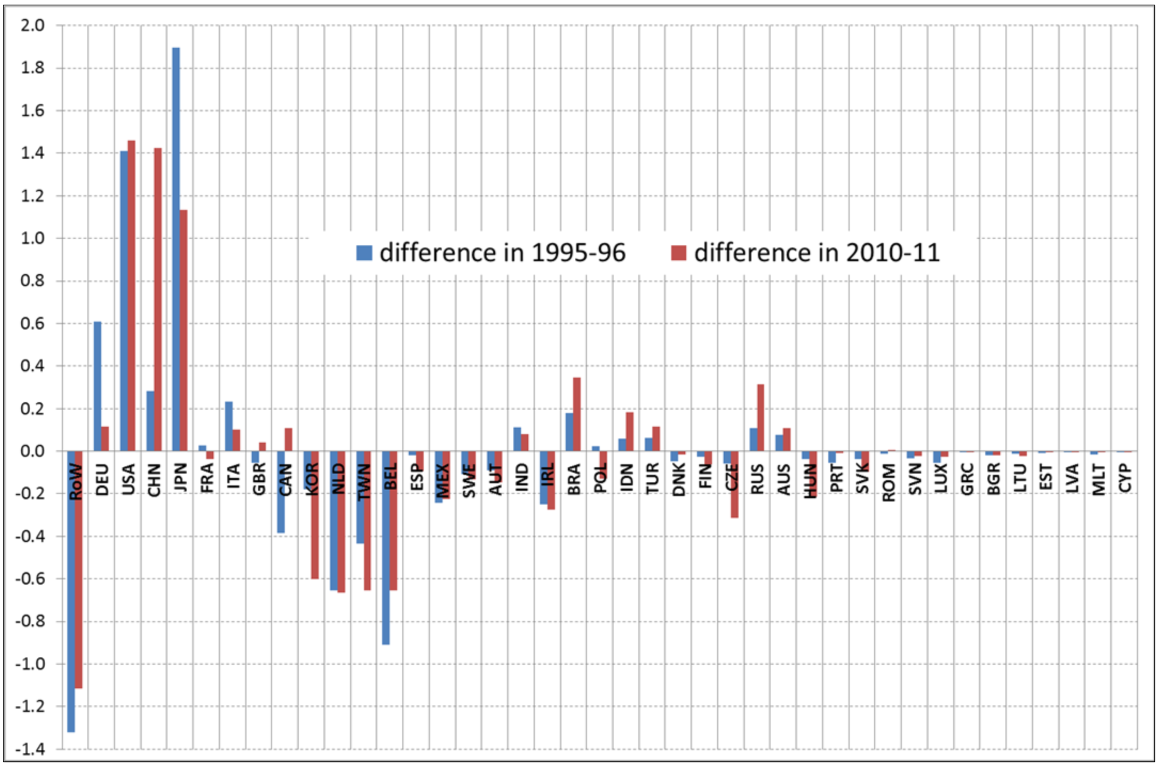
Figure 3. Percentage changes between biennia 1995-96 and 2010-11 in gross-exports market shares and in value-added market shares (1)
(percentage changes)



Source: authors' calculations on WIOD data.
(1) Countries are ordered according to the change in their GDPX-share. Only exports of manufactures are considered.

On the other side, China and other emerging economies recorded an increase in the distance between the two shares; however, while China's GDPX-share was higher than the GX-share at the beginning of the period and even more so at the end, for other Asian economies (Korea and Taiwan in particular) and the main Eastern European exporters (Hungary, Czech Republic and Slovakia, but essentially also Poland) the GDPX-share was lower than the GX-share at the beginning of the period and even more so at the end. The gap between the two shares remains particularly large (above 1 percent, in absolute value) only for the US, China, Japan and the "Rest of the world".

Figure 4. Difference between each country's GX-share and GDPX-share: evolution between biennium 1995-96 and biennium 2010-11 (1)
(percentage points)

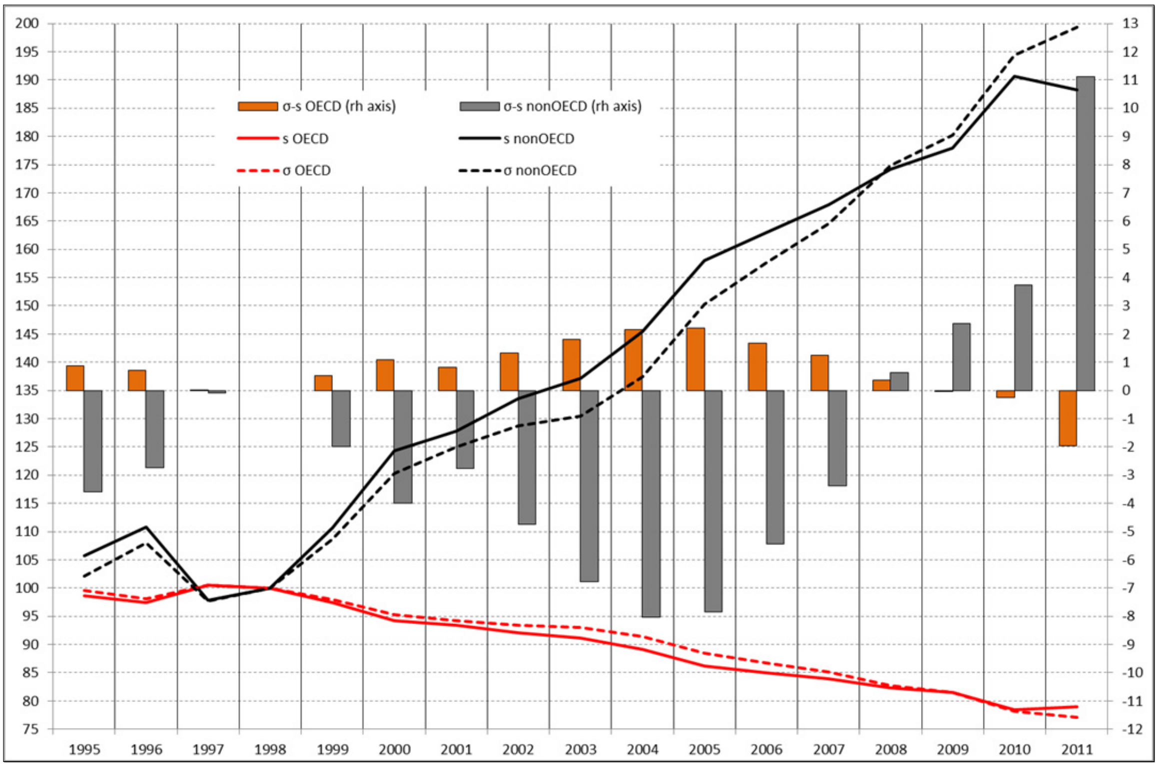


Source: authors' calculations on WIOD data.
(1) A positive (negative) bar indicates that the share in value added is larger (smaller) than the share in gross exports. Countries are ordered in terms of decreasing GX-share, averaged out over the entire sample period 1995-2011 (same ordering as in Fig. 1). Only exports of manufactures are considered.

A rough yet still useful distinction can be made by separating emerging countries from advanced economies (here, for simplicity, identified with OECD members).[9] Figure 5 shows the temporal evolution of the two shares (solid line for the GX-share, dotted line for the GDPX-share; indices 1998=100) for the two groups (advanced economies in red, emerging countries in black); the figure also displays the time series of the difference between the indices of the two shares, on the right-hand-side axis, for each group of countries (orange bars for advanced economies, grey bars for emerging countries). While from 1997-1998 to 2004 the growth of emerging economies as surmised from market shares was stronger in gross-exports terms than in value-added terms (increasing height of grey bars in the negative quadrant), since 2004 a trend in the opposite direction has set off. The mirror-image dynamics for advanced economies show that from 1997-98 to 2004-05 their shares in value added were more resilient, whereas in the following years they contracted at a slightly faster pace than shares in gross exports. The broad message stands that the two shares tend to move together in the medium run; only in 2011 do they show changes in opposite directions, but this may be due to the preliminary nature of 2011 data in WIOD tables.

Figure 5. Advanced vs emerging countries: shares dynamics and difference between GDPX-shares and GX-shares (1)

(shares as index numbers 1998=100)



Source: authors' calculations on WIOD data.

(1) In the legend, σ indicates the GDPX-share, *s* indicates the GX-share, OECD indicates the aggregation of all OECD countries in the WIOD database (our proxy for advanced economies) and "nonOECD" indicates the aggregation of all remaining economies (our proxy for emerging economies). A positive bar indicates a GDPX-share larger than the GX-share. Only exports of manufactures are considered.

[9] There is of course no univocal criterion for qualifying a country as an "advanced economy". In the WEO dataset the IMF indicates 37 countries as "advanced economies". The 34 OECD members do overlap to a large extent with the set of the "advanced economies" group defined by the IMF. Only four OECD members are not classified as "advanced economies" also by the IMF: they are Hungary, Poland, Turkey and Mexico. Of the 34 OECD members, 6 are not present in the WIOD database: Chile, Iceland, Israel, New Zealand, Norway and Switzerland.

In summary, the year 2004 seems to mark a turning point. Until the mid-2000s, an increasing number of emerging economies progressively integrated into GVCs, predominantly as downstream assemblers; the result was a strong increase in exports coupled with a faster reduction, relative to advanced countries, in their GDPX-intensity. This process eventually met a countervailing force which had been gaining momentum: emerging economies started producing and exporting manufactures embodying a larger and larger content of domestic value added, therefore registering an increase in their GDPX-intensity relative to advanced countries and a growth of their GDPX-share faster than that of their GX-share. Commodity prices may again be playing a role, with the steep increase in oil prices suspiciously starting around 2004, as our analysis does not entirely sterilize their effects, and since natural resources tend to be concentrated in developing countries.

Aside from this caveat, a common narrative for the pivotal role of year 2004 refers to the moving position of emerging economies along the "smile curve; while the methodology we borrow from Cappariello and Felettigh (2015) is in fact able to verify whether manufacturing exports increasingly activated value added in the services sector,[10] this is left for future research.

4. A focus on the four largest euro-area countries

We now focus on France, Germany, Italy and Spain in order to (i) take a closer look at the dynamics of their GX-shares and GDPX-shares, and (ii) provide a sectorial interpretation of the evolution of these two global market shares.

4.1. Aggregate analysis

Figure 6 shows that in each of the four countries the two shares tend to be very similar in levels and display almost identical medium-term dynamics over time. This is especially true for France and Spain. For Germany,[11] and to a lesser extent for Italy, the GDPX-share (red bars) is always slightly higher than the GX-share (blue bars), with the difference dying off in 2010-11, although the caveat that WIOD data after 2009 are of a preliminary nature should be kept in mind.[12] While shares tend to display a negative trend in France and Italy, they are basically flat in the case of Spain. German shares undergo a sharp decrease in 1999-2000, which is recovered immediately after, and a relatively larger contraction in the final years.

Relative dynamics are more evident in Figure 7, which plot shares as index numbers (1995 = 100). The medium-term co-movement of the two shares is apparent for all countries; it is especially tight for France and Germany. For Spain, the evolution of the GDPX-share in the late 1990s was somewhat more disappointing than the evolution of the GX-share, but the opposite happened in the early 2000s. While for Germany the cumulative contraction was more pronounced in value added terms throughout the period, the shares in value added of Italy and France were more resilient than their respective shares in gross exports; up until the Great Trade Collapse in 2009, the Italian market share recorded a cumulative drop of around 15 percentage points in gross-export terms relative to Germany, only around 9.5 in value-added terms.

The picture for Germany and Spain being somewhat less favourable, in relative terms, when evaluated on the basis of GDPX-shares may be the flip-side of the stronger resilience of both their market shares, relative to France and Italy, if a larger drop in GDPX-intensity, due to deeper involvement into GVCs and better availability of "cheap intermediates", was associated with faster competitiveness gains which in turn sustained the trajectory of both their GX-shares and GDPX-shares. Policy evaluations should take into account the existence of such likely trade-off between GDPX-intensity and market shares dynamics: a higher GDPX-intensity is good for GDP growth (in expansionary phases); on the other side, defending export market shares may require a deeper involvement into GVCs, which tends to lower the country's GDPX-intensity.

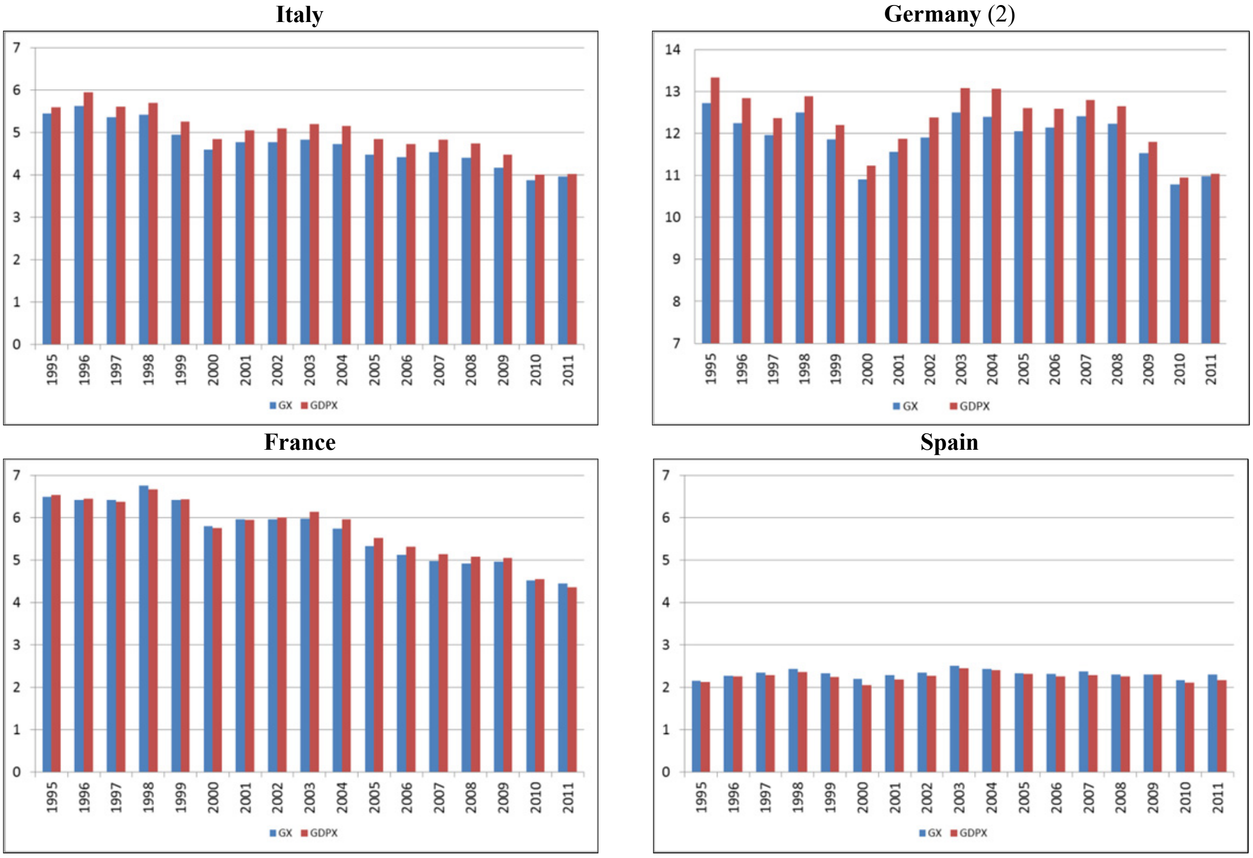
On the other hand, increasing a country's GDPX-intensity need not be beneficial for its GDP growth: while given a positive shock to foreign demand and the ensuing increase in a country's exports, a larger GDPX-intensity translates into a larger rise in GDP, one also needs to consider the counterfactual scenario where a lower GDPX-intensity, associated with gains in price and non-price competitiveness, would have enabled a

[10] Cappariello and Felettigh (2015) find that this tends to be the case for the largest euro-area economies.
[11] For Germany, only the extension of the scale in the graph is uniform relative to the other three countries.
[12] In percentage terms, the difference between the two shares is higher in Italy than in Germany.

larger increase in gross exports. We will come back on this point in the last part of this section, when dealing with the sectorial analysis.

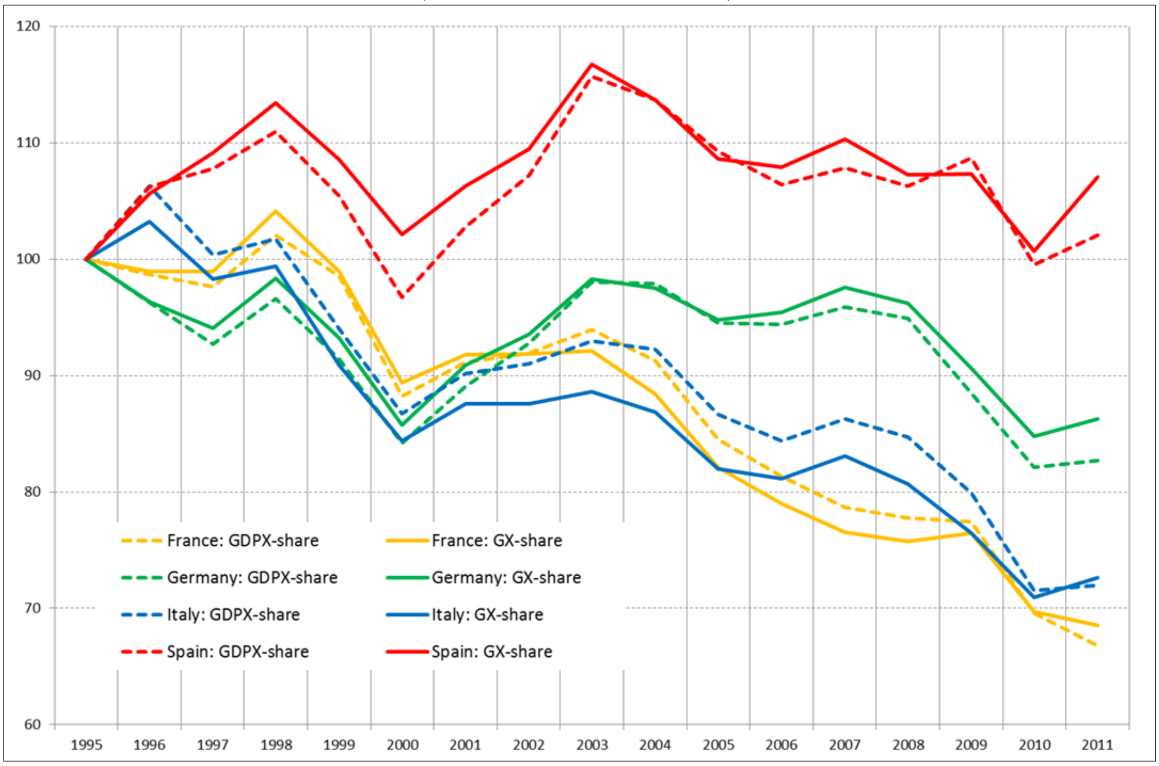
The information summarized in Figures 6-7 can be re-cast in terms of GDPX-intensities, as explained in Section 2. Figure 8 plots the GDPX-intensities of our four countries, together with the world average and, as a further benchmark, the average of the remaining euro-area member states. All countries show a declining trend in their GDPX-intensity, with fluctuations following closely those of the world average. The GDPX-intensity of Italy is the highest, while that of Spain is the lowest and the only one below the world average. The large gap between the GDPX-intensity of the four main euro-area countries and the average for the rest of the euro area reflects, in particular, the weight of Netherlands, Belgium and Ireland, characterised by particularly low GDPX-intensities, as already shown in Section 3.1.

Figure 6. GX-shares and GDPX-shares for the four largest euro-area countries (1)
(percentage points)



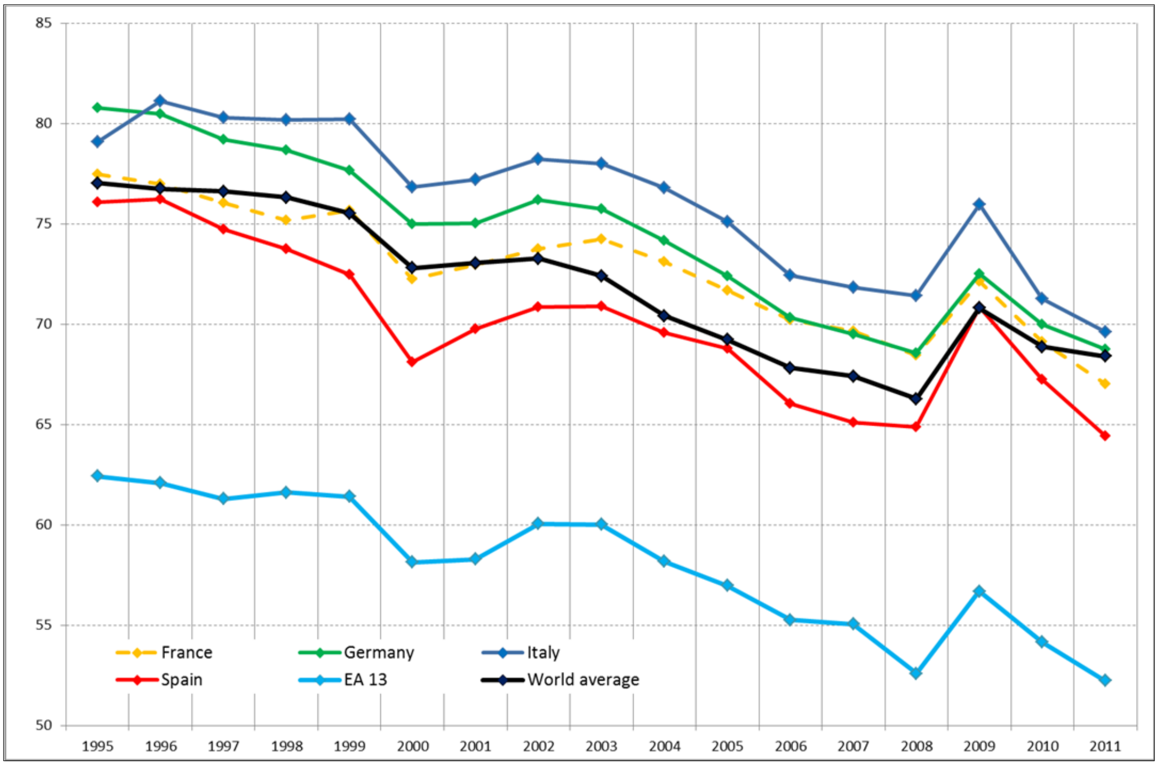
Source: authors' calculations on WIOD data.
(1) Only exports of manufactures are considered.
(2) Differently from the other countries, for Germany the scale on the left-hand-side axis begins at 7 rather than 0.

Figure 7. Dynamics in market shares in value added and in manufacturing gross exports
(index numbers 1995=100)



Source: authors' calculations on WIOD data.

Figure 8. GDPX-intensities over time (1)
(percentage points)



Source: authors' calculations on WIOD data.
(1) Only exports of manufactures are considered.
Notes: EA13 is the euro area with 17 members less France, Germany, Italy and Spain.

4.2. Analysis by sector

Explaining the dynamics of countries' market shares in gross exports and in value added[13] is beyond the descriptive scope of this paper. Some economic interpretation can however be put forth thanks to the sectorial detail of WIOD tables. In particular, Figure 8 has shown that GDPX-intensities in each of the largest euro-area countries fell along a descending trend between 1995 and 2011. A natural question that arises is whether such changes are mostly due to variations in sectorial GDPX-intensities or rather to changes in the sectorial composition. For example, was Italy's drop in GDPX-intensity (around 10 percentage points) mostly driven by the fact that Italy became increasingly specialised in sectors with a low GDPX-intensity? Or was it mostly due to the fact that in 1995 Italy was specialized in sectors that were set to record the biggest contraction in GDPX-intensity in the years to follow? A direct answer to such questions can be given by an algebraic decomposition of the aggregate GDPX-intensity of a country, which is indeed an average of the GDPX-intensities of the various economic sectors k (γ_k), weighted by the sectorial shares in gross exports (s_k):

$$\gamma = \sum_k s_k \gamma_k \, . \tag{4}$$

The total variation as of an initial year t_0 (indicated by the operator Δ) can then be decomposed into three terms:

$$\Delta\gamma = \sum_k s_k^{t_0} \cdot \Delta\gamma_k + \sum_k \Delta s_k \cdot \gamma_k^{t_0} + \sum_k \Delta s_k \cdot \Delta\gamma_k \, . \tag{5}$$

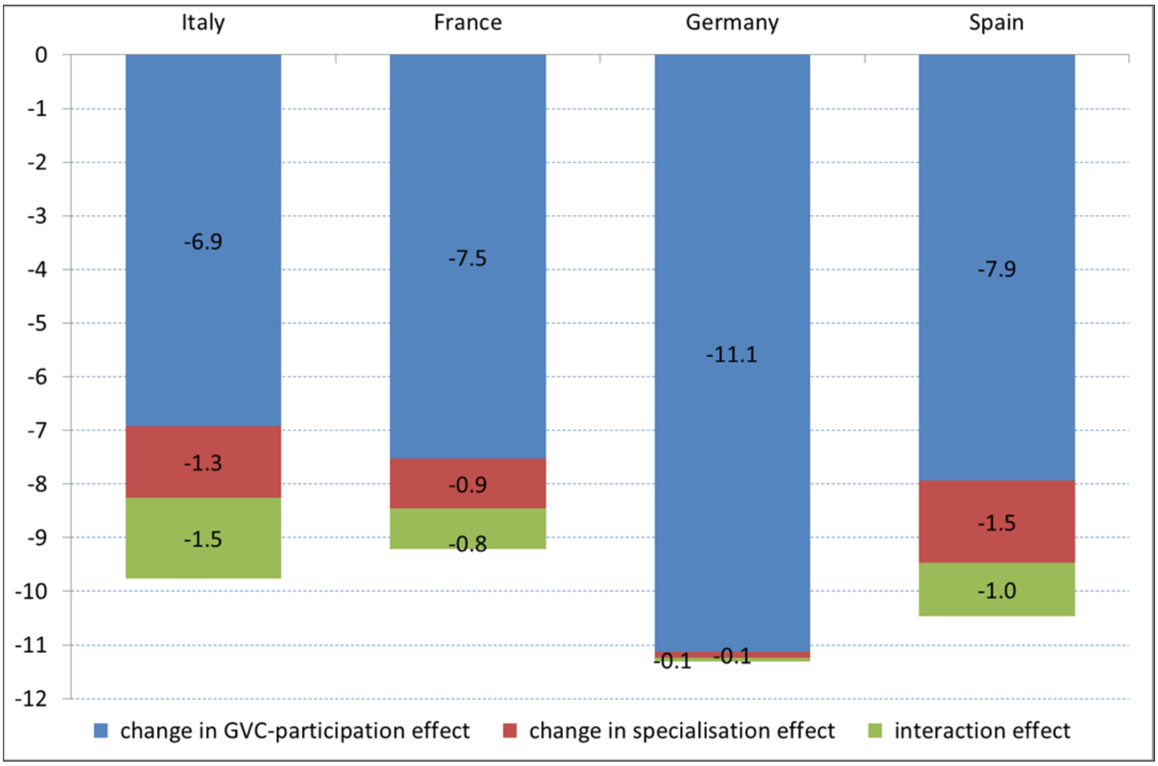
The three terms are:

1. a partial variation due to the shifts of the sectorial GDPX-intensities, measuring the change in γ that would have been observed had the sectorial composition of exports remained constant since t_0 ("change in GVC-participation effect");
2. a partial variation due to changes in the sectorial composition of exports, measuring the change in γ that would have been observed had the sectorial GDPX-intensities remained constant at their initial levels ("change in specialisation effect");
3. an interaction term capturing the second-order effect of simultaneous changes in shares and in GDPX-intensities ("interaction effect").

The results of our decomposition are presented in Figure 9. Two regularities emerge: (i) all three effects have a negative sign, i.e. they all contributed to the fall in aggregate GDPX-intensities, and (ii) the first effect ("change in GVC-participation") is largely dominant, as it accounts for a proportion of the observed change in the aggregate GDPX-intensity ranging from an almost totalitarian 98% for Germany to an hefty 71% for Italy (Table 2 details percentage contributions).

[13] See Benkovskis and Wörz (2015) for a contribution along these lines.

Figure 9. Decomposition of changes in aggregate GDPX-intensities between biennia 1995-96 and 2010-11 (1)
(percentage points)



Source: authors' calculations on WIOD data.
(1) Only exports of manufactures are considered.

The "change in specialisation effect" is negligible for Germany, while it weighs between 10 and 15% for the other three countries, which still translates into modest contributions: had Italy kept its sectorial composition unchanged since 1995-96, its overall GDPX-intensity in 2010-11 would have been 1.3 percentage points higher (71.7% instead of 70.4%). The three effects displayed in Figure 9, that is the three components of equation (5), can be broken down into sectorial contributions (i.e. the addends in each summation). We focus exclusively on the first term ("change in GVC-participation effect"), given its predominance (Figure 10; see Table A1 in the Appendix for evidence on unweighted sectorial GDPX-intensities shifts).

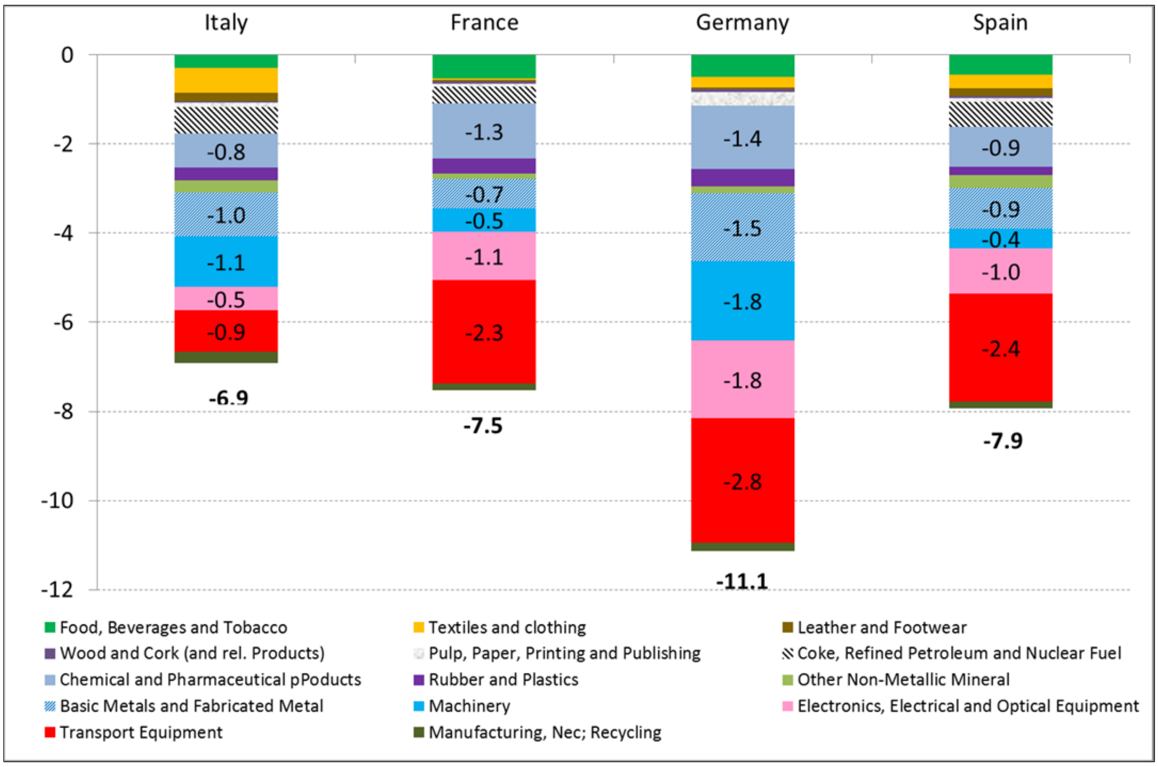
Table 2. Decomposition of changes in aggregate GDPX-intensities between biennia 1995-96 and 2010-11 (1)
(percentage points)

Countries	Total variation in GDPX-intensity	Change in GVC-participation effect	Change in specialisation effect	Interaction effect
		Contributions of the three effects		
France	**-9.2**	-7.5	-0.9	-0.8
Germany	**-11.3**	-11.1	-0.1	-0.1
Italy	**-9.8**	-6.9	-1.3	-1.5
Spain	**-10.5**	-7.9	-1.5	-1.0
		Percentage contributions of the three effects		
France	**-100**	-81.8	-10.0	-8.2
Germany	**-100**	-98.4	-1.0	-0.6
Italy	**-100**	-70.9	-13.7	-15.4
Spain	**-100**	-75.9	-14.6	-9.5

Source: authors' calculations on WIOD data.
(1) Only exports of manufactures are considered.

Five sectors played a major role in the fall of GDPX-intensities in all four countries: (i) transport equipment, (ii) electrical and electronic equipment, (iii) machinery, (iv) chemicals and pharmaceutical products and (v) basic and fabricated metals. These five sectors account for 83% of the overall "change in GVC-participation effect" in Germany, 77% in France, 72% in Spain, 63% in Italy. These cumulative shares for Spain and Italy are smaller because for these countries the weight of refined oil products is also relevant (together with the weight of textiles, in the case of Italy).

Figure 10. "Change in GVC-participation effect": sectorial contributions (1)
(percentage points)



Source: author's calculations on WIOD data.
(1) Only exports of manufactures are considered.

The evolution of national GDPX-intensities in the main sectors is reported in Figure 11, where averages for relevant groups of benchmark countries were also added: euro-area member states other than France, Germany, Italy and Spain, the OECD group and the world average. All four countries tend to display GDPX-intensities consistently above the world average in all sectors, with a few exceptions: transport equipment in Spain and France (and, especially in recent years, Germany), chemical and pharmaceutical products in Italy, textiles (as well as basic and fabricated metal products, especially in the 2000s) in Germany.

Table 3 offers a wider perspective on sectorial GDPX-intensities across all manufacturing sectors, enlarging the view presented in Figure 11. The country-sector cells reporting a GDPX-intensity higher than the world average have been shaded in light blue. Apart from the US, Japan and China, which display GDPX-intensities higher than the world-average in virtually all sectors, Italy and the United Kingdom have the largest number of sectors where their GDPX-intensity is higher than the global average. Spain, which was the country with the highest number of sectors with a GDPX-intensity below the global average, was replaced by Germany at the end of the period. Drops in GDPX-intensities took place in the vast majority of country-sector pairs; according to the world average, they were particularly sharp in the sectors of refined petroleum (no. 8 in Table 3), chemical and pharmaceutical products (no. 9), metal products (no. 12), machinery (no. 13) and transport equipment (no. 15). Many of these productions make intensive use of raw materials and their GDPX-intensity was thus penalized by the surge in commodity prices that took place during the 2000s. The transport equipment sector (no. 15) is often characterized as one of those more exposed to the diffusion of GVCs, with GDPX-intensities decreasing the most in Germany, France and the

US. On the other hand, traditional sectors seem to show GDPX-intensities that are higher and declined less than the average (across products).

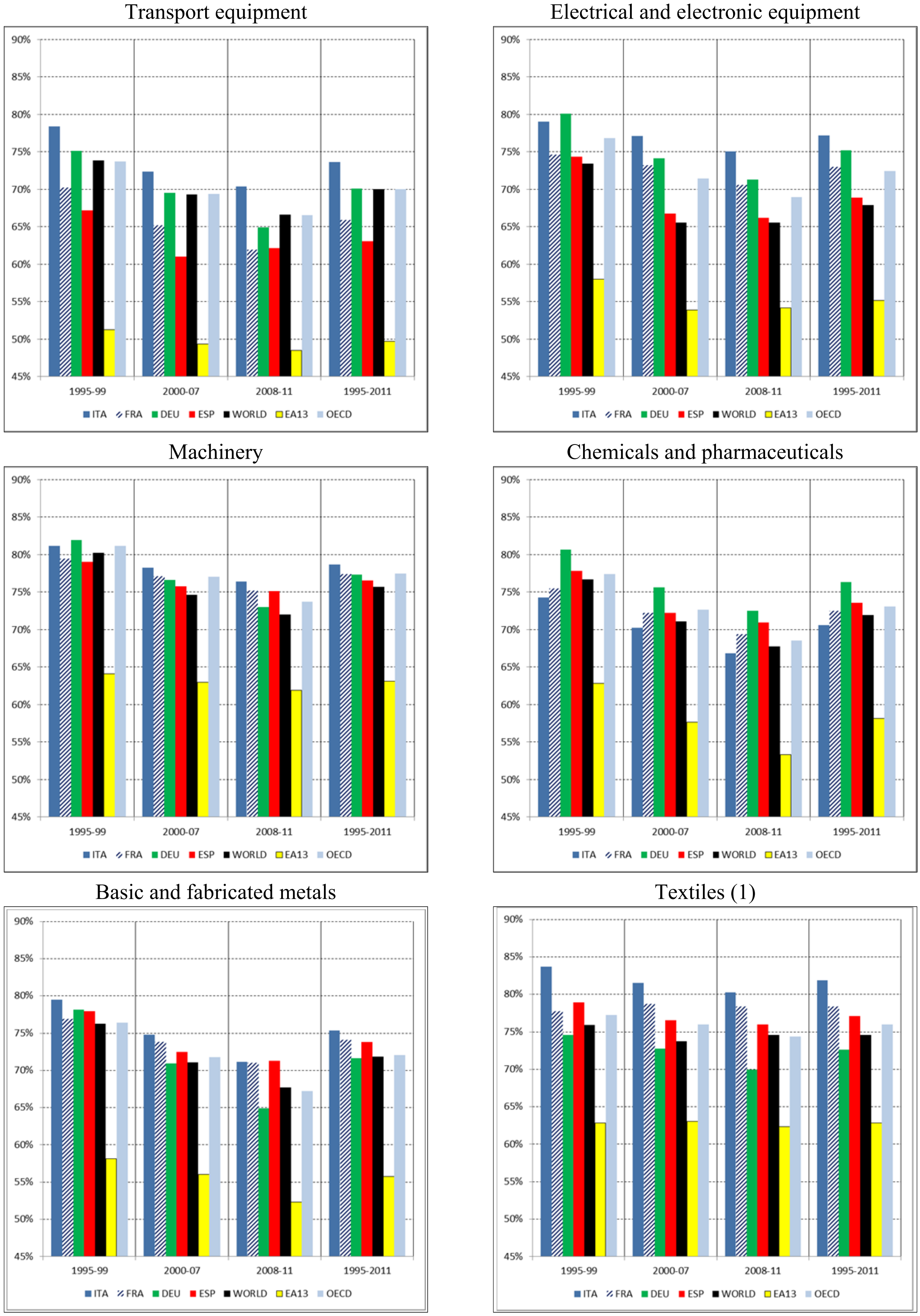
Figure 12 brings the focus back on the four largest euro-area economies to show that there is a (statistically significant) negative relationship between medium-term changes in the sectorial composition of exports and medium-term changes in sectorial GDPX-intensities. On average, when a sector increases its share in a country's gross exports by 1 percentage point, its GDPX-intensity falls by 1.2 percentage points.[14] Although we cannot identify the direction of causality, a lesson emerges: the sectors whose exports grew faster than the national average in the last fifteen years or so are also the sectors whose GDPX-intensity fell the most, which tends to signal that their involvement into GVCs was more dynamic than the average, possibly entailing improved competitiveness via outsourcing of intermediates inputs from abroad at cheaper prices (or of better quality).

Such empirical regularity at the sectorial level (sectors within a country) matches the interpretation we proposed at the geographical level (countries within the euro area). To summarize, in a comparative static framework a larger GDPX-intensity translates into a larger rise in GDP, given a positive shock to foreign demand and the ensuing increase in a country's or a sector's exports. Our empirical findings, however, seem to indicate that in a dynamic framework, one should also consider that higher GDPX-intensities tend to be associated with a lower degree of involvement into GVCs, more limited access to "competitive" intermediate inputs and, ultimately, worse export performance: the increase in exports following the given positive shock to foreign demand tends to be smaller for countries/sectors with a high GDPX-intensity. According to our sectorial analysis, though, the static effect still prevails, as the dynamic medium-term trade-off in is on average between a decrease in the GDPX-intensity and a less than proportionate increase in the export share.

[14] The OLS slope is -1.18, with p-value below 0.5%. Equivalently, the correlation coefficient between changes in sectorial export shares and changes in sectorial GDPX-shares is 0.76.

Figure 11. Sectorial GDPX-intensities: time-averages for the main manufacturing sectors

(percentage points)



Source: authors' calculation on WIOD data

(1) In the text the "Coke, refined petroleum and nuclear fuel sector" is also mentioned, but it is not represented here due to out-of-scale values.

Table 3. Sectorial GDPX-intensities by country/area and by manufacturing sector
(percentage points)

Average in 1995-2011

	3	4	5	6	7	8	9	10	11	12	13	14	15	16	TOT
ITA	83.3	81.9	82.3	81.0	81.6	35.8	70.6	74.8	82.9	75.3	78.6	77.2	73.7	78.8	76.2
FRA	84.8	78.3	80.9	81.8	80.2	43.7	72.5	73.9	83.3	74.1	77.4	73.0	65.9	78.1	72.7
DEU	80.7	72.6	72.4	78.7	81.4	57.9	76.4	75.8	82.7	71.6	77.3	75.2	70.1	79.0	74.4
ESP	82.0	77.1	77.2	79.0	80.0	35.1	73.6	73.7	82.3	73.8	76.6	68.9	63.1	77.1	70.0
GBR	85.3	79.0	85.0	79.0	84.9	67.9	77.6	80.1	82.8	75.7	76.7	72.3	68.4	78.7	74.8
USA	88.9	86.1	82.8	87.4	90.1	65.3	84.5	84.6	89.9	84.5	84.7	85.3	79.1	87.8	83.5
CHN	90.8	83.2	83.1	85.3	84.1	70.2	80.1	79.2	86.4	79.8	80.7	71.0	80.5	86.0	77.9
JPN	92.3	90.7	92.4	86.9	93.0	59.9	86.5	89.5	87.2	84.7	88.9	88.3	89.5	90.0	87.7
EA13	66.5	62.8	67.3	71.6	66.8	36.8	58.2	60.7	70.6	55.8	63.1	55.2	49.7	65.3	58.0
EA17	75.7	73.9	78.1	75.4	74.6	40.6	68.5	71.2	79.4	67.7	74.8	68.8	65.4	74.8	69.3
OECD	79.2	76.0	78.1	79.4	79.3	48.5	73.1	74.5	81.2	72.1	77.5	72.4	70.0	77.5	72.9
WORLD	**80.4**	**74.6**	**77.5**	**79.3**	**79.3**	**59.5**	**71.9**	**74.1**	**80.5**	**71.8**	**75.7**	**67.9**	**70.0**	**74.9**	**71.9**

Average in 2010-11

	3	4	5	6	7	8	9	10	11	12	13	14	15	16	TOT
ITA	79.7	79.1	80.3	78.2	78.7	14.4	65.1	70.5	78.7	69.7	75.5	73.1	69.5	76.9	70.4
FRA	81.6	77.3	79.8	78.2	78.7	38.4	68.1	68.1	80.3	69.7	74.6	68.5	60.6	74.7	68.1
DEU	74.7	69.3	70	73.5	77.9	68.4	72.2	70.7	79.4	64.2	72.3	70	64	74.4	69.4
ESP	80	73.9	75.3	79.1	79.6	24.9	70.2	71.5	80.2	70.2	74.7	65.6	61	75.4	65.8
GBR	83.7	77.3	82.8	78.5	83.8	48.7	74.5	77.3	80.9	68.8	71.7	70.3	62.5	75.7	69.5
USA	86.4	80.9	83.2	86.5	88.1	57.2	80.6	81.3	87	80.3	82.7	88	72	86.3	79.8
CHN	88.9	85.5	85.2	83.7	81.6	59	76.4	77.1	83.7	73.7	77.6	69.4	77.7	85.5	75.7
JPN	89.6	88.4	89.6	84.8	91.1	48.3	80.3	83.8	80.1	76.6	84.5	84.1	84.8	85.4	81.9
EA13	62.9	61.9	66.5	69.5	62.9	22.8	53	59.2	67.9	51.5	61.9	54.4	48.5	63.3	53.2
EA17	71.8	72.1	76.8	72.5	71.7	29.2	63.9	67.5	76.2	62.3	71.2	65.9	61.2	72.0	64.4
OECD	76	73.6	76.5	76.7	76.9	39.8	68.1	71	78.1	66.7	73.5	68.8	65.9	75.2	68.1
WORLD	**79.1**	**73.9**	**78.6**	**78.4**	**77.5**	**53.1**	**68.2**	**71.4**	**78.4**	**68.1**	**71.9**	**65.7**	**66.3**	**70.7**	**68.6**

Percentage difference between average in biennium 2010-11 and average in biennium 1995-96

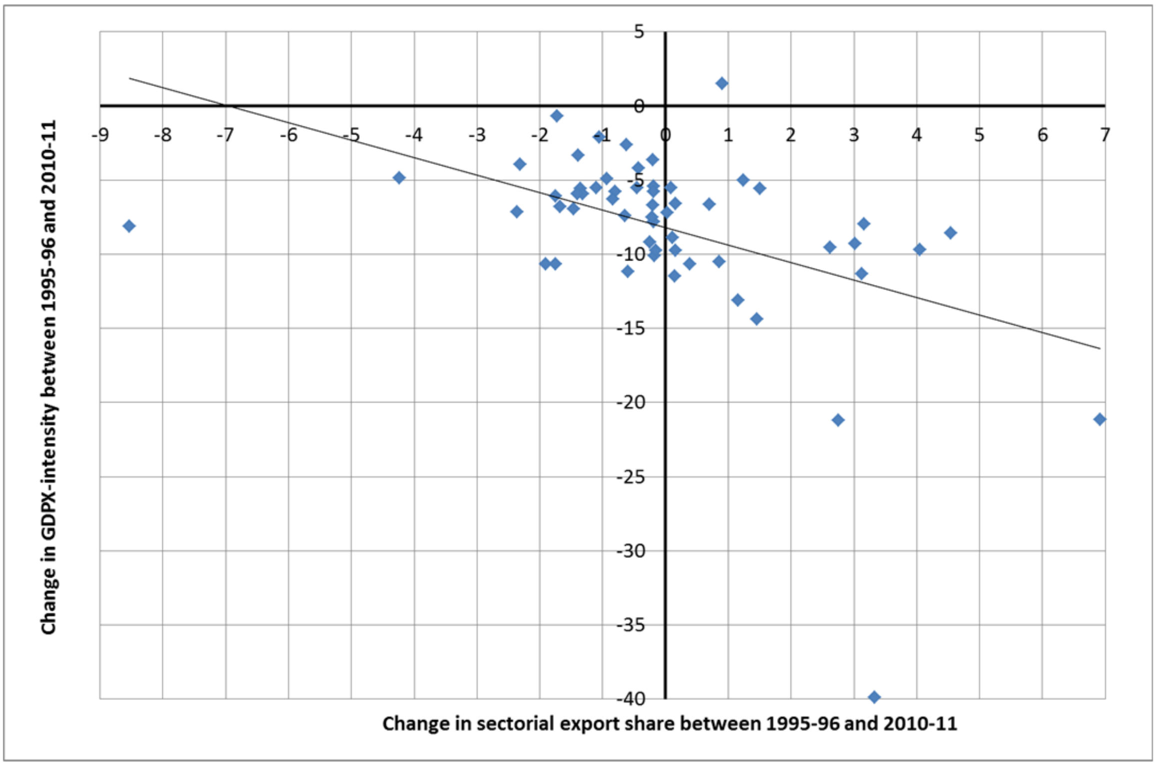
	3	4	5	6	7	8	9	10	11	12	13	14	15	16	TOT
ITA	-5.5	-4.8	-3.2	-5.3	-4.2	-40.0	-9.2	-7.1	-6.8	-9.5	-5.4	-5.4	-8.8	-3.9	-9.7
FRA	-4.8	-0.6	-3.7	-7.5	-2.1	-21.1	-7.9	-9.7	-5.8	-7.3	-5.5	-7.1	-11.3	-6.5	-9.2
DEU	-10.4	-6.1	-6.6	-11.5	-7.8	1.0	-10.1	-10.6	-9.1	-14.3	-10.6	-11.2	-13.1	-9.7	-11.3
ESP	-5.0	-6.5	-5.9	-5.8	-2.7	-21.0	-8.6	-5.5	-7.0	-9.4	-5.9	-10.7	-8.0	-6.3	-10.3
GBR	-0.8	0.2	-3.6	1.2	0.6	-27.6	-3.5	-1.8	-2.2	-8.5	-6.1	-2.0	-8.3	-2.4	-6.6
USA	-3.9	-8.1	-1.0	-2.4	-2.6	-13.9	-7.6	-6.5	-4.7	-6.8	-4.3	3.5	-10.6	-3.4	-6.1
CHN	-3.4	2.3	2.6	-1.8	-4.8	-20.7	-8.7	-5.6	-5.9	-11.4	-8.3	-9.2	-6.7	-0.3	-7.6
JPN	-4.6	-5.1	-4.8	-4.2	-3.9	-36.1	-13.2	-10.5	-12.1	-15.3	-9.4	-9.0	-9.6	-8.1	-11.5
EA13	-6.1	-1.1	-4.3	-5.6	-7.0	-25.3	-10.8	-2.3	-4.5	-6.8	-2.5	-4.6	-2.5	-3.1	-9.1
EA17	-6.1	-2.5	-3.7	-6.9	-5.5	-23.6	-10.1	-6.7	-6.5	-9.7	-7.5	-7.7	-9.3	-5.5	-9.9
OECD	-5.3	-3.8	-3.9	-6.2	-4.8	-18.7	-10.0	-6.7	-6.1	-10.1	-8.3	-9.2	-8.9	-4.6	-9.9
WORLD	**-3.0**	**-2.1**	**-0.5**	**-3.3**	**-4.2**	**-14.1**	**-8.7**	**-5.7**	**-5.7**	**-8.3**	**-8.6**	**-8.3**	**-8.6**	**-7.8**	**-8.3**

WIOD Codes for sectors

3	Food, Beverages and Tobacco	11	Other Non-Metallic Mineral
4	Textiles and clothing	12	Basic Metals and Fabricated Metal
5	Leather and Footwear	13	Machinery
6	Wood and Cork (and rel. products)	14	Electronics, Electrical and Optical Equipment
7	Pulp, Paper, Printing and Publishing	15	Transport Equipment
8	Coke, Refined Petroleum and Nuclear Fuel	16	Manufacturing, Nec; Recycling
9	Chemical and Pharmaceutical Products	TOT	Total manufacturing
10	Rubber and Plastics		

Source: author's calculations on WIOD data.
Notes: EA17 is the euro area with 17 members; EA13 is EA17 less France, Germany, Italy and Spain. Shaded cells indicate values of the sectorial GDPX-intensity larger than the world average for that sector, i.e. countries having a sectorial share in value added larger than the corresponding share in gross exports.

Fig. 12. Sectorial GDPX-intensity and sectorial specialisation (1)
(percentage points)



Source: authors' calculation on WIOD data.
(1) For each manufacturing sector in each country, the x-axis reports the variation between biennium 1995-96 and biennium 2010-11 in the sectorial export share (i.e., the share of that sector in the country's overall manufacturing exports); the y-axis reports the variation of the sectorial GDPX-intensity. The countries under examination are France, Germany, Italy and Spain. The OLS regression line is also reported.

5. Concluding remarks

We have offered an analysis of two competing metrics, market shares in manufacturing gross exports and market shares in value added (embodied in manufacturing exports), both in levels and in dynamics. We have focussed on the four largest economies of the euro-area within a broader context considering all forty countries available in our dataset and the dichotomy between advanced and developing economies. Our focus on France, Italy, Germany and Spain has widened the analysis by deepening into the sectorial dimension.

Moving from one metric to the other does not alter the "general picture", more so in levels than in dynamics, and more so for advanced large exporters than for emerging economies. Differences do emerge, however, which can be non-negligible for individual countries and/or specific periods. Relative comparisons between countries are especially prone to be affected when such differences have opposite sign or diverge in time.

When considering all forty countries in the WIOD database, we find evidence supporting the common narrative interpretation of recent developments in GVCs: as emerging economies initially specialized in low-value-added manufacture and assembly activities, the large increase in their export shares was not matched by an equal surge in the domestic value added generated by exports; later on (we find 2004 to be the turning point), as these countries started climbing the "smile curve" towards pre- and post-manufacturing high-value-added services activities, the growth of emerging economies as surmised from market shares was stronger in value-added terms than in gross-exports terms.

The two market shares tend to be very similar in levels and display alike medium-term dynamics over time also when focusing in turn on each of the largest euro-area countries (France, Germany, Italy and Spain). Differences are starker when countries are compared one against the other: when looking at the cumulative evolution since 1995, the German share in value added contracted more than the corresponding share in gross exports throughout the period, while the opposite held for Italy and France. It follows that the performance of Germany is less outstanding when looked at in value-added terms: from 1995 up until the

Great Trade Collapse in 2009, the Italian market share recorded a cumulative drop, relative to Germany, of around 10 percentage points, while the gap widens to 15 percentage points in gross-exports terms.

The fact that the picture for Germany tends to be less rosy when evaluated on the basis of GDPX-shares may be the flip-side of the stronger resilience of its market shares, relative to France and Italy. Indeed, a larger drop in the ability of German exports at activating domestic value added, due to deeper involvement into GVCs and better availability of "cheap intermediates", is likely to have been associated with faster competitiveness gains which in turn sustained the trajectory of German GX-shares.

In summary, there may be a trade-off between positive market shares dynamics and the ability of gross exports in contributing to GDP growth. The findings of our sectorial analysis point in the same direction: on average, when a sector increases its share in a country's gross exports by 1 percentage point, its GDPX-intensity falls by almost 1.2 percentage points.

In conclusion, evaluating a country's ability to compete on world markets by means of its GX-share is *on average* largely equivalent to grounding the evaluation on its GDPX-share. Changes in the two shares are highly correlated, both in time-series and in cross-section. Yet for specific time spans and/or countries the two metrics point to divergent indications. In fact, every year, on average, four out of forty countries record changes in their GX share and in their GDPX share with opposite sign. Even more strikingly, every year, on average, 5.4 per cent of the countries that experienced an increase in the level of gross exports over the year actually recorded a decrease in the level of GDPX. That is, the quest for export expansion led to a GDP contraction, and the point is more subtle than the ordinary notion that *net* exports matter for GDP growth.

The diffusion of global value chains weakens the causal link between "external competitiveness" developments and GDP growth. This is a warning about the perils of attributing excessive emphasis on export market shares developments when assessing "external competitiveness" and calls for a more informed analysis of the underlying phenomena. Taking GDPX-shares into the picture indeed helps in this respect, despite this requires data that are not as timely and that involve considerable margins of uncertainty due to estimation.

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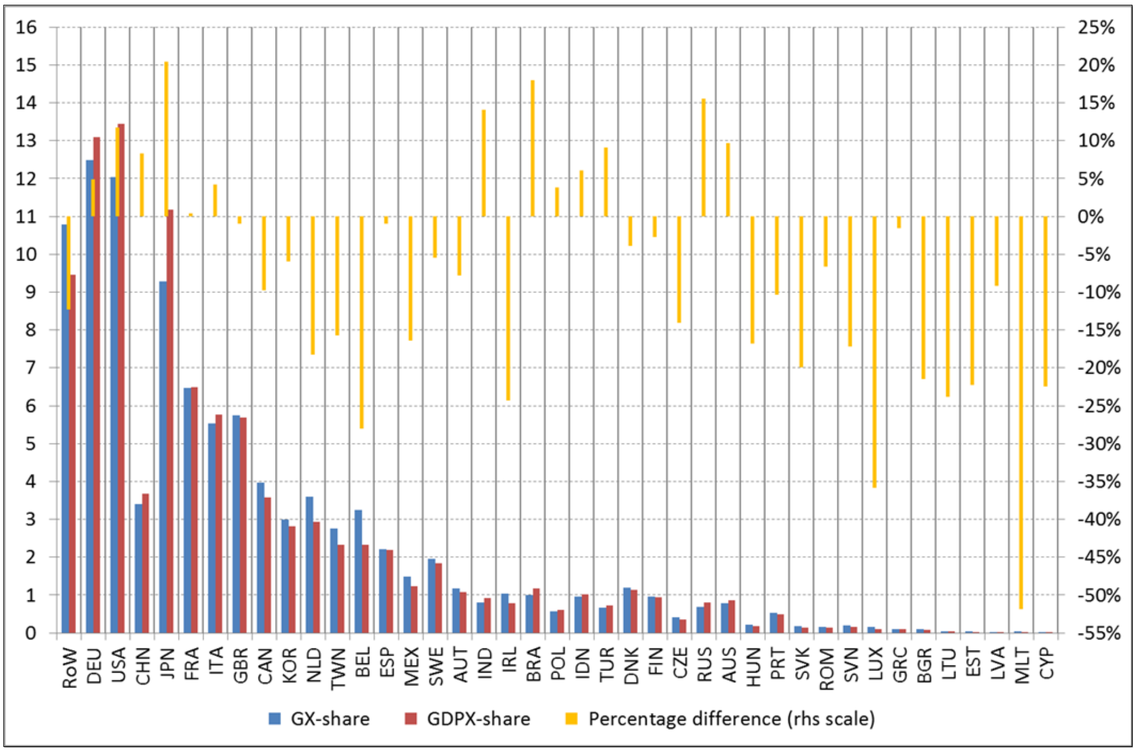
Statistical Appendix

Fig. A1. Market shares in gross exports and in value added, averages in biennium 1995-96 (1)

(percentage points)

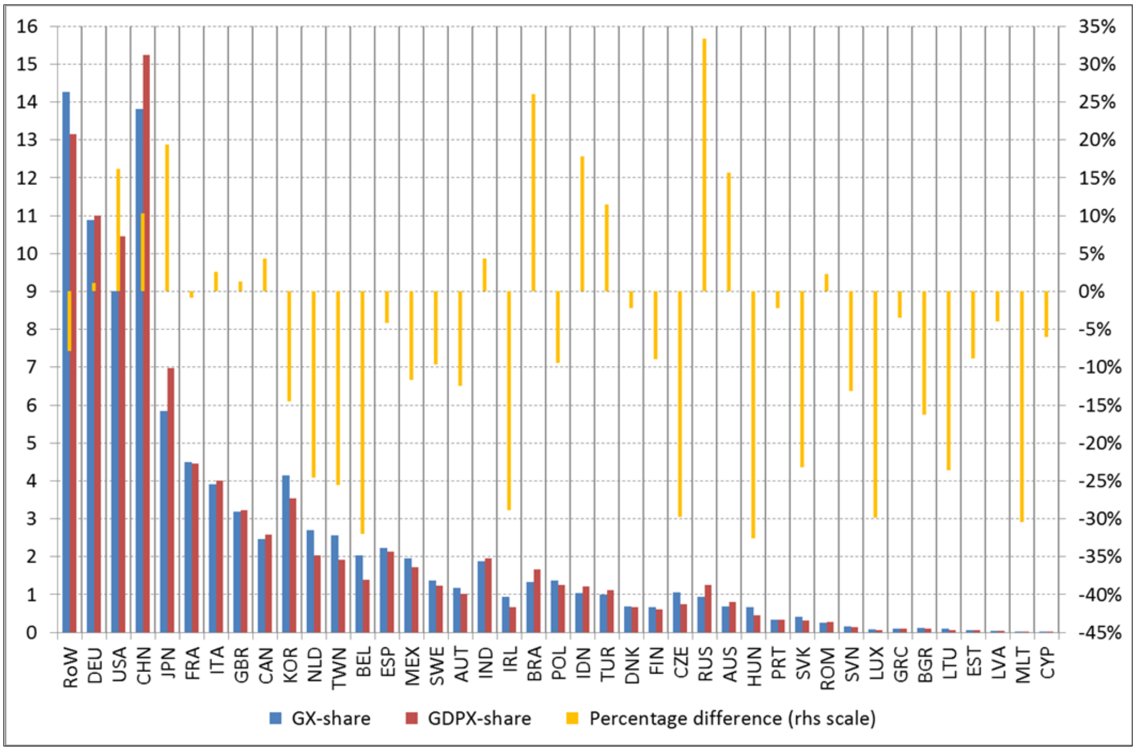


Source: authors' calculations on WIOD data.

(1) Countries are ordered as in Figure 1 in the main text. The percentage difference (right-hand scale) is computed between countries' GDPX-share and GX-share. Only exports of manufactures are considered.

Fig. A2. Market shares in gross exports and in value added, averages in biennium 2010-11 (1)

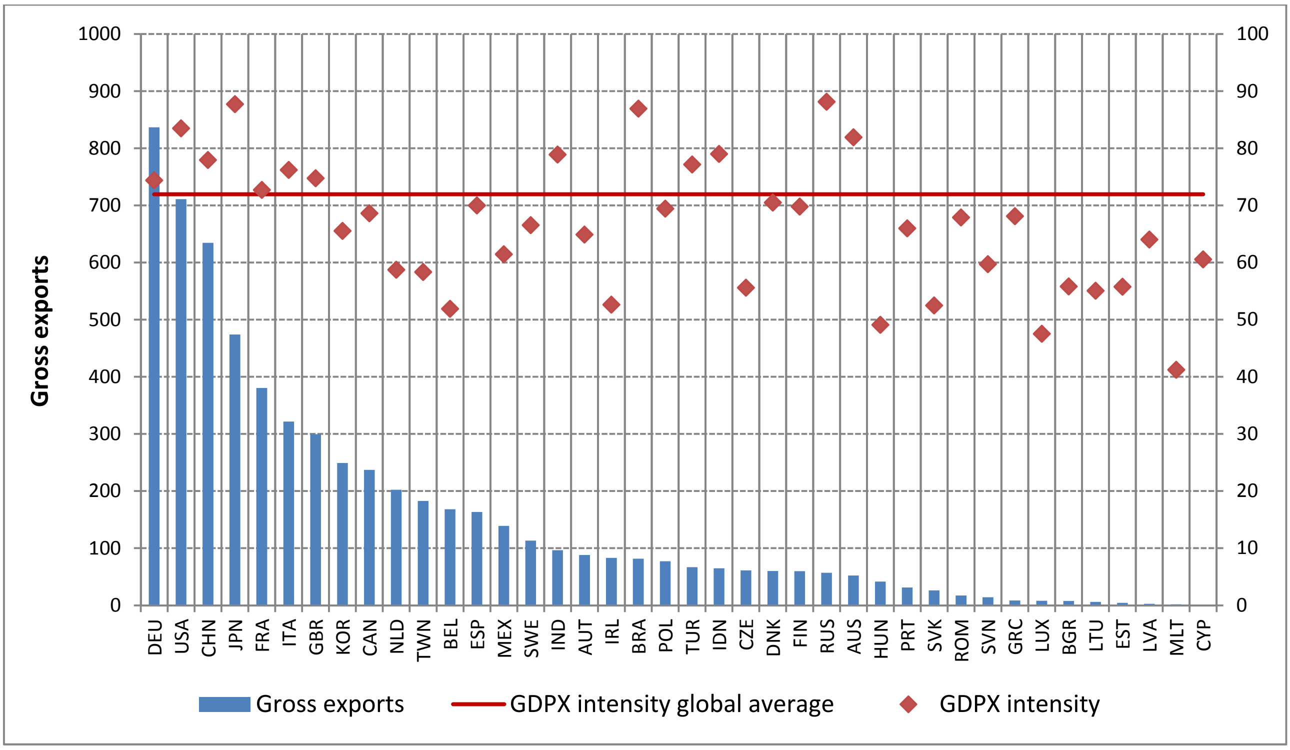
(percentage points)



Source: authors' calculations on WIOD data.

(1) Countries are ordered as in Figure 1 in the main text. The percentage difference (right-hand scale) is computed between countries' GDPX-share and GX-share. Only exports of manufactures are considered.

Figure A3. Gross exports and GDPX-intensity by country (1)
(USD billion for exports; percentage points for GDPX-intensities, on the right-hand scale)



Source: Authors' calculation on WIOD data.
(1) All values are averaged over the whole period 1995-2011. Countries are ordered by size of gross exports. Only exports of manufactures are considered. GDPX-intensities are plotted on the right-hand scale.

Table A1. Sectorial GDPX-intensity variations between biennia 1995-96 and 2010-11 for the four largest euro-area countries
(percentage points)

	Italy	France	Germany	Spain
Food, Beverages and Tobacco	-5.57	-4.89	-10.49	-5.03
Textiles	-4.84	-0.66	-6.10	-6.63
Leather and Footwear	-3.35	-3.65	-6.68	-5.92
Wood and Cork (and rel. Products)	-5.40	-7.52	-11.47	-5.76
Pulp, Paper, Printing and Publishing	-4.19	-2.09	-7.79	-2.65
Coke, Refined Petroleum and Nuclear Fuel	-39.88	-21.20	1.51	-21.18
Chem. & Pharma. Products	-9.27	-7.98	-10.11	-8.60
Rubber and Plastics	-7.19	-9.73	-10.67	-5.52
Other Non-Metallic Mineral	-6.82	-5.80	-9.17	-6.97
Basic Metals and Fabricated Metal	-9.68	-7.43	-14.37	-9.52
Machinery	-5.58	-5.53	-10.69	-5.93
Electrical, IT & Optical Equip.	-5.51	-7.13	-11.18	-10.68
Transport Equipment	-8.86	-11.34	-13.11	-8.10
Manufacturing, Nec; Recycling	-3.96	-6.61	-9.77	-6.31
Total manufacturing	**-9.76**	**-9.21**	**-11.30**	**-10.46**

Source: authors' calculations on WIOD data.

Methodological Appendix

WIOD tables, as the vast majority of available IO tables, assume that all producers within a sector are homogeneous ("homogeneity assumption"). On the contrary, it is a fact that different productions within a sector (or even within a firm) are characterized by a different intensity of domestic value added. Even if we take as correct the WIOD estimate for the overall value added generated by a sector in a given country,[15] the domestic-value added content of its exports (the "true" GDPX-intensity of that sector) then also depends on how each production is split between domestic consumption and exports.

Measuring accurately the GDPX-intensity of a sector requires distinguishing all its "productions" on the basis of both their own GDPX-intensity and their propensity to be exported (i.e. what share of total production is sold abroad).[16] Among the factors affecting this characteristics pair, the following are of crucial importance, and they ought to be taken into account (to the maximum possible extent) when compiling official statistics:

- Exporting status. Exporters are more likely to be also importers, and this tends to be reflected in a lower GDPX-intensity; on the other side, non-exporters do not contribute to GDPX at all. Also, especially in developing countries, goods for exports tend to be of a higher "quality", which may entail a larger resort to imported intermediate inputs. More generally, there is a wide consensus in the literature that exporters are "special", in developing and developed countries alike, in that they are bigger, more productive, pay higher wages and so on (see the classic survey in Bernard et al., 2007).
- "Processing trade",[17] that is exports of goods processed in the country using imports of intermediates from abroad, imported under the strict condition of being used only in the export-oriented production (an extreme case of exporting status). Specifically targeted policies are often in place in order to favour processing trade: imports of intermediate goods are usually waived by tariffs and receive special customs treatment under the condition that they are not used in the production for the local market.
- Foreign ownership or being part of a multi-national group. Firms that are foreign-owned or that belong to a multi-national group are more likely to be interconnected in GVCs, so that they tend to import more intermediate inputs, which is reflected in a lower GDPX-intensity.

The "homogeneity assumption" we have been discussing is related to the well-known "proportionality assumption"[18] nested in input-output tables, as the former refers to the computation of domestic value added in exports, while the latter is related to imports of intermediate inputs. National input-output tables do not have information on the allocation of imported intermediates across domestic sectors. This is estimated using the "proportionality assumption": in each sector and for each intermediate input, the share of imported intermediates in total demand for that input by that sector is computed as the corresponding share for the entire economy.[19] This is equivalent to posing that imported inputs are used *evenly* across sectors and, within sectors, in the production of domestic and exports sales.

In summary, GDPX may be over-estimated when calculated using ordinary IO tables, i.e. under the homogeneity assumption. The bias might be particularly large for the emerging countries more involved in processing trade, as in this case two distinct "production regimes" are likely: one devoted mainly to sales abroad and the other one to internal consumption. How large can this measurement bias be? In order to have a sense of the answer, we substituted for China and Mexico the GDPX-intensities we derived from the WIOD dataset with the improved estimates taken from Koopman, Wang and Wei (2014), as mentioned in the main text.[20] We then recalculated the shares in global value added of all the countries in WIOD for the benchmark year 2005. The results are shown in Table 1; total domestic value

[15] That is, we take as granted that WIOD tables measure each country's GDP correctly.
[16] The main obstacle to fulfilling this goal is, at present, data availability, although efforts are under way to disentangle trade on the basis of enterprise characteristics (Trade by Enterprise Characteristics, in the OECD wording), and some preliminary estimations for a restricted set of countries are available: see for instance Piacentini (2015).
[17] The World Custom Organisation defines "processing trade" as «the Customs procedure under which certain goods can be brought into a custom territory conditionally relieved from payment of tariffs and taxes on the basis that such goods are intended for manufacturing, processing or repair and subsequent exportation».
[18] Also named "import comparability" assumption; see for example Feenstra et al. (2010), and Feenstra and Jensen (2012).
[19] WIOD supply and use tables improve upon the standard "proportionality assumption" by resorting to bilateral trade data on import flows disaggregated according to the Broad Economic Categories (BEC) classification, which assigns each good to a use category (intermediates, final consumption or investment) depending on its prevalent use. The proportionality assumption is then applied within the use category of intermediates.
[20] The GDPX-intensity for China calculated by the three authors is very close to the value published by the OECD in the TiVA database, where data for China were corrected from 2005 onwards thanks to the availability of more disaggregated IO tables.

added embodied in world exports shrinks by a mere 1.2%; at the country level, the GDPX-shares of China and Mexico are heavily reduced, with no significant change, however, for the other main exporters in the world.

Table 1. Potential bias in measurement of domestic value added in 2005 (1)
(USD million for exports and GDPX; percentage points for GDPX-intensities and shares)

Country	γ (original value)	γ (revised value)*	Gross exports	GDPX (original value)	GDPX (revised value)	σ (original value)	σ (revised value)
China	70.7	63.6	682343	482299	433970	8.9	8.1
Germany	72.4		946499	685251	685251	12.6	12.8
Spain	68.8		183011	125908	125908	2.3	2.3
France	71.7		418714	300134	300134	5.5	5.6
Italy	75.1		351033	263674	263674	4.9	4.9
Japan	86.9		516887	448929	448929	8.3	8.4
Mexico	59.5	51.7	151079	89871	78108	1.7	1.5
US	81.8		722755	591298	591298	10.9	11.0
World	69.2		7850625	5434379	5374287	100.0	100.0

Source: authors' calculations on WIOD data and estimates from Koopman, Wang and Wei (2014).
(1) In the notation introduced earlier, γ denotes the GDPX-intensity, σ denotes the market share in world GDPX. Only exports of manufactures are considered.
(*) Data for China and Mexico are taken from Koopman, Wang and Wei (2014).

The exercise is rather simplistic, since a thorough assessment of the impact of the homogeneity bias would require correcting estimates for all the countries in the dataset (including advanced economies). Moreover, revised values of the GDPX-intensity γ as taken from KWW (2014) are calculated on export flows of goods and services; since exports of services tend to be much more GDPX-intensive than exports of goods, it is very likely that a revised estimate of γ for manufacturing exports alone would lead to an even lower value than that reported by KWW. We can conclude from our tentative assessment that shares in value added seem to be sufficiently robust to reasonable revisions to country-level GDPX-intensities, even if we would expect some rebalancing in favour of advanced countries to occur if the homogeneity bias were properly dealt with in corrected and improved global IO tables.

How does multinational production affect the measurement of competitiveness?

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April 2015

Abstract

This work assembles a unique bilateral dataset on multinational production in the manufacturing sector, where value added and factor incomes are broken down by location country and by ultimate owner country. Using this dataset, which covers 44 countries over the years 2004-2011, we compute measures of production capabilities where value added is allocated across countries not according to the location of the activity but according to the nationality of firms or to the nationality of factors involved in production (Baldwin and Kimura 1998). These indicators based on the ownership of production are then compared to standard geography-based indicators. This framework is also applied to the analysis of the two modes of supply of foreign markets (exports and FDI) using a common metric based on value added (domestic value added in exports versus value added of foreign affiliates). Overall, the evidence suggests that there are significant differences between geography-based and ownership-based measures, proving that, in an increasingly integrated global economy, ownership matters for the measurement of competitiveness.

Keywords: multinational companies, foreign direct investment, ownership-based competitiveness, global value chains.
JEL Classifications: F21, F23, F14, L60.

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The author is grateful to Rita Cappariello for the discussions that led to this paper and to Riccardo De Bonis, Emmanuel Dhyne, Silvia Fabiani, Sara Formai and participants to the 2014 European Trade Study Group conference, to the OECD Working Group on International Investment Statistics and to the ECB-Banco de Espana 12th CompNet Workshop for helpful comments. The views expressed in this paper are those of the author and do not necessarily reflect those of the Bank of Italy.

1 Introduction

In a world with multinational companies, the geographical location of production does not coincide with the ownership of production. The increasing relevance of multinational groups at the global level determines therefore a growing separation between measures of activity based on location (domestic or geography-based indicators) and measures based on the nationality of firms or factors involved in production (national or ownership-based indicators). In particular, standard measures of competitiveness based on exports or income generated in the production of tradable goods might be strongly affected by the strategies of multinational companies; for instance, they might not adequately capture the effects of a dominant presence of foreign affiliates in certain countries or of a sudden expansion of activities abroad by domestic investors.

However, the lack of detailed bilateral datasets on foreign affiliates' activity has thus far prevented a thorough analysis of how multinational production affects the measurement of the competitiveness of a nation's companies in an increasingly integrated global economy. This paper attempts to fill this gap. It starts by assembling a unique bilateral dataset where value added and factor incomes are simultaneously broken down by country of location and by firms' ultimate owner country. The dataset, which covers 44 countries over the years 2004-2011, is built using a combination of foreign affiliates statistics from international sources, national sources, commercial firm-level databases and various estimation procedures.

Using this innovative dataset, the work puts forwards new measures of production capabilities of the manufacturing sector, where value added is allocated across countries not according to the location of the activity but according to the nationality of firms or to the nationality of factors involved in production. The first measure corresponds to the value added generated at home or abroad by domestically-owned firms, which is an indication of the capabilities of the home-country's geographically mobile factors (capital, management, production techniques and designs), combined with various countries' immobile factors. The second measure corresponds to the value added generated by national factors (labor at home and domestically-owned capital at home or abroad). We argue that these new indicators, which take into account of the ownership structure of multinational groups, capture important aspects of the competitiveness of a country's firms or factors of production and could be used to supplement standard indicators based on the location of the activity.

This framework is also applied to the analysis of the choice between export versus foreign direct investment (FDI) as alternative modes to serve foreign markets. The problem of finding a common metric for a proper comparison between exports and the activity of foreign affiliates can be solved via an approach based on value added, where we compare the domestic value added in exports and the value added of foreign affiliates.

This work builds on the seminal contribution of Baldwin and Kimura (1998) and related work on ownership-based measures of competitiveness (Kimura and Baldwin 1998, Lipsey, Blomstrom and Ramstetter 1998 and Ando and Kimura 2005). Our study shares the same motivation underlying this literature, i.e. the increasing importance of multinational activity and the focus on value added as a nonduplicative measure that allows for a proper comparison of production capabilities and of the alternative modes of supply of foreign markets.[1] With respect to this literature, which focused exclusively on two countries (the United States and Japan), our main contribution concerns the much larger set of countries that are considered, thus allowing for the first systematic comparative analysis at the global level.

Our work is also related to the wide literature on foreign direct investment (for a recent survey see Antras and Yeaple 2014). While rich and detailed datasets on the activity of multinational companies are available for selected countries, cross-country research has been hampered by the lack of bilateral datasets on multinational production at the global level. The use of FDI data, which are available on a cross-country basis in the balance of payments statistics, has several limitations. As they capture financial flows and stocks, these data cannot be easily compared to production or exports data. Moreover, the frequent use of special purpose entities, pass-through vehicles and holding companies strongly influence the country and industry distribution of FDI, providing a poor approximation to country and industry distribution of the actual production activity of multinationals (Lipsey 2007). A few recent papers have assembled bilateral datasets on multinational production (Fukui and Lakatos 2012, Ramondo 2014, Ramondo, Rodriguez-Clares and Tintelnot 2013, Alviarez 2014), although generally with a more limited set of variables and a smaller time span than those considered in this work.

A related line of research is the rapidly growing literature on global value chains (GVC; Johnson and Noguera 2012, Johnson 2014, Koopman, Wang and Wei 2014). We take into account a major lesson arising from these studies, discarding gross measures such as exports or sales in favor of a non-duplicative measure such as value added. This is particularly important in the case of the activity of foreign affiliates, which tend to have a relatively low degree of vertical integration: we estimate that the value added of foreign affiliates is only 22 percent of their total sales, reflecting the large amount of inputs that foreign affiliates acquire from the multinational group or from independent suppliers. Unfortunately existing data sources provide very limited evidence on foreign affiliates' trade flows and basically no evidence on the destination and use of affiliates' output, thus preventing us from fully integrating multinational production in the analysis of global value chains. However, we indirectly contribute to this literature in two ways: first, we compare the domestic value added in exports to the value added of foreign affiliates, using value added as a common metric to evaluate the relative importance of the modes of supply of foreign markets; second, we show that measuring value added on an ownership basis rather than a location basis has a significant impact on countries' relative competitiveness, thus providing an important qualification to existing measures of GVC incomes on a location basis (Timmer, Los, Stehrer and de Vries 2013).

The rest of the paper is organized as follows. Section 2 describes the data sources and the methodology. Section 3 describes the ownership-based measures of production capabilities. Section 4 presents the comparison between exports and the activity of foreign affiliates on a value added basis. Section 5 concludes.

[1]Along this line of reasoning, Greenaway, Lloyd and Milner (2001) also argue in favor of the value added by factors owned by residents as the ideal approach to avoid any double counting in the context of international production.

2 Data

2.1 Bilateral dataset on foreign affiliates

We assemble a detailed bilateral dataset on the activity of foreign affiliates for 44 countries (which cover more than 90 percent of world value added in the manufacturing sector) and a 'Rest of the world' aggregate. The bilateral nature of the dataset refers to the availability of a simultaneous breakdown by location of activity and by ultimate owner country (e.g. value added of U.S.-owned companies in Brazil). The set of countries includes 25 EU countries (the only exceptions are Cyprus, Malta and Croatia), Switzerland, Russia, Turkey, 4 countries in the Americas (United States, Canada, Mexico and Brazil), 11 countries in Asia (China, Hong Kong, Korea, India, Indonesia, Japan, Malaysia, Philippines, Singapore, Taiwan, Thailand) and Australia.

The time span of our final dataset covers the years 2004-2011. In principle, we collect foreign affiliates' statistics since 1995, but we do not report results for the first decade due to serious concerns about data gaps and breaks in the time series, which usually reflect profound changes in the definition of foreign affiliates or in the statistical methodology.

We consider only foreign affiliates operating in the manufacturing sector.[2] This reflects various issues, including: the lower data availability for foreign affiliates in the agriculture, mining and service sectors; the higher relevance of tax havens - which do not typically report foreign affiliates' statistics - as a location of foreign affiliates in the service sector; the large heterogeneity within the service sector, which makes the use of imputation methods (in order to recover detailed aggregates from sales or employment data) more controversial. The exclusion of non-manufacturing affiliates from the scope of our analysis, although dictated by data constraints, carries with it potentially significant limitations: the structure of multinational groups specialized in the production of manufacturing goods often includes several non-manufacturing foreign affiliates, which perform specialized business functions such as R&D, financial services, cash pooling.[3]

For each country pair (location country and ultimate owner country) we consider the following variables: sales; number of employed persons; value added (on a gross basis); labor compensation (wages and social benefits); capital compensation (gross operating surplus).

2.2 Sources and methods

Data on multinational production is based on the statistics of foreign affiliates (FATS) reported by Eurostat, OECD and national sources. Inward FATS data describe the overall activity of foreign affiliates resident in the reporting economy. Outward FATS data report instead the activity abroad of affiliates controlled by ultimate owners resident in the

[2]The dataset does not include information on sub-sectors within the manufacturing sector (e.g. textile, machinery, transport equipment, etc.). Although in principle the datasets provided by Eurostat, OECD and national sources include data at the sub-sector level, in practice many cells at this level are flagged as confidential by reporting countries and therefore are not available.

[3]An additional concern is related to transfer pricing practices, through which multinational groups allocate their profits in favor of foreign affiliates located in tax havens; these affiliates would typically be non-manufacturing companies, such as holdings or financial services companies. The implications of transfer pricing are discussed in section 2.2.

reporting economy. We combine inward and outward FATS data in order to maximize the available information on each country pair, with a preference for inward data. The reason is that inward data on foreign-owned firms are usually compiled from the same sources as data for the rest of the economy and are therefore very comparable to the latter (Lipsey, Blomstrom and Ramstetter 1998).[4] This can be seen, for example, in Eurostat regulations, which require countries to report a considerably longer list of variables for inward FATS statistics than for outward FATS statistics. An exception is made for countries with a long tradition of high-quality outward FATS statistics (United States and Japan). Data on foreign affiliates generally include only majority-owned affiliates and are broken down by country of ultimate controlling institutional unit.

For a number of country pairs no information was available on some or all of the variables in foreign affiliates' statistics. This usually reflects the following issues: first, a few countries do not report statistics on foreign affiliates, while some countries report statistics on foreign affiliates only for selected partners; second, outward statistics often include information on employment and sales but not on value added and factor incomes; third, figures for specific country-pairs might be considered confidential by the reporting country. When only a subset of the variables is missing for a given country pair, we impute them using various estimation methods (e.g. applying interpolation or extrapolation methods or using standard ratios - value added per employed person, wages per employed person, etc. - from other countries' foreign affiliates in the same location country). If none of the variables was available for a given country pair, we estimate the main aggregates from Bureau van Dijk's Orbis, the world's largest commercial firm-level database.[5] We extract information on firms' sales, employment and ultimate owner company and use it to estimate the level of sales and employment for the foreign affiliates of a given country pair. We then estimate the remaining variables following the same imputation methods as above. The remaining country pairs for which no foreign affiliate was found in Orbis were assumed to have zero or negligible levels of foreign affiliates' activity.

For countries which report inward FATS statistics, we take the overall level of foreign affiliates operating in a country as given and impose that the sum across all countries (including the 'Rest of the world' aggregate) is equal to the total reported by the location country. We run consistency checks with country totals derived from outward FATS statistics, in order to ensure that our estimates are broadly in line with data reported from the controlling country.[6] For further consistency checks, we compute the share of of foreign affiliates on domestic activity using data on each country's activity in the entire manufacturing sector drawn from the WIOD Socio-economic accounts (Timmer 2012), OECD, Eurostat and national sources.

Table 1 reports that 78 per cent of foreign affiliates' global sales in our database is derived from FATS statistics in 2011, while the remaining 22 percent is derived either from Orbis or from estimation methods. For employment, value added and labor compensation

[4]For instance, in most European Union countries inward FATS data are compiled on the basis of the structural business statistics survey (Eurostat 2012).

[5]The Orbis database has been used by several papers, see for instance Cravino and Levchenko (2014).

[6]Overall, FDI and FATS data are affected to a much lower extent by the 'under-reporting' of assets which characterizes other financial assets such as portfolio securities or deposits. This is shown, for instance, by the comparison of FDI assets and liabilities at the world level, which do not show the huge asymmetry that is found for portfolio assets. There are, however, significant asymmetries at the bilateral level, the most significant of which are mentioned in the Appendix.

the share accounted by FATS is around 60 percent. The reasonably good coverage of FATS statistics, despite the fact that some of the countries included in the sample do not report FATS data, reflects the high concentration of the activity of foreign affiliates, especially on the outward side: five controlling countries (U.S, Japan, Germany, U.K. and France) account for 62 percent of global sales by foreign affiliates. The relative importance of the different data sources varies significantly across countries: for foreign affiliates controlled by the U.S, Germany, Japan, France and Italy, FATS statistics account for 85-95 percent of sales, while their coverage is much lower for several Asian economies (see Tables A1 and Tables A2).

Before moving to the presentation of the results, two methodological considerations are in order. First, the figures should be taken as rough estimates, with potentially significant errors, especially for country-pairs with limited availability of foreign affiliates' statistics in official sources. Even for countries with data available in official sources, there might be statistical issues, such as those related to the identification of the ultimate owner country and to the sector classification of the affiliate. In general, the coverage of FATS data is larger for the main advanced economies and for the majority of EU countries, while tends to be lower for emerging Asian economies.

Second, the value added of foreign affiliates might clearly be influenced by transfer pricing strategies aimed to minimize the tax burden for the multinational group as a whole. The increasing importance of intangible inputs (patents, trademarks, company logos, processes, etc.), which might be allocated to affiliates on the basis of tax-accounting considerations, raises the issue of the extent to which the allocation of value added in a multinational company accurately reflects the actual distribution of inputs (Lipsey 2008, Rassier and Koncz-Bruner 2013). While we are not able to make an assessment about how pervasive such strategies are, this issue should certainly be borne in mind when interpreting our results. On the other hand, assembling a bilateral dataset on value added might also help in pointing out the existence of outliers (e.g. foreign affiliates with extremely high ratios of valued added on sales) that might be related to very favorable tax conditions.

2.3 Aggregate evidence

We estimate that in 2011 (the last year for which data are available) the total sales of foreign affiliates in the manufacturing sector amount to USD 9.3 trillion, with a value added of USD 2.1 trillion and 26.8 million people employed (Table 2). Foreign affiliates account for 21 percent of sales and 18 percent of value added in the global manufacturing sector, even if they account for only 6.7 percent of employment.[7]

[7] Our figures are in line with Alviarez (2014), who estimates that foreign affiliates' sales account for 24 percent of sales of manufactures in a sample of 35 reporting countries. The discrepancy might reflect the fact that our sample includes a larger set of countries, including a few Asian economies with a relatively low incidence of foreign affiliates. Furthermore, our figures are based on world totals (not totals for the sample of countries) at the denominator. In other terms, the denominator includes the 'Rest of the World' aggregate, for which, by construction, we assume away intra-FDI activity (i.e. foreign affiliates owned by countries in the 'Rest of the World' and located in other countries of the 'Rest of the World'). A comparison can also made with the Unctad (2014) estimate, which refers however to all sectors of the economy: total sales of foreign affiliates in all sectors amount USD 24.2 trillion, with a value added of USD 6.3 trillion and 83.0 million people employed. The manufacturing sector seems therefore to account

The share of manufacturing employment operating in foreign affiliates is considerably high (between 30 and 50 percent) in some Central and Eastern European countries (Slovakia, Czech Republic and Hungary), Belgium, Sweden and a few very small countries (Table 3, columns A and B). In particular, foreign affiliates controlled by a given country account for a significant portion of the manufacturing activity in selected countries. For instance, 21 percent of manufacturing employment in Ireland belongs to U.S.-owned affiliates, which account for an even larger share in terms of value added. U.S.-owned affiliates also account for 12 percent of manufacturing employment in Canada, while German-owned affiliates contribute to 13 percent of manufacturing employment in the Czech Republic and more than 10 percent in Austria and Hungary.

There is also significant heterogeneity on the outward side, i.e. when we compare the activity of foreign affiliates to the activity in the controlling country (Table 3, columns C and D). For France, U.S. and U.K the level of employment in foreign affiliates operating abroad is between 50 and 65 percent their domestic employment, while it amounts to 35-40 percent for Germany and Japan and only 15 percent for Italy. This is in line with the evidence suggesting that outward FDI is mostly concentrated among large advanced economies, reflecting the global reach of large multinational groups based in those countries. This is also consistent with the list of the world's top 100 non-financial multinational corporations ranked by foreign assets (Unctad 2014), which shows a dominant presence of companies headquartered in the 5 largest advanced economies.

Among other EU countries, the ratio is even higher in the Netherlands, Sweden and Ireland (80-95 percent), relatively high in Austria and Belgium (35-45 percent) and much lower in economies such as Greece, Portugal and Spain (3-7 percent). The vast majority of developing and emerging countries record a very low, and often negligible, share of employment in foreign affiliates operating abroad on their domestic employment.[8] This is consistent with the evidence reported in the literature on FDI pointing to a strong correlation between outward FDI activity and GDP per capita.

Notice that these figures underestimate the propensity to engage in international production of domestically-owned companies, since the denominator includes domestic activities of foreign-owned companies.[9] It should also be remarked that the figures also include the activities of non-multinational domestically-owned companies in the denominator and therefore they underestimate to an even larger extent the actual propensity to engage in international production of domestically-owned multinational companies.

To illustrate the information available in our dataset, Table 4 reports a snapshot of the largest 20 country pairs in terms of value added. There is a prevalence of advanced countries among these pairs, with all controlling countries being advanced countries and location countries being also mostly advanced countries (13 out of 20). The largest country

for approximately a third of global value added of foreign affiliates in all sectors.

[8]For China, the extremely low level of outward foreign affiliates may be affected by the use of pass-through companies located in Hong Kong, which might be erroneously reported as ultimate companies in FATS or Orbis data. The main reason is however the combination of a low propensity to produce abroad, at least in the manufacturing sector, and the huge size of the Chinese manufacturing sector. Even if we suppose that all affiliates of Hong-Kong-owned companies are ultimately owned by Chinese companies, the value added generated abroad would only be just 1.5 percent of the value added generated in China.

[9]The use of the same denominator as the one for the inward ratios is motivated by the need to facilitate comparisons between outward and inward ratios.

pair regards the activity of U.K.-owned affiliates in the U.S., with value added amounting to USD 68 billion in 2011. It is followed by U.S.-owned affiliates in Canada and by Japanese-owned affiliates in China, with value added amounting to USD 63 and 45 billion, respectively.

There is significant variation in terms of value added per employed person, ranging from USD 33 thousand of Japanese-owned affiliates in China to USD 670 thousand for U.S.-owned affiliates in Ireland. Relative productivity (where the value added per employed person of foreign affiliates operating in the location country is divided by the value added per employed person in the entire manufacturing sector of the location country) is also quite heterogeneous, although almost always above one, in line with the evidence of productivity premia for foreign affiliates. There is also significant variation in terms of the ratio of value added to sales (with about 20 percent for foreign affiliates in China and Mexico to values above 35 percent for Swiss-owned affiliates in the U.S. and U.S.-owned affiliates in Ireland). The average value added-to-sales ratio of foreign affiliates is usually lower than that of the domestically-owned firms operating in the same location country; this might be taken as evidence of a lower vertical integration for foreign affiliates, although there might be other explanations.[10]

Capital compensation as a share of value added (defined as gross operating profits, thus including capital depreciation allowances, business taxes and interest) also shows significant heterogeneity, with low values for foreign affiliates operating in some advanced markets (e.g. U.S.-owned affiliates in Japan) and high values for U.S.-owned affiliates in Ireland and for Japanese-owned affiliates in India. The capital share of foreign affiliates is often higher than the capital share of domestically-owned firms in a given location country, especially in developing or emerging markets; this suggests the ability of multinational companies to extract a higher share of value added, combining proprietary technology, know-how, management skills or brands with low-wage labor.

3 Ownership-based measures of production capabilities

3.1 Definitions

This section shows how the breakdown by firms' ultimate owner country allows us to aggregate value added with a view to computing ownership-based indicators of a country's competitiveness. Note that by competitiveness we refer to production capabilities in the manufacturing sector; data limitations prevent us from considering the service sector, either as a final good or as an input in the production of manufacturing goods.

The standard "domestic" value added (or location-based value added) corresponds to the value added generated in a given country. It can be defined as the sum of the value added generated in country i by domestically-owned firms (i.e. firms headquartered in the same country) and of the value added generated in country i by foreign-owned firms:

[10] Other explanations include: a) foreign affiliates that, together with their primary manufacturing activity, also perform secondary activities as wholesale traders; b) a low level of profitability (especially if competition is strong or if foreign affiliates are in their initial stages of activity); c) transfer pricing strategies (Baldwin and Kimura 1998).

$$VA_i^{location} = VA_{i,i} + \sum_{j \neq i} VA_{i,j} \tag{1}$$

where the first subscript indicates the location country and the second subscript indicates the controlling country.

Following Baldwin and Kimura (1998) and Lipsey, Blomstrom and Ramstetter (1998), value added can be allocated not only according to the location of activity but also according to the nationality of firms. This measure corresponds to the global value added of domestically-owned firms of country i, which can be defined as the sum of the value added generated across the world by firms whose ultimate owner is headquartered in country i:

$$VA_i^{firms} = VA_{i,i} + \sum_{j \neq i} VA_{j,i} \tag{2}$$

This measure reflects the global capabilities of domestically-owned firms, that is the capabilities of the mobile factors controlled by the country's firms (capital, management, production techniques), combined with various other countries' immobile factors (Lipsey, Blomstrom and Ramstetter 1998). It is different from domestic or location-based value added, which instead reflects the combination of the country's immobile factor (labor) with various other countries' mobile factors (domestically-owned capital and foreign-owned capital). The two indicators serve different purposes. While the location-based measure refers to the value added that is generated in a given country, the ownership-based indicator allows to get a broader perspective of the global reach of firms headquartered in a given country.

Value added can also be aggregated according to the nationality of factors (labor and capital) involved in production. This global value added generated by national factors can be obtained as the sum of labor compensation at home, capital compensation in domestically-owned firms and capital compensation abroad in foreign affiliates controlled by domestically-owned firms. This measure corresponds to the sum of the value added by factors owned by residents, or in other terms the gross incomes accruing to domestic factors:

$$VA_i^{factors} = VA_{i,i} + \sum_{j \neq i} LAB_{i,j} + \sum_{j \neq i} CAP_{j,i} \tag{3}$$

Notice that these are gross incomes, which may differ significantly from net incomes (i.e. the profits that multinationals actually earn from their foreign activities after taxation) due to effects of consumption of fixed capital and taxation.[11]

[11] It might be debated whether, in the context of our nationality-based approach, the consumption of fixed capital in foreign-owned firms should be considered as part of the income of the controlling country or of the location country. Although the latter would be more consistent with the practice of national accounts, we choose the former solution because capital compensation data are only available on a gross basis. To correct for the consumption of fixed capital, we would have to estimate depreciation rates for capital used by foreign affiliates, on which no systematic evidence exists.

3.2 Main results

How do ownership-based measures differ from geography-based measures? Figure 1 provides a first answer to this question for the 15 largest economies in terms of value added in the manufacturing sector in 2011. The figure reports the percentage difference between value added by nationality of firms (or factors) and value added by location of activity for each of the 15 countries.

The value added by nationality of firms (blue histograms) is significantly larger than the value added by location for France and the U.K. (about 25 percent), Japan (15 percent) and the U.S. and Germany (10 percent). This suggests the value added generated in the outward activity is considerably larger than the value added generated by the inward activity in these countries. There are significant differences in terms of the geographical distribution of foreign affiliates. These patterns usually reflect a combination of factors, including market size, language, colonial links, distance or other location advantages. For instance, the value added of U.S.-owned affiliates is very large in the other large Anglo-Saxon countries (Canada and the U.K.), but also in Germany, Ireland and the 'Rest of the world', while Japanese-owned affiliates tend to be mainly concentrated in other Asian economies (China, Thailand and Indonesia). The presence of U.K.-owned affiliates is especially strong in the U.S. and in the 'Rest of the world', presumably reflecting language and colonial history. For French-owned affiliates, the most important location countries include all the other large EU countries, but also the U.S. and Brazil, while German-owned affiliates are relatively more concentrated in extra-EU countries (U.S., Brazil, China and the 'Rest of the world').

The value added by nationality of firms is instead very similar to domestic value added in the case of Italy. The value added generated abroad by Italian-owned affiliates (especially in the U.S., Brazil and in large EU countries) is offset by an approximately similar amount of value added generated in Italy by foreign-owned companies (with U.S. and large EU economies as the main controlling countries).[12] For almost all the other economies considered in Figure 1 the value added based on the nationality of firms is smaller than the domestic value added (7 percent for China, 15-20 percent for Mexico, Spain, Indonesia and Canada and almost 30 percent for Brazil).

Considering the full set of countries, value added by nationality of firms tends to be smaller than domestic value added (as indicated by the ratio of the two indicators reported in the last column of Table 5) in Central and Eastern European countries, emerging and developing countries (which are typically FDI recipients, reflecting the need for foreign capital and technologies) but also in a few selected euro-area countries with high levels of inward FDI (e.g. Belgium and Ireland, where fiscal and proximity advantages might play a role). The difference is extremely large (with value added by nationality of firms about 50-55 percent less than value added by location) in countries such as Hungary, Czech Republic and Thailand. Conversely, value added by nationality of firms is much larger than domestic value added in countries such as the Netherlands and Switzerland (about 75 and 90 percent, respectively) and in small countries such as Luxembourg and Hong

[12]Looking at FDI stocks in the manufacturing sector, Italy's outward FDI tends instead to be larger than Italy's inward FDI (by approximately 20 percent in 2011). The difference with respect to the comparison based on value added might reflect several factors, such as differences in the ownership threshold (10 percent for FDI, 50 percent for FATS data), to the immediate versus ultimate counterpart principles and in the economic aggregate (FDI assets versus value added).

Kong.

Looking at Figure 1, the percentage difference with respect to the domestic value added becomes smaller if we allocate value added by nationality of factors (equation (3), red histograms in the Figure) instead of nationality of firms. This is expected since the nationality of factors includes all the labor income in inward foreign affiliates and differs from the location of activity only for the difference between capital income in foreign affiliates and capital income in outward foreign affiliates. Nonetheless, differences remain significant, around 10-15 percent for the largest advanced economies and between -10 and -15 percent for some of the largest emerging economies.

A remarkably different picture also arises when we consider the change in the global market share between 2004 and 2011 according to the different measures (Figure 2 and Table 6). For instance, France records a 39 percent decline in its world market share in terms of value added by location, but only a 24 percentage point decline in terms of value added by nationality of firms. U.K and Japan record a similar trend, with their market share falling by 42 and 29 percent respectively in terms of location value added but only 34 and 24 percent respectively using the nationality of firms. These patterns mostly reflect the expansion of French-owned affiliates in emerging countries and in Germany., of U.K.-owned affiliates in the U.S. and of Japanese-owned affiliates in Asia. Italy also records a relatively more favorable picture in terms of nationality of firms (-29 percent) than in terms of location (-32 percent), which reflects the significant increase in the value added of Italian-owned affiliates after the Chrysler acquisition by Fiat.

There are instead only minor differences between market shares in terms of value added by nationality of firms and value added by location for countries such as the U.S., Germany and Spain. A caveat to this analysis is that value added data are at current prices and exchange rates and the results might be influenced by differences in inflation rates; unfortunately, a constant-price analysis is complicated by the unavailability of data on foreign affiliates' deflators.[13]

4 Exports and foreign affiliates' activity on a value added basis

4.1 Definitions

An approach based on value added proves to be very useful also for a joint analysis of the two modes of supply of foreign markets: cross-border exports and production in foreign affiliates. Comparing exports with FDI flows or FDI income suffers from an apples-and-oranges problem, because exports are a measure of gross sales while FDI flows and FDI income are indicators of financial flows and factor incomes, respectively. A comparison between exports and sales of foreign affiliates is also flawed, because they are both measures of gross output where a given value added may be counted twice or more

[13] Alternatively, one could make the assumption that, in a given location country, the growth rate of value added deflators for foreign affiliates is the same as the growth rate of value added deflator for the entire manufacturing sector of the location country. Although this assumption might be problematic, given the evidence pointing to specific differences between intra-firm trade pricing practices and arm's-length trade pricing practices (Neiman 2010), it might be worth exploring its implications on the results.

times; this happens, for instance, when exports from one country to another country are used by foreign affiliates in the latter country as inputs to their production.

Following Baldwin and Kimura (1998), a proper analysis of the two modes of supply of foreign markets can instead be made on a value added basis, where the value added of foreign affiliates is related to the domestic value added in exports. The former captures the mode of supply of foreign markets via production by foreign affiliates, while the latter captures the mode of supply via cross-border exports. In both cases the use of a value added metrics allows to avoid duplications (i.e. counting twice the same value added) which arise when one works with gross measures. Defining VAX_i as the domestic value added in exports from country i to the rest of the world[14] and $VAFA_i$ as the value added of foreign affiliates with country i as ultimate owner (i.e. all firms in the rest of the world which are ultimately owned by country i), the sum of the two terms (Y_i) represents the total amount of value added generated by country i (either directly via exports or indirectly via its own foreign affiliates) to serve foreign markets:

$$Y_i = VAX_i + VAFA_i \tag{4}$$

Notice that by considering the total value added of foreign affiliates we are implicitly making the strong assumption that the value added of foreign affiliates is entirely activated by foreign demand. This assumption is necessary because, apart from a few countries, there is no systematic evidence on the destination of the output of foreign affiliates. Existing data for selected countries suggest that only a small share of the output of foreign affiliates is sold back to the home country, at least for the manufacturing sector as a whole (10-15 percent for the U.S., Japan and Italy, although there is wide heterogeneity across sectors or across countries of location of foreign affiliates).[15]

Another methodological consideration is in order. Ideally, with detailed information on the export activity of foreign affiliates, one would like to introduce a distinction between exports of domestically-owned firms in country i and exports of foreign-owned firms in country i. Using the same notation as in the previous section with the first subscript for the country of location and the second subscript for the controlling country, this can be expressed as follows:

$$Y_i = VAX_i + VAFA_i = VAX_{i,i} + \sum_{j \neq i} VAX_{i,j} + VAFA_i \tag{5}$$

An ownership-based measure of the two modes of supply of foreign markets by domestically-owned firms would include only the first and the third term, excluding the second term (which corresponds to the domestic value added in exports of foreign-owned firms in country i). However, the distinction between exports of domestically-owned and foreign-owned firms goes beyond data availability for our sample of countries, with only a few exceptions. As a consequence, in the next subsection we will report results based on

[14] I am grateful to Alberto Felettigh and Giacomo Oddo for sharing their data on value added in exports of manufacturing products for 38 countries included in the WIOD database and for the world total. Specifically, we use the GDP in exports (items (1)-(5) of the decomposition in Koopman et al. 2014). For simplicity, we use the term 'value added in exports' (VAX).

[15] Considering the manufacturing sector, the share of output of foreign affiliates amounts to 8 percent in the United States and 12 percent in Italy according to national sources, while for Japan Baldwin and Okubo (2012) report a 14 percent share.

the definition of supply of foreign markets as the sum of domestic value added in exports of country i (including foreign-owned firms) and the value added of foreign affiliates, as in equation 4.[16]

4.2 Main results

Figure 3 shows the difference between world market shares in terms of the overall value added to serve foreign markets and world market shares in terms of value added in exports only. As before, the results are reported for the largest 15 countries in terms of manufacturing value added by location in 2011. As shown by the figure, including the value added of foreign affiliates would increase the world market share of the U.S. and of the U.K. approximately by 30 percent with respect to considering only the share in terms of value added in exports. The world market share of France and Japan would also increase after considering the activity of foreign affiliates, although by a lower extent (10 percent). With the exception of Germany, whose market share would remain almost unchanged with the inclusion of the value added of foreign affiliates, each of the remaining 10 countries would see their market share decrease (between 7-8 percent for Canada, Italy and Korea, 12-14 percent for India and Spain and 15-20 percent for the remaining countries).

Considering the full set of countries (Table 7), Netherlands, Finland, Sweden and Ireland would record a significantly larger market share (between 15 and 30 percent)[17], while several Central and Eastern European countries and emerging markets would record a 15-20 percent lower market share after the inclusion of the value added of foreign affiliates.

Including the value added of foreign affiliates among the modes of supply of foreign markets also matters for cross-country comparisons of the change in world market shares over recent years. This is shown in Figure 4, which reports the percentage change in world market shares on exports and on the sum of exports and foreign affiliates' activity (in value added terms) for the largest 15 countries over the years 2004-2011 (data for the full set of countries are reported in Table 8). Japan represents the country with a striking difference between the decrease in its world market share on value added in exports (-23 percent) and the decrease in its world market share on the sum of value added in exports and value added of foreign affiliates (-13 percent). This reflects the very large increase in the value added of Japanese-owned companies in China, Thailand and Indonesia.

Among G7 countries, France, United Kingdom and Italy also record a more favorable performance after including the value added of foreign affiliates. For Italy, this reflects to a large extent the Chrysler acquisition by Fiat, which has significantly increased the

[16]Notice that the inclusion of value added in exports of foreign-owned firms in our measure of the total value added to serve foreign markets determines a duplication at the world level (but not at the country level). For instance, value added in exports of U.S.-owned firms in Italy are counted twice (in Italy's Y_i as part of the value added in Italian exports and also in U.S.' Y_i as part of the value added of U.S. foreign affiliates). The denominator at the world level, which is the sum of the world value added in exports and the world value added of foreign affiliates, also includes the same duplication, which ensures that all countries' market shares sum up to 100.

[17]In percentage terms, the increase is even larger for Luxembourg, whose market share goes from 0.06 percent in terms of value added in exports to 0.27 percent in terms of the sum of value added in exports and value added of foreign affiliates; this mainly reflects the activity of Luxembourg-owned companies in France, Germany and U.K.

value added of Italian-owned affiliates. The expansion of value added of affiliates in the U.S. also explains the more favorable performance of the U.K. on the measure that includes international production, while France benefits instead from an increase in the value added of its foreign affiliates mainly in Brazil, China and Germany. Among the other large economies reported in Figure 4, the differences between the two world market shares tend instead to be smaller.

Overall, this analysis suggests that including the value added of foreign affiliates has a significant impact on the relative performance of countries on world markets. While we are not arguing that an indicator which includes the value added of foreign affiliates is strictly preferable to indicators based on exports or value added in exports, we believe nonetheless that building measures of competitiveness that take the activity of foreign affiliates into account contributes to a more complete understanding of the performance of firms in the global economy.

5 Concluding remarks

This paper is the first to assemble a detailed bilateral dataset on multinational production, where value added and factor incomes are broken down by location of activity and by ultimate owner country. Our motivation lies in the increasing relevance of multinational companies at the global level, which determines a growing disconnect between the location of production and the ownership of production.

We use this newly developed dataset to compute a set of ownership-based measures of competitiveness in the production of tradable goods, where manufacturing value added is allocated across countries not according to the location of the activity but according to the nationality of firms or on the nationality of factors involved in production. The dataset is also applied to the analysis of the two modes of supply of foreign markets (exports and production in foreign affiliates), using a common metric based on value added.

We find that there are marked differences between geography-based and ownership-based measures of competitiveness, which reflect the strong heterogeneity in terms of outward and inward activity of foreign affiliates. There are significant differences even within the group of main advanced economies, which have typically been among the largest investor countries in terms of FDI. For instance, value added by nationality of firms is 25 percent larger than value added by location of activity in France and U.K., compared to 15 percent in Japan and only 10 percent in the U.S. and Germany; for Italy there is no significant difference between the two measures, reflecting the roughly similar size of outward activity (value added generated abroad by Italian-owned affiliates) and inward activity (value added generated in Italy by foreign-owned companies).

Considering the value added of foreign affiliates among the modes of supply of foreign markets also matters for cross-country comparisons of world market shares. In level terms, the increase in market share after the inclusion of the value added of foreign affiliates is particularly pronounced for the U.K. and the U.S. (30 percent) and for France and Japan (10 percent), while Germany's market share remains almost unchanged and Italy's market share becomes slightly smaller (reflecting the lower propensity to invest abroad compared to export). Taking into account the activity of foreign affiliates matters also for an analysis of the various countries' recent performance on international markets. In particular, over the years 2004-2011 the performance of Japan, U.K. and, to a lower extent, France and

Italy turns out to be more favorable after including the value added of foreign affiliates, while the performance of Germany and the U.S. is only slightly affected.

The use of ownership-based indicators in the economic analysis does not imply that we have to discard geography-based measures, which - as already noted by Baldwin and Kimura (1998) - remain the appropriate measures “for most public policy and research issues”. But taking into account the ownership of production is necessary for several purposes, ranging from the analysis of the competitiveness of a country’s firms and factors of production to monetary policy analysis (since foreign affiliates may react differently than domestic firms to a monetary policy impulse), from taxation (given that multinationals may apply transfer pricing strategies in order to minimize their tax burden) to trade negotiations (which focus on market access and have to consider the different modes of cross-border supply). It seems therefore reasonable to argue, again in line with Baldwin and Kimura (1998), that “ownership as well as geography matters for economic behavior”.

This work is a first step toward a better understanding of the role of multinational companies on a comparative basis for a large set of countries. Our figures should be taken as rough estimates, especially for country pairs with a limited availability of foreign affiliates data in official sources. A logical next step would be to extend the analysis to the natural resources and services sectors. This would require a larger use of imputation techniques, due to the more sparse availability of data for sectors other than manufacturing. The relation between multinational production and trade flows also deserves further investigation, in order to shed light on multinational firms’ role in global value chains. This research agenda would greatly benefit from an improvement of available statistics on the activity of foreign affiliates.

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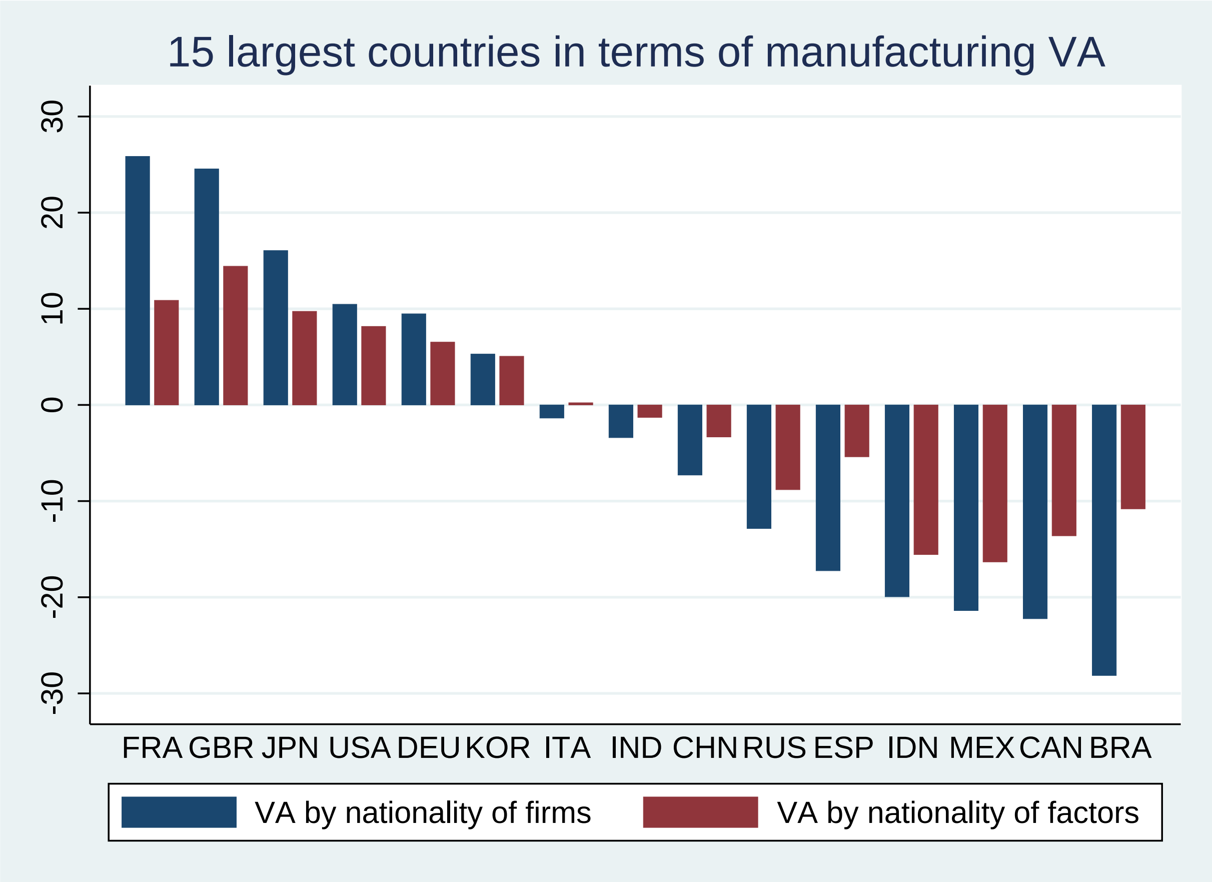
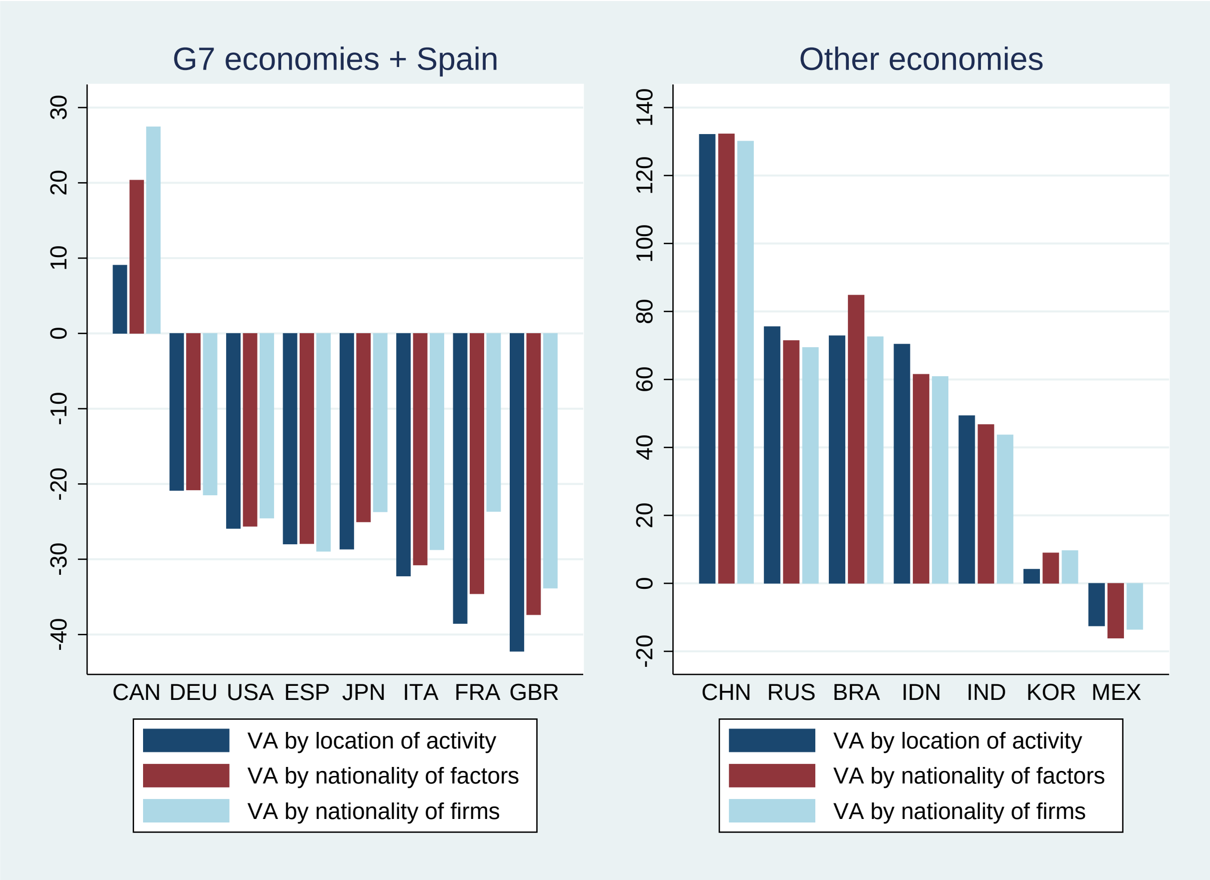
Figure 1: **How does value added by nationality of firms (or factors) differ from value added by location of activity? (percentage differences)**



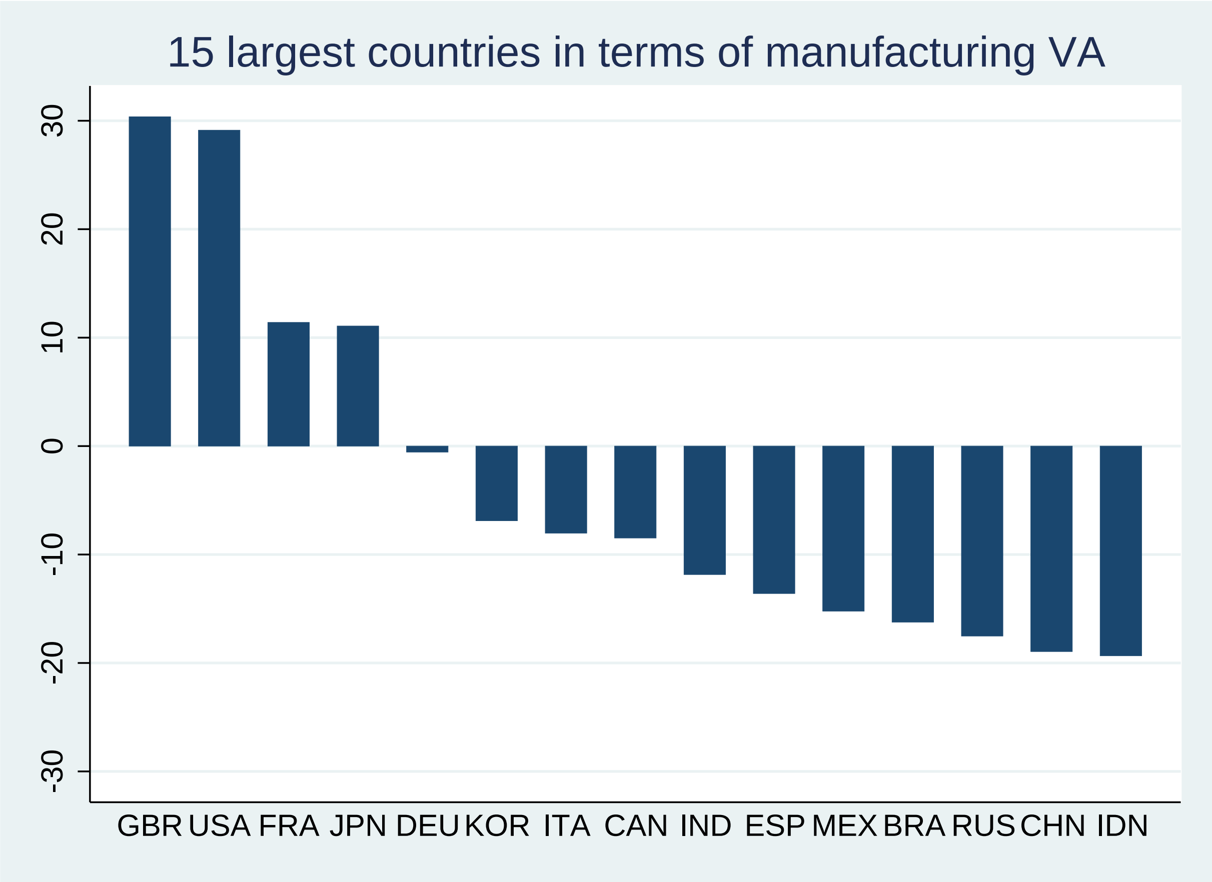
Source: author's estimates. The histograms represent the percentage difference between value added by nationality of firms (or factors involved in production) and value added by location of activity for each country's manufacturing sector in 2011. For instance, for France the value added by nationality of firms is about 25 percent larger than the value added by location of activity, while the value added by nationality of factors is 10 percent larger than the value added by location of activity. The graph includes the largest 15 countries in terms of manufacturing value added by location of activity. Value added is measured at current prices and exchange rates.

Figure 2: **Comparing changes in world market shares on value added by location, by nationality of firms and by nationality of factors: 2004-2011 (percentage changes)**



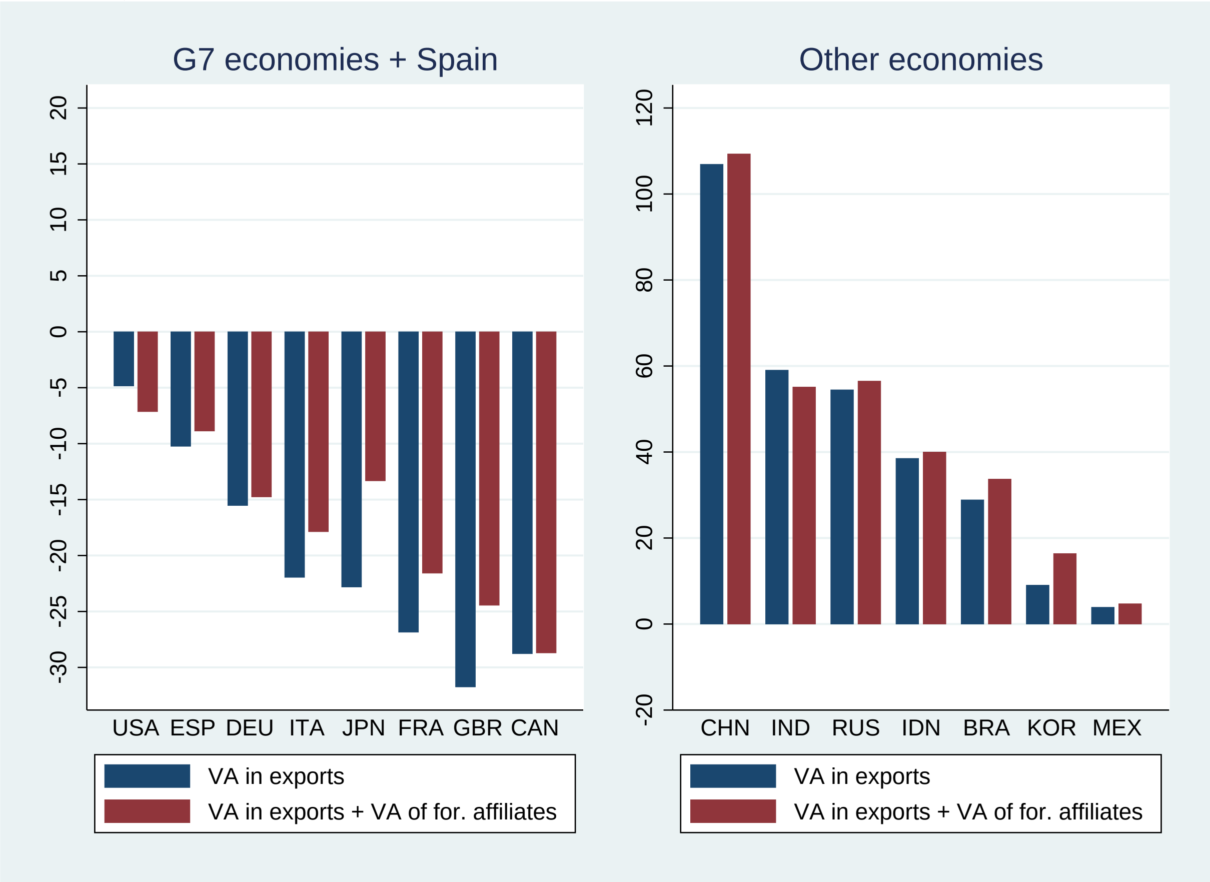
Source: author's estimates. The histograms represent the percentage change in world market shares over the years 2004-2011 according to value added by location of activity, by nationality of firms and by nationality of factors involved in production for each country's manufacturing sector. For instance, Canada records approximately a 10 percent increase in its world market share in terms of value added by location of activity, a 20 percent increase in its share in terms of value added by nationality of factors and a 27 percent increase in its share in terms of value added by nationality of firms. The graph includes the largest 15 countries in terms of manufacturing value added by location of activity. Value added is measured at current prices and exchange rates.

Figure 3: **What happens to world market shares on exports if we include the value added of foreign affiliates? (percentage differences)**



Source: author's estimates. The histograms represent the percentage difference between each country's world market share in terms of the overall value added to serve foreign markets (sum of value added in exports and value added of foreign affiliates) and the country's world market share in terms of value added in exports. For instance, for the U.K. the world market share in terms of the overall value added to serve foreign markets is 30 percent larger than its share in terms of value added in exports. Value added in exports and value added of foreign affiliates refer to the manufacturing sector in 2011. The graph includes the largest 15 countries in terms of manufacturing value added by location of activity. Value added in exports and value added of foreign affiliates are measured at current prices and exchange rates.

Figure 4: **Comparing changes in world market shares in terms of exports and foreign affiliates' activity on a value added basis: 2004-2011 (percentage changes)**



Source: author's estimates. The histograms represent the percentage change in world market shares over the years 2004-2011 according to value added in exports and to the sum of value added in exports and value added of foreign affiliates. For instance, Japan records a 23 percent decrease in its world market share in terms of value added in exports and a 13 percent in terms of the sum of the overall value added to serve foreign markets (VA in exports + VA of foreign affiliates). The graph includes the largest 15 countries in terms of manufacturing value added by location of activity in 2011. Value added is measured at current prices and exchange rates.

Table 1: **Share of activity of foreign affiliates for which FATS data is available (percentage shares)**

Year	Sales	Empl	VA	LAB	CAP
2004	78	55	58	60	55
2005	78	55	57	58	54
2006	75	56	61	62	55
2007	77	60	63	63	58
2008	75	58	62	63	60
2009	79	63	58	65	53
2010	77	60	59	61	54
2011	78	62	58	61	54

Source: author's estimates. The table reports the percentage share of global activity of foreign affiliates - measured by the five variables in column - for which FATS data is available in a given year. For instance, FATS data account for 78 percent of global sales of foreign affiliates in 2011; the remaining 22 percent is estimated either using imputation methods (using FATS data for other variables for the same country pair and applying interpolation or extrapolation methods or using standard ratios from other countries' foreign affiliates in the same location country) or Orbis data. The variables are the following: sales; number of employed persons; gross value added; labor compensation (wages and social benefits); capital compensation (gross operating surplus).

Table 2: **Global activity of foreign affiliates (USD billion, thousand persons and percentage shares)**

Year	Sales	%	Empl	%	VA	%	LAB	%	CAP	%
2004	5339	22.9	23389	6.7	1258	18.3	650	17.2	608	19.6
2005	5882	22.7	24086	6.7	1349	18.2	693	17.4	657	19.2
2006	6705	23.2	24606	6.7	1533	19.2	762	17.9	771	20.5
2007	7668	22.8	25444	6.7	1798	19.9	864	18.3	934	21.6
2008	8587	22.6	26076	6.8	1899	19.5	946	18.4	953	20.5
2009	7174	21.4	25441	6.7	1646	18.6	856	18.6	790	18.4
2010	8179	21.1	26343	6.6	1907	18.9	917	18.5	990	19.3
2011	9337	21.2	26758	6.7	2052	18.0	1012	18.3	1040	17.7

Source: author's estimates. The table reports estimates of the global activity of foreign affiliates in the manufacturing sector and its share on the global manufacturing sector. The variables are the following: sales; number of employed persons; gross value added; labor compensation (wages and social benefits); capital compensation (gross operating surplus). Sales, value added, labor compensation and capital compensation in USD billion at current prices and exchange rates. Number of people employed in thousand persons.

Table 3: **Ratio of inward and outward activity of foreign affiliates on domestic activity: 2011 levels (manufacturing sector)**

Country	Inward		Outward	
	VA	Empl	VA	Empl
	(A)	(B)	(C)	(D)
CHN	0.08	0.03	0.00	0.00
USA	0.18	0.16	0.29	0.52
JPN	0.04	0.02	0.20	0.41
DEU	0.20	0.16	0.30	0.37
ITA	0.16	0.09	0.15	0.14
BRA	0.30	0.10	0.02	0.01
KOR	0.10	0.04	0.15	0.16
CAN	0.33	0.21	0.11	0.14
RUS	0.14	0.06	0.01	0.01
IND	0.09	0.01	0.06	0.00
GBR	0.41	0.24	0.66	0.66
FRA	0.30	0.24	0.55	0.58
MEX	0.25	0.10	0.04	0.01
IDN	0.20	0.05	0.00	0.00
ESP	0.25	0.17	0.07	0.07
TUR	0.17	0.04	0.01	0.01
AUS	0.43	0.25	0.05	0.08
THA	0.56	0.11	0.01	0.00
NLD	0.32	0.23	1.06	0.94
TWN	0.12	0.04	0.19	0.16
CHE	0.38	0.20	1.28	1.55
POL	0.43	0.23	0.03	0.01
SWE	0.40	0.36	0.60	0.81
MYS	0.32	0.29	0.02	0.02
AUT	0.36	0.26	0.32	0.46
BEL	0.55	0.40	0.37	0.36
IRL	0.72	0.32	0.47	0.92
SGP	0.73	0.40	0.28	1.18
CZE	0.53	0.37	0.01	0.01
PHL	0.19	0.10	0.01	0.00
FIN	0.22	0.17	0.62	0.73
ROM	0.22	0.25	0.00	0.00
DNK	0.29	0.28	0.43	0.71
HUN	0.56	0.36	0.06	0.03
GRC	0.19	0.06	0.05	0.06
PRT	0.21	0.14	0.05	0.03
SVK	0.50	0.48	0.03	0.03
SVN	0.27	0.22	0.06	0.11
BGR	0.28	0.20	0.00	0.00
LTU	0.51	0.24	0.03	0.03
HKG	0.25	0.20	4.47	5.65
LUX	0.53	0.51	6.68	9.94
EST	0.53	0.35	0.05	0.05
LVA	0.29	0.28	0.03	0.04

Source: author's estimates. Column A reports the ratio of value added of inward foreign affiliates on domestic value added (i.e. value added by location of activity). Column B reports the ratio of employment of inward foreign affiliates on domestic employment. Column C reports the ratio of value added of outward foreign affiliates on domestic value added. Column D reports the ratio of employment of outward foreign affiliates on domestic employment. Data for the manufacturing sector in 2011. Value added is at current prices and exchange rates. Countries are ranked in terms of manufacturing value added by location of activity in 2011. Figures for the Rest of the world are not reported in the table.

Table 4: **Snapshot of largest country pairs in terms of value added of foreign affiliates (USD billion, thousands of persons and ratios; manufacturing sector)**

Ctrl	Loc	VA	Sales	Empl	VA/Emp	Rel VA/Emp	VA/Sales	Cap/VA
GBR	USA	68	271	235	289	1.99	0.25	0.59
USA	CAN	63	281	287	220	2.02	0.22	0.64
JPN	CHN	45	239	1382	33	2.06	0.19	0.40
DEU	USA	44	199	257	171	1.17	0.22	0.38
USA	GBR	40	192	272	147	1.87	0.21	0.57
USA	DEU	38	174	322	119	1.19	0.22	0.34
CHE	USA	36	106	154	232	1.60	0.34	0.48
JPN	THA	35	112	374	94	4.72	0.31	0.63
USA	IRL	35	99	52	670	3.14	0.35	0.85
JPN	USA	35	195	297	117	0.80	0.18	0.37
USA	BRA	29	128	316	93	3.32	0.23	0.58
NLD	USA	29	200	104	277	1.90	0.14	0.55
FRA	USA	27	102	170	162	1.11	0.27	0.39
USA	CHN	26	129	574	46	2.91	0.20	0.69
KOR	CHN	24	126	452	53	3.33	0.19	0.63
USA	FRA	23	110	178	129	1.41	0.21	0.33
USA	MEX	21	110	534	40	1.76	0.19	0.58
CHE	DEU	21	83	180	117	1.17	0.26	0.39
USA	JPN	20	127	63	311	2.43	0.16	0.16
JPN	IDN	19	60	304	61	4.55	0.31	0.80

Source: author's estimates. The table reports selected statistics on the activity of foreign affiliates for the largest 20 country pairs, ranked in terms of value added in 2011 for the manufacturing sector (Ctrl is the controlling country, Loc is the location country). Number of people employed in thousand persons. Sales and value added in USD billion at current prices and exchange rates. Value added per employed person in USD thousands.

Table 5: **World market shares on value added by location of activity, by nationality of factors and by nationality of firms: 2011 levels (percentage shares and ratios; manufacturing sector)**

Country	Location (A)	Factors (B)	Firms (C)	Ratio B/A	Ratio C/A
CHN	21.05	20.35	19.51	0.97	0.93
USA	16.22	17.55	17.92	1.08	1.10
JPN	9.57	10.51	11.11	1.10	1.16
DEU	6.45	6.87	7.06	1.07	1.09
ITA	2.88	2.89	2.84	1.00	0.99
BRA	2.75	2.45	1.98	0.89	0.72
KOR	2.75	2.89	2.89	1.05	1.05
CAN	2.36	2.04	1.84	0.86	0.78
RUS	2.29	2.09	2.00	0.91	0.87
IND	2.28	2.25	2.20	0.99	0.97
GBR	2.26	2.59	2.82	1.15	1.25
FRA	2.25	2.49	2.82	1.11	1.26
MEX	1.73	1.45	1.36	0.84	0.79
IDN	1.69	1.42	1.35	0.84	0.80
ESP	1.60	1.51	1.32	0.95	0.83
TUR	1.10	0.96	0.92	0.88	0.84
AUS	1.04	0.83	0.64	0.80	0.62
THA	0.95	0.60	0.43	0.64	0.45
NLD	0.93	1.32	1.61	1.41	1.73
TWN	0.89	0.90	0.95	1.01	1.07
CHE	0.77	1.04	1.46	1.36	1.90
POL	0.71	0.55	0.43	0.77	0.60
SWE	0.70	0.78	0.83	1.12	1.20
MYS	0.62	0.46	0.43	0.75	0.70
AUT	0.61	0.61	0.59	1.00	0.96
BEL	0.59	0.58	0.48	0.99	0.83
IRL	0.47	0.29	0.35	0.63	0.75
SGP	0.46	0.26	0.25	0.56	0.55
CZE	0.43	0.32	0.21	0.74	0.48
PHL	0.41	0.37	0.34	0.88	0.81
FIN	0.37	0.43	0.52	1.17	1.41
ROM	0.35	0.31	0.27	0.89	0.78
DNK	0.29	0.31	0.32	1.08	1.13
HUN	0.27	0.19	0.14	0.71	0.50
GRC	0.25	0.22	0.21	0.91	0.86
PRT	0.24	0.23	0.20	0.92	0.83
SVK	0.15	0.12	0.08	0.79	0.52
SVN	0.08	0.07	0.06	0.92	0.80
BGR	0.07	0.06	0.05	0.85	0.73
LTU	0.06	0.03	0.03	0.61	0.52
HKG	0.04	0.10	0.21	2.61	5.23
LUX	0.03	0.10	0.22	3.16	7.15
EST	0.02	0.02	0.01	0.76	0.53
LVA	0.02	0.02	0.02	0.86	0.74

Source: author's estimates. The table reports each country's world market share on value added by location of activity (column A), by nationality of factors (column B), by nationality of firms (column C). Market shares are based on value added at current prices and exchange rates in the manufacturing sector in 2011. Countries are ranked by world market share on location-based value added. Figures for the Rest of the world are not reported in the table.

Table 6: **World market shares on value added by location of activity, by nationality of factors and by nationality of firms: 2004-2011 changes (percentage points and percentage changes; manufacturing sector)**

Country	Absolute changes			Percentage changes		
	Location	Factors	Firms	Location	Factors	Firms
CHN	11.98	11.59	11.03	132.1	132.2	130.1
USA	-5.67	-6.05	-5.83	-25.9	-25.6	-24.5
JPN	-3.85	-3.51	-3.45	-28.7	-25.0	-23.7
DEU	-1.70	-1.81	-1.93	-20.9	-20.8	-21.5
ITA	-1.37	-1.28	-1.15	-32.2	-30.8	-28.7
BRA	1.16	1.13	0.83	72.9	84.8	72.6
KOR	0.11	0.24	0.25	4.2	9.0	9.6
CAN	0.20	0.35	0.40	9.1	20.4	27.4
RUS	0.99	0.87	0.82	75.5	71.4	69.4
IND	0.75	0.72	0.67	49.3	46.7	43.7
GBR	-1.65	-1.55	-1.44	-42.2	-37.4	-33.8
FRA	-1.41	-1.32	-0.87	-38.5	-34.6	-23.6
MEX	-0.25	-0.28	-0.21	-12.5	-16.1	-13.5
IDN	0.70	0.54	0.51	70.4	61.5	60.9
ESP	-0.62	-0.59	-0.54	-28.0	-27.9	-28.9
TUR	0.13	0.16	0.14	13.7	19.4	18.3
AUS	0.01	-0.02	-0.06	1.0	-2.3	-8.3
THA	0.21	0.13	0.09	27.9	28.1	28.4
NLD	-0.20	-0.19	-0.35	-17.5	-12.6	-17.8
TWN	-0.25	-0.24	-0.19	-21.7	-21.2	-16.9
CHE	-0.17	-0.20	-0.23	-18.2	-16.2	-13.8
POL	0.09	0.08	0.05	14.3	16.6	12.4
SWE	-0.22	-0.14	-0.10	-24.4	-15.1	-11.1
MYS	0.08	0.05	0.05	15.9	13.4	13.7
AUT	-0.12	-0.07	-0.02	-16.2	-9.6	-3.1
BEL	-0.23	-0.15	-0.07	-28.3	-20.6	-13.4
IRL	-0.15	-0.02	0.01	-23.8	-7.8	4.4
SGP	0.03	-0.03	0.04	6.7	-9.3	18.9
CZE	0.04	0.04	0.01	11.5	13.4	3.3
PHL	0.10	0.10	0.10	30.7	35.4	39.5
FIN	-0.20	-0.23	-0.21	-34.8	-34.4	-28.4
ROM	0.12	0.11	0.10	51.9	55.9	60.3
DNK	-0.15	-0.15	-0.17	-34.7	-33.1	-35.0
HUN	-0.01	-0.00	0.00	-4.3	-0.8	0.6
GRC	-0.03	-0.02	-0.02	-11.9	-9.0	-7.5
PRT	-0.10	-0.09	-0.07	-28.7	-27.5	-26.7
SVK	0.02	0.01	0.00	14.7	10.0	2.1
SVN	-0.03	-0.03	-0.02	-29.1	-28.1	-29.4
BGR	0.01	0.02	0.02	26.6	38.9	47.5
LTU	-0.01	-0.02	-0.02	-10.8	-35.7	-39.9
HKG	-0.05	-0.00	0.05	-54.5	-2.8	31.8
LUX	-0.01	0.02	-0.03	-29.1	19.9	-11.3
EST	-0.00	-0.00	-0.00	-9.7	-16.7	-20.3
LVA	-0.00	-0.00	-0.00	-5.5	-5.3	-6.0

Source: author's estimates. The table reports each country's change in world market share over the years 2004-2011 in terms of value added by location of activity, by nationality of factors and by nationality of firms. Market shares are based on value added at current prices and exchange rates in the manufacturing sector. Countries are ranked by world market share on location-based value added. Figures for the Rest of the world are not reported in the table.

Table 7: **World market shares on exports and foreign affiliates' activity on a value added basis: 2011 levels (percentage shares; manufacturing sector)**

Country	VAX+VAFA (A)	VAX (B)	%Diff A/B
USA	13.35	10.34	29.1
CHN	12.63	15.58	-18.9
DEU	10.97	11.04	-0.6
JPN	7.40	6.66	11.1
FRA	4.86	4.36	11.3
GBR	4.19	3.21	30.3
ITA	3.71	4.03	-8.0
KOR	3.30	3.54	-6.9
NLD	2.72	2.06	31.9
CAN	2.35	2.57	-8.5
ESP	1.87	2.16	-13.6
IND	1.73	1.96	-11.8
TWN	1.67	1.85	-9.6
MEX	1.47	1.74	-15.2
BRA	1.47	1.75	-16.2
SWE	1.47	1.26	16.2
BEL	1.35	1.38	-2.4
RUS	1.14	1.39	-17.5
POL	1.04	1.26	-17.4
AUT	1.04	1.03	1.2
IDN	1.01	1.25	-19.3
TUR	0.92	1.13	-18.5
IRL	0.77	0.67	15.8
FIN	0.73	0.60	22.1
AUS	0.68	0.76	-11.5
DNK	0.66	0.65	0.9
CZE	0.62	0.76	-18.9
HUN	0.38	0.45	-15.6
LUX	0.27	0.06	345.7
PRT	0.26	0.31	-15.3
SVK	0.26	0.32	-18.1
ROM	0.22	0.27	-19.3
SVN	0.12	0.14	-15.8
GRC	0.09	0.09	-3.4
BGR	0.08	0.09	-19.1
LTU	0.06	0.07	-17.2
EST	0.04	0.05	-16.7
LVA	0.03	0.03	-17.1

Source: author's estimates. The table reports each country's world market share in 2011 in terms of the sum of value added in exports and value added of foreign affiliates (VAX+VAFA) and of value added in exports (VAX), and the percentage difference between the former and the latter. Market shares refer to the manufacturing sector only. Value added in exports and value added of foreign affiliates are at current prices and exchange rates. Countries are ranked by world market share on the sum of value added in exports and value added of foreign affiliates. Data on domestic value added in exports for Hong Kong, Malaysia, Philippines, Singapore, Switzerland, Thailand are not available.

Table 8: **World market shares on exports and foreign affiliates' activity on a value added basis: 2004-2011 changes (percentage points and percentage changes; manufacturing sector)**

	Absolute changes		Percentage changes	
Country	VAX+VAFA	VAX	VAX+VAFA	VAX
USA	-1.03	-0.53	-7.1	-4.8
CHN	6.60	8.05	109.3	106.9
DEU	-1.90	-2.03	-14.8	-15.5
JPN	-1.14	-1.97	-13.3	-22.8
FRA	-1.34	-1.60	-21.6	-26.9
GBR	-1.35	-1.49	-24.4	-31.7
ITA	-0.81	-1.13	-17.9	-22.0
KOR	0.46	0.29	16.4	9.0
NLD	-0.57	-0.35	-17.3	-14.3
CAN	-0.95	-1.04	-28.7	-28.8
ESP	-0.18	-0.25	-8.9	-10.2
IND	0.61	0.73	55.1	59.0
TWN	-0.10	-0.23	-5.7	-11.3
MEX	0.07	0.07	4.7	3.9
BRA	0.37	0.39	33.7	28.9
SWE	-0.22	-0.36	-13.2	-22.3
BEL	-0.39	-0.43	-22.5	-23.9
RUS	0.41	0.49	56.5	54.5
POL	0.26	0.29	33.9	29.6
AUT	-0.05	-0.17	-4.7	-13.9
IDN	0.29	0.35	40.0	38.5
TUR	0.12	0.14	15.5	14.0
IRL	-0.22	-0.37	-22.0	-35.9
FIN	-0.24	-0.30	-24.9	-33.2
AUS	-0.14	-0.14	-16.7	-15.3
DNK	-0.19	-0.21	-22.4	-24.0
CZE	0.08	0.10	15.2	14.5
HUN	0.03	0.02	8.3	4.5
LUX	-0.05	-0.02	-15.0	-24.6
PRT	-0.10	-0.13	-27.1	-29.2
SVK	0.04	0.07	17.2	30.4
ROM	0.04	0.05	22.2	20.8
SVN	-0.03	-0.04	-18.6	-20.8
GRC	-0.03	-0.04	-24.1	-30.6
BGR	0.01	0.01	16.6	15.5
LTU	0.01	0.01	10.3	8.3
EST	0.00	0.00	11.0	8.5
LVA	0.00	0.00	10.1	6.4

Source: author's estimates. The table reports each country's change in world market share over the years 2004-2011 in terms of the sum of value added in exports and value added of foreign affiliates (VAX+VAFA) and of value added in exports (VAX). Market shares refer to the manufacturing sector. Value added in exports and value added of foreign affiliates are at current prices and exchange rates. Countries are ranked by world market share on the sum of value added in exports and value added of foreign affiliates. Data on domestic value added in exports for Hong Kong, Malaysia, Philippines, Singapore, Switzerland, Thailand are not available.

Appendix - Sources and construction of the dataset

This section provides further clarifications on the sources and methodology used to obtain our estimates of bilateral data on the activity of foreign affiliates.

Sources and methods - Data on output, employment, value added, labor compensation and capital compensation in the manufacturing sector over the years 1995-2011 are collected from the following sources: a) WIOD Socio-Economic Accounts for 38 countries (i.e. all countries included in the WIOD database except Cyprus and Malta, which we include in the 'Rest of the World' aggregate); b) Structural Business Statistics published by Eurostat for Switzerland; c) UN National Accounts and national sources for Hong Kong, Malaysia, Philippines, Singapore and Thailand. We use imputation methods to correct for a few missing values (e.g. breakdown of labor and capital compensation for some countries in WIOD dataset over the years 2010-11). We estimate 'Rest of the World' aggregates using data on value added in the manufacturing sector from the UN National Accounts and applying imputation methods based on developing countries' ratios for the remaining variables.

We collect statistics on the activity of foreign affiliates from OECD, Eurostat and national sources (both on the inward and on the outward side). We combine inward and outward FATS data in order to maximize the available information on each country pair, with a preference for inward data.

For a number of country pairs no information was available on some or all of the variables in foreign affiliates' statistics. When only a subset of the variables is missing for a given country pair, we impute them using various estimation methods (e.g. applying interpolation or extrapolation methods or using standard ratios - value added per employed person, wages per employed person, etc. - from other countries' foreign affiliates in the same location country).[18]

If none of the variables was available for a given country pair, we estimate the main aggregates from Bureau van Dijk's Orbis, the world's largest commercial firm-level database. We reconstruct backward the controlling country by merging it with Bureau van Dijk's Zephyr database on mergers and acquisitions. We then extract information on firms' sales, employment and ultimate owner company and (after correcting for missing values for a given firm-year observations assuming that firms' share on the manufacturing sector of the location country is constant) use it to estimate the level of sales and employment for the foreign affiliates of a given country pair. We then estimate the remaining variables following the same imputation methods as above. The remaining country pairs for which no foreign affiliate was found in Orbis were assumed to have zero or negligible levels of foreign affiliates' activity.

We take the total inward activity reported by each country as given, using data from OECD, Eurostat and national sources for countries which report inward FATS statistics (all except the following countries: Australia, Belgium, Brazil, Canada, China, Greece, India, Indonesia, Korea, Mexico, Philippines, Russia, Switzerland, Taiwan, Turkey). We then apply a proportional correction method using the inward totals by location country.

Table A1 reports the share of FATS data on the activity of each controlling country's foreign affiliates in 2011. The share of FATS data is relatively high for the majority of advanced countries, while it is very low for most Asian countries, whose affiliates are mainly concentrated in the region and for which data are based on imputations from FATS data for previous years or from Orbis data. Table A2 reports the share of FATS data on the activity of foreign affiliates on each location country in 2011. The coverage tends to be larger for most countries, reflecting the concentration of the activity of foreign affiliates in a relatively small number of investing

[18]Further work is needed to evaluate the sensitivity of our estimates of foreign affiliates' activity to alternative imputation methods.

countries which report complete FATS data.

Asymmetries between inward and (mirror) outward data - We do not impose consistency with outward totals for each controlling country. Table A3 reports the level of total sales of foreign affiliates according to our estimates and according to the outward statistics reported by the controlling country in 2011 for the 15 countries with the largest level of outward activity for which outward data are available. Differences arise because of the preference assigned by our methodology to inward data, given their generally higher quality and consistency with national accounts and structural business statistics of the location country. As we explain below, a limited number of large asymmetries between inward and (mirror) outward data for country pairs explain the discrepancies.

Sales according to our estimates are significantly higher (more than 15 percent) than sales according to outward data reported by the controlling countries in the following countries: Belgium, Ireland, Luxembourg, United Kingdom. For Belgium, this reflects to a large extent the activity of Belgian-owned affiliates in U.S., Germany and France, for which the figures based on inward data reported by those countries are significantly larger than the mirror figures in the outward data reported by Belgium. For Ireland, this reflects to a large extent the activity of Irish-owned affiliates in the U.S., for which the figure based on inward data reported by the U.S. is much larger than the mirror figure in the outward data reported by Ireland. For Luxembourg, this reflects to a large extent the activity of Luxembourg-owned affiliates in Germany, for which the figure based on inward data reported by Luxembourg is much larger than the mirror figure in the outward data reported by Germany. For the U.K., this reflects to a large extent the activity of U.K.-owned affiliates in the U.S. and Germany, for which the figures based on inward data reported by those countries are significantly larger than the mirror figures in the outward data reported by the U.K.; in addition, the U.K. reports a very significant level of outward activity in the 'Rest of the world' aggregate according to Orbis data, which might reflect issues related to the identification of the actual ultimate owner country.

Sales according to our estimates are significantly smaller (less than 15 percent) than sales according to outward data reported by the controlling countries in the following countries: Canada, France and Sweden. For Canada, the only available outward figure corresponds to the world total, therefore all data are based on mirror inward data or Orbis data. For France, outward figures tend to be higher than mirror inward figures for many country pairs. For Sweden, this reflects the activity of Swedish-owned affiliates in the U.S., for which the inward data reported by the U.S. are significantly smaller than the outward data reported by Sweden.

Representativeness of Orbis - To check the representativeness of Orbis data, Figure A1 report the scatterplot of log employment in FATS and log employment in Orbis data at a country-pair level in 2011. Figure A2 report the scatterplot of log sales in FATS and log sales in Orbis data at a country-pair level in 2011. The slope of the regression coefficient for log employment is 0.80 (with a standard error of 0.03), while for log sales it amounts to 0.81 (with a standard error of 0.04). The R-squared is 0.73 for log employment and 0.75 for log sales.

Table A1: **Share of activity of foreign affiliates for which FATS data is available by controlling country (percentage shares)**

Ctrl	%World	Sales	Empl	VA	LAB	CAP
USA	26.3	90	63	89	91	88
JPN	10.6	98	99	27	34	20
DEU	10.2	90	80	56	62	50
GBR	8.8	83	41	58	58	58
FRA	6.5	88	82	50	95	62
NLD	6.3	78	77	64	76	54
RoW	4.9	0	0	0	0	0
CHE	4.6	77	62	79	79	79
ITA	2.6	92	93	58	34	33
KOR	2.5	5	2	3	0	0
SWE	2.2	96	93	53	42	30
CAN	1.4	79	72	76	78	73
FIN	1.3	91	94	48	97	34
LUX	1.3	69	65	68	70	64
HKG	1.1	1	1	9	2	3
AUT	1.1	95	91	55	61	48
BEL	1.1	97	93	90	69	31
TWN	1.0	4	1	5	0	0
IRL	0.9	75	68	79	33	31
IND	0.8	10	4	7	0	0
DNK	0.7	67	86	63	52	57
SGP	0.7	11	4	8	0	0
ESP	0.7	86	73	56	55	36
BRA	0.4	92	0	86	0	0
CHN	0.4	28	30	18	22	15
MEX	0.3	0	37	49	0	0
AUS	0.3	60	43	71	20	25
POL	0.2	61	68	24	51	16
RUS	0.2	43	41	27	31	25
HUN	0.2	91	54	8	15	4
GRC	0.1	92	87	16	25	5
PRT	0.1	82	81	62	55	85
THA	0.1	0	0	0	0	0
MYS	0.1	0	0	0	0	0
TUR	0.0	16	45	18	14	19
CZE	0.0	87	94	83	68	140
SVN	0.0	51	28	42	66	9
SVK	0.0	88	83	87	93	76
PHL	0.0	0	0	0	0	0
LTU	0.0	59	52	0	0	0
EST	0.0	34	87	32	36	24
LVA	0.0	93	99	76	70	90
IDN	0.0	0	0	0	0	0
ROM	0.0	93	81	74	90	53
BGR	0.0	0	0	0	0	0

Source: author's estimates. The first column of the table reports the percentage share of each controlling country on the global sales of foreign affiliates. The remaining columns report the share of available FATS data by controlling country for each variable. For instance, FATS data account for 90 percent of sales of U.S.-owned affiliates in 2011; the remaining 10 percent is estimated either using Orbis data or imputation methods (using other aggregate variables for the same country pair and applying standard ratios from other countries' foreign affiliates in the same location country). Rest of the world figures are entirely derived from Orbis. The variables are the following: sales; number of employed persons; gross value added; labor compensation (wages and social benefits); capital compensation (gross operating surplus).

Table A2: **Share of activity of foreign affiliates for which FATS data is available by location country (percentage shares)**

Loc	%World	Sales	Empl	VA	LAB	CAP
USA	16.1	95	87	95	78	74
CHN	10.2	58	57	14	24	22
DEU	8.3	95	94	93	93	93
RoW	6.3	0	0	0	0	0
GBR	4.7	93	90	90	85	95
CAN	4.3	93	85	70	63	84
BRA	4.1	80	82	31	33	46
FRA	4.0	95	95	95	96	95
ESP	2.7	91	95	83	86	78
BEL	2.7	80	89	37	42	51
ITA	2.6	82	91	80	74	88
SGP	2.5	62	63	41	40	44
JPN	2.4	85	82	50	58	54
NLD	2.2	96	97	94	95	94
MEX	2.2	91	87	43	66	36
THA	2.1	79	77	19	13	23
AUS	1.8	77	86	34	39	35
POL	1.7	81	86	62	93	79
CHE	1.5	68	78	35	39	44
CZE	1.5	89	90	88	90	86
KOR	1.4	58	77	25	32	27
RUS	1.4	61	45	17	28	17
SWE	1.3	89	91	75	81	65
IDN	1.2	70	61	15	10	17
IRL	1.2	98	95	98	97	98
IND	1.2	85	62	20	25	26
MYS	1.2	70	63	25	23	27
AUT	1.0	95	95	94	94	95
HUN	1.0	90	96	89	94	85
TUR	0.7	78	72	33	37	37
SVK	0.7	81	87	64	76	49
TWN	0.6	87	88	36	27	43
ROM	0.5	39	87	0	16	0
PHL	0.4	77	76	27	22	30
DNK	0.4	81	92	81	79	85
FIN	0.4	76	73	37	41	39
PRT	0.3	67	92	61	60	62
HKG	0.2	68	74	24	30	26
BGR	0.2	42	83	0	5	0
LTU	0.1	6	81	0	5	0
GRC	0.1	45	39	49	44	65
LUX	0.1	87	77	67	69	63
SVN	0.1	84	71	79	79	79
EST	0.1	87	81	45	84	42
LVA	0.0	41	89	0	16	0

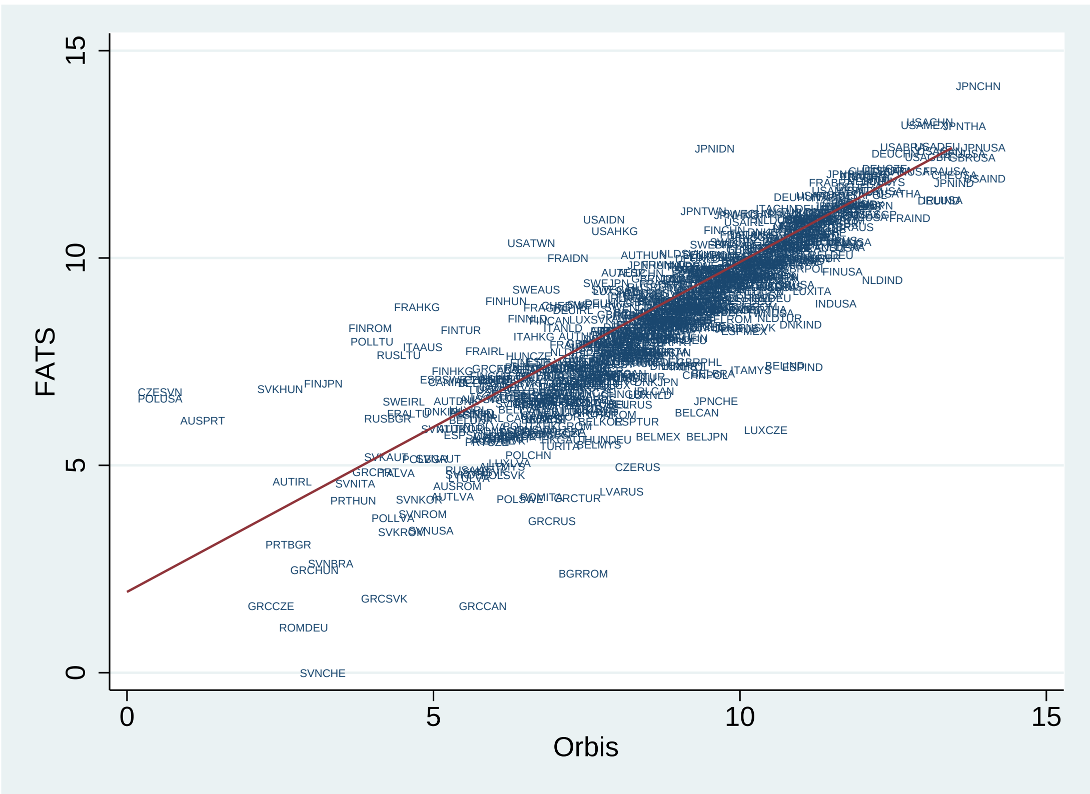
Source: author's estimates. The first column of the table reports the percentage share of each location country on the global sales of foreign affiliates. The remaining columns report the share of available FATS data by location country for each variable. For instance, FATS data account for 95 percent of sales of foreign-owned affiliates in the U.S. in 2011; the remaining 5 percent is estimated either using Orbis data or imputation methods (using other aggregate variables for the same country pair and applying standard ratios from other countries' foreign affiliates in the same location country). Rest of the world figures are entirely derived from Orbis. The variables are the following: sales; number of employed persons; gross value added; labor compensation (wages and social benefits); capital compensation (gross operating surplus).

Table A3: **Comparison with total sales reported by the controlling country (outward data; USD billion and ratio)**

Ctrl	Sales (our estim.)	Sales (outward FATS)	Ratio
USA	2459	2611	0.94
JPN	987	1108	0.89
DEU	957	879	1.09
GBR	826	641	1.29
FRA	602	802	0.75
ITA	242	278	0.87
SWE	202	248	0.82
CAN	132	169	0.78
FIN	122	130	0.94
LUX	118	88	1.34
AUT	106	83	1.27
BEL	105	30	3.52
IRL	82	27	3.05
ESP	63	62	1.01
POL	20	18	1.12

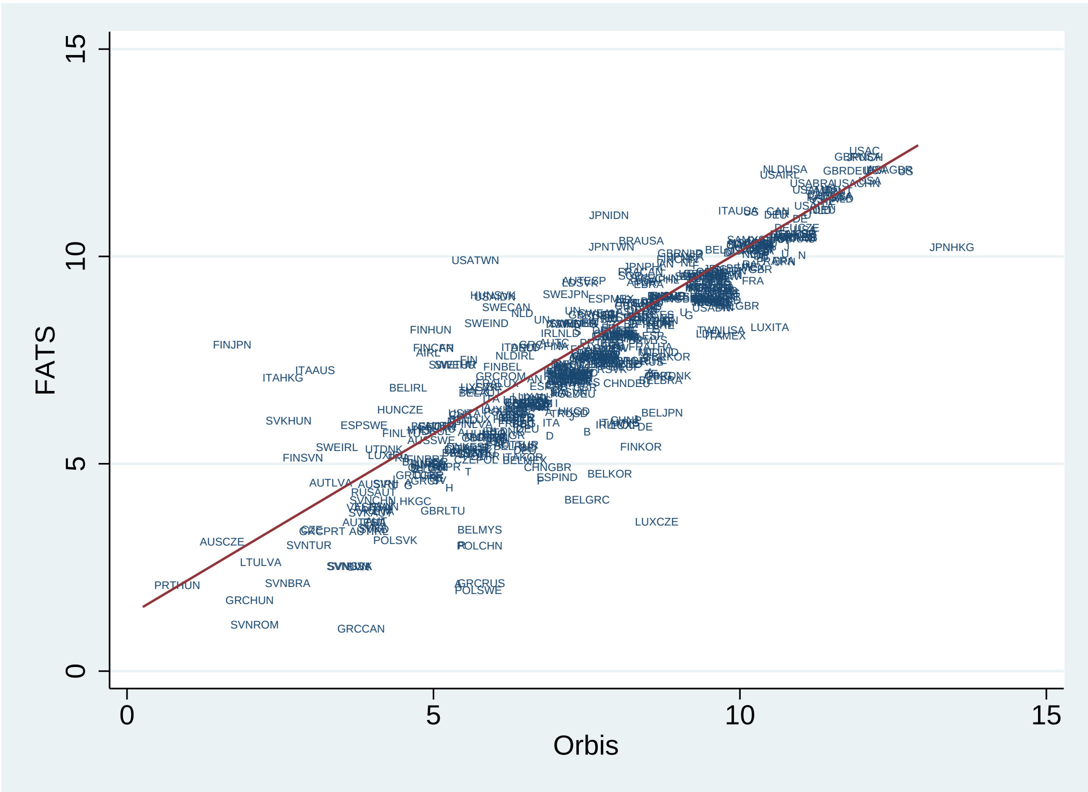
Source: author's estimates. The table reports each controlling country's total sales according to our estimates (which assign a preference to inward FATS data), according to outward FATS data reported by the controlling country and the ratio between the former and the latter. The set of countries includes the 15 countries with the largest total sales of foreign affiliates for which outward FATS totals are available. Data refer to the manufacturing sector in 2011.

Figure A1: **FATS vs. Orbis data: Log employment**



Source: author's estimates.

Figure A2: **FATS vs. Orbis data: Log sales**



Source: author's estimates.

Follow the value added: bilateral gross export accounting?

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September 2015

Abstract

The diffusion of international production networks has challenged the capability of traditional trade statistics to provide an adequate representation of supply and demand linkages among the economies. To address this issue, new statistical tools (the Inter-Country Input-Output tables) and new analytical frameworks have been developed. Koopman, Wang and Wei propose an accounting methodology to decompose a country's total gross exports by source and final destination of their embedded value added. We develop this approach further by deriving a fully consistent counterpart for bilateral trade flows, enabling us also to refine the definition of the various items originally proposed. Along with the contributions of Wang et al. (2013) and Nagengast and Stehrer (2014), our methodology completes the bridge between traditional trade statistics and the systems of national accounts and provides new tools for investigating global value chains. Here we present two empirical applications of two different versions of our decomposition of bilateral trade flows: one explores the forward linkages of Italian exports; the second derives a measure of the share of value-chain-related trade and assesses how its evolution since the mid-1990s has affected the relationship between world trade and income.

Keywords: global value chains,input-output tables, trade in value added, trade elasticity.
JEL Classifications: E16, F1, F14, F15.

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This work is part of the Bank of Italy Working Group on Global Value Chains. We thank Rita Cappariello and Alberto Felettigh for sharing their deep knowledge with us and providing us with essential tools. We also thank Riccardo Cristadoro, Stefano Federico and Julia Wörz for insightful comments. The views expressed in this paper are solely those of the authors and do not involve the responsibility of the Bank of Italy. The usual disclaimer applies.

"This is your last chance. After this, there is no turning back. You take the blue pill - the story ends, you wake up in your bed and believe whatever you want to believe. You take the red pill - you stay in Wonderland and I show you how deep the rabbit-hole goes. [...] sooner or later you're going to realize just as I did that there's a difference between knowing the path and walking the path."

— Morpheus, *Matrix*

1 Introduction

The international fragmentation of production processes has challenged the capability of the standard trade statistics to truly represent supply and demand linkages among economies. In general bilateral exports differ from the portion of a country's GDP related with the production of goods and services shipped to a certain outlet market. Indeed, on one hand exports also embed imported intermediate inputs, on the other hand the directly importing country often differs from the ultimate destination where the good is absorbed by final demand. Whenever production is organized in sequential processing stages in different countries, trade statistics repeatedly double-count the same value added. The diffusion of global value chains (GVC) has therefore deepened the divergence between gross flows, as recorded by traditional trade statistics, and the data on production and final demand as accounted for in statistics based on value added (above all GDP).

Koopman, Wang and Wei (2014) (hereafter KWW) propose a comprehensive decomposition of total gross exports that bridges the gap between the official gross trade statistics and the System of National Accounts. This is not the first scheme to classify trade flows by the source and destination of their embedded valueadded, but their framework does encompass most of the methodologies proposed in the literature (e.g. Hummels, Ishii and Yi, 2001; Daudin et al., 2009; and Johnson and Noguera, 2012). KWW point out that different schemes of international fragmentation of production yield different proportions of value added content in gross exports. In particular, they show that not all the double-counted flows in gross trade statistics are alike. Moreover, in the spirit of Johnson and Noguera (2012), they classify value added in exports in such a way as to take account also of the destination of final absorption.

Exports of a given country are often thought as a proxy for foreign demand, but gross trade flows give only a rough picture. Indeed some products are exported only for processing abroad, and then re-imported to supply domestic demand. Such exports, clearly, are not generated by foreign demand. In other cases, even when the final good is consumed abroad, the country of final absorption may be different from the original importer. Using inter-country input-output tables like the WIOD (Timmer et al. 2015) or the OECD-WTO TiVA, one can track value added along the supply chain from the origin to the country of final use and so better evaluate the role of foreign demand more precisely, distinguishing the intermediate exports for final use at home from those absorbed abroad, and pinpointing the final markets for exported inputs. Through the KWW taxonomy of total gross exports it is possible to exploit the data in these international input-output tables to link the country of origin of with the one where the value added is finally absorbed.

Following this reasoning, KWW break gross exports down into different components of domestic and foreign value added plus two items of 'pure' double counting. As to the latter, they show that gross exports do not in general consist only of value added that can be traced back to GDP generated either at home or abroad. Instead, some trade flows are purely double-counted, as when intermediate inputs cross a country's borders several times according to the different stages of production. A more detailed account of this mechanism is given below. In any event it is worth noting that double-counted items are increasingly important in international trade flows (see Wang et al., 2013 and Cappariello and Felettigh, 2015). This is one reason why it could be useful to adopt the KWW approach in the analysis of bilateral trade flows.

Our aim, in fact, is to extend KWW's methodology in order to obtain a consistent decomposition of bilateral exports. Measuring the value added composition of trade at bilateral level offers additional information on a good many matters that cannot be investigated using simple gross trade data or aggregate trade in value added, as in KWW. By focusing on bilateral trade flows, the methodology we propose can further contribute to form a bridge between traditional trade statistics and systems of national accounts.

In studying global value chains, it is useful to analyze the overall structure of production networks and to identify all the international and intersectoral links. Methodologies like KWW's can track the value added linkages between the country of origin and that of final destination. But we may also be interested in the position of a country (or a sector) within the production process and in identifying its direct upstream and downstream trade partners. Furthermore deepening the knowledge of these linkages provides insight into the role and the level of participation of individual countries in the global value chains and the way in which this affects bilateral trade balances. The potential policy implications are clearly significant. Although the inter-country I-O tables are only available with a lag, we can still use our procedures as tools to interpret recent trends in gross trade or to project future dynamics, insofar as the value added structure of bilateral exports can be presumed to be quite persistent. For example, if we know that in motor vehicles manufacturing a considerable share of the intermediate components exported from Italy to Germany are used to produce cars for the American market, we presume that a slackening of US demand is likely to result in a reduction in shipments of parts from Italy to Germany.

Lastly, while the different components in the KWW taxonomy discriminate accurately between the value added in exports consumed abroad and that re-imported and finally used at home, their methodology cannot properly distinguish between the value added absorbed by direct importers and that going to final uses in a third country. Conversely, going through bilateral trade flows we can better pinpoint these two components, while also refining the classification of aggregate gross exports.

Our work is closely related to that of Nagengast and Stehrer (2014) and Wang et al. (2013). Nagengast and Stehrer (2014) point out that there are different ways to account value added in bilateral trade. Indeed they propose two alternative methodologies: a first one takes the perspective of the country where the value added originates (the source-based approach), a second one takes the perspective of the country that ultimately absorbs it in final demand (the sink-based approach). However, neither methodology can properly account for all the domestic value added exported in the bilateral flow. Wang et al. (2013) follow KWW closely and propose a single breakdown of bilateral exports that can be exactly mapped into the original KWW decomposition summing all the export flows across the destinations. Nevertheless they use different approaches to single out domestic value added of the different components, so that their methodology suffers from internal inconsistency. In this work we breakdown bilateral gross exports both using a fully consistent sink-based approach and adopting a source-based perspective. Both our decompositions correctly take into account the domestic value added and the double-counted components as defined in the original KWW framework.

The paper is organized as follows. The second section recalls KWW's accounting, derives a decomposition of bilateral exports consistent with their framework, and illustrates how this new tool can help to assess international production networks. The third section presents two empirical applications exploiting the decomposition of bilateral trade flows. Section four concludes.

2 The decomposition of bilateral gross exports

2.1 KWW's breakdown of total exports

The methodology proposed by KWW constitutes a rigorous and comprehensive accounting framework for gross foreign trade. The way in which this tool can improve our evaluation of countries' trade relationships is offered by the two stylized production-consumption-trade schemes shown in Figure 1. In panel 1.a) production is organized in stages, each in a different country. First country A produces 1 USD worth of intermediate components using only its own resources and ships them to B, which adds 1 USD of value to produce more refined intermediate products, which are sent to C. Here they undergo a final processing stage, worth another 1 USD, before being sold as final goods back to A for 3 USD. In panel 1.b, instead of having sequential stages of production in A and B, initially each country produces intermediate components worth 1 USD using only its own productive factors and ships them to C; here the different inputs are assembled, adding another 1 USD of value to produce final goods that are absorbed by final demand in A, as before.

Gross trade statistics indicate that in case 1.a country A's exports are generated by demand from country B, and in case 1.b. by demand from C. Since KWW trace both the origin and the final destination of value added, however, their decomposition shows that in both cases the exports are actually activated by country A's own domestic demand.

Before analyzing bilateral trade flows, let us start from the accounting framework for total exports introduced by Koopman, Wang and Wei (2014). Their methodology is based on a global input-output model with G countries and N sectors (for details see Appendix A which also gives an exhaustive definition of our notation, which is essentially identical to KWW). Here let us only recall that $\mathbf{Y}_{sr}$ indicates the demand vector of final goods produced in s and consumed in r, $\mathbf{B}$ is the global Leontief inverse matrix for the entire inter-country model, $\mathbf{A}$ is the matrix of input coefficients, $\mathbf{V}_s$ incorporates the value added shares embedded in each unit of gross output produced by country s, $\mathbf{E}_{s*}$ is the vector of total exports of country s for the N sectors, and $\mathbf{u}_N$ is the $1{\times}N$ unit row vector.

The essential decomposition of total exports of country s ($\mathbf{u}_N\mathbf{E}_{s*}$) in KWW is summarized by the following accounting relationship:

$$\begin{aligned}
\mathbf{u}_N\mathbf{E}_{s*} &= \left\{\mathbf{V}_s\sum_{r\neq s}^{G}\mathbf{B}_{ss}\mathbf{Y}_{sr} + \mathbf{V}_s\sum_{r\neq s}^{G}\mathbf{B}_{sr}\mathbf{Y}_{rr} + \mathbf{V}_s\sum_{r\neq s}^{G}\sum_{t\neq s,r}^{G}\mathbf{B}_{sr}\mathbf{Y}_{rt}\right\} \\
&+ \left\{\mathbf{V}_s\sum_{r\neq s}^{G}\mathbf{B}_{sr}\mathbf{Y}_{rs} + \mathbf{V}_s\sum_{r\neq s}^{G}\mathbf{B}_{sr}\mathbf{A}_{rs}(\mathbf{I}-\mathbf{A}_{ss})^{-1}\mathbf{Y}_{ss}\right\} \\
&+ \mathbf{V}_s\sum_{r\neq s}^{G}\mathbf{B}_{sr}\mathbf{A}_{rs}(\mathbf{I}-\mathbf{A}_{ss})^{-1}\mathbf{E}_{s*} \\
&+ \left\{\sum_{t\neq s}^{G}\sum_{r\neq s}^{G}\mathbf{V}_t\mathbf{B}_{ts}\mathbf{Y}_{sr} + \sum_{t\neq s}^{G}\sum_{r\neq s}^{G}\mathbf{V}_t\mathbf{B}_{ts}\mathbf{A}_{sr}(\mathbf{I}-\mathbf{A}_{rr})^{-1}\mathbf{Y}_{rr}\right\} \\
&+ \sum_{t\neq s}^{G}\sum_{r\neq s}^{G}\mathbf{V}_t\mathbf{B}_{ts}\mathbf{A}_{sr}(\mathbf{I}-\mathbf{A}_{rr})^{-1}\mathbf{E}_{r*} \qquad (1)
\end{aligned}$$

KWW defines the nine items in equation (1) as follows:

1. $\mathbf{V}_s\sum_{r\neq s}^{G}\mathbf{B}_{ss}\mathbf{Y}_{sr}$: domestic value added in direct final goods exports;
2. $\mathbf{V}_s\sum_{r\neq s}^{G}\mathbf{B}_{sr}\mathbf{Y}_{rr}$: domestic value added in intermediate exports absorbed by direct importers;
3. $\mathbf{V}_s\sum_{r\neq s}^{G}\sum_{t\neq s,r}^{G}\mathbf{B}_{sr}\mathbf{Y}_{rt}$: domestic value added in intermediate goods re-exported to third countries;
4. $\mathbf{V}_s\sum_{r\neq s}^{G}\mathbf{B}_{sr}\mathbf{Y}_{rs}$: domestic value added in intermediate exports reimported as final goods;
5. $\mathbf{V}_s\sum_{r\neq s}^{G}\mathbf{B}_{sr}\mathbf{A}_{rs}(\mathbf{I}-\mathbf{A}_{ss})^{-1}\mathbf{Y}_{ss}$: domestic value added in intermediate inputs reimported as intermediate goods and finally absorbed at home;
6. $\mathbf{V}_s\sum_{r\neq s}^{G}\mathbf{B}_{sr}\mathbf{A}_{rs}(\mathbf{I}-\mathbf{A}_{ss})^{-1}\mathbf{E}_{s*}$: double-counted intermediate exports originally produced at home;
7. $\sum_{t\neq s}^{G}\sum_{r\neq s}^{G}\mathbf{V}_t\mathbf{B}_{ts}\mathbf{Y}_{sr}$: foreign value added in exports of final goods;
8. $\sum_{t\neq s}^{G}\sum_{r\neq s}^{G}\mathbf{V}_t\mathbf{B}_{ts}\mathbf{A}_{sr}(\mathbf{I}-\mathbf{A}_{rr})^{-1}\mathbf{Y}_{rr}$: foreign value added in exports of intermediate goods;

9. $\sum_{t\neq s}^{G}\sum_{r\neq s}^{G}\mathbf{V}_t\mathbf{B}_{ts}\mathbf{A}_{sr}(\mathbf{I}-\mathbf{A}_{rr})^{-1}\mathbf{E}_{r*}$: double-counted intermediate exports originally produced abroad.

Although KWW's methodology allows to improve the knowledge of value added content of total exports, it provides no insight into the structure of single bilateral flows. This could be relevant, especially from a policy perspective, in assessing bilateral trade balances. For example, evaluated in terms of gross trade flows, in Figure 1.a A runs a 1 USD surplus with B and a 3 USD deficit with C; in case 1.b, A shows a net bilateral balance of -2 USD towards C and zero with respect to B. In value added terms, A has a net trade deficit position of 1 USD with B and C in both cases. Thus while A's overall deficit is exactly the same in value added as in gross terms (2 USD), its bilateral positions differ considerably between the two accounting methods. Using basic accounting relationships and inter-country I-O tables, we can compute the bilateral positions in value added terms (see equation (A.7) in Appendix A). Yet this is not enough to disentangle the international production linkages and the ultimate demand forces that generate a particular surplus/deficit between two countries in gross terms; nor does the original KWW breakdown shed light on these matters when multiple trade partners and sources of final demand are involved.

Moreover some of KWW's definitions are questionable, but this will become clear only in the analysis of bilateral trade flows, so we prefer to return to this issue at the end of the following section.

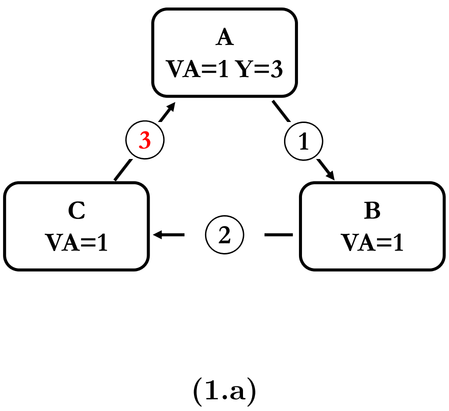

Figure 1: Value added versus gross export accounting of bilateral trade balances

2.2 The decomposition of bilateral trade

Through the analysis of bilateral trade flows we can follow the pattern of value added in exports along the downstream phases of the value chain. However the input-output framework potentially allows for infinite rounds of production. Hence we face a trade-off between adding details about the international production linkages and providing an analytically tractable and conceptually intelligible framework. Our compromise is to track first where the value added is directly exported, then - if it is not absorbed there - we consider the additional destinations of re-export from the direct importers; at this stage, we take into account all the possible linkages to the final producer and absorber in final demand through the Leontief inverse matrix **B**. In summary, our strategy is to decompose gross bilateral trade flows identifying the following actors: *i*) the country of origin of value added; *ii*) the direct importers; *iii*) the (eventual) second destination of re-export; *iv*) the country of completion of final products; *v*) the ultimate destination market.

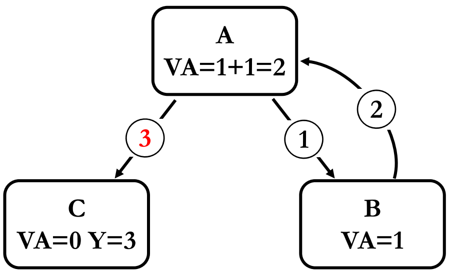

Figure 2: Value added and double counting in bilateral trade flows

Another conceptual issue that arises in considering the single bilateral flows regards the purely double counting items. As pointed out by Nagengast and Stehrer (2014), when a certain portion of value added crosses the same border more than once it has to be assigned to a particular gross bilateral trade flow, while it should be recorded as purely double counted in the other shipments. The issue is clearly pointed out by the scheme reported in Figure 2: here the 1 USD of value added originally produced in A is first exported to B as intermediate inputs, processed there, then shipped back to A and used to produce final goods for re-export to C. In this case, the value added generated in the very first stage of production in A is counted twice in its gross bilateral exports to B and C. The question is the following: in which case should we consider it as 'domestic value added' and in which as 'double counted'? Nagengast and Stehrer (2014) point out that it is an arbitrary choice and propose two alternative approaches: a first one takes the perspective of the country where the value added originates (the source-based approach), a second one that of the country that ultimately absorbs it in final demand (the sink-based approach). As regards the example in Figure 2, according to the source-based approach the original 1 USD of production of country A would be considered as 'domestic value added' in the gross exports to B (and 'double counted' in the shipments to C); vice-versa using the sink-based approach it would be considered as 'domestic value added' in the exports to C (and 'double counted' in the shipments to B).

In short we can say that the source-based method accounts the value added the first time it leaves the country of origin, while the sink-based approach considers it the last time it crosses the national borders. The choice between the two frameworks depends on the particular empirical issue we want to address. For instance if one is interested in inquiring the trade linkages through which the value added reaches a certain market of final destination, the sink-based approach is probably more appropriate. On the contrary the source-based method allows to trace the very first destination of value added from the country of origin. In section 3 we show two different empirical applications, each one adopting one of the two approaches described above. Hereafter we derive our decomposition of bilateral trade flows following a sink-based logic, since it represents the most significant contribution to the literature. In Appendix C we also provide a fully consistent counterpart for the source-based approach; while this decomposition of bilateral exports is more closely related to those proposed by Wang et al. (2013) and Nagengast and Stehrer (2014), we overcome some critical aspects of their methodologies.

The gross bilateral exports of country s to country r consist in final goods and intermediate inputs for the production of gross output in country r ($\mathbf{X}_r$):

$$\mathbf{E}_{sr} = \mathbf{Y}_{sr} + \mathbf{A}_{sr}\mathbf{X}_r. \tag{2}$$

In country r, in turn, the intermediate inputs imported from s undergo one or more processing phases to produce final products for domestic consumption or goods for re-export (both intermediate and final):

$$\mathbf{A}_{sr}\mathbf{X}_r = \mathbf{A}_{sr}(\mathbf{I} - \mathbf{A}_{rr})^{-1}\mathbf{Y}_{rr} + \mathbf{A}_{sr}(\mathbf{I} - \mathbf{A}_{rr})^{-1}\mathbf{E}_{r*}. \tag{2-bis}$$

Thus bilateral exports can be re-expressed as:

$$\mathbf{E}_{sr} = \mathbf{Y}_{sr} + \mathbf{A}_{sr}(\mathbf{I} - \mathbf{A}_{rr})^{-1}\mathbf{Y}_{rr} + \mathbf{A}_{sr}(\mathbf{I} - \mathbf{A}_{rr})^{-1}\mathbf{E}_{r*} \tag{3}$$

From equation (3) we can already identify some of the components of the KWW decomposition simply by applying the following property of the value added matrix **VB** (see A.6):

$$\mathbf{u}_N = \mathbf{V}_s\mathbf{B}_{ss} + \sum_{t\neq s}^{G}\mathbf{V}_t\mathbf{B}_{ts}$$

Applying this equivalence to both sides of equation 3, we get an initial decomposition of bilateral gross exports in value added terms:

$$\begin{aligned}
\mathbf{u}_N\mathbf{E}_{sr} &= \mathbf{V}_s\mathbf{B}_{ss}\mathbf{Y}_{sr} + \mathbf{V}_s\mathbf{B}_{ss}\mathbf{A}_{sr}(\mathbf{I}-\mathbf{A}_{rr})^{-1}\mathbf{Y}_{rr} \\
&+ \mathbf{V}_s\mathbf{B}_{ss}\mathbf{A}_{sr}(\mathbf{I}-\mathbf{A}_{rr})^{-1}\mathbf{E}_{r*} \\
&+ \sum_{t\neq s}^{G}\mathbf{V}_t\mathbf{B}_{ts}\mathbf{Y}_{sr} + \sum_{t\neq s}^{G}\mathbf{V}_t\mathbf{B}_{ts}\mathbf{A}_{sr}(\mathbf{I}-\mathbf{A}_{rr})^{-1}\mathbf{Y}_{rr} \\
&+ \sum_{t\neq s}^{G}\mathbf{V}_t\mathbf{B}_{ts}\mathbf{A}_{sr}(\mathbf{I}-\mathbf{A}_{rr})^{-1}\mathbf{E}_{r*} \qquad (4)
\end{aligned}$$

The first term in (4) is the counterpart of KWW's 'domestic value added in direct final goods exports'. Indeed, the sum of $\mathbf{V}_s\mathbf{B}_{ss}\mathbf{Y}_{sr}$ across all the r countries of destination gives exactly the first term in KWW's decomposition. Since it makes use of (a portion of) the global inverse Leontief matrix **B**, this term fully account for the entire domestic value added embedded in exports of final goods. This means that if a certain product requires a first stage of processing at home, a second stage abroad and a final stage again at home, the domestic value added generated in both the first and the last stages is fully accounted for in this term. The peculiar feature of the sink-based approach is indeed to record the value added originated in all the upstream production stages the last time that a certain product leaves the country.

The last three terms in (4) correspond to the last three items of KWW accounting of total gross exports. $\sum_{t\neq s}^{G}\mathbf{V}_t\mathbf{B}_{ts}\mathbf{Y}_{sr}$ and $\sum_{t\neq s}^{G}\mathbf{V}_t\mathbf{B}_{ts}\mathbf{A}_{sr}(\mathbf{I}-\mathbf{A}_{rr})^{-1}\mathbf{Y}_{rr}$ measure respectively the foreign value added in final and intermediate goods exported to country r. As KWW point out, the last term represents pure double-counting of value added related to intermediate goods originally produced abroad.

We can define the second term in equation (4) $(\mathbf{V}_s\mathbf{B}_{ss}\mathbf{A}_{sr}(\mathbf{I}-\mathbf{A}_{rr})^{-1}\mathbf{Y}_{rr})$ as the actual 'domestic value added in intermediate exports absorbed by direct importers'. However, this item differs from what KWW designate by this expression.

Indeed, as Nagengast and Stehrer (2014) point out, the second term in KWW's decomposition does not encompass only the domestic value added exports in the intermediate products directly exported to country r and then processed to satisfy r's final demand. Rather, it corresponds to the total value added generated in s and contained in the goods finally produced and consumed in r, including products undergoing other processing stages in third countries.

To reassemble all the components in KWW's accounting method we still need to decompose the domestic content of intermediate goods processed in r and then re-exported to s or to third countries (i.e. the third term in 4). Recalling the accounting identity used in 2, we can split the (re)exports from country r into intermediate goods and final products, isolating among the latter the re-imports of the original exporter, country s.

$$\mathbf{E}_{r*} = \sum_{j\neq r, j\neq s}^{G} \mathbf{Y}_{rj} + \mathbf{Y}_{rs} + \sum_{j\neq r}^{G} \mathbf{A}_{rj}\mathbf{X}_{j} \tag{5}$$

Plugging the decomposition in (5) into the right-hand side of equation (4), we can identify portions of the third and fourth term in KWW's decomposition. In particular $\mathbf{V}_s\mathbf{B}_{ss}\mathbf{A}_{sr}(\mathbf{I}-\mathbf{A}_{rr})^{-1}\sum_{j\neq r,s}^{G}\mathbf{Y}_{rj}$ correspond to the domestic value added embedded in the re-export of final goods by the direct bilateral importer r. Unlike the third term in KWW's accounting, this term does not consider the goods that are further processed in other countries before reaching their final destination. Similarly, $\mathbf{V}_s\mathbf{B}_{ss}\mathbf{A}_{sr}(\mathbf{I}-\mathbf{A}_{rr})^{-1}\mathbf{Y}_{rs}$ represents only a portion of the domestic value added in re-imports of final goods, since it encompasses only the value added in intermediate inputs exported to r, processed and re-imported by s as final goods, without any further processing elsewhere.

In order to obtain a full decomposition of bilateral exports in the spirit of the KWW accounting, we still need to identify some components that are nested in the re-exports of intermediate goods from r to all the other j countries (i.e. $\sum_{j\neq r}^{G}\mathbf{A}_{rj}\mathbf{X}_j$). At this point, our aim is to find a way to link the gross output of country j with the demand in final destination countries, to retrieve the missing portions of domestic value added in exports included in terms 2, 3, 4 and 5 in the KWW decomposition. In principle this mapping is obtained readily through the Leontief inverse matrix $\mathbf{B}$ (see equation A.2 in appendix); however, we must also take into account the pure double-counting that stems from the trade flows that cross the borders of country s more than once. To isolate this double-counting component, let us look at the Leontief inverse as a sum of infinite series:

$$\mathbf{B} = \mathbf{I} + \mathbf{A} + \mathbf{A}^2 + \mathbf{A}^3 + \ldots + \mathbf{A}^n \quad n \to \infty \tag{6}$$

This representation shows that the $\mathbf{B}$ matrix identifies the gross output required to satisfy the final demand at the end of the process ($\mathbf{I}$) and in all the upstream production stages ($\mathbf{A} + \mathbf{A}^2 + \mathbf{A}^3 + \ldots$). Since the pure double-counting issue stems from the re-export of intermediate inputs by s, we should exclude these particular flows at any stage of production and modify the series in 6 accordingly. Algebraically, this is done simply by setting the coefficients that identify the requirement of inputs imported from country s within the $\mathbf{A}$ matrix equal to 0:

$$\mathbf{A}^{\not s} = \begin{bmatrix} \mathbf{A}_{11} & \mathbf{A}_{12} & \cdots & \mathbf{A}_{1s} & \cdots & \mathbf{A}_{1G} \\ \vdots & \vdots & \ddots & \vdots & \vdots & \vdots \\ \mathbf{0} & \mathbf{0} & \cdots & \mathbf{A}_{ss} & \cdots & \mathbf{0} \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ \mathbf{A}_{G1} & \mathbf{A}_{G2} & \cdots & \mathbf{A}_{Gs} & \cdots & \mathbf{A}_{GG} \end{bmatrix} \tag{7}$$

Then we can re-express the general relationship of production and trade in our global I-O setting (see A.1), disentangling the export flows from country s as follows:

$$\mathbf{X} = \mathbf{A}^{\not s}\mathbf{X} + \mathbf{A}^{s}\mathbf{X} + \mathbf{Y}^{\not s} + \mathbf{Y}^{s} \tag{8}$$

where $\mathbf{A}^s = (\mathbf{A} - \mathbf{A}^{\not s})$, $\mathbf{Y}^{\not s}$ is the final demand matrix $\mathbf{Y}$ with the block matrix corresponding to exports of final goods from s equal to 0 (but including domestic final demand $\mathbf{Y}_{ss}$), and $\mathbf{Y}^s$ is simply equal to $(\mathbf{Y} - \mathbf{Y}^{\not s})$. Given that the sum of $\mathbf{A}^s\mathbf{X}$ and $\mathbf{Y}^s$ is a $GN \times N$ matrix with the total exports from country s in the corresponding block submatrix and zeros elsewhere ($\mathbf{E}^s$), we can re-arrange (8) as follows:

$$\mathbf{X} = \widehat{\mathbf{B}}^{\not s}\mathbf{Y}^{\not s} + \widehat{\mathbf{B}}^{\not s}\mathbf{E}^{s} \tag{9}$$

where $\widehat{\mathbf{B}}^{\not s} \equiv (\mathbf{I} - \mathbf{A}^{\not s})^{-1}$ is the Leontief inverse matrix derived from the new input coefficient matrix $\mathbf{A}^{\not s}$, which excludes the input requirement of other economies from country s.[1] Since $\mathbf{X}_j = \sum_l^G \mathbf{X}_{jl}$, we can apply the new accounting relationship in

[1]Notice that the domestic input coefficient matrix $\mathbf{A}_{ss}$ is part of the $\mathbf{A}^{\not s}$ matrix, in which only the other $\mathbf{A}_{st}$ submatrices, with $t \neq s$, have all the elements equal to zero. This allows to include in the domestic value added of exports of the goods that undergo a final processing stage in country s and are ultimately used there.

(9) to the decomposition of (re)exports from the original importer r (equation 5):

$$\begin{aligned}\mathbf{E}_{r*} &= \sum_{j\neq r, j\neq s}^{G} \mathbf{Y}_{rj} + \mathbf{Y}_{rs} + \sum_{j\neq r}^{G} \mathbf{A}_{rj} \sum_{k\neq s}^{G} \sum_{l}^{G} \widehat{\mathbf{B}}^{\not s}_{jk} \mathbf{Y}_{kl} \\ &+ \sum_{j\neq r}^{G} \mathbf{A}_{rj} \widehat{\mathbf{B}}^{\not s}_{js} \mathbf{Y}_{ss} + \sum_{j\neq r}^{G} \mathbf{A}_{rj} \widehat{\mathbf{B}}^{\not s}_{js} \mathbf{E}_{s*} \qquad (10)\end{aligned}$$

We can now fully decompose bilateral exports from s to r into the domestic and foreign value added embedded in final demand ($\mathbf{Y}$) and the pure double-counting components stemming from re-exports from the importing country ($\mathbf{E}_{r*}$) or from the country of origin ($\mathbf{E}_{s*}$). To come into line with the original decomposition by KWW, all we need to do now is further disentangle the third term in equation (10) to distinguish: i) the domestic value added finally absorbed in the country of origin through the imports of final goods ($\sum_{k\neq s}^{G} \mathbf{Y}_{ks}$); ii) the domestic value added finally absorbed in a foreign country as a local good ($\sum_{l\neq s}^{G} \mathbf{Y}_{ll}$); and iii) the domestic value added finally absorbed in a foreign country as a foreign good ($\sum_{k\neq s}^{G} \sum_{l\neq s,k}^{G} \mathbf{Y}_{kl}$).

A full sink-based decomposition of bilateral exports can be expressed by the following accounting relationship:

$$\begin{aligned}\mathbf{u}_N \mathbf{E}_{sr} &= \overset{\mathbf{1}}{\mathbf{V}_s \mathbf{B}_{ss} \mathbf{Y}_{sr}} \\ &+ \mathbf{V}_s \mathbf{B}_{ss} \mathbf{A}_{sr} (\mathbf{I} - \mathbf{A}_{rr})^{-1} \left[\overset{\mathbf{2a}}{\mathbf{Y}_{rr}} + \overset{\mathbf{2b}}{\sum_{j\neq r}^{G} \mathbf{A}_{rj} \widehat{\mathbf{B}}^{\not s}_{jr} \mathbf{Y}_{rr}} + \overset{\mathbf{2c}}{\sum_{j\neq r}^{G} \mathbf{A}_{rj} \sum_{k\neq s,r}^{G} \widehat{\mathbf{B}}^{\not s}_{jk} \mathbf{Y}_{kk}} \right] \\ &+ \mathbf{V}_s \mathbf{B}_{ss} \mathbf{A}_{sr} (\mathbf{I} - \mathbf{A}_{rr})^{-1} \left[\overset{\mathbf{3a}}{\sum_{j\neq r,s}^{G} \mathbf{Y}_{rj}} + \overset{\mathbf{3b}}{\sum_{j\neq r}^{G} \mathbf{A}_{rj} \sum_{l\neq s,r}^{G} \widehat{\mathbf{B}}^{\not s}_{jr} \mathbf{Y}_{rl}} \right. \\ &\qquad \left. + \overset{\mathbf{3c}}{\sum_{j\neq r}^{G} \mathbf{A}_{rj} \sum_{k\neq s,r}^{G} \widehat{\mathbf{B}}^{\not s}_{jk} \mathbf{Y}_{kr}} + \overset{\mathbf{3d}}{\sum_{j\neq r}^{G} \mathbf{A}_{rj} \sum_{k\neq s,r,l}^{G} \sum_{l\neq s,r}^{G} \widehat{\mathbf{B}}^{\not s}_{jk} \mathbf{Y}_{kl}} \right] \\ &+ \mathbf{V}_s \mathbf{B}_{ss} \mathbf{A}_{sr} (\mathbf{I} - \mathbf{A}_{rr})^{-1} \left[\overset{\mathbf{4a}}{\mathbf{Y}_{rs}} + \overset{\mathbf{4b}}{\sum_{j\neq r}^{G} \mathbf{A}_{rj} \widehat{\mathbf{B}}^{\not s}_{jr} \mathbf{Y}_{rs}} + \overset{\mathbf{4c}}{\sum_{j\neq r}^{G} \mathbf{A}_{rj} \sum_{k\neq s,r}^{G} \widehat{\mathbf{B}}^{\not s}_{jk} \mathbf{Y}_{ks}} \right] \\ &+ \overset{\mathbf{5}}{\mathbf{V}_s \mathbf{B}_{ss} \mathbf{A}_{sr} (\mathbf{I} - \mathbf{A}_{rr})^{-1} \sum_{j\neq r}^{G} \mathbf{A}_{rj} \widehat{\mathbf{B}}^{\not s}_{js} \mathbf{Y}_{ss}}\end{aligned}$$

$$
\begin{aligned}
&+ \overset{\mathbf{6}}{\mathbf{V}_s\mathbf{B}_{ss}\mathbf{A}_{sr}(\mathbf{I}-\mathbf{A}_{rr})^{-1}\sum_{j\neq r}^{G}\mathbf{A}_{rj}\widehat{\mathbf{B}}^{\not s}_{js}\mathbf{E}_{s*}} \\
&+ \overset{\mathbf{7}}{\sum_{t\neq s}^{G}\mathbf{V}_t\mathbf{B}_{ts}\mathbf{Y}_{sr}} + \overset{\mathbf{8}}{\sum_{t\neq s}^{G}\mathbf{V}_t\mathbf{B}_{ts}\mathbf{A}_{sr}(\mathbf{I}-\mathbf{A}_{rr})^{-1}\mathbf{Y}_{rr}} \\
&+ \overset{\mathbf{9}}{\sum_{t\neq s}^{G}\mathbf{V}_t\mathbf{B}_{ts}\mathbf{A}_{sr}(\mathbf{I}-\mathbf{A}_{rr})^{-1}\mathbf{E}_{r*}} \qquad (11)
\end{aligned}
$$

We can define the items that form the bilateral decomposition of gross exports as follows:

1 domestic value added (VA) in direct final good exports;

2a domestic VA in intermediate exports absorbed by direct importers as local final goods;

2b domestic VA in intermediate exports absorbed by direct importers as local final goods only after additional processing stages abroad;

2c domestic VA in intermediate exports absorbed by third countries as local final goods;

3a domestic VA in intermediate exports absorbed by third countries as final goods from direct bilateral importers;

3b domestic VA in intermediate exports absorbed by third countries as final goods from direct bilateral importers only after further processing stages abroad;

3c domestic VA in intermediate exports absorbed by direct importers as final goods from third countries;

3d domestic VA in intermediate exports absorbed by third countries as final goods from other third countries;

4a domestic VA in intermediate exports absorbed at home as final goods of the bilateral importers;

4b domestic VA in intermediate exports absorbed at home as final goods of the bilateral importers after additional processing stages abroad;

4c domestic VA in intermediate exports absorbed at home as final goods of a third country;

5 domestic VA in intermediate exports absorbed at home as domestic final goods;

6 double-counted intermediate exports originally produced at home;

7 foreign VA in exports of final goods;

8 foreign VA in exports of intermediate goods;

9 double-counted intermediate exports originally produced abroad.

The enumeration of the items recalls the original KWW components, which can be obtained as a simple summation over the importing countries r of the corresponding items in our bilateral decomposition (e.g. the second term in KWW is equal to the sum across the r destinations of **2a**+**2b**+**2c**).[2]

Comparing our definitions of the items here above with those originally assigned by KWW, which have been quoted below equation (1), despite the algebraical consistency between the two classifications, there are a few discrepancies. The reason is that KWW's classification does not properly allocate the domestic value added embedded in intermediate exports between the share going to direct importers and the share absorbed in third markets (see Nagengast and Sterher, 2014). Essentially, our breakdown of bilateral trade flows results in a refinement of the original KWW classification of aggregate exports.

According to KWW, the first and second components of domestic value added of exports go entirely to direct importers' final demand. Using the decomposition of bilateral exports in equation (11), we observe that only sub-items **2a** and **2b** are actually part of the direct importers' final demand. Conversely, part of the third item (**3c**), which KWW classify as third countries' final demand, should be also considered as direct importers' absorption of domestic VA. This makes the total value added produced at home and finally absorbed by the bilateral trade partners equal to the sum across destinations of: **1**, **2a**, **2b** and **3c**. This clearly differs from KWW's definition (i.e. **1**+**2**). The schemes reported in Figure 3 may clarify the differences between the two approaches.

Panel 3.a diagrams a simple trade relationship in which country A produces 1 USD of intermediate inputs, which are used by B to produce 4 USD of local final

[2]For a formal proof of this equivalence for each item in equation (11), see Appendix B.

goods. In this case, both KWW and our own bilateral decomposition classify (in components **2** and **2a** respectively) the exports from A to B as 'domestic VA in intermediate exports absorbed by direct importers'. In panel 3.b we now assume that B performs only a partial processing stage (worth 1 USD of VA) before sending the intermediate products to C, which assembles and consumes the final goods. The 1 USD of domestic VA exported by A is now absorbed in a third country (C), not the bilateral importer (B). This is correctly traced in our bilateral breakdown, as the A-B trade flow is allocated to component **2c** (i.e. 'domestic VA in intermediate exports absorbed by third countries as local final goods'). In KWW's breakdown, however, it would be recorded by the term $\mathbf{V}_A\mathbf{B}_{AC}\mathbf{Y}_{CC}$ and improperly classified as domestic VA of country A absorbed by the direct importer C, since in this case only B directly imports from A. Indeed the $\mathbf{B}_{AC}$, being part of the global inverse Leontief matrix, accounts for all the possible ways in which the intermediate inputs of country A contribute to final goods produced in C, not only those directly imported by C.

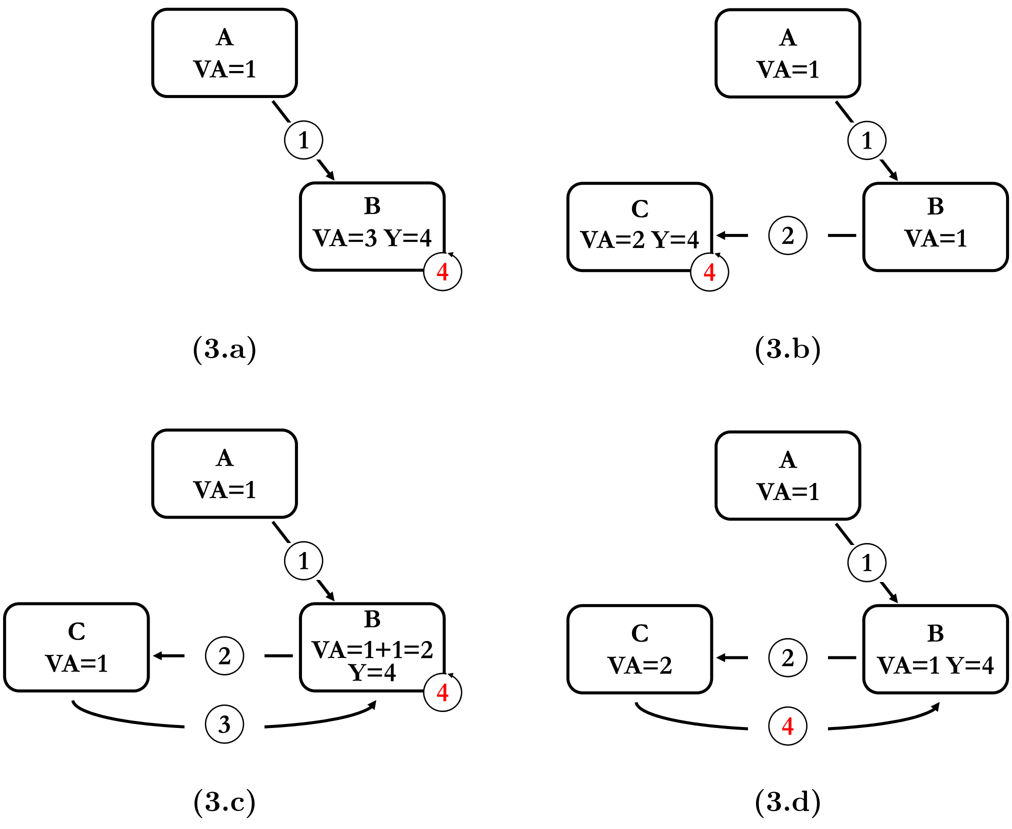

Figure 3: Accounting of the absorption of domestic value added of exports by direct importers

In the example diagrammed in Figure 3.c, the intermediate products are processed in two subsequent production stages in B and C, then returned to B for a final stage before serving final demand. The very first shipment from A to B is correctly classified as 'domestic VA in intermediate exports absorbed by direct importers' both in KWW and in our own decomposition. But only our decomposition correctly recognizes that the domestic VA is absorbed by direct importers as local final goods only after additional processing stages abroad (**2c**). This also indicates the differences between the two arrangements of international fragmentation of production in sub-schemes 3.a and 3.c.

Scheme 3.d differs from 3.c only in that the final assembly stage is performed in C rather than B, which is still the country of final destination. As regards country A, B is both the direct importer and the final demand absorber, so its exports to B should be considered as domestic VA absorbed by a direct importer, which is how they are mapped in our decomposition (in item **3c**), whereas in KWW's method they are allocated to third countries' absorption of domestic VA of exports.

The value added decomposition of bilateral trade flows offers useful information for valuing trade balances between countries, reconciling the gross export data with value added accounting. For instance, going back to the example in Figure 1, in case 1.a we see that the exports from A to B are generated by A's demand for C's final goods, since they are classified in item **4c** of equation (11) (i.e. 'domestic VA in intermediate exports absorbed at home as final goods of a third country'). In example 1.b, instead, exports from A to C are classed under **4a** (i.e. 'domestic VA in intermediate exports absorbed at home as final goods of the bilateral importers'). This differentiation, which is not envisaged in KWW's original framework, gives insights into the structure of international production and demand linkages, especially in dealing with the sort of complex production networks that prevail in the real world.

Our sink-based decomposition summarized by equation (11) differs also substantially from the one in Nagengast and Sterher (2014). In fact they classify as domestic value added absorbed by direct importers only that embedded in goods that do not leave this country again, assigning the remainder to the double counted component. In this way they do not take into account what we have classified in the **2b** and **3c** components, underestimating the domestic value added absorbed by direct importers. It means that, for instance, in the scheme 3.c and 3.d described above, the exports from country A to country B would be entirely classified as double counted in the decomposition of their bilateral flows. Also their definitions of the domestic value added finally absorbed at home and by third countries turn out to be imprecise, leading in this case to an overestimation of the domestic value added in exports. This drawback also applies to their source-based decomposition. The scheme diagrammed in Figure 4 highlights this particular issue. In this case, two stages of production, each worth 1 USD of value added, are performed both in country A and B, before the final good being shipped from B to the destination market C. The total bilateral gross exports from A to B are equal to 4 USD, which consist of 2 USD of VA generated in A, 1 USD of VA generated in B and 1 USD of double counted VA, originated in the first stage of production in A and embedded in the second shipment from A to B. Both in the source and in the sink-based approach of Nagengast and Sterher (2014) this 1 USD of double counted items would be assigned to the domestic value added of A absorbed by third country C, overestimating this component.[3]

This inaccuracy in defining some of the items entails that neither methodology proposed by Nagengast and Sterher (2014) can retrieve the entire domestic value added exported by a country summing the corresponding items across the bilateral flows. On the contrary both our sink and source-based methodologies, shown in Appendix C, provide this result. Also Wang et al. (2013) breakdown of bilateral exports shares this property. However, they use different approaches to single out the different components, so that their methodology suffers from internal inconsistency. In particular they follow a sink-based approach for the domestic value added embedded in direct exports of final goods, while the remainder of the bilateral gross flows is classified accordingly to a source-based approach. This makes the single items of the decomposition not comparable with each other. Moreover, since the trade in intermediaries and that in final goods are treated in different ways by Wang et al. (2013), it could be tricky also to use this methodology to compare the value added structure of two (or more) distinct trade flows, as in the analysis of bilateral trade balances. In general, having specific and internal consistent methodologies both for the sink-based and the source-based approach allows to choose the most

[3]This overestimation stems from the double use of the global inverse Leontief matrix in some of the terms of the decomposition of Nagengast and Sterher (2014). In fact in the example of Figure 4, the domestic value added absorbed in third countries would be calculated as $\mathbf{V}_A\mathbf{B}_{AA}\mathbf{A}_{AB}\mathbf{B}_{BB}\mathbf{Y}_{BC}$ (both in sink and source-based methodology). Since $\mathbf{B}_{AA}$ accounts for all the possible ways in which the intermediate inputs of country A contribute to the production in A, $\mathbf{V}_A\mathbf{B}_{AA}$ encompasses the entire value added of A generated both in the first and the second stage of production. Then the $\mathbf{V}_A\mathbf{B}_{AA}$ matrix should be applied only to the second export flow to B, in order to extract A's value added following the sink-based logic. Instead, since they account the B's gross output necessary for the production of the final good exported to C through the $\mathbf{B}_{BB}$ matrix, they are recording both the first and the second stage of production in B and hence both the shipments of intermediate inputs from A. So they end up with an overestimation of the VA produced in A.

appropriate to the purpose of the analysis.

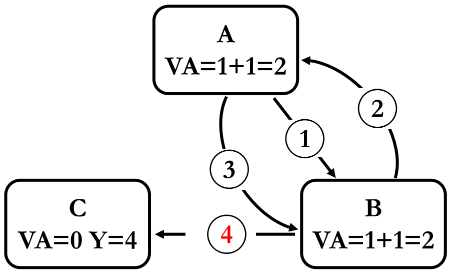

Figure 4: Domestic value added and double counting with final destination in third countries

3 Two empirical applications

We use the World Input-Output Database (see Dietzenbacher et al. 2013, Timmer et al. 2015) for the period 1995-2011 to show two different ways of exploiting our proposed value added decompositions of bilateral trade. The first application follows the sink-based approach developed in the previous section and focuses on Italian exports of domestic VA, tracing flows from direct importers to final demand. The second follows the source-based approach and derives a new measure of the share of GVC-related trade in order to determine how its evolution since the mid-1990s has affected the long-run relationship between global demand and world trade.

3.1 Italian forward connections

Cappariello and Felettigh (2015) give a detailed assessment of the participation of Italy, France, Germany and Spain in global value chains. Applying the original KWW methodology to the WIOD data, they also analyze the way in which foreign demand has activated domestic value added in these four euro-area economies since the creation of the European monetary union. Among other results, they find that one common pattern is increasing dependence on final internal demand originated outside the EU. We use our decomposition of bilateral export flows to add information on the downstream structure of the production networks in which Italy is involved. In particular, we aim to investigate the channels through which Italian exports reach the markets of final destination. Then for this exercise the sink-based decomposition presented in equation (11) is better suited since it accounts the value the last time it crosses the national borders, which is the export flow more closely related with the market of ultimate absorption.[4]

We consider Italy's exports to the top sixteen importing countries, which take two-thirds of total Italian exports of goods and services. First, we compute the shares of domestic VA, foreign VA and pure double-counting embedded in Italian exports in 2011 (the last year for which the WIOD tables are available). The first component is the sum of the following items of equation (11): **1**, **2** (i.e. **2a**+**2b**+**2c**), **3**, **4** and **5** (divided by the total exports to each country). Similarly the foreign VA of exports is obtained by summing items **7** and **8**. Finally, pure double-counting comes from items **6** and **9**. Cappariello and Felettigh (2015) observe that in 2011 domestic value added accounted for 72.7% of Italy's total gross exports, foreign VA for 20.5%, and pure double-counting for 6.8%. The bottom rows in Table 1 report the shares in Italy's bilateral exports to each importer. The share of domestic VA turns out to be smaller than average in exports to the other EU economies except the UK, and particularly smaller in those to Spain and Austria. Conversely, the double-counting shares in those export flows are relatively large. Since this component is generated by trade flows that cross the same borders more than once, this finding should be taken as evidence of the deep interconnection of intra-EU production networks. At the same time, the export flows that embed the largest shares of domestic VA are those to the major emerging economies, such as China, Russia and Brazil.

The domestic VA embedded in exports can be further broken down according to country of final absorption. In particular, three sub-components can be defined on the basis of equation (11): the domestic VA that serves the final demand in the direct importing country (i.e. **1**+**2a**+**2b**+**3c**, *direct absorption*); the domestic VA that ultimately comes back to the country of origin to be consumed there (i.e. **4a**+**4b**+**4c**, *reflection*); and the domestic VA absorbed by final demand in third countries (i.e. **2c**+**3a**+**3b**+**3d**, *redirection*). The first three rows in Table 1 show the weights of these three items in domestic VA exported by Italy. The non-European markets also have the largest proportion of direct absorption of value added generated and exported by Italy. Conversely, about a third of the domestic VA exported to Germany is embedded in intermediate goods that are processed

[4] To further clarify this point we refer to the example shown in Figure 2. With the sink-based approach all the value added generated in A and finally absorbed in C is entirely accounted within the bilateral exports of final goods from A to C, while with the source-based approach a part of this would be assigned to the bilateral flow from A to B.

there and re-exported to third markets. Similar shares for the redirection term are registered in exports to Austria and Poland.[5] Thus Germany and, to a lesser extent, these other EU economies play an important role in the downstream stages of the international production chains in which Italy takes part. Indeed, between 40% and 60% of Italian domestic value added that passes through EU trade partners before being re-exported is ultimately absorbed in other European markets. But exports to Germany are different, in that substantial portions of Italian intermediate goods are used in the in production of goods that are finally consumed outside Europe, notably in the US and China. Briefly, the analysis of bilateral exports shows Italy's thorough integration into the 'factory of Europe' in which Germany plays the leading role (see also Amador et al., 2015)

[5]The *redirection* share is nearly 40% for Belgium and the Netherlands, whose import data are distorted by the substantial transshipment activity of the leading European ports (Rotterdam, Antwerp and Amsterdam).

Destination of bilateral gross exports from Italy

		DEU	FRA	USA	ESP	CHN	GBR	RUS	TUR
Italian VA	**Absorption**	64.9	76.0	91.7	76.6	81.7	80.6	85.7	93.4
	Reflection	2.0	1.6	0.1	1.8	0.4	0.8	1.0	0.5
	Redirection	33.1	22.3	8.2	21.6	17.9	18.6	13.4	6.1
	EU27	*39.8*	*42.6*	*20.2*	*51.2*	*19.4*	*37.7*	*47.5*	*31.8*
	USA	*10.5*	*9.6*	*0.0*	*8.2*	*23.5*	*13.9*	*6.4*	*10.7*
	Japan	*2.2*	*2.5*	*4.5*	*1.6*	*8.5*	*2.3*	*1.0*	*5.7*
	EME ASIA excl. China	*3.8*	*3.2*	*6.6*	*2.1*	*9.4*	*3.8*	*2.4*	*5.4*
	China	*9.9*	*6.7*	*10.7*	*3.5*	*0.0*	*7.0*	*3.1*	*11.3*
	Other EMEs countries	*33.9*	*35.4*	*57.9*	*33.4*	*39.1*	*35.3*	*39.6*	*35.2*
	Italian VA	**72.4**	**70.9**	**73.3**	**62.7**	**77.6**	**74.5**	**71.8**	**75.8**
	Foreign VA	16.2	21.0	24.0	27.0	18.2	19.7	23.4	22.1
	Double counting	11.4	8.1	2.7	10.3	4.2	5.8	4.7	2.1
	Bilateral gross exports	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Memorandum: share on total gross exports	*12.3*	*9.4*	*7.1*	*5.7*	*5.1*	*4.3*	*3.3*	*2.6*

		AUT	POL	BEL	BRA	JPN	NLD	GRC	ROM
Italian VA	**Absorption**	65.1	65.4	57.9	91.1	92.8	61.6	79.1	88.6
	Reflection	2.1	2.5	2.4	0.2	0.1	2.3	2.8	0.3
	Redirection	32.9	32.1	39.6	8.7	7.1	36.0	18.1	11.1
	EU27	*49.8*	*56.2*	*58.1*	*21.4*	*13.5*	*58.6*	*47.1*	*16.9*
	USA	*9.0*	*5.8*	*8.6*	*15.5*	*19.2*	*8.1*	*5.3*	*6.3*
	Japan	*1.8*	*1.0*	*1.6*	*3.3*	*0.0*	*1.6*	*1.7*	*1.5*
	EME ASIA excl. China	*2.9*	*1.6*	*3.9*	*3.8*	*10.2*	*3.5*	*2.6*	*2.7*
	China	*6.6*	*3.7*	*5.4*	*12.1*	*19.6*	*5.9*	*3.2*	*3.2*
	Other EMEs countries	*29.8*	*31.7*	*22.4*	*43.8*	*37.5*	*22.2*	*40.2*	*69.5*
	Italian VA	**69.3**	**72.4**	**74.2**	**78.4**	**74.7**	**73.5**	**72.8**	**72.9**
	Foreign VA	19.2	16.9	13.5	19.6	23.1	14.6	21.1	24.5
	Double counting	11.5	10.6	12.3	2.1	2.2	11.9	6.1	2.6
	Bilateral gross exports	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Memorandum: share on total gross exports	*2.1*	*2.0*	*1.9*	*1.9*	*1.6*	*1.4*	*1.4*	*1.3*

Table 1 : Value added decomposition of Italian bilateral gross exports

3.2 Measuring the weight of Global Value Chains in world trade

Following the seminal article of Hummels et al. (2001), a number of works have used input-output tables to gauge the relevance of GVCs in world trade (Johnson and Noguera, 2012; Rahman and Zhao, 2013; Los et al., 2014). Various measures of the integration of a country (or a region) in international production networks have been developed. One of the most common is the 'vertical specialization' indicator of Hummels et al. (2001), based on the content of foreign inputs in a country's exports. As Cappariello and Felettigh (2014) observe, however, this is only a partial measure of participation in global value chains, as it considers only the backward linkages. To take forward linkages too into account, Rahman and Zhao (2013), based on Koopman et al. (2011), include in the share of trade generated by international fragmentation of production the domestic value added embedded in the intermediate exports absorbed by third countries and by the exporting country itself via re-imports. Cappariello and Felettigh (2014) take a similar approach, measuring the 'international fragmentation of production' of a country as the share of total exports consisting in components **3** to **9** in KWW's breakdown. The idea is that all trade flows are related in some way to international production networks, except for the exports of domestic VA that is directly absorbed by the first importer (**1**+**2** in KWW's classification).

As we have seen, however, KWW do not properly allocate the domestic VA embedded in intermediate exports between the share going to direct importers and that absorbed in third markets. Through the decomposition of bilateral exports we provide a more precise definition of 'direct absorption', which we also employed in the previous empirical application (section 3.1). Since in general our proposed classification aims to map value added accordingly to the ultimate destination market, we believe 'direct absorption' should also include the domestic VA absorbed by direct bilateral importers only after additional processing stages abroad, i.e. **2b** and **3c** in equation (11).

In order to measure the international fragmentation of production, a slightly different notion of 'direct absorption' is necessary. In this case the aim is to single out the trade flows involved in global value chains, conventionally defined as production processes that require at least two international shipments of goods (including both intermediate inputs and final products). It is therefore necessary to exclude from GVC-related trade flows only the fraction of domestic value added that never leaves the first importing country. Following this logic, a source-based methodology is better suited than a sink-based one. In fact this breakdown of bilateral trade flows, shown in Appendix C, permits to single out the fraction of domestic value added that is exported just once by the domestic country and is directly absorbed by the importer (terms **1a*** and **2a*** in equation (C.1)). Summing across the bilateral flows, we obtain the entire domestic value added of country s absorbed by his direct importers without any further processing stages abroad or at home, a measure of traditional 'Ricardian' trade, as

$$DAVAX_s = \Bigg[\overbrace{\mathbf{V}_s(\mathbf{I} - \mathbf{A}_{ss})^{-1} \sum_{r \neq s}^{G} \mathbf{Y}_{sr}}^{\sum_{\mathbf{r}\neq\mathbf{s}} \mathbf{1a*}} + \overbrace{\mathbf{V}_s(\mathbf{I} - \mathbf{A}_{ss})^{-1} \sum_{r \neq s}^{G} \mathbf{A}_{sr}(\mathbf{I} - \mathbf{A}_{rr})^{-1}\mathbf{Y}_{rr}}^{\sum_{\mathbf{r}\neq\mathbf{s}} \mathbf{2a*}} \Bigg]. \tag{12}$$

Differently from the sink-based methodology (terms **1** and **2a** in equation (11)), here the domestic component of the global inverse Leontief matrix (i.e. $\mathbf{B}_{ss}$) is replaced with the local inverse Leontief matrix (i.e. $(\mathbf{I} - \mathbf{A}_{ss})^{-1}$). This allows to exclude all the backward linkages of the domestic country within the international production networks.[6]

Thus, it is possible to measure GVC-related trade flows simply by excluding the entire domestic value added of country s absorbed directly by his direct importers ($DAVAX_s$) from his total exports:

$$GVCX_s = \mathbf{u}_N \mathbf{E}_{s*} - DAVAX_s. \tag{13}$$

Therefore, GVC-related trade share in total exports is

$$GVC_s = \frac{GVCX_s}{E_{s*}}, \tag{14}$$

where $E_{s*} = \mathbf{u}_N \mathbf{E}_{s*}$.

Employing WIOD tables, we have computed the share of GVC-related trade

[6]To grasp the difference between these two measures, consider the following example. Suppose that country A performs the first stage of a production process, ships the intermediate products abroad for a second processing stage, and re-imports them for final completion. Finally, the goods are exported to serve final demand. Computing the domestic value added embedded in the exports of final goods using the local inverse Leontief matrix ($(\mathbf{I} - \mathbf{A}_{AA})^{-1}$ we consider only the last stage of production performed in A, while with the sub-componet $\mathbf{B}_{AA}$ of the global Leontief matrix we take account of the VA generated both in the first and in the last stage. Thus the $\mathbf{B}_{ss}$ matrix differs from the local Leontief whenever two (or more) distinct stages of production are performed in the domestic country s. Since this entails some international fragmentation of production, it would appear better, in computing the portion of trade that is not involved in GVC, to use the local Leontief matrix.

in total world exports using three different methods (see Table 2): an index of vertical specialization very similar to Hummels et al., 2001; a GVC indicator based on components 3 to 9 of the original KWW decomposition (GVC-KWW), as calculated in Cappariello and Felettigh (2015); and our own GVC measure in equation (14). As expected, our indicator finds a considerably larger weight of GVCs in total trade than the KWW decomposition, which in turn gives a share about 10 percentage points greater than the fraction indicated by the vertical specialization indicator. The evolution of the three indicators over time is quite similar, however. Our indicator puts the share of GVC-related trade at between a third and nearly half the total during our sample period.[7] Almost all of the difference between our indicator and the measure derived from the original KWW decomposition is due to the different classification of the value added absorbed by direct importers, whereas the impact of using the local as against the global-domestic Leontief is minor.[8]

As is shown by the black line in Figure 3, the GVC share of total trade, measured as in equation (14), has been growing since the mid-1990s, reaching 40% in 2000, then stagnating since untill 2003 and rising to nearly 47% before the recession. In 2009 total trade contracted by about 10%. GVC trade fell even more sharply and has recovered only marginally since then.

These measures of international fragmentation can be employed to quantify the contribution of global value chains in explaining the decline of the income elasticity of trade, i.e. the ratio of trade to GDP growth. In fact, while cyclical factors - the investment slump, the weakness of economic activity in the euro area - have been key drivers of the trade slowdown, a major role has also been played by structural factors, including global value chains, as suggested by Constantinescu et al. (2015), Ferrantino and Taglioni (2014) and Escaith et al. (2010). Since world exports are equal to world imports (i.e. at any time t we have that $M_{(t)} = E_{(t)} = \sum_s^G E_{s*}$), we can express the latter as the sum of traditional 'Ricardian' trade ($DAVAX_{(t)}$) plus

[7]The weight of GVC-related trade might seem quite great, and to be sure there are some factors that could result in an overestimate of this and other measures of GVC-related trade. For example, in the WIOD tables a significant component of intermediate inputs is raw materials, whose inclusion in GVC trade is questionable (Cappariello and Felettigh 2015). In addition, the separate consideration of each country in the highly integrated euro area could engender an upward bias (Amador et al., 2015)

[8]Computing the GVC indicators for single countries, we find similar differences between countries with the sole exception of commodity exporters (such as Russia, Australia and Brazil), for which the difference between our indicator and the KWW-GVC index is much larger. For Italy, in 2011, GVC-related exports accounted for 43.7% of the total by our index and 36.3% by the KWW-GVC measure.

	VS		*GVC-KWW*		*GVC*	
	share	Δ	share	Δ	share	Δ
1995	19.5		28.5		35.2	
2000	22.7	3.2	33.1	4.6	40.4	5.2
2005	25.2	2.5	35.8	2.7	44.0	3.7
2011	25.5	0.3	35.8	0.0	44.5	0.5

Table 2: Indices of international fragmentation for world exports.

VS: vertical specialization, foreign value added and both domestic and foreign double counting on total exports; *GVC-KWW*: index of international fragmentation used in Cappariello and Felettigh (2015), summing terms 3 to 9 of KWW decomposition, on total exports; *GVC* refined index calculated as total exports excluding terms 1a* and 2a* of our source-based decomposition, on total exports.

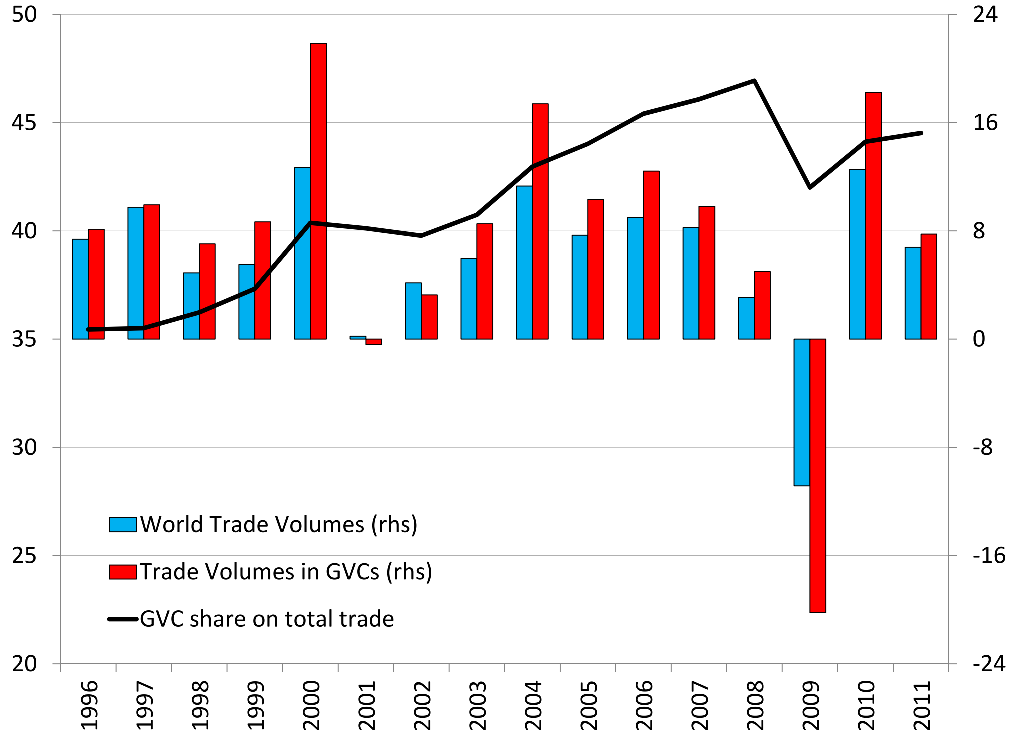

Figure 5: Growth rates of world trade volumes and GVC share

GVC-related trade ($GVCX_{(t)}$). We define world imports as

$$M_{(t)} \equiv \frac{M_{(t)}}{DAVAX_{(t)}} \frac{DAVAX_{(t)}}{Y_{(t)}} Y_{(t)}. \tag{15}$$

where the first ratio on the right hand side is a measure of international fragmentation strictly related to $GVC_{(t)}$: $GVC^*_{(t)} \equiv M_{(t)}/DAVAX_{(t)} = 1/(1 - GVC_{(t)})$; the second ratio $DMFD_{(t)} \equiv DAVAX_{(t)}/Y_{(t)}$ indicates the direct import content of final demand. Taking growth rates

$$\frac{\Delta M_{(t)}}{M_{(t)}} = \frac{\Delta GVC^*_{(t)}}{GVC^*_{(t)}} + \frac{\Delta DMFD_{(t)}}{DMFD_{(t)}} + \frac{\Delta Y_{(t)}}{Y_{(t)}}, \tag{16}$$

and dividing both sides by the GDP growth rate, we get an expression for the income elasticity of trade:

$$\frac{\Delta M_{(t)}}{M_{(t)}} \frac{Y_{(t)}}{\Delta Y_{(t)}} = \frac{\Delta GVC^*_{(t)}}{GVC^*_{(t)}} \frac{Y_{(t)}}{\Delta Y_{(t)}} + \frac{\Delta DMFD_{(t)}}{DMFD_{(t)}} \frac{Y_{(t)}}{\Delta Y_{(t)}} + 1. \tag{17}$$

The income elasticity of trade, then, has three components: the constant unitary value, the income elasticity of international fragmentation intensity, and the income elasticity of the (direct) import content of final demand:

$$\eta^{M}_{(t-s),(t)} = 1 + \eta^{GVC}_{(t-s),(t)} + \eta^{DMFD}_{(t-s),(t)}. \tag{18}$$

		η^{GVC}	η^{DMFD}	η^{M}
1996-2000	1.00	0.45	0.61	2.06
2001-2005	1.00	0.33	0.12	1.45
2006-2011	1.00	0.04	0.09	1.13

Table 3: Decomposition of income elasticity of trade.

The decomposition follows equation (18). η^M is the average income elasticity of trade.

As Table 3 shows, the contribution of global value chains to total trade elasticity was substantial until 2005 and has declined significantly since then. The considerable contribution of the (direct) import content of final demand to trade elasticity in the late 1990s is presumably linked to the trade liberalization that was carried out in that period, owing mainly to the Uruguay round of multilateral talks.

4 Concluding remarks

The diffusion of international production networks during the last two decades requires new tools for evaluating supply and demand relationships among countries, which can no longer be adequately gauged by gross trade flows. Global input-output tables have been instrumental in filling the gap in the statistical sources. New methodologies have been developed to utilize these data to measure trade in value added terms. This makes it possible to isolate the contribution of different countries' final demand and demand for intermediate inputs to production in any given economy. Koopman et al. (2014) have proposed a rigorous and comprehensive method for breaking aggregate export flows down according to the source and the destination of their value added content. Applying this framework to a global input-output database like WIOD, it is possible to explore many issues relating to the role of international fragmentation of production in trade (see Cappariello and Felettigh, 2015). However, this decomposition neglects the bilateral dimension of trade flows and may accordingly be inadequate for analysis of such other features as a country's backward and forward linkages within the global value chains.

We propose two decompositions of bilateral exports that are fully consistent with the KWW approach, in line with the spirit of Nagengast and Stehrer (2014). A first one takes the perspective of the country where the value added originates (the source-based approach), a second one that of the country that ultimately absorbs it in final demand (the sink-based approach). The original components in KWW can be exactly retrieved from our decompositions by summing the bilateral export flows across the destinations. At the same time, we also refine the classification of domestic value added embedded in exports, singling out additional sub-components. This disaggregation, finer than in KWW's original framework, proves to be quite helpful in analyzing trade flows and GVC structures. In particular, our approach can both account for the entire domestic value added embedded in bilateral shipments and discriminate precisely between the exports that are finally absorbed by the direct importers and those that are consumed in third countries. These issues have not been properly addressed by KWW or in the rest of the literature (see Wang et al., 2013; Nagengast and Stehrer, 2014).

Examining bilateral flows through the lens of their value added content, we can assess a country's position within the international production processes, identifying the direct upstream and downstream trade partners. In this way we can also gauge the effect on bilateral trade balances exerted by participation in GVCs and by final demand from third countries.

Applying our sink-based methodology to Italian exports, we find some heterogeneity in the roles of different trading partners. In particular, Germany, Austria and Poland contribute significantly to the downstream stages in Italy's international production chains. Conversely, direct exports to non-European markets, mainly serving local demand, have considerably greater content of Italian value added.

Thanks to our source-based bilateral decomposition, we develop a new measure of international fragmentation of production. GVC-related trade has been much more volatile than total trade; after reaching almost half of all world trade in 2008, it plunged by 20% in 2009, while trade unrelated to international fragmentation of production shrank only by 2.5%. In the aftermath of the recession the share of global value chains in total trade has recovered only marginally.

This measure of GVC-related trade has been used to inquire into the role played by international fragmentation of production in the changes of the long-term relation between trade and income. The contribution of GVCs on the income elasticity of trade was substantial until 2005, but since then it has declined significantly, suggesting that the slowdown in trade in 2012-14 may have been driven in part by structural factors.

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A Appendix

This appendix simply recalls our notation, which is broadly the same as KWW (2014), together with some basic accounting relationships.

We consider the general case of G countries producing N goods that are internationally traded both as intermediate inputs and as final good. Thus, $\mathbf{X}_s = (x_1^s \; x_2^s \; \cdots \; x_N^s)'$ is the $N \times 1$ vector of the gross output of country s and Y_s is the $N \times 1$ vector of final goods, which is equal to the final demand for goods produced in s in each country of destination r: $\sum_r^G \mathbf{Y}_{sr}$. To produce one unit of gross output of good i a country uses a certain amount a of intermediate good j produced at home or imported from other countries. Thus each unit of gross output can be either consumed as a final good or used as an intermediate good at home or abroad:

$$\mathbf{X}_s = \sum_r^G (\mathbf{A}_{sr}\mathbf{X}_r + \mathbf{Y}_{sr})$$

where $\mathbf{A}_{sr}$ is the $N \times N$ matrix of coefficients for intermediate inputs produced in s and processed further in r:

$$\mathbf{A}_{sr} = \begin{bmatrix} a_{1,1}^{sr} & a_{1,2}^{sr} & \cdots & a_{1,N}^{sr} \\ a_{2,1}^{sr} & a_{2,2}^{sr} & \cdots & a_{2,N}^{sr} \\ \vdots & \vdots & \ddots & \vdots \\ a_{N,1}^{sr} & a_{N,2}^{sr} & \cdots & a_{N,N}^{sr}. \end{bmatrix}$$

Using the block matrix notation, the general setting of production and trade with G countries and N goods can be expressed as follows:

$$\underset{(NG\times 1)}{\begin{bmatrix} \mathbf{X}_1 \\ \mathbf{X}_2 \\ \vdots \\ \mathbf{X}_G \end{bmatrix}} = \underset{(NG\times NG)}{\begin{bmatrix} \mathbf{A}_{11} & \mathbf{A}_{12} & \cdots & \mathbf{A}_{1G} \\ \mathbf{A}_{21} & \mathbf{A}_{22} & \cdots & \mathbf{A}_{2G} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{A}_{G1} & \mathbf{A}_{G2} & \cdots & \mathbf{A}_{GG} \end{bmatrix}} \underset{(NG\times 1)}{\begin{bmatrix} \mathbf{X}_1 \\ \mathbf{X}_2 \\ \vdots \\ \mathbf{X}_G \end{bmatrix}} + \underset{(NG\times G)}{\begin{bmatrix} \mathbf{Y}_{11} & \mathbf{Y}_{12} & \cdots & \mathbf{Y}_{1G} \\ \mathbf{Y}_{21} & \mathbf{Y}_{22} & \cdots & \mathbf{Y}_{2G} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{Y}_{G1} & \mathbf{Y}_{G2} & \cdots & \mathbf{Y}_{GG} \end{bmatrix}} \underset{(G\times 1)}{\begin{bmatrix} 1 \\ 1 \\ \vdots \\ 1 \end{bmatrix}} \tag{A.1}$$

from which it is straightforward to derive the following relationship between gross output and final demand:

$$\begin{bmatrix} \mathbf{X}_1 \\ \mathbf{X}_2 \\ \vdots \\ \mathbf{X}_G \end{bmatrix} = \begin{bmatrix} \mathbf{I}-\mathbf{A}_{11} & -\mathbf{A}_{12} & \cdots & -\mathbf{A}_{1G} \\ -\mathbf{A}_{21} & \mathbf{I}-\mathbf{A}_{22} & \cdots & -\mathbf{A}_{2G} \\ \vdots & \vdots & \ddots & \vdots \\ -\mathbf{A}_{G1} & -\mathbf{A}_{G2} & \cdots & \mathbf{I}-\mathbf{A}_{GG} \end{bmatrix}^{-1} \begin{bmatrix} \sum_r^G \mathbf{Y}_{1r} \\ \sum_r^G \mathbf{Y}_{2r} \\ \vdots \\ \sum_r^G \mathbf{Y}_{1G} \end{bmatrix}$$

$$= \begin{bmatrix} \mathbf{B}_{11} & \mathbf{B}_{12} & \cdots & \mathbf{B}_{1N} \\ \mathbf{B}_{21} & \mathbf{B}_{22} & \cdots & \mathbf{B}_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{B}_{G1} & \mathbf{B}_{G2} & \cdots & \mathbf{B}_{GG} \end{bmatrix} \begin{bmatrix} \sum_r^G \mathbf{Y}_{1r} \\ \sum_r^G \mathbf{Y}_{2r} \\ \vdots \\ \sum_r^G \mathbf{Y}_{1G} \end{bmatrix} \qquad \text{(A.2)}$$

where $\mathbf{B}_{sr}$ denotes the $N \times N$ block of the Leontief inverse matrix in a global IO setting. It indicates how much of country's s gross output of a certain good is required to produce one unit of country r's final production.

It is useful to recall two equivalences that are used extensively in KWW (2014) and that we use to derive the results presented in section 2. Considering the following property of inverse matrix B:

$$\mathbf{B}(\mathbf{I}-\mathbf{A}) = (\mathbf{I}-\mathbf{A})\mathbf{B} = \mathbf{I}$$

it is easily shown that the generic block diagonal element $\mathbf{B}_{ss}$ may be expressed as follows:

$$\begin{aligned} \mathbf{B}_{ss} &= \sum_{t \neq s}^{G} \mathbf{B}_{st}\mathbf{A}_{ts}(\mathbf{I}-\mathbf{A}_{ss})^{-1} + (\mathbf{I}-\mathbf{A}_{ss})^{-1} = \\ &= (\mathbf{I}-\mathbf{A}_{ss})^{-1} + (\mathbf{I}-\mathbf{A}_{ss})^{-1} \sum_{t \neq s}^{G} \mathbf{A}_{st}\mathbf{B}_{ts} \end{aligned} \qquad \text{(A.3)}$$

while the generic off-diagonal block element $\mathbf{B}_{rs}$ corresponds to:

$$\begin{aligned} \mathbf{B}_{rs} &= \sum_{t \neq s}^{G} \mathbf{B}_{rt}\mathbf{A}_{ts}(\mathbf{I}-\mathbf{A}_{ss})^{-1} = \\ &= (\mathbf{I}-\mathbf{A}_{rr})^{-1} \sum_{t \neq r}^{G} \mathbf{A}_{rt}\mathbf{B}_{ts} \end{aligned} \qquad \text{(A.4)}$$

The direct value added share in each unit of gross output produced by country s is equal to one minus the sum of the direct intermediate input share of all the domestic and foreign suppliers:

$$\mathbf{V}_s = \mathbf{u}_N(\mathbf{I} - \sum_r^G \mathbf{A}_{rs}) \tag{A.5}$$

where $\mathbf{u}_N$ is the $1 \times N$ unit row vector. Thus the $G \times GN$ direct domestic value added matrix for all countries can be defined as:

$$\mathbf{V} = \begin{bmatrix} \mathbf{V}_1 & \mathbf{0} & \cdots & \mathbf{0} \\ \mathbf{0} & \mathbf{V}_2 & \cdots & \mathbf{0} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{0} & \mathbf{0} & \cdots & \mathbf{V}_G \end{bmatrix}$$

while the overall $G \times GN$ value added share matrix is obtained by multiplying the $\mathbf{V}$ matrix by the Leontief inverse $\mathbf{B}$:

$$\mathbf{VB} = \begin{bmatrix} \mathbf{V}_1\mathbf{B}_{11} & \mathbf{V}_1\mathbf{B}_{12} & \cdots & \mathbf{V}_1\mathbf{B}_{1G} \\ \mathbf{V}_2\mathbf{B}_{21} & \mathbf{V}_2\mathbf{B}_{22} & \cdots & \mathbf{V}_2\mathbf{B}_{2G} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{V}_G\mathbf{B}_{G1} & \mathbf{V}_G\mathbf{B}_{G2} & \cdots & \mathbf{V}_G\mathbf{B}_{GG} \end{bmatrix}$$

Since the domestic value shares of different countries in final demand have to sum to one the following property holds:

$$\sum_r^G \mathbf{V}_s\mathbf{B}_{sr} = \mathbf{u}_N \tag{A.6}$$

Defining the $GN \times G$ final demand matrix as:

$$\mathbf{Y} = \begin{bmatrix} \mathbf{Y}_{11} & \mathbf{Y}_{12} & \cdots & \mathbf{Y}_{1G} \\ \mathbf{Y}_{21} & \mathbf{Y}_{22} & \cdots & \mathbf{Y}_{2G} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{Y}_{G1} & \mathbf{Y}_{G2} & \cdots & \mathbf{Y}_{GG} \end{bmatrix}$$

we can derive the $G \times G$ value added matrix by pairs of source-absorption countries:

$$\overline{\mathbf{VA}} \equiv \mathbf{VBY} =$$

$$= \begin{bmatrix} \mathbf{V}_1 \sum_r^G \mathbf{B}_{1r}\mathbf{Y}_{r1} & \mathbf{V}_1 \sum_r^G \mathbf{B}_{1r}\mathbf{Y}_{r2} & \cdots & \mathbf{V}_1 \sum_r^G \mathbf{B}_{1r}\mathbf{Y}_{rG} \\ \mathbf{V}_2 \sum_r^G \mathbf{B}_{2r}\mathbf{Y}_{r2} & \mathbf{V}_2 \sum_r^G \mathbf{B}_{2r}\mathbf{Y}_{r2} & \cdots & \mathbf{V}_2 \sum_r^G \mathbf{B}_{2r}\mathbf{Y}_{rG} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{V}_G \sum_r^G \mathbf{B}_{Gr}\mathbf{Y}_{rG} & \mathbf{V}_G \sum_r^G \mathbf{B}_{Gr}\mathbf{Y}_{rG} & \cdots & \mathbf{V}_G \sum_r^G \mathbf{B}_{Gr}\mathbf{Y}_{rG} \end{bmatrix} \tag{A.7}$$

To get the domestic value added by sector, one must apply a different form of the direct value added matrix. Defining $\widehat{\mathbf{V}}_s$ as the $N\times N$ diagonal matrix with the direct value added coefficients along the principal diagonal, the $GN\times GN$ block diagonal matrix for all countries and sectors of origin becomes:

$$\widehat{\mathbf{V}} = \begin{bmatrix} \widehat{\mathbf{V}}_1 & \mathbf{0} & \cdots & \mathbf{0} \\ \mathbf{0} & \widehat{\mathbf{V}}_2 & \cdots & \mathbf{0} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{0} & \mathbf{0} & \cdots & \widehat{\mathbf{V}}_G \end{bmatrix}$$

The $GN\times G$ matrix that reproduces the composition of value added by sector-county of origin and country of final destination is:

$$\mathbf{VA} \equiv \widehat{\mathbf{V}}\mathbf{BY} =$$

$$= \begin{bmatrix} \widehat{\mathbf{V}}_1 \sum_r^G \mathbf{B}_{1r}\mathbf{Y}_{r1} & \widehat{\mathbf{V}}_1 \sum_r^G \mathbf{B}_{1r}\mathbf{Y}_{r2} & \cdots & \widehat{\mathbf{V}}_1 \sum_r^G \mathbf{B}_{1r}\mathbf{Y}_{rG} \\ \widehat{\mathbf{V}}_2 \sum_r^G \mathbf{B}_{2r}\mathbf{Y}_{r2} & \widehat{\mathbf{V}}_2 \sum_r^G \mathbf{B}_{2r}\mathbf{Y}_{r2} & \cdots & \widehat{\mathbf{V}}_2 \sum_r^G \mathbf{B}_{2r}\mathbf{Y}_{rG} \\ \vdots & \vdots & \ddots & \vdots \\ \widehat{\mathbf{V}}_G \sum_r^G \mathbf{B}_{Gr}\mathbf{Y}_{rG} & \widehat{\mathbf{V}}_G \sum_r^G \mathbf{B}_{Gr}\mathbf{Y}_{rG} & \cdots & \widehat{\mathbf{V}}_G \sum_r^G \mathbf{B}_{Gr}\mathbf{Y}_{rG} \end{bmatrix} \tag{A.8}$$

The off-diagonal elements of the **VA** matrix correspond to the value added exports as defined in KWW(2014), i.e. the vector of domestic value added originated in country s and finally absorbed in country r:

$$\mathbf{VT}_{sr} \equiv \mathbf{VA}_{sr} = \widehat{\mathbf{V}}_s \sum_g^G \mathbf{B}_{sg}\mathbf{Y}_{gr} \tag{A.9}$$

Finally we may be interested in relating the sector/country in which the value added is generated with the sector/country of final demand absorption. This result can be easily derived from equation A.8, simply by modifying the final demand matrix $\mathbf{Y}$. In particular we can define $\widehat{\mathbf{Y}}_{sr}$ as the $N\times N$ diagonal matrix with country r's demand for final goods produced in country s along the principal diagonal:

$$\widehat{\mathbf{Y}}_{sr} = \begin{bmatrix} y_1^{sr} & 0 & \cdots & 0 \\ 0 & y_2^{sr} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & y_N^{sr} \end{bmatrix}$$

Then the distribution of global value added by combinations of sector/county of origin and sector-country of final destination is represented by the following $GN \times GN$ matrix:

$$\widehat{\mathbf{VA}} \equiv \widehat{\mathbf{V}}\mathbf{B}\widehat{\mathbf{Y}} =$$

$$= \begin{bmatrix} \widehat{\mathbf{V}}_1 \sum_r^G \mathbf{B}_{1r}\widehat{\mathbf{Y}}_{r1} & \widehat{\mathbf{V}}_1 \sum_r^G \mathbf{B}_{1r}\widehat{\mathbf{Y}}_{r2} & \cdots & \widehat{\mathbf{V}}_1 \sum_r^G \mathbf{B}_{1r}\widehat{\mathbf{Y}}_{rG} \\ \widehat{\mathbf{V}}_2 \sum_r^G \mathbf{B}_{2r}\widehat{\mathbf{Y}}_{r2} & \widehat{\mathbf{V}}_2 \sum_r^G \mathbf{B}_{2r}\widehat{\mathbf{Y}}_{r2} & \cdots & \widehat{\mathbf{V}}_2 \sum_r^G \mathbf{B}_{2r}\widehat{\mathbf{Y}}_{rG} \\ \vdots & \vdots & \ddots & \vdots \\ \widehat{\mathbf{V}}_G \sum_r^G \mathbf{B}_{Gr}\widehat{\mathbf{Y}}_{rG} & \widehat{\mathbf{V}}_G \sum_r^G \mathbf{B}_{Gr}\widehat{\mathbf{Y}}_{rG} & \cdots & \widehat{\mathbf{V}}_G \sum_r^G \mathbf{B}_{Gr}\widehat{\mathbf{Y}}_{rG} \end{bmatrix} \quad (A.10)$$

B Appendix

In this Appendix we show that each component of KWW's original decomposition (equation 36 in KWW, 2014) may be retrieved starting from our decomposition in equation (11), as total exports are simply the sum of all the bilateral export flows (i.e. $\mathbf{E}_{s*} = \sum_{r\neq s}^{G} \mathbf{E}_{sr}$). As observed, it is straightforward to recognize this correspondence for the first item (i.e. *the domestic value added in direct final good exports*) and for the last three items, which identify the foreign content of gross exports. In these cases, the original KWW components can be obtained as a simple sum over the importing countries r of the corresponding items in our bilateral decomposition. For the remaining components a few more steps are needed to prove the equivalence between the two expressions.

In deriving our bilateral decomposition we introduced a modified version of the Leontief inverse matrix, $\widehat{\mathbf{B}}^{\not s}$. We start by showing how it relates to the original Leontief inverse $\mathbf{B}$ that appears in the KWW equation. First, $\widehat{\mathbf{B}}^{\not s}$ is obtained by setting equal to 0 the coefficients that identify the requirement of inputs from country s in the $\mathbf{A}$ matrix (excepting only the domestic input requirement matrix $\mathbf{A}_{ss}$). Thus the modified matrix of input can be expressed as follows:

$$\mathbf{A}^{\not s} = (\mathbf{A} - \mathbf{A}^{s}) \tag{B.1}$$

where $\mathbf{A}^{s}$ is the $GN\times GN$ matrix with the coefficients of intermediate inputs imported from s in the corresponding sub-matrices and zero elsewhere. Since $\widehat{\mathbf{B}}^{\not s}$ is the inverse of $(\mathbf{I} - \mathbf{A}^{\not s})$, the following relationship holds:

$$(\mathbf{I} - \mathbf{A}^{\not s})\widehat{\mathbf{B}}^{\not s} = \widehat{\mathbf{B}}^{\not s}(\mathbf{I} - \mathbf{A}^{\not s}) = \mathbf{I} \tag{B.2}$$

Substituting (B.1) into (B.2) we get:

$$(\mathbf{I} - \mathbf{A})\widehat{\mathbf{B}}^{\not s} + \mathbf{A}^{s}\widehat{\mathbf{B}}^{\not s} = \mathbf{I} \tag{B.3}$$

and multiplying both sides of (B.3) by $\mathbf{B} \equiv (\mathbf{I} - \mathbf{A})^{-1}$ we obtain the following equivalence:

$$\mathbf{B} = \widehat{\mathbf{B}}^{\not s} + \mathbf{B}\mathbf{A}^{s}\widehat{\mathbf{B}}^{\not s} \tag{B.4}$$

Then we focus on the off-diagonal block element $\mathbf{B}_{sr}$ that identifies the gross output generated in s necessary to produce one unit of r final good. According to equation (B.4) this sub-matrix can be expressed as follows:

$$\mathbf{B}_{sr} = \widehat{\mathbf{B}}^{\not s}_{sr} + \mathbf{B}_{ss} \sum_{t \neq s} \mathbf{A}_{st} \widehat{\mathbf{B}}^{\not s}_{tr} \tag{B.5}$$

where $\mathbf{B}^{\not s}_{sr}$ is equal to $\mathbf{0}$ for each $r \neq s$, since it corresponds to a summation of infinite terms all equal to the null matrix. Therefore if we single out the $\widehat{\mathbf{B}}^{\not s}_{rr}$ element from the final summation of the right-hand side of equation (B.5) we get:

$$\mathbf{B}_{sr} = \mathbf{B}_{ss}\mathbf{A}_{sr}\widehat{\mathbf{B}}^{\not s}_{rr} + \mathbf{B}_{ss} \sum_{t \neq s,r} \mathbf{A}_{st} \widehat{\mathbf{B}}^{\not s}_{tr} \tag{B.6}$$

Then applying to the elements of matrix $\widehat{\mathbf{B}}^{\not s}$ the properties of $\mathbf{B}$ sub-matrices illustrated in (A.3) and (A.4):

$$\widehat{\mathbf{B}}^{\not s}_{rr} = (\mathbf{I} - \mathbf{A}_{rr})^{-1} + (\mathbf{I} - \mathbf{A}_{rr})^{-1} \sum_{j \neq r} \mathbf{A}_{rj} \widehat{\mathbf{B}}^{\not s}_{jr} \tag{B.7}$$

$$\widehat{\mathbf{B}}^{\not s}_{tr} = (\mathbf{I} - \mathbf{A}_{tt})^{-1} \sum_{j \neq t}^{G} \mathbf{A}_{tj} \widehat{\mathbf{B}}^{\not s}_{jr} \tag{B.8}$$

Plugging (B.7) and (B.8) into (B.6) we obtain the following expression for $\mathbf{B}_{sr}$:

$$\begin{aligned} \mathbf{B}_{sr} &= \mathbf{B}_{ss}\mathbf{A}_{sr}(\mathbf{I} - \mathbf{A}_{rr})^{-1} + \mathbf{B}_{ss}\mathbf{A}_{sr}(\mathbf{I} - \mathbf{A}_{rr})^{-1} \sum_{j \neq r} \mathbf{A}_{rj} \widehat{\mathbf{B}}^{\not s}_{jr} \\ &+ \mathbf{B}_{ss} \sum_{t \neq s,r} \mathbf{A}_{st} (\mathbf{I} - \mathbf{A}_{tt})^{-1} \sum_{j \neq t}^{G} \mathbf{A}_{tj} \widehat{\mathbf{B}}^{\not s}_{jr} \end{aligned} \tag{B.9}$$

Finally we can sum across the $G-1$ foreign countries (i.e. $\sum_{r \neq s}^{G}$) to show that the remaining items in the accounting of bilateral trade flows in equation (11) can be mapped into the corresponding components of the original KWW decomposition of aggregate exports. For instance, pre-multiplying by matrix $\mathbf{V}_s$, post-multiplying by $\mathbf{Y}_{rr}$ and summing across r both sides of equation (B.9) we exactly retrieve the second component of the KWW decomposition:

$$
\begin{aligned}
\mathbf{V}_s \sum_{r \neq s} \mathbf{B}_{sr} \mathbf{Y}_{rr} = {} & \mathbf{V}_s \sum_{r \neq s} \mathbf{B}_{ss} \mathbf{A}_{sr} (\mathbf{I} - \mathbf{A}_{rr})^{-1} \mathbf{Y}_{rr} \\
& + \mathbf{V}_s \sum_{r \neq s} \mathbf{B}_{ss} \mathbf{A}_{sr} (\mathbf{I} - \mathbf{A}_{rr})^{-1} \sum_{j \neq r} \mathbf{A}_{rj} \widehat{\mathbf{B}}^{\not s}_{jr} \mathbf{Y}_{rr} \\
& + \mathbf{V}_s \sum_{r \neq s} \mathbf{B}_{ss} \sum_{t \neq s,r} \mathbf{A}_{st} (\mathbf{I} - \mathbf{A}_{tt})^{-1} \sum_{j \neq t}^{G} \mathbf{A}_{tj} \widehat{\mathbf{B}}^{\not s}_{jr} \mathbf{Y}_{rr}
\end{aligned} \tag{B.10}
$$

where the left-hand side of equation (B.10) corresponds to the sum across all direct importers (r) of the components **2a**, **2b** and **2c** in equation (11):

$$
\begin{aligned}
\sum_{r \neq s} (\mathbf{2a} + \mathbf{2b} + \mathbf{2c}) = {} & \mathbf{V}_s \sum_{r \neq s} \mathbf{B}_{ss} \mathbf{A}_{sr} (\mathbf{I} - \mathbf{A}_{rr})^{-1} \mathbf{Y}_{rr} \\
& + \mathbf{V}_s \sum_{r \neq s} \mathbf{B}_{ss} \mathbf{A}_{sr} (\mathbf{I} - \mathbf{A}_{rr})^{-1} \sum_{j \neq r}^{G} \mathbf{A}_{rj} \widehat{\mathbf{B}}^{\not s}_{jr} \mathbf{Y}_{rr} \\
& + \mathbf{V}_s \sum_{r \neq s} \mathbf{B}_{ss} \mathbf{A}_{sr} (\mathbf{I} - \mathbf{A}_{rr})^{-1} \sum_{j \neq r}^{G} \mathbf{A}_{rj} \sum_{k \neq s,r}^{G} \widehat{\mathbf{B}}^{\not s}_{jk} \mathbf{Y}_{kk}
\end{aligned} \tag{B.11}
$$

The first two terms on the left-hand side are clearly identical, and the equivalence between the last items is readily verified by replacing the subscript k with r and the subscript r with t in the last term of equation (B.11). However, it should be noticed that for this last term the single addends in the summation across the r foreign countries differ between the two equations. This is because this portion of domestic value added produced in s for final use in r gets to the final destination markets by passing through one or more third countries; that is, it is not part of the bilateral exports from s to r.

Starting from the definition of the $\mathbf{B}_{rs}$ matrix in equation (B.9) and following the same procedure employed for the second item of the KWW decomposition, it is easy to prove that the third and forth components too can be obtained as the sum of the corresponding items in our bilateral decomposition across all the destinations.

Finally, we use a slightly different procedure to show that also the fifth and sixth terms in the KWW main accounting relationship are exactly mapped within the bilateral exports. We start by singling out the block matrix $\mathbf{B}_{ss}$ from the principal diagonal of the $\mathbf{B}$ matrix. According to equation (B.4) this matrix is equal to:

$$\mathbf{B}_{ss} = \widehat{\mathbf{B}}^{\not f}_{ss} + \mathbf{B}_{ss} \sum_{r \neq s} \mathbf{A}_{sr} \widehat{\mathbf{B}}^{\not f}_{rs} \tag{B.12}$$

We can then apply to the $\widehat{\mathbf{B}}^{\not f}$ the property of the block diagonal elements of the $\mathbf{B}$ matrix illustrated in (A.3):

$$\widehat{\mathbf{B}}^{\not f}_{ss} = (\mathbf{I} - \mathbf{A}^{\not f}_{ss})^{-1} + \sum_{t \neq s} \mathbf{B}^{\not f}_{st} \mathbf{A}_{ts} (\mathbf{I} - \mathbf{A}^{\not f}_{ss})^{-1} = (\mathbf{I} - \mathbf{A}_{ss})^{-1} \tag{B.13}$$

where the last equality follows from the fact that, by construction, $\mathbf{B}^{\not f}_{st}$ is equal to $\mathbf{0}$ for each $t \neq s$. Therefore (B.12) can be rewritten as follows:

$$\mathbf{B}_{ss} = (\mathbf{I} - \mathbf{A}_{ss})^{-1} + \mathbf{B}_{ss} \sum_{r \neq s} \mathbf{A}_{sr} \widehat{\mathbf{B}}^{\not f}_{rs} \tag{B.14}$$

Then, applying the same property of the block diagonal elements of the $\mathbf{B}$ matrix to the left hand side of (B.14) and rearranging we obtain:

$$\sum_{r \neq s} \mathbf{B}_{sr} \mathbf{A}_{rs} (\mathbf{I} - \mathbf{A}_{ss})^{-1} = \sum_{r \neq s} \mathbf{B}_{ss} \mathbf{A}_{sr} \widehat{\mathbf{B}}^{\not f}_{rs} \tag{B.15}$$

Finally, using the property presented in (A.4) to the $\widehat{\mathbf{B}}^{\not f}_{rs}$ matrix we get:

$$\sum_{r \neq s} \mathbf{B}_{sr} \mathbf{A}_{rs} (\mathbf{I} - \mathbf{A}_{ss})^{-1} = \sum_{r \neq s} \mathbf{B}_{ss} \mathbf{A}_{sr} (\mathbf{I} - \mathbf{A}_{rr})^{-1} \sum_{j \neq r} \mathbf{A}_{rj} \widehat{\mathbf{B}}^{\not f}_{js} \tag{B.16}$$

Now it is straightforward to see that the fifth and sixth terms in the KWW decomposition are simply the sum of the same terms in equation (11) across all the bilateral destinations.

C Appendix

The decomposition of bilateral exports in a source-based approach can be expressed as follows:

$$
\begin{aligned}
\mathbf{u}_N\mathbf{E}_{sr} = {} & \overset{\mathbf{1a*}}{\mathbf{V}_s(\mathbf{I}-\mathbf{A}_{ss})^{-1}\mathbf{Y}_{sr}} \\
& + \mathbf{V}_s(\mathbf{I}-\mathbf{A}_{ss})^{-1}\mathbf{A}_{sr}(\mathbf{I}-\mathbf{A}_{rr})^{-1}\left[\overset{\mathbf{1b*}}{\sum_{j\neq r}^{G}\mathbf{A}_{rj}\mathbf{B}_{js}\mathbf{Y}_{sr}} + \overset{\mathbf{1c*}}{\sum_{j\neq r}^{G}\mathbf{A}_{rj}\sum_{k\neq s,r}^{G}\mathbf{B}_{js}\mathbf{Y}_{sk}}\right] \\
& + \mathbf{V}_s(\mathbf{I}-\mathbf{A}_{ss})^{-1}\mathbf{A}_{sr}(\mathbf{I}-\mathbf{A}_{rr})^{-1}\left[\overset{\mathbf{2a*}}{\mathbf{Y}_{rr}} + \overset{\mathbf{2b*}}{\sum_{j\neq r}^{G}\mathbf{A}_{rj}\mathbf{B}_{jr}\mathbf{Y}_{rr}} + \overset{\mathbf{2c*}}{\sum_{j\neq r}^{G}\mathbf{A}_{rj}\sum_{k\neq s,r}^{G}\mathbf{B}_{jk}\mathbf{Y}_{kk}}\right] \\
& + \mathbf{V}_s(\mathbf{I}-\mathbf{A}_{ss})^{-1}\mathbf{A}_{sr}(\mathbf{I}-\mathbf{A}_{rr})^{-1}\left[\overset{\mathbf{3a*}}{\sum_{j\neq r,s}^{G}\mathbf{Y}_{rj}} + \overset{\mathbf{3b*}}{\sum_{j\neq r}^{G}\mathbf{A}_{rj}\sum_{l\neq s,r}^{G}\mathbf{B}_{jr}\mathbf{Y}_{rl}}\right. \\
& \qquad \left. + \overset{\mathbf{3c*}}{\sum_{j\neq r}^{G}\mathbf{A}_{rj}\sum_{k\neq s,r}^{G}\mathbf{B}_{jk}\mathbf{Y}_{kr}} + \overset{\mathbf{3d*}}{\sum_{j\neq r}^{G}\mathbf{A}_{rj}\sum_{k\neq s,r,l}^{G}\sum_{l\neq s,r}^{G}\mathbf{B}_{jk}\mathbf{Y}_{kl}}\right] \\
& + \mathbf{V}_s(\mathbf{I}-\mathbf{A}_{ss})^{-1}\mathbf{A}_{sr}(\mathbf{I}-\mathbf{A}_{rr})^{-1}\left[\overset{\mathbf{4a*}}{\mathbf{Y}_{rs}} + \overset{\mathbf{4b*}}{\sum_{j\neq r}^{G}\mathbf{A}_{rj}\mathbf{B}_{jr}\mathbf{Y}_{rs}} + \overset{\mathbf{4c*}}{\sum_{j\neq r}^{G}\mathbf{A}_{rj}\sum_{k\neq s,r}^{G}\mathbf{B}_{jk}\mathbf{Y}_{ks}}\right] \\
& + \overset{\mathbf{5*}}{\mathbf{V}_s(\mathbf{I}-\mathbf{A}_{ss})^{-1}\mathbf{A}_{sr}(\mathbf{I}-\mathbf{A}_{rr})^{-1}\sum_{j\neq r}^{G}\mathbf{A}_{rj}\mathbf{B}_{js}\mathbf{Y}_{ss}} \\
& + \overset{\mathbf{6*}}{\mathbf{V}_s(\mathbf{I}-\mathbf{A}_{ss})^{-1}\sum_{t\neq s}^{G}\mathbf{A}_{rt}\mathbf{B}_{ts}\mathbf{E}_{sr}} \\
& + \overset{\mathbf{7}}{\sum_{t\neq s}^{G}\mathbf{V}_t\mathbf{B}_{ts}\mathbf{Y}_{sr}} + \overset{\mathbf{8}}{\sum_{t\neq s}^{G}\mathbf{V}_t\mathbf{B}_{ts}\mathbf{A}_{sr}(\mathbf{I}-\mathbf{A}_{rr})^{-1}\mathbf{Y}_{rr}} \\
& + \overset{\mathbf{9}}{\sum_{t\neq s}^{G}\mathbf{V}_t\mathbf{B}_{ts}\mathbf{A}_{sr}(\mathbf{I}-\mathbf{A}_{rr})^{-1}\mathbf{E}_{r*}}
\end{aligned}
\tag{C.1}
$$

We can define the items above as:

1a* domestic value added (VA) in final good exports directly absorbed by bilateral importers;

1b* domestic VA in intermediate exports absorbed by bilateral importers as domestic final goods after additional processing stages;

1c* domestic VA in intermediate exports absorbed by third countries as domestic final goods after additional processing stages;

2a* domestic VA in intermediate exports absorbed by direct importers as local final goods;

2b* domestic VA in intermediate exports absorbed by direct importers as local final goods only after further processing stages;

2c* domestic VA in intermediate exports absorbed by third countries as local final goods;

3a* domestic VA in intermediate exports absorbed by third countries as final goods from direct bilateral importers;

3b* domestic VA in intermediate exports absorbed by third countries as final goods from direct bilateral importers only after further processing stages;

3c* domestic VA in intermediate exports absorbed by direct importers as final goods from third countries;

3d* domestic VA in intermediate exports absorbed by third countries as final goods from other third countries;

4a* domestic VA in intermediate exports absorbed at home as final goods of the bilateral importers;

4b* domestic VA in intermediate exports absorbed at home as final goods of the bilateral importers after further processing stages;

4c* domestic VA in intermediate exports absorbed at home as final goods of a third country;

5* domestic VA in intermediate exports absorbed at home as domestic final goods;

6* double-counted intermediate exports originally produced at home;

7 foreign VA in exports of final goods;

8 foreign VA in exports of intermediate goods;

9 double-counted intermediate exports originally produced abroad.

As for the sink-based decomposition, the enumeration of the items here above recalls the original KWW components, which can be obtained as a simple summation over the importing countries r of the corresponding items in our bilateral decomposition (a formal proof is available upon request). Note that terms **7**, **8** and **9** are precisely equal to those of the sink-based methodology in equation (11).

Quantifying the productivity effects of global value chains

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September 2015

Abstract

The diffusion of international production networks has challenged the capability of traditional trade statistics to provide an adequate representation of supply and demand linkages among the economies. To address this issue, new statistical tools (the Inter-Country Input-Output tables) and new analytical frameworks have been developed. Koopman, Wang and Wei propose an accounting methodology to decompose a country's total gross exports by source and final destination of their embedded value added. We develop this approach further by deriving a fully consistent counterpart for bilateral trade flows, enabling us also to refine the definition of the various items originally proposed. Along with the contributions of Wang et al. (2013) and Nagengast and Stehrer (2014), our methodology completes the bridge between traditional trade statistics and the systems of national accounts and provides new tools for investigating global value chains. Here we present two empirical applications of two different versions of our decomposition of bilateral trade flows: one explores the forward linkages of Italian exports; the second derives a measure of the share of value-chain-related trade and assesses how its evolution since the mid-1990s has affected the relationship between world trade and income.

Keywords: global value chains,input-output tables, trade in value added, trade elasticity.
JEL Classifications: E16, F1, F14, F15.

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We are grateful to Andrei Levchenko for kindly sharing with us the data used in the calculation of the technology levels and to Vasco Carvalho, Pietro Catte, Giancarlo Corsetti, Andrea Finicelli, Patrizio Pagano, Massimo Sbracia, Giacomo Oddo, Julia Wörtz and seminar participants at the Bank of Italy and the Universities of Cambridge and Nottingham for helpful comments. Parts of this paper were completed while Vergara Caffarelli was visiting the Faculty of Economics of the University of Cambridge, whose hospitality is gratefully acknowledged. The opinions expressed in this paper are the authors' own and do not necessarily reflect those of the Bank of Italy.

1 Introduction

International production, trade and investment are increasingly structured in so-called global value chains (GVCs) where each country specialises in one or few stages of the overall production process. This is a well-known phenomenon labelled in the literature "international fragmentation of production" (Jones and Kierzkowski, 1990).[1] Today, more than half of world trade in manufacturing goods consists of intermediate goods and more than 70% of trade in services involves intermediate services (de Backer and Miroudot, 2013). Thanks to lower trade and investment barriers and to advances in information and communication technologies, firms are able to organise their operations internationally through outsourcing and offshoring of activities, according to the comparative advantage of the different locations in increasingly specific tasks: R&D, production of individual parts and components, assembly, marketing, distribution, etc.. As firms are profit maximizing agents, the decision to participate in GVCs should be motivated by higher productivity and competitiveness, for instance through the access to either cheaper or better intermediate goods and services.

From a macro perspective, fragmentation of production across borders may have both positive and negative effects on a country's aggregate productivity, output and employment growth. This depends, for instance, on the share of value added produced by the production stages that are kept domestically compared to those that are outsourced, as well as on their technological or skill content. There is a widespread perception that the positive effects, both static (lower costs and better inputs) and dynamic (reallocation of factors towards more efficient tasks), more than offset any loss due to the outsourcing of valued added previously produced domestically. Nevertheless, especially due to data limitations, we still lack of empirical evidence to quantify these positive effects in terms of some measure of macroeconomic performance.

This paper makes a first attempt to fill this gap: using country-sector data, we evaluate the impact of the international fragmentation on the growth of productivity and employment. The analysis presented in this work focuses on the effects of backward fragmentation, defined as the propensity of a economy to exploit GVCs in order to obtain intermediate inputs from abroad. [2] We consider several measures of productivity, in order to shed some light on the channels through which participation in GVCs affects economic growth.

First of all, we look at standard measures of labour productivity, such as output and value added per worker. Moreover, we look at aggregate employment to test whether the changes

[1] Alternative terms used in the literature are: vertical specialisation (Hummels et al., 1998), global production sharing (Feenstra, 1998), international outsourcing (Grossman and Helpman 2002), international production networks (Ernst and Guerrieri, 1998).

[2] In a previous version of this work, we also looked at forward integration, defined as the propensity to export intermediate goods, but we could not find any effect of this form of GVC participation on productivity growth. This "no-result" could indicate that the mechanisms through which exporting intermediates affects macroeconomic variables are more complex than those from assembling components into final goods, and that our framework is not suitable to capture them. We leave the issue for further research.

induced to labour productivity can be explained, at least in part, by changes in the number of workers employed.[3]

We then try to understand the effect of the integration into GVCs on TFP growth. While any change in labour productivity can depend also on changes in the use of capital and, in the case of output per worker, in the use of intermediate goods, TFP is instead defined as the residual efficiency of the production process that cannot be explained by inputs' services. At the firm level, TFP growth is determined by technical and organizational innovations that improve the efficiency in the use and combination of inputs. We will refer to this component of TFP generically as technology. At a more aggregate level, for instance at the country-sector level that characterizes our analysis, TFP can vary not only in response to changes in technology within firms, but also in response to the reallocation of resources between firms with different levels of TFP. Borrowing from Finicelli et. al (2013), who extended the work of Eaton and Kortum (2002), we will decompose the growth rate in aggregate TFP at the country-sector level into the technological growth and the growth driven by resource reallocation. We will then asses the effect of the international fragmentation of production on the two components separately.

Our empirical strategy is based on the methodology introduced by Rajan and Zingales (1996) to deal with reverse causality between external finance and growth. Here we identify the effect of participation in GVCs on productivity and employment growth by exploiting the variation in the degree of integration in GVCs across 50 countries and the "fragmentability" of the production process across 18 sectors.[4] The interaction term between the country-specific measure and the sector-specific measure captures how much a country is exploiting the sector's potential for production fragmentation.

We measure backward integration in GVCs using indexes of specialization in importing intermediate goods. In defining "fragmentability", we distinguish between sequential GVCs (*snakes*) and horizontal GVCs (*spiders*) (see Baldwin and Venables (2013)). Snake production chains require the processing of intermediates to be performed in sequential stages, until final assembly. Spider-type chains, instead, involve simultaneous production of all parts and components, which are then assembled in the final good. We will consequently measure both the length and the width of GVCs as they refer, respectively, to the snake and spider dimensions of the production chain.

We find that the participation in GVCs positively affects labour productivity and TFP in sectors with long and wide production chains in countries specialised in importing intermediate goods. We also find that the impact on TFP in sequential GVCs comes from technology improvement, which could be driven both by the availability of a wider variety and better quality of inputs

[3]Participation in GVCs is often perceived as resucing employment, because it leads to a reduction in the demand of workers employed in those stages of production that can be outsourced.

[4]The actual sample size varies depending on data availability.

and by higher incentives to innovation. On the other hand, in horizontal GVCs TFP growth comes essentially from resource reallocation, probably due to an import competition effect.[5] Finally, there appears to be a negative effect on aggregate employment growth only in case of of horizontal fragmentation.

The existence of a positive link between productivity growth and firms' access to new inputs through imports is not novel in the literature: other papers document the beneficial effect of imported intermediates. Amiti and Konings (2006) show that a reduction in import tariffs generates the largest productivity gains (in comparison with a reduction of export tariffs), since it stimulates intermediate imports. The existence of a link between intermediate imports and productivity is also confirmed by Bas and Strauss-Kahn (2014) in France and by Kasahara and Lapham (2013) in Chile. Halpern et al. (2011) estimate that one third of productivity growth in Hungary between the early '90s and the early 2000s was due to imported inputs. In India, Goldberg et al. (2010) also uncover substantial gains from trade through access to previously unavailable imported inputs. In the EU import competition from China has led to an increase in technical change within firms and a reallocation of employment towards more technologically advanced firms. These effects account for almost one sixth of EU technology upgrading between 2000 and 2007 (Bloom et al., forthcoming).

The rest of the paper is organised as follows. Section 2 describes our empirical methodology and the key regressors. Section 3 presents the productivity measures which will be the dependent variables in the empirical analysis in section 4. Section 5 presents some concluding remarks. The appendices collect some supplementary material and all the tables.

2 Empirical strategy

Interpreting the relation existing between a country's economic performance (*e.g.* productivity) and its degree of integration in GVCs as causal can present several challenges. There can be omitted variables underlying the correlation between the two phenomena: for instance, integration in GVCs is positively correlated with trade openness, and trade openness tends to be positively correlated with real GDP and productivity growth (Alcalà and Ciccone, 2004). Another problem is given by reverse causality: is it integration in GVCs that drives productivity growth or higher productivity growth that makes it easier for countries to integrate in GVCs?

To interpret these correlations in a more causal sense it is necessary to identify the mechanism through which participation in GVCs affects macroeconomic performance and to find evidence supporting its relevance. Participation in GVCs could allow a country to increase productivity by enabling firms to access the best intermediate inputs, by stimulating the reallocation of resources towards more efficient tasks or by triggering technological advances. Of course these

[5] See for instance Amiti and Konings (2007), Trefler (2004) and Roberts and Tybout (1991).

effects tend to be larger, the more the production process characterising a given sector can indeed be fragmented into many separate production stages. We then test whether sectors whose technical characteristics make them more “fragmentable” are relatively “better off” in economies with a high degree of participation in GVCs. This simple test, inspired by Rajan and Zingales (1996), has two main virtues. First, it focuses on the mechanism via which participation on GVCs could affect macroeconomic performance, thus providing a stronger test of causality. Second, as it is based on the simultaneous variation of both a country-specific and a sector-specific dimension, it allows to control for missing variables using fixed effects for both countries and industries.

Our empirical model is thus given by:

$$z_{i,s} = \alpha + \beta Y_i \times W_s + \delta ln(Z_{i,s}) + \gamma \Phi_{i,s} + \theta_i + \omega_s + \epsilon_{i,s} \quad (1)$$

where $z_{i,s}$ is the growth rate of macroeconomic variable $Z_{i,s}$ (either productivity or employment) in country i and sector s between the ’90s and the 2000s, Y_i is the country-specific measure for participation in GVCs, W_s is a sector-specific measure of the possibility to fragment the production process and $\Phi_{i,s}$ is any country-sector control. All the *r.h.s.* variables are computed with data referring to the beginning of the period (the ’90s) in order to avoid further problems of reverse causality. Our specification always includes country fixed effects, θ_i, so as to capture all those sector invariant country characteristics that could affect macroeconomic performance (*e.g.* trade openness and specialization, institutional development, etc.); industry fixed effects, ω_s, to capture any industry-specific characteristics that could also affect the economic performance (*e.g.* technological content, level of world demand, etc.); and the level of the dependent variable in the ’90s, $ln(Z_{i,s})$, to control for the initial condition Our task is to estimate the coefficient β for the interaction term between the country-specific and the sector-specific variables. A positive coefficient would tell us that the benefits from a country’s integration in GVCs are higher for sectors that provide greater opportunities to fragment the production process.

As we aim at describing the long-run relationship between international fragmentation of production and macroeconomic performance, avoiding short-term fluctuations, our variables are constructed as ten-year averages, with the ’90s given by the period 1990-1999 and the 2000s by 2000-2009. We thus focus on the growth rate between the ’90s and the 2000s, when the international fragmentation of production became a defining feature of international trade flows.

In order to estimate equation (1), we take as a measure of countries’ integration in GVCs a Balassa (1965) index that measures a country’s propensity to import intermediate goods relative to the world average, as well as a refinement of the same index that controls for sectoral specialisation in international trade. As for the sectors’ technological propensity to fragmentation, we construct two measures. The first is the length of the production process in terms of the number of stages embodied in each product; the second is the complexity, *i.e.* width, of the assembly operations in terms of the number of parts and components from different sectors put together to produce the final product. In both cases the interpretation is the same: the larger the number of inputs, the greater the feasible fragmentation across different locations. The following subsections describe the key regressors in detail.

2.1 Measures of fragmentability

Our empirical strategy requires us to measure the extent to which production in each sector can be efficiently fragmented. Our goal is to capture fragmentability as a technological feature of each sector, with the idea that it is the engineering of the production process that dictates the way in which different stages of production are linked and can be unbundled. This constitutes only a prerequisite for fragmentation to take place: only if the country has the propensity and the capabilities needed to efficiently split the production process can the fragmentation indeed occur, domestically or internationally, again depending on country's characteristics.

A GVC is a production network that connects the different phases of an internationally fragmented production process, i.e. such that different stages of production take place in different countries. GVCs can be rather complex production networks. Figure 1, borrowed directly from Baldwin and Venables (2013), depicts a "general" GVC which may have a rather intricate architecture.

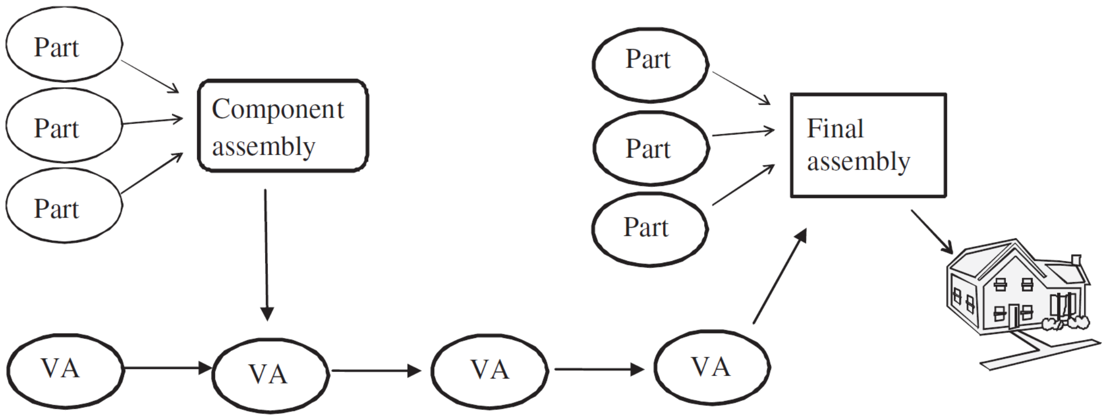

Figure 1: A general GVC (from Baldwin and Venables, 2013)

In line with Baldwin and Venables (2013) we consider two extreme structures for the production process: snakes and spiders. Snakes are production networks where value is added sequentially in each stage of the process, from upstream to downstream, up to final assembly (fig. 2). A spider is a production network where the parts are produced simultaneously and shipped to a hub to form a body (final assembly in fig.3), which may be the final product or a new component. Indeed most GVCs are complex mixtures of the two, and the interest in studying these extreme cases lies in the fact that they are the elementary building blocks of any production network.

Cotton to yarn to fabric to shirts is a snake-like process, but adding buttons is a spider-type element. Silicon to chips to computers is snake-like, but much of value added in producing a computer is spider-like final assembly of parts from different sources.

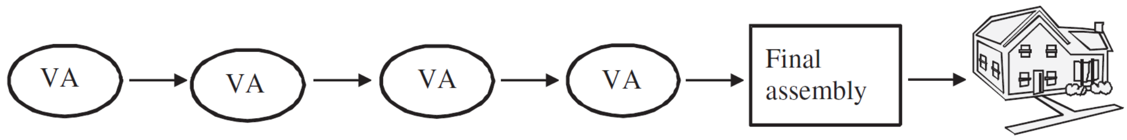

Figure 2: A snake GVC

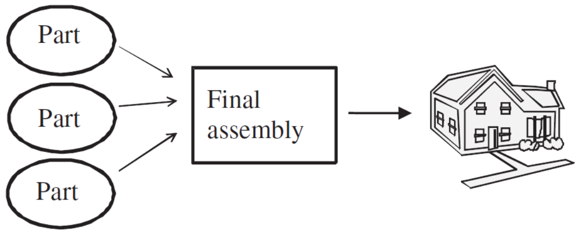

Figure 3: A spider GVC

Snakes and spiders can also be interpreted as two different dimensions of fragmentability: the first vertical, the second horizontal. We thus define two sector-specific indicators that characterize the fragmentability of the production process:

i. N_s^{Snake}, for the length of the value chain, borrowed from Fally (2012), that measures the number of production stages required for producing the final output of a given industry s (vertical fragmentability);

ii. N_s^{Spider}, for the width of the production process in a given industry s, that measures the number of commodities used in the final production stage (horizontal fragmentability).

Both indicators are based on I-O data for the US provided by the Bureau of Economic Analysis (BEA). The I-O tables provide a detailed snapshot of the economy, as they show the number and the quantity of commodity inputs that are used by each industry to produce its output (the so called "use table"), the commodities produced by each industry (the "make table"), and the use of commodities by final consumers. This offers us a sort of recipe book for the production in the US .

The index N_s^{Snake} is defined recursively: the average number of production stages of each industry depends on the number of production stages required by the inputs used:

$$N_s^{Snake} = 1 + \sum_k \mu_{sk} N_k^{Snake}. \tag{2}$$

where μ_{sk} is the value of input k used to produce 1 dollar value of output of industry s. In other words, the index is equal to 1 (the final production stage), plus the number of stages required to produce each of the inputs, weighted according to the unit input requirements. Equation (2) provides a system of linear equations that, for $\sum_k \mu_{sk} < 1$, has a unique solution for the vector $\boldsymbol{N}^{Snake}$.

In practice, starting from the make and use tables, first we derive the direct requirement table: this is an n-by-n matrix DR with entries μ_{sk}. Then, we obtain the n-by-n total requirement table $TR = (I - DR)^{-1}$, which shows the production required of a given commodity k, both directly and indirectly, per dollar value of delivery to final use by each industry s.[6] For instance, if the diagonal entry for the computer and electronic good industry and the computer and electronic commodities is equal to 1.2, it means that, to provide final users with \$1 billion of output from the computer and electronic good industry, requires \$1.2 billion of computer and electronic products, both directly and indirectly in the production of other commodities (for instance in producing machinery and equipment, that are then used as direct inputs by the computer and electronic good industry). The solution to the system in (2) is simply the sum of the total requirements of each industry.

As shown by Failly (2012), the "snake" measure is the average number of stages of the production chain, in which each stage is weighted by the share of value added in that stage. High values of the index indicate that many sectors are involved in the process, thus making it feasible to reallocate different production phases in different countries. With this index we aim at capturing only the potential, not the actual, extent of (international) fragmentation. One limitation of Failly's (2012) index is that it takes into account only the sequence of the different stages without considering their horizontal complexity. For instance, a good that is produced using one input only, which is also produced using only one input, produced again with one input, has three production stages, each properly weighted, while a good produced by assembling 3 different raw materials as inputs has only one production stage.

In order to account for the horizontal complexity of the production process, we define the index N_s^{Spider} simply as the number of inputs k used by industry s, considering only those inputs that enter directly in the final stage of the production process:

$$N_s^{Spider} = \sum_k \mathbf{1}_{\{\mu_{sk}>0\}}, \tag{3}$$

[6]Playing around with the make and use tables, it is possible to derive different version of the direct and total requirement tables: commodity-by-industry, commodity-by-commodity, industry-by-industry, and industry-by-commodity (see also Horovitz and Oosterhoven, 2016), where the distinction between industries and commodities comes from the fact that some firms are classified into industries according to their primary commodity output, but they could produce more then one commodity. Following Fally (2012), we present the results using the commodity-by-industry approach, meaning that the tables present the value of commodities required as inputs for the output of the different industries. Nevertheless, our results are robust to using alternative approaches, as the fragmentability measures computed with the different approaches are highly correlated.

meaning that we count the row's entries μ_{sk} of the commodity-industry direct requirement table that are different from zero.[7]

The spider-type index is a measure of width of the production process. As such it strictly counts the number of inputs that are put together in the last stage for final assembly.[8] The higher the number of the components needed to assemble the final good, the more complex the production process, irrespective of the contribution of each component to the overall value added. For this reason, we do not weigh the inputs in terms of their contribution to the vale of the final good. This is an important difference with respect to the snake-measure: in that case, as we are interested in measuring the length of the production process, we have to consider the contribution of all the inputs ever used in any of the stages that brings to the final assembly. It is then necessary to weigh each intermediate stage's contribution in order to take into account its relevance in the overall production chain.

We compute both our indicators for the 127 industries (53 thereof belong to manufacturing) that enter the BEA's I-O table at the NAICS 4 digit-level of disaggregation. We then aggregate the indexes at the same level of the of the productivity data provided by Levcehnko and Zhang (2014), which is 2-digit ISIC rev. 3 with few adjustments, encompassing 18 manufacturing sectors. (see table 1).[9] [10]

We use US data, as we want to measure a technological feature of the production process that does not depend on each single country's characteristics. Industries in the US, being on average on the technological frontier and not heavily constrained by institutional inefficiencies and frictions, should be able to organise the production process in a way that is as close as possible to the optimum and that best reflects the technological characteristics of the sectors. In other words, technical and institutional characteristics of the US economy should allow firms to fragment the production process as much as it is profitable, given the technical characteristics of the sector. We are well aware that by doing so we are underestimating the length and the complexity of the foreign part of US production chains, since all foreign production steps are collapsed into a single commodity, generically labeled as "imports". Indeed we are imposing for each sector that the length of its global production chain is given by the longest domestic

[7]Nunn (2007) uses the same indicator to measure a firm's difficulty to vertical integrate, as the greater the number of inputs, the harder is for a firm to vertical integrate with all its suppliers.

[8]Alternatively, as we did for the snake-measure, we could have counted the number of inputs used both directly and indirectly, not just those in the last stage. The index then would not allow us to distinguish between horizontal and vertical features of the process.

[9]The aggregation is given by the weighted average of the indicators for the sectors at the NAICS 4 digit-level that match into the same ISIC 2-digit-level, according to the concordance table provided by UNSTAT. A perfect correspondence between ISIC Rev. 3 and NAICS is not possible, even when we consider the NAICS at the 6 digit level: some sectors are associated with more than one ISIC 2-digit code. We chose to match the 4 digit NAICS I/O code with the more frequent corresponding 2-digit ISIC rev.3 code.

[10]Alternatively we could have "translated" from NAICS 4 digit to ISIC 2 digit the use and make table, before computing the indicators. Although this approach implies the loss of valuable information in understanding the inter-linkages between industries, which can be more easily captured the more disaggregated the data are, our results are robust to the use of this alternative way of computing the fragmentation indicators.

chain. However, as the sectors we consider are rather large, we believe that the size of this measurement error is small.

Data are from the 1997 I-O tables, because this is the earliest release adopting the current NAICS (North American Industry Classification System), which has a cleaner correspondence with the ISIC classification than the one covered by our analysis (1990-2010). A problem with this choice could be that, if the structure of the US production changes fast, then 1997 is not necessarily representative of the entire period covered by our analysis (1990-2009). To provide evidence that this is not the case, we computed N_s^{Snake} and N_s^{Spider} using both the 1997 and the 2002 release of the I-O tables. According to Table 3 in the appendix, for both measures, the indexes computed in 1997 and 2002 are highly correlated ($\geq .90$). This suggests that they tend to remain quite stable over time and, if anything, we are committing a small mistake. Also note that the snake- and spider-measures are little correlated with each other, suggesting that we are indeed capturing different dimensions of fragmentability.

Figure 4 shows the values of the length of the production chains we computed for the sectors considered in our analysis, while figure 5 depicts their width, i.e. the spider dimension.[11] The length of the average production chain is 2.4 (table 2). This means that, on average, weighting each production stage by the value added in that stage, the number of stages in the production chain is 2.4. The longest chains are found in the Food and Beverages, Electrical Machinery, Communication Equipment and Textiles sectors (respectively 2.78, 2.69 and 2.67 stages) while the shortest are in Tobacco Products, Medical, Precision, and Optical Instruments and Rubber and Plastics Products (respectively 1.78, 2.02 and 2.05 stages).

The width of the average production chain is 96 (out of the 127 that we consider), i.e. on average each final good requires assembling 97 inputs from both the manufacturing and the service sector. The widest production chains are found in Food and Beverages, Rubber and Plastics Products, Furniture and other Manufacturing and Transport Equipment, while the narrowest are Leather Products and Tobacco Products. As this measure is not weighted, it depends on the level of aggregation of the data. For instance, in our case the index could never exceed 127. To eliminate any issue about the scale, in our empirical specification we will take the natural log of this variable.

The comparison between the two indices also leads to interesting remarks: Optical Instruments is a sector with a short but wide production chain; in Tobacco Products it is both short and narrow; in Leather Products it is long and simple; and in Transport Equipment it is both long and wide.

[11] We exclude Coke, petroleum products and nuclear fuels.

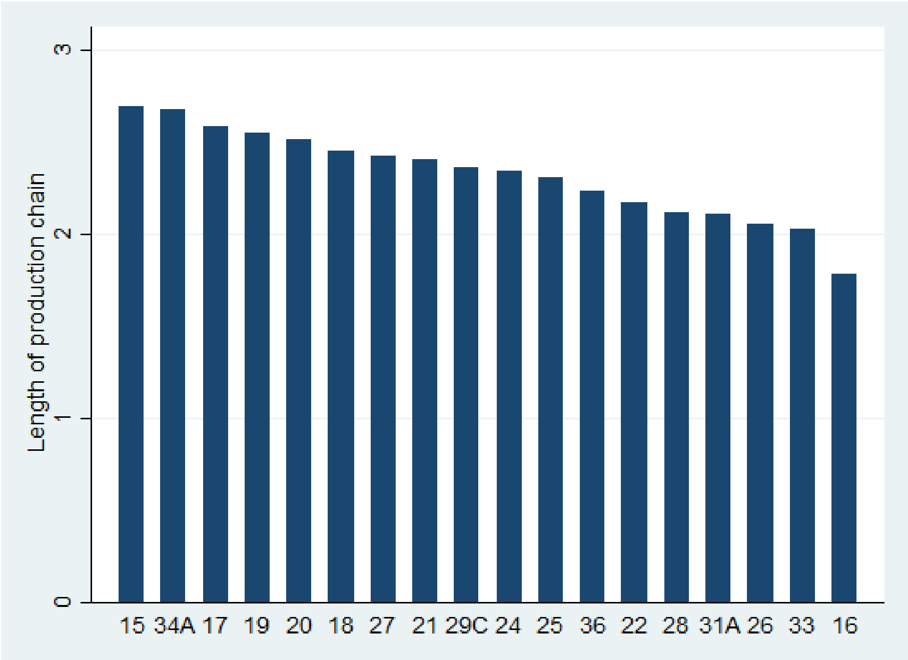

Figure 4: Length of value chains from 1997 Input-Output US data (snake dimension)

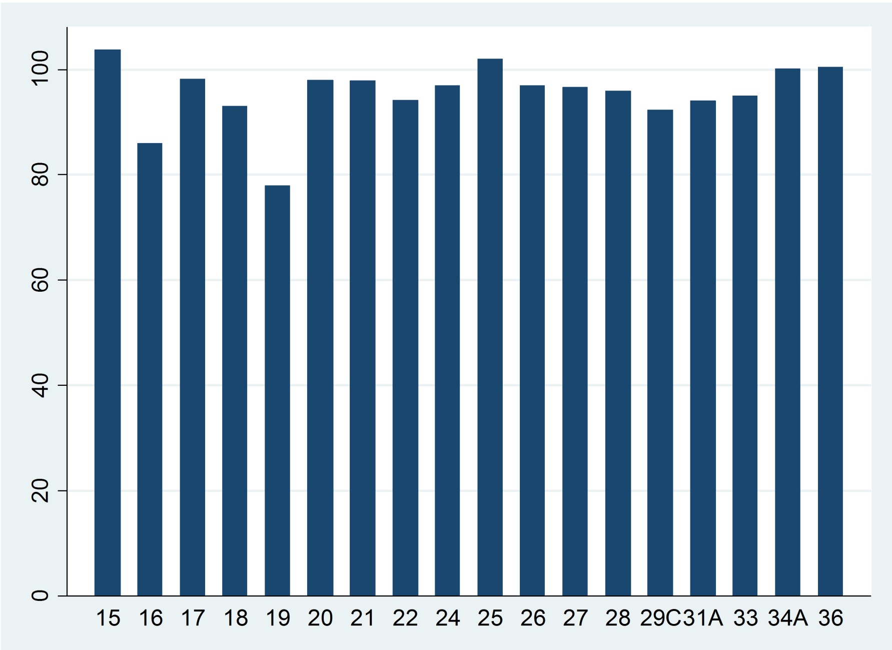

Figure 5: Width of value chains from 1997 Input-Output US data (spider dimension)

2.2 Index of intensity of international fragmentation

To measure the intensity in international fragmentation of production we employ a variant of the Revealed Comparative Advantage index (Balassa, 1965), proposed by Hoen and Oosterhaven (2006). This index compares the share of intermediate goods in manufacturing imports for each country with the average world share:

$$RCA_i = \frac{\sum_{j \in S} M_{i,j}^{\text{Int}}}{\sum_{j \in S} M_{i,j}^{\text{Tot}}} - \frac{\sum_{i,j \in S} M_{i,j}^{\text{Int}}}{\sum_{i,j \in S} M_{i,j}^{\text{Tot}}} \tag{4}$$

in which M stands for imports of manufacturing, the superscripts Int and Tot refer to intermediate-good and total trade flows respectively, i is the country whose imports are considered, j the partner country and S is the set of countries under analysis ; all the data refer to the '90s.[12] Goods belonging to the ISIC division 23 (Coke, petroleum products and nuclear fuels) have been excluded from total trade to minimise the effect of oil price volatility on trade values.[13]

The range of the indices is $[-1, +1]$: positive (negative) values indicate that the country is relatively (de)specialised in the trade of intermediate goods with respect to the world average. We interpret an index above zero as an indication that producers in country i engage in international fragmentation of production. In particular, RCA_i measures the relative specialisation in the assembly operations of goods using imported intermediates. Data are from the Bilateral Trade in Goods by Industry and End-use Category Database by the OECD (Zhu et al., 2011), which provides values of imports and exports of goods broken down by industrial sectors and by end-use categories (intermediate goods, household consumption goods and capital goods).

Measures of international fragmentation are being continuously proposed in the literature.[14] We prefer to stick with a more traditional Balassa (1965) type index because it captures the involvement in GVC using a very simple logic: i) GVCs determine trade flows in intermediates, which can be easily measured, and ii) the relative intensity of these trade flows reveals the countries' specialisation in intermediate intensive-activities, i.e. in GVCs.

One possible concern is that a country could have a high RCA measure because it imports more from sectors that involve a higher share of intermediate goods, rather than more intermediates within each sector. This means that the variation of the measure across countries would depend more on their trade specialization than on their propensity to fragment production. To address this issue we decomposed the RCA measure into two components: one that accounts for the variation in the share of intermediates across sectors, and therefore depends on the sectoral specialization; the other that accounts for the variation in the share of intermediate within each sector (see Johnson and Noguera (2013)):

[12] The countries analysed in this paper are listed in Appendix A.

[13] Consequently we leave raw materials completely out of our analysis as i) we restrict to manufacturing, hence excluding agricultural and mining raw materials, and ii) we explicitly exclude ISIC division 23 goods.

[14] See, among others, Lafay (1992), Johnson and Noguera (2013) and Koopman et al. (2014). Most of these measure provide an in-depth view on the role of a country within the GVC (i.e. the position in the "value-added ladder"), which is not relevant for our analysis although very interesting.

$$RCA_i = \underbrace{\frac{1}{2}\sum_s \left(\frac{M^{INT}_{i,s}}{M^{TOT}_{i,s}} - \frac{\sum_j M^{INT}_{j,s}}{\sum_j M^{TOT}_{j,s}}\right)\left(\frac{M^{TOT}_{i,s}}{\sum_s M^{TOT}_{i,s}} + \frac{\sum_j M^{TOT}_{j,s}}{\sum_{j,s} M^{TOT}_{j,s}}\right)}_{\text{within RCA}} \quad (5)$$

$$+ \underbrace{\frac{1}{2}\sum_s \left(\frac{M^{TOT}_{i,s}}{\sum_s M^{TOT}_{i,s}} - \frac{\sum_j M^{TOT}_{j,s}}{\sum_{j,s} M^{TOT}_{j,s}}\right)\left(\frac{M^{INT}_{i,s}}{M^{TOT}_{i,s}} + \frac{\sum_j M^{INT}_{j,s}}{\sum_j M^{TOT}_{j,s}}\right)}_{\text{between RCA}} \quad (6)$$

We will then be interested in first the component RCA_i^{within}, which by construction is free from any effect driven by trade specialisation.

Figure 6 shows the values of the index and its decomposition for the countries in our estimation sample. [15] Most of the variability in the total index comes from the within component, which on average accounts for roughly 80% of the overall RCA. India, Korea and Indonesia have the highest comparative advantage in final assembly (with index values respectively of .27, .15 and .15), while Norway, Australia and the US the least (respectively equal to -.05, -.08 and -.08). The fact that the index for the US is very low confirms that the country is a relatively closed economy that imports few intermediates. This evidence further corroborates our choice of calculating the indices of fragmentability on the domestic I-O tables for the US: indeed the foreign part of th US final-good production chains is small.

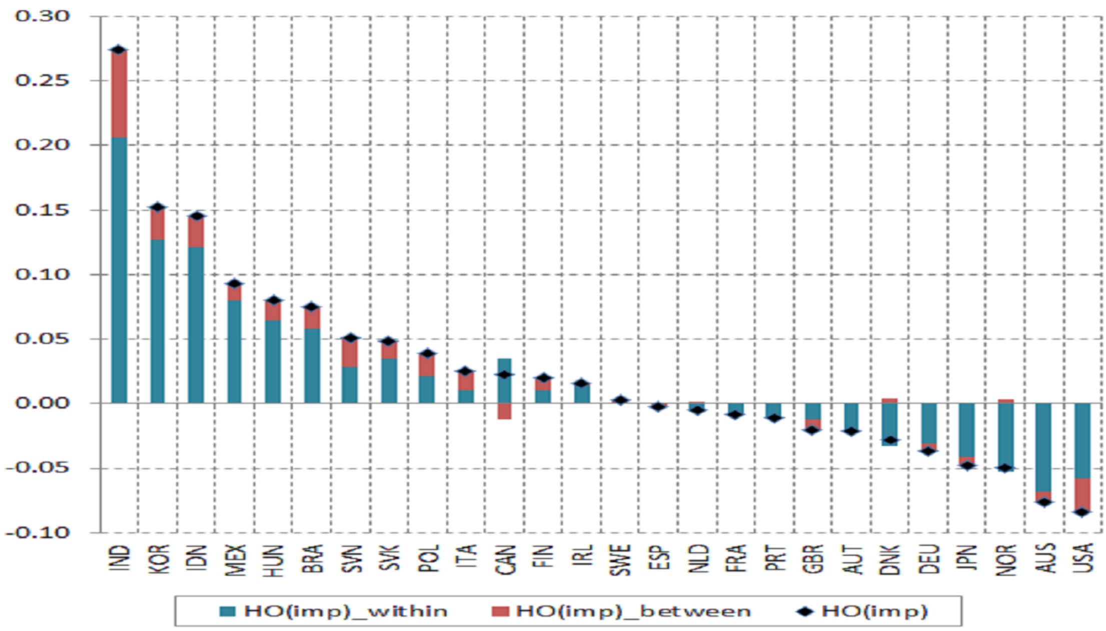

Figure 6: RCA Index and within and between components

[15]The reference group used in computing the index is given by a sample of 50 countries that account for most of world trade.

3 Measures of productivity

We start our analysis by looking at the effects of fragmentation on some common measures of macroeconomic performance: labour productivity and employment. We will then turn to theory to estimate a measure of TFP.

3.1 Labour productivity and employment

We measure labour productivity as both (real) output per worker and (real) value added per worker. An increase in total output can be explained by an increase in TFP and/or in the use of other inputs (capital and intermediate goods). By definition, an increase in value added, instead, should not be driven by an increase in the quantity of intermediate goods employed per worker and can thus be preferred as a measure of labour productivity. On the other hand, an improvement in the quality of the inputs can be hardly expected to be captured by a standard measure of value added, and would result in an increase of TFP. Unfortunately, we are not able to control for changes in the capital stock, which can also affect output and value added per worker: no data with a sufficient time span exists for the required country-sector coverage.[16] This data limitation is a common problem in cross-country analysis and no satisfactory solution has been proposed yet.

Output per worker and value added per worker could increase also in response to a decline in sectoral employment. In fact, besides the effects of participation in GVCs on productivity growth, those on total employment are also widely discussed in both the academic and the policy debate. International outsourcing may reduce the demand of domestic workers in those countries and sectors that are more involved in GVCs. To address this possibility, we consider as another measure of macroeconomic performance the growth rate of employment at the country-industry level.

Output, value added and employment data come from the 2013 UNIDO Industrial Statistics Database at the country-industry level. Raw data are expressed in nominal terms. To obtain real measures of output and value added we use the Producer Price Index (PPI) as the main deflator. PPIs are collected from OECD (Main Economic Indicators) and IMF (International Financial Statistics, IFS), supplemented by national sources. Following Rajan and Zingales (1996), for high-inflation countries, where the difference in collection times between UNIDO data and the PPI may induce sizeable measurement errors, we replace the PPI with an implicit deflator of industrial production, given by the ratio between UNIDO nominal manufacturing output and the index of (real) industrial production (from IMF IFS).

[16] The EU KLEMS (O'Mahony and Timmer, 2009) database, which to our knowledge has the best coverage, provides data on capital stock and gross fixed capital formation for just 17 countries and only 14 manufacturing sectors from 1970 to 2007, with the same gaps for both series. This is too little to include the stocks variables as controls in a regression as well as to fill the gaps in the stock series using methods such as perpetual inventory.

According to Table 2, which presents the summary statistics based only on those observations that enter our estimations, excluding outliers, the average growth of output per worker across countries and manufacturing sectors between the 90s and the 00s has been around 20%. The average growth in value added per worker has been lower (11%), while average employment slightly decreased (−3%). This could probably be explained by an increase in the share of services, excluded from our analysis, in many of the countries that enter our sample.

3.2 TFP and its components

This section describes the method used to estimate TFP at the country-sector level. Unlike the measures of productivity described above, TFP is usually defined as the residual efficiency of the production process that cannot be explained by inputs' services (labour, capital and intermediate inputs). Estimating TFP has always been tricky, as it is a non observable parameter of the production function. We obtain a model-based measure of TFP from the structural estimation of a set of Eaton and Kortum (2002) gravity equations, using some calibration and measurements from US data.

Levchenko and Zhang (2013), building on Finicelli et al. (2013), show that in a multi-sectoral version of the Eaton and Kortum (2002) model the average TFP, Λ_i^s, of an open economy i in sector s is given by:

$$\Lambda_i^s = \left[T_i^s \left(1 + \sum_{n \neq i} \frac{X_{in}^s}{X_{ii}^s} \right) \right]^{1/\theta}, \qquad (7)$$

where T_i^s is a technological parameter, X_{in}^s are the imports of country i from country n in sector s, X_{ii}^s is production net of exports of county i in sector s, and θ is a parameter that captures the dispersion in the distribution of the technological level across firms. In this theoretical framework, T_i^s characterises the mean of the country-sector-specific distribution of firms' productivities and it can be interpreted as the state of technology of sector s in country i.[17] The term

$$\Omega_i^s \equiv \left(1 + \sum_{n \neq i} \frac{X_{in}^s}{X_{ii}^s} \right) = \left(1 + \frac{IMP_i^s}{PROD_i^s - EXP_i^s} \right) \qquad (8)$$

is a measure of trade openness and captures the effect that the allocation of resources across firms with different productivities has on the average country-sector productivity.

According to this framework, a technological improvement that increases the mean of firms' productivity is captured by an increase in T_i^s and leads to an increase of average TFP.[18] Analogously, anything that induces a reallocation of resources from the least to the most productive

[17] Eaton and Kortum (2002) assume a Frechet distribution for firm productivity.

[18] In the original Eaton and Kortum (2002) model without technological change, T_i^s is an exogenous and constant primitive of the model.

firms is captured by an increase in Ω_i^s, and also leads to an increase in average TFP.

We obtain estimations for T_i^s and Ω_i^s, and then study the effect of GVCs participation on TFP growth via the two different channels. The dependent variable and the results from our analysis depend on the assumptions that characterise Eaton and Kortum's (2002) model. Nevertheless, as all measures of TFP are either based on proxies or derived from the estimation of an underling production function, we believe that our approach should not necessarily entail more serious measurement error problems than the other approaches.

3.2.1 The estimation of TFP

The multi-sectoral version of the Eaton and Kortum (2002) model, besides the TFP decomposition described above, provides simple structural equations for bilateral trade between any two countries in terms of the relative technology level and geographic barriers:

$$\frac{X_{in}^s}{X_{ii}^s} = \frac{T_n^s(c_n^s \tau_{in}^s)^{-\theta}}{T_i^s(c_i^s)^{-\theta}}, \tag{9}$$

where c_i^s is the unit cost of country i in sector s and τ_{in}^s is a measure for the trade costs between countries i and n for sector s, that can be accounted by bilateral distances (d_{in}^s), border effects (b_{in}^s), regional trade agreements RTA_{in}^s, global remoteness (captured by an exporter fixed effect ex_n^s, see Waugh(2010)) and an error term:

$$ln\tau_{in}^s = d_{in}^s + b_{in}^s + RTA_{in}^s + ex_n^s + \eta_{in}^s$$

Taking logs and plugging in the above expression, equation (9) becomes:

$$ln\left(\frac{X_{in}^s}{X_{ii}^s}\right) = ln\left(T_n^s(c_n^s)^{-\theta}\right) - \theta ex_n^s - ln\left(T_i^s(c_i^s)^{-\theta}\right) - \theta(d_{in}^s + b_{in}^s + RTA_{in}^s) - \theta\eta_{in}^s$$

and it can be estimated, for each sector and period separately, using OLS with exporter and importer fixed effects.[19] The estimated importer fixed effects provide a measure for the technology-cum-unit-cost term $T_i^s(c_i^s)^{-\theta}$. Given the available degrees of freedom, the estimation performed by Levchenko and Zhang (2013) is expressed in relative terms with respect the US, taken as reference country.

The authors kindly provided us with the estimated measure $\frac{T_i^s}{T_{US}^s}$ for 75 countries, 20 sectors and the five decades from the 60s to the 00s. As we are interested, not only in the cross-country variation, but also in the time variation of the technological productivity, we need to estimate

[19]All variables used for the estimation by Levchenko and Zhang (2013) are taken as ten-year averages of the underlying yearly series.

T^s_{US} in order to pin down each country's T^s_i. The production function used in Levchenko and Zhang (2013) implies:

$$lnQ^s_{US} = ln\Lambda^s_{US} + \alpha^s\beta^s lnL^s_{US} + (1-\alpha^s)\beta^s lnK^s_{US} + (1-\beta^s)\sum_k \gamma_{ks} lnM^{ks}_{US}$$

where Q^s is the output in sector s, α^s and β^s are Cobb Douglas parameters, L^s denotes labour, K^s denotes capital, M^{ks} denotes intermediate inputs from each other sector k, with total requirement γ^{ks}, and Λ^s_{US} is the total factor productivity (henceforth, TFP). Using data on output, inputs of labour, capital, and intermediates from the NBER-CES Manufacturing Industry Database together with the values for α^s and β^s calibrated by Levchenko and Zhang (2013), we compute the observed US TFP level Λ^s_{US} for each manufacturing tradeable sector implied by the above equation. As in Levchenko and Zhang (2013), with Comtrade data we derive Ω^s_{US} from (8) and use it, together with the estimated Λ^s_{US} to get T^s_{US} from (7). Finally, from the $\frac{T^s_i}{T^s_{US}}$ provided by Levchenko and Zhang (2013), we can pin down each T^s_i and, using again the same two equations, obtain Ω^s_i and the overall TFP for all the other 74 countries.

According to Table 2, the average growth rate in TFP between the 90s and the 00s in our sample was 8%, mainly driven by technological change (6%). Growth driven by an improvement in resource allocation was contained (2%). The sectors "Electrical Machinery and Communication Equipment" and "Office, Accounting, Computing, and Other Machinery" are, not surprisingly, among those with the highest TFP growth, especially in emerging and eastern european economies (as Mexico and Bulgaria). Among the sectors with negative TFP growth, we find "Wearing Apparel, Fur", "Printing and Publishing" and, more surprisingly, "Medical, Precision and Optical Instruments", both in advanced economies (as Japan and Australia) and emerging economies (Brazil).

Figure 7 shows the non-parametric distribution of the growth rate for the technological parameter T^s_n for all the country-sector couples for which we have data, regardless of the observation entering the estimations. Compared to a Normal distribution, the empirical distribution has a fat tail to the right, indicating that some sectors grew exceptionally fast. We obtain a similar picture for the distributions of TFP and Ω. This is a further assurance of the plausibility of our model-based estimates.

4 Estimation Results

In this section we discuss the estimation of equation (1):

$$z^s_i = \alpha + \beta Y_{i,90} \times W_s + \delta ln(Z^s_{i,90}) + \gamma VAshare_{i,90} + \theta_i + \omega_s + \epsilon_{is}$$

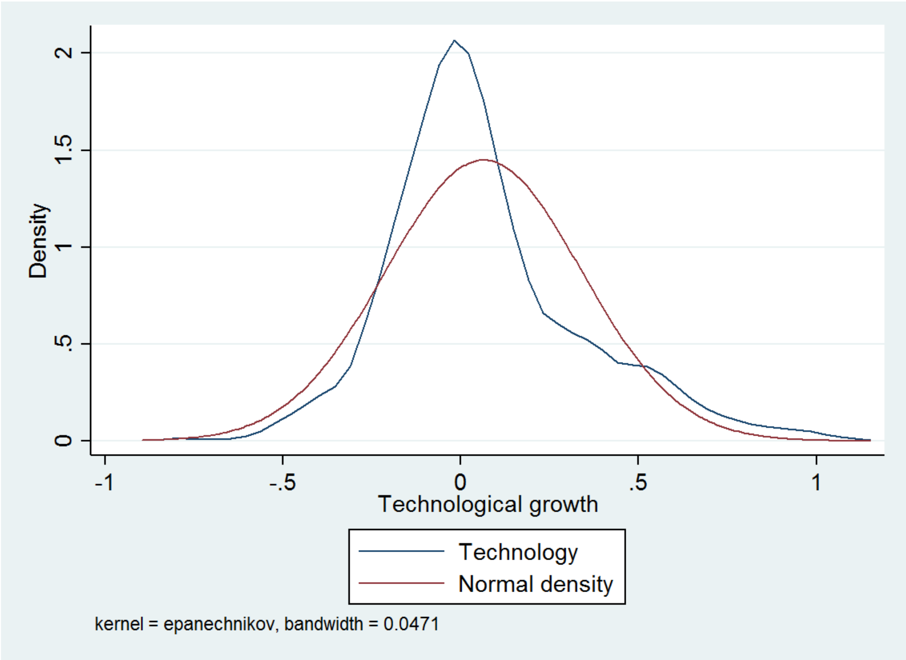

Figure 7: Distribution of the estimated technological growth rates

for different choices of the variable of interest $Z^s_{i,t}$ and for the different measures of fragmentability W_s and intensity in GVC participation $Y_{i,90}$ discussed in the previous sections. As we study the effect of global production networks on the growth rate z^s_i between the years 90s and 00s, our specification includes the initial value of the dependent variable, $Z^s_{i,90}$. In addition to country and sector fixed effects θ_i and ω_s, we also control for the value added share of each sector in each country at the beginning of the period, $VAshare_{i,90}$. This variable aims to capture any effect coming from countries' sectoral specialization. In the estimation we exclude outliers, defined as observations which are more than 3 standard deviations away from the sample mean.[20]

Table 4 displays the results for the specification using the "snake" measure of fragmentability that, as broadly discussed above, measures the backward length of the production chain: the higher N^{Snake}_s, the higher the number of production stages required to produce s, accounting also for the stages embodied in the inputs. The length measure is interacted with country i's overall revealed comparative advantage for the imports of intermediate goods, RCA_i. The higher the index, the more a country is specialized in importing intermediate goods. The first two columns show the effect of participation in GVCs on the standard measures of labor productivity: for both real output per worker and real value added per worker, the coefficients of the interaction terms are positive, statistically different from zero and close in magnitude between the two equations. This means that, for sectors that are at the end of long vertical production chains, labor productivity growth has been stronger between the 90s and the 00s

[20] We also exclude from the estimation sample goods belonging to the ISIC division 23 (Coke, petroleum products and nuclear fuels).

in those countries that, at the beginning of the period, were highly involved in GVCs by specializing in importing intermediate goods. The coefficient of the variable capturing the initial condition is always significant with the expected negative sign, while the coefficient for sectoral specialization is not statistically different from zero.

Any increase in output and value added per worker in sector s could be driven by a decrease in the denominator, the number of people employed in the same sector, L_s. For instance, participation in GVCs could imply the outsourcing of inputs previously produced domestically and, for those inputs that also belong to s, this could reduce the total employment in the sector. We check for this possibility by estimating the effect of GVCs participation on the growth rate of employment. Column (3) of Table 4 shows that this is not significantly different from zero. In other words, the positive effect on labour productivity is not achieved by a reduction in the number of workers, but by an increase in the output and value they produce.

The last three columns of Table 4 show the results for the effect of GVC participation on the model-based measure of TFP and its components: technology and resource allocation (columns (5) and (6) respectively). Our intent is to asses whether the positive effect we found on labour productivity is driven only by an increase in the use of inputs other than labour, as well as by an overall improvement in the way inputs are combined either at the micro or aggregate level. According to column (4) there is a positive and significant effect on TFP and this is entirely driven by a positive effect on T_i^s, the technological component (column (5)). In fact, the parameter that captures the effect via Ω_i^s is null (column (6)). Global value chains increase the variety and the quality of the inputs available for production, and this would have a direct effect on TFP (see also Amiti and Knoings (2007), Kasahara and Lapham (2013) and Halperen et al. (2011)). There could also be an indirect effect on the incentives to innovate, given by the higher profitability stemming from the use of better inputs and the need to meet the possibly higher technological standards of the imported inputs. Both effects would show up in the technological parameter T_i^s.

One possible concern with the results shown in Table 4 is that, by construction, the RCA measure takes into account the sectoral specialization of a country, not only its intensity in the use of imported intermediated inputs. This means that a given country i could have a high RCA measure because it imports more from sectors that involve a higher share of intermediate goods, rather than more intermediates within each sector. To address this issue we decomposed the RCA measure into two components, one that account for the variation in the share of intermediates across sectors, and that depends on the sectoral specialization, the other that accounts for the variation in the share of intermediate within each sector (see section 2.2). Table 5 reports the estimation results when the overall RCA measure is replaced by its "within" component. The findings are unchanged: the parameters have the same sign and significance than in Table 4, if anything they are slightly higher in magnitude.

The effects we found are economically relevant. For instance, consider the case of a country increasing its participation to GVCs from the 25th to the 75th percentile of the distribution of the overall RCA measure, everything else being held constant.[21]. The positive effect on TFP would be between 9 percentage points for the sector with the shortest production chain (Tobacco products) and 13.7 percentage points for the sector with the longest production chain (Food products and beverages). This is a sizeable impact given that the average growth rate of the technology level between the 90s and the 2000s in our sample is 7.4% (table 2).

When we turn to the 'spider' measure of fragmentability, which assesses the horizontal complexity of the production process, the picture looks slightly different. Sectors that use a greater variety of inputs in their last production stage experience a much stronger increase in labour productivity in countries that specialize in importing intermediates (columns (1) and (2) of Table 6). This result is in large part driven by a decrease in sectoral employment: the coefficient of the interaction term in column (3) is negative and significantly different from zero. According to column (4), there is also a positive and significant effect on TFP which, unlike for the 'snake' measure, arises from a more efficient allocation of resources across firms at the sector-country level (column (6)). On the other hand, the effect on the technological component of TFP is not statistically different from zero. When the overall RCA measures is replaced by the 'within' measure (Tabel 7), findings are basically unchanged.

The results confirm the positive effect of participation in GVCs on both labour productivity and TFP, but they also suggest that the technological improvement triggered by a greater variety and quality of inputs is not the only mechanism that can lead to this outcome. Many studies found positive import competition effects on productivity, see for instance Amiti and Konings (2007), Trefler (2004) and Roberts and Tybout (1991). The main idea is that imported varieties increase competition on the domestic market, forcing the least productive domestic firm out of business and spurring reallocation of resources toward the more productive surviving ones. As the 'spider' measure considers only the last stage of production, many of the inputs tend to be closely related to the output and to belong to the same ISIC 2 digit-sector (i.e. the majority of inputs lie on the diagonal of the direct requirement matrix). If the country tends to import a relatively high share of intermediates, in this sector competition from foreign varieties increases. Competition pushes employment either towards the most efficient firms in the sector, or towards firms in other sectors. In the end, this increases labour productivity and TFP at the country-sector level, even if employment decreases.

We performed several robustness checks: we exclude from our sample the United States, which we used as a benchmark for the length and width measures; we reintroduce the ISIC rev.3 code 23 (Coke, petroleum products and nuclear fuels), which was excluded from our baseline sample; and we control for some measure of capital stock.[22] The results are not affected by

[21]This would corresponds to a country such as South Africa to increases its integration in GVCs to the level of Brazil.

[22]There are no good measure for capital stock at the country and sectoral level of our analysis. We included the cumulate gross fixed capital formation at the country-sector level from the UNIDO IndStat data base.

such changes. We also tested whether the effect is different between countries and sectors: we did not find any evidence when distinguishing between advanced and emerging economies and between low and high R&D intensive sectors. As a final analysis we insert the interaction terms with both the 'snake' and the 'spider' measures of fragmentability that, according to Table 3, are positively, yet weakly, correlated (0.38). Results are reported in Table 8. Signs and magnitudes of coefficients are basically unchanged, but the effect of 'snake'-type fragmentability on labor productivity loses some of its significance, while the negative effect on resource allocation becomes significantly different from zero.

Overall our results suggest that countries that are involved in global production chains via the import of intermediate goods experience a stronger productivity growth in sectors with high fragmentability. Productivity gains can occur thanks to both the availability of more and better inputs, which increases firms' TFP, and the import competition that forces the reallocation of resources towards the most efficient firms within a given sector.[23]

5 Conclusions

In this paper, we have presented an analysis of the effect of participation in Global Value Chains (GVC) on labour productivity and total factor productivity (TFP). We appliedhe methodology that Rajan and Zingales (1998) proposed to overcome possible reverse causality between external finance and growth to the relationship between GVC participation and productivity growth. To this aim we developed several indicators: at the sector level we measure both the length and the width of GVCs, and at the country level we consider the overall involvement in imports of intermediate goods as well as a measure that excludes the effect of trade sectoral specialisation.

Our results support the widespread perception that importing intermediate goods through GVCs increases productivity in the importing countries. Sectors with long GVCs operating in countries specialised in importing intermediates experience a boost in labour productivity (in terms of both output per worker and value added per worker) and in TFP. The latter effect is entirely driven by a technological advancement, whereas employment levels are unchanged and no effect comes from resource reallocation. When we turn our attention to sectors with wide GVCs (i.e. GVCs involving the use of many direct inputs from a variety of different sectors) we confirm the result on labour productivity and on TFP, yet the channels are different. Notwithstanding a contraction in employment, there appears to be a significant impact of resource reallocation but not of tecnological change.

[23] On the contrary, we do not find any effect of forward integration in GVCs: countries specialised in exporting intermediate goods do not experience higher productivity growth in sectors that are intensively used as inputs in the production of other goods.

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A List of countries

The countries analysed in this paper are: Argentina (ARG), Australia (AUS), Austria (AUT), Belgium-Luxembourg (BLX), Brazil (BRA), Bulgaria (BGR), Canada (CAN), Chile (CHL), China (CHN), Czech Republic (CZE), Denmark (DNK), Finland (FIN), France (FRA), Germany (DEU), Greece (GRC), Hungary (HUN), Iceland (ISL), India (IND), Indonesia (IDN), Ireland (IRL), Israel (ISR), Italy (ITA), Japan (JPN), Malaysia (MYS), Mexico (MEX), Netherlands (NLD), New Zealand (NZL), Norway (NOR), Philippines (PHL), Poland (POL), Portugal (PRT), Romania (ROM), Russia (RUS), Saudi Arabia (SAU), Slovakia (SVK), Slovenia (SVN), South Africa (ZAF), South Korea (KOR), Spain (ESP), Sweden (SWE), Switzerland (CHE), Taiwan (TWN), Thailand (THA), Turkey (TUR), United Kingdom (GBR), and United States (USA).

B tables

Table 1: List of sectors

$ISIC_{LVK}$	description
15	Food and Beverages
16	Tobacco Products
17	Textiles
18	Wearing Apparel, Fur
19	Leather, Leather Products, Footwear
20	Wood Products (excluding Furniture)
21	Paper and Paper Products
22	Printing and Publishing
23	Coke, Refined Petroleum Products, Nuclear Fuel
24	Chemical and Chemical Products
25	Rubber and Plastics Products
26	Non-Metallic Mineral Products
27	Basic Metals
28	Fabricated Metal Products
29C	Office, Accounting, Computing, and Other Machinery
31A	Electrical Machinery, Communication Equipment
33	Medical, Precision, and Optical Instruments
34A	Transport Equipment
36	Furniture and Other Manufacturing

Table 2: Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
$\Delta ln(Q/L)$	0.21	0.32	-0.89	1.38	546
$\Delta ln(VA/L)$	0.11	0.33	-1	1.15	546
$\Delta ln(L)$	-0.03	0.39	-1.72	1.56	546
$\Delta ln(TFP)$	0.08	0.24	-0.42	0.84	501
$\Delta ln(T)$ T	0.06	0.25	-0.56	0.79	546
$\Delta ln(\Omega)$	0.02	0.07	-0.53	0.49	501
N_s^{Snake}	2.36	0.24	1.79	2.72	546
N_s^{Spider}	96	6	78	104	546
RCA_i	0.03	0.08	-0.1	0.27	546
RCA_i^{within}	0.02	0.06	-0.1	0.21	546

Table 3: Measures of Fragmentability - Correlations

	N_{1997}^{Snake}	N_{1997}^{Spider}	N_{2002}^{Snake}	N_{2002}^{Spider}
N_{1997}^{Snake}	1.00	-	-	-
N_{1997}^{Spider}	0.38	1.00	-	-
N_{2002}^{Snake}	0.94	0.61	1.00	-
N_{2002}^{Spider}	0.32	0.90	0.52	1.00

Table 4: Snake-type GVCs and overall RCA in intermediates

	(1) $\Delta ln\frac{Q}{L}$	(2) $\Delta ln\frac{VA}{L}$	(3) ΔlnL	(4) ΔlnTFP	(5) ΔlnT	(6) $\Delta ln\Omega$
$N_s^{Snake} \times RCA_i$	1.20**	1.05**	0.05	0.48**	0.31*	-0.14
	(0.45)	(0.51)	(0.72)	(0.22)	(0.17)	(0.11)
$VAshare_{90s}$	0.19	-0.09	-0.22	0.43***	0.66***	-0.48***
	(0.53)	(0.56)	(0.64)	(0.13)	(0.15)	(0.12)
$Depend_{90s}$	-0.09*	-0.14**	-0.01	-0.42***	-0.24***	-0.52***
	(0.05)	(0.06)	(0.04)	(0.06)	(0.07)	(0.11)
$Constant$	1.51**	2.13***	-0.27	0.68***	0.42***	0.03***
	(0.68)	(0.71)	(0.35)	(0.10)	(0.10)	(0.01)
N	546	546	546	501	546	501

All regressions include country and sector fixed effects. Robust standard errors in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table 5: Snake-type GVCs and "within-sector"RCA in intermediates

	(1) $\Delta ln\frac{Q}{L}$	(2) $\Delta ln\frac{VA}{L}$	(3) ΔlnL	(4) ΔlnTFP	(5) ΔlnT	(6) $\Delta ln\Omega$
$N^{Snake} \times RCA^{within}$	1.51**	1.28**	-0.09	0.61**	0.45**	-0.19
	(0.59)	(0.62)	(0.91)	(0.28)	(0.20)	(0.14)
$VAshare_{90s}$	0.18	-0.10	-0.22	0.43***	0.66***	-0.48***
	(0.53)	(0.56)	(0.63)	(0.13)	(0.15)	(0.12)
$Depend_{90s}$	-0.09*	-0.14**	-0.01	-0.42***	-0.24***	-0.52***
	(0.05)	(0.06)	(0.04)	(0.06)	(0.07)	(0.11)
$Constant$	1.52**	2.13***	-0.27	0.68***	0.42***	0.03***
	(0.69)	(0.71)	(0.35)	(0.10)	(0.10)	(0.01)
N	546	546	546	501	546	501

All regressions include country and sector fixed effects. Robust standard errors in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table 6: Spider-type GVCs and overall RCA in intermediates

	(1) $\Delta ln\frac{Q}{L}$	(2) $\Delta ln\frac{VA}{L}$	(3) ΔlnL	(4) ΔlnTFP	(5) ΔlnT	(6) $\Delta ln\Omega$
$ln(N^{Spider}) \times RCA$	8.06***	7.95***	-6.95**	1.62**	0.37	0.87**
	(1.92)	(1.89)	(2.87)	(0.63)	(0.55)	(0.34)
$VAshare_{90s}$	0.31	0.03	-0.01	0.46***	0.66***	-0.47***
	(0.51)	(0.53)	(0.61)	(0.12)	(0.15)	(0.12)
$Depend_{90s}$	-0.09*	-0.15**	-0.030	-0.41***	-0.23***	-0.52***
	(0.05)	(0.06)	(0.04)	(0.06)	(0.07)	(0.11)
$Constant$	0.69	1.28*	0.74	0.50***	0.37***	-0.07*
	(0.68)	(0.71)	(0.55)	(0.12)	(0.13)	(0.04)
N	546	546	546	501	546	501

All regressions include country and sector fixed effects. Robust standard errors in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table 7: Spider-type GVCs and "within-sector"RCA in intermediates

	(1) $\Delta ln\frac{Q}{L}$	(2) $\Delta ln\frac{VA}{L}$	(3) ΔlnL	(4) ΔlnTFP	(5) ΔlnT	(6) $\Delta ln\Omega$
$ln(N^{Spider}) \times RCA^{within}$	9.93***	9.34***	-8.76**	2.09**	0.57	1.15**
	(2.27)	(2.19)	(3.81)	(0.77)	(0.66)	(0.44)
$VAshare_{90s}$	0.30	0.01	-0.01	0.46***	0.66***	-0.47***
	(0.51)	(0.53)	(0.60)	(0.12)	(0.15)	(0.12)
$Depend_{90s}$	-0.09*	-0.14**	-0.03	-0.41***	-0.23***	-0.52***
	(0.05)	(0.06)	(0.04)	(0.06)	(0.07)	(0.11)
$Constant$	0.83	1.46**	0.60	0.52***	0.37***	-0.06*
	(0.68)	(0.71)	(0.52)	(0.11)	(0.12)	(0.03)
N	546	546	546	501	546	501

All regressions include country and sector fixed effects. Robust standard errors in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table 8: Snake and spider-type GVCs and overall RCA in intermediates

	(1) $\Delta ln\frac{Q}{L}$	(2) $\Delta ln\frac{VA}{L}$	(3) ΔlnL	(4) ΔlnTFP	(5) ΔlnT	(6) $\Delta ln\Omega$
$ln(N^{Snake}) \times RCA$	0.71	0.54	0.59	0.40*	0.31*	-0.22*
	(0.45)	(0.46)	(0.70)	(0.20)	(0.17)	(0.12)
$ln(N^{Spider}) \times RCA$	8.94***	8.58***	-9.51**	1.53***	0.08	1.52***
	(2.21)	(2.08)	(4.10)	(0.55)	(0.59)	(0.55)
$VAshare_{90s}$	0.27	-0.01	-0.00	0.42***	0.66***	-0.47***
	(0.51)	(0.53)	(0.60)	(0.13)	(0.15)	(0.12)
$Depend_{90s}$	-0.10*	-0.15**	-0.03	-0.42***	-0.24***	-0.52***
	(0.05)	(0.06)	(0.04)	(0.06)	(0.07)	(0.11)
$Constant$	0.812	1.353*	0.814	0.549***	0.414***	-0.094**
	(0.666)	(0.694)	(0.557)	(0.112)	(0.123)	(0.046)
N	546	546	546	501	546	501

All regressions include country and sector fixed effects. Robust standard errors in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Final Destination: China

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August 2015

Abstract

China's rebalancing process will have a remarkable impact on the structure of global demand. Drawing on information from the World Input-Output Database (WIOD) and newly developed analytical frameworks, this paper analyzes i) the evolution of final demand in China since the mid-1990s, ii) how it has activated production in other countries, focusing in particular on the major euro area economies and iii) how the future growth of Chinese demand and the changes in its composition will affect production in Italy, France and Germany.

Keywords: China, final demand, trade, input-output tables, euro area.

JEL Classification: E16, E21, E22, E27, F14, F15.

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This work is part of the Bank of Italy Working Group on Global Value Chains. We thank Rita Cappariello, Pietro Catte, Riccardo Cristadoro, Cristina Jude, Giuseppe Parigi and Lucia Tajoli for insightful comments. The views expressed in this article are those of the Authors and not necessarily those of the Bank of Italy.

1. Introduction

China's imports in 2014 reached 10 per cent of the world total, about twice the share of Japan's and slightly lower than that of the euro area (excluding intra-area trade). China's share of total Italian exports has more than doubled since 2000, while its share of total German exports has grown nearly fivefold. Due to the export-led growth model that has characterized China in the last decades, about three quarters of its imports from advanced countries are intermediate and capital goods. After joining the WTO, China's consumption growth – albeit very rapid in absolute terms – has not kept the pace with exports and investment. Indeed, between 2000 and 2010 the private consumption share of GDP has decreased by more than 10 percentage points (from 46 to 35 per cent), owing to disposable income dynamics significantly below that of total output and to Chinese households' high propensity to save (35 per cent on average during the period considered).

The global economic crisis brought to light risks associated with an excessive dependence on external demand. Moreover the old growth model has become unsustainable as several structural factors (demographic and social) are changing China's economic environment. This has induced Chinese authorities to change their long term policy strategy.

In the post-war period, countries like Japan, Korea and Taiwan experienced a rapid economic expansion characterized by subdued private consumption and strong export and investment growth. However, once their per capita income (in real terms) got close to that now reached by China they moved toward a more balanced growth path. It is possible that, to some extent, China has been following a similar pattern. If this is the case, this adjustment will probably be accompanied by a sizable slowdown of the Chinese economy. Nevertheless, China is expected to keep growing at faster pace compared with advanced countries and to many other emerging economies, so its share of global demand will continue to increase over the medium to long term.

The purpose of this study is twofold: *i*) to investigate China's role as a final destination market for the products of the major Eurozone countries (France, Germany, Italy or 'EA3'), aiming to evaluate to what extent Chinese final demand has activated production in these countries; *ii*) to assess how a future change in China's demand will affect these countries and, in particular, which sectors/countries will benefit (or be harmed) the most. To this end two elements are needed: on the one hand, a medium-long term projection of Chinese demand; on the other hand, mapping the linkages through which final demand in China activates production abroad, taking into account the structure of global production networks.

To address the first issue we have relied on the OECD's long-term projections, which provide insights into the aggregate dynamics of China's consumption and investment. According to these estimates, Chinese domestic demand will continue to increase so that it will account for about one quarter of the world total in 2030 (valued at market exchange rates). In the same period the GDP share of total consumption should increase by about 15 percentage points, thus exceeding 65 per cent, while the investment share will decrease by a similar proportion. Finally, the gap in per capita income with respect to the advanced economies will narrow, leading to a remarkable expansion of the 'middle income class'. This is expected to bring relevant changes to the composition of final consumption. We exploit some long term structural relationships in order to assess how these changes will reshape Chinese final demand.

As regards the second issue, due to the diffusion of global production networks, traditional (gross) trade statistics no longer provide an adequate representation of supply and demand linkages among the economies. This is particularly true in the case of China where processing trade flows represent a relevant share of imports and exports, since it plays a central role within the Asian supply chain (Factory Asia). Consequently, we use data from WIOD's international input-output tables and new analytical tools (Koopman et al., 2014, Borin and Mancini, 2015) to provide a more satisfactory picture of production and demand linkages.

The article is organized as follows: in section two, we first describe the evolution of China's demand and consumption since the mid-nineties; relying on OECD long-term projections, we then estimate its future recomposition; in section three, using WIOD data, we assess how China's final demand activates production in the other countries; in section four, we analyze the linkages with the EA-3 economies and assess how the future evolution of Chinese demand will affect the GDP and sectoral value added of Italy, France and Germany.

2. Evolution of Chinese demand

2.1 The demand composition

Since the late 1970s, when China opened up to market forces, its domestic demand has grown at impressively high rates by international standards (at around 10% on average between 1980 and 2014). In 2014 it exceeded 13 per cent of the world GDP (evaluated at market exchange rates),[1] compared with a 23.4 per cent share for the United States, a 16.8 per cent share for the whole euro area and a 6.2 per cent share for Japan. According to the projections of the International Monetary Fund (*World Economic Outlook* of April 2015), in 2016 Chinese demand will surpass that of the euro area as well, becoming the world's second largest market after the United States.

In the last three decades the Chinese growth model has relied on exports and investment, while consumption growth has been far less vigorous. On average, between 1980 and 2014 the annual growth rate of real private consumption was about 2 percentage points lower than that of investment. This divergent trend has become more pronounced after China's accession to the WTO in the early 2000s. Private consumption share of GDP declined by about 10 percentage points, from 45 to about 35 per cent between 2000 and 2008, whereas the investment share continued to grow during the crisis thanks to the government's fiscal stimulus (Figure 1). Owing also to subdued investments in advanced economies in the aftermath of the crisis (Banerjee e al., 2015, FMI *World Economic Outlook,* 2015), China now accounts for almost one quarter of global investments, while its share of world consumption was just 8 per cent in 2014.

The reduction in the consumption share since the early 2000s reflects both the shift in the distribution of income towards profits (a remarkable part of which is undistributed), and the rapid increase in the household saving rate. In the pre-crisis years Chinese savings grew even more rapidly than investment, contributing to the widening of external imbalances between China and its trading partners (Obstfeld and Rogoff, 2009, Cristadoro and Marconi, 2012).[2]

The global economic crisis has highlighted the risks stemming from an excessive dependence on foreign demand. Moreover some structural forces have started to change the economic environment, affecting the medium to long-term trajectory of the Chinese economy.[3] In order to avoid the country getting stuck in a 'middle-income trap', China needs to move towards a new growth model, one less dependent on foreign demand and investment (World Bank, 2013). This is acknowledged also by Chinese authorities, who have

[1] Evaluated at PPP the share of China's domestic demand is even higher, equal to 16.5 per cent of world GDP.

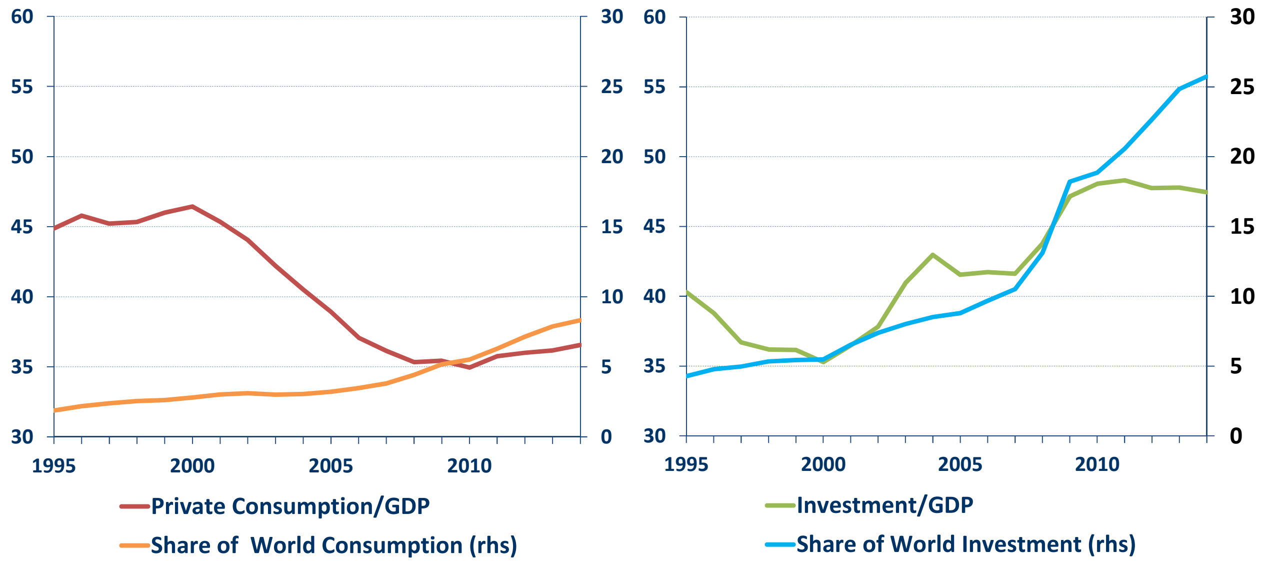
[2] Cristadoro and Marconi (2012) show that between 2000 and 2008 the shares of savings in the public sector and in non-financial corporations grew to 20 and 8 per cent of GDP, respectively. Although household savings remained broadly stable at around 20 per cent of GDP, it demonstrated the most unusual trend: while the output share allocated to household disposable income shrank from 38 to 28 per cent, their saving rate rose by about 10 percentage points. The growth of corporate savings was similar to that of the other advanced and emerging economies in the same period. Instead, the growth of public savings reflects an increase in the tax revenues not matched by an equal increase in public spending.

[3] Di Stefano and Marconi (2015) estimate that in 2013 the potential growth rate was equal to 7.7 per cent, four percentage points below the level recorded in the two-year period 2006-07.

announced a comprehensive reform program aimed at fostering a more domestic consumption-based growth.[4]

Figure 1. Share of private consumption and investments in China

(percentage points)



Source: IMF-WEO

The case of China is unique due to the country's size, however China's development path over the last three decades is in line with other Asian economies that experienced a rapid expansion in the post-World War II period. In Japan, Korea, Taiwan and Malaysia the share of private consumption fell during the first decades of rapid growth, then stabilized and gradually rebounded once their per capita incomes (in real terms) reached China's current levels (Figure 2).[5]

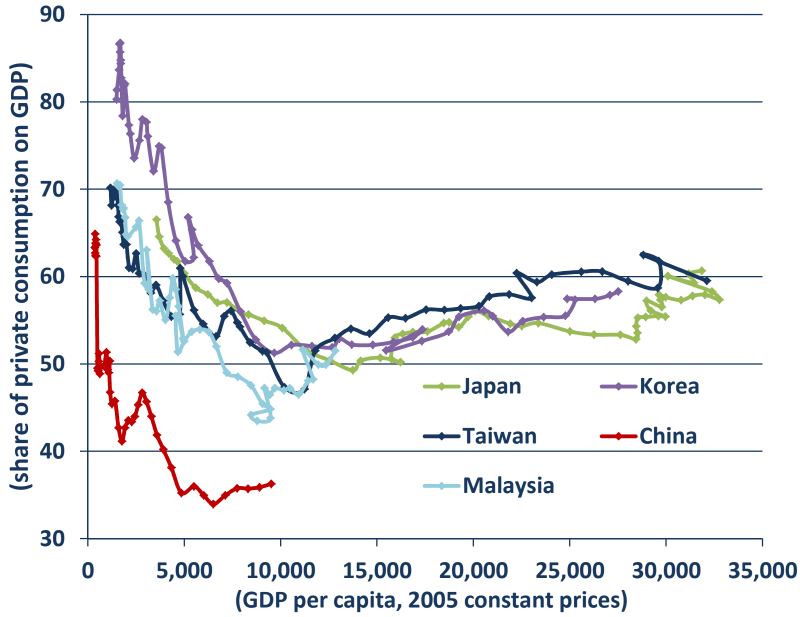
Over the last few years, initial signs of rebalancing have already emerged: between 2011 and 2014 consumption's contribution to GDP growth regularly outperformed that of investment, while the contribution of net exports turned slightly negative. Moreover, household disposable income has grown at faster pace compared to GDP (by more than 8 per cent per year).

[5] The rebalancing of the economy was already listed as a priority in the XII five-year plan (2011-16), and was also confirmed in the 3rd Plenary Session of the Central Committee of the CPC at the end of 2013 (see the official statement of the *18th Central Committee of the Communist Party of China*, http://goo.gl/cBX1uI). Measures aimed at supporting the growth of consumption include the strengthening of the welfare state, which could lower the precautionary savings of households (Blanchard and Giavazzi, 2005; Kuijs, 2005; Cristadoro and Marconi, 2012; Atella et al., 2015) and the reform of the financial system, which, by reducing the financial repression , would provide more resources to households, increasing the return on savings (Lardy, 2008).

[5] Compared to countries with similar per capita income, the share of consumption on GDP in China is remarkably lower. Huang e al. (2013) claim that this is also due to the underestimation of private consumption by official statistical surveys, particularly for services. According to their estimates, in 2010 the actual share of consumption was 15-20 points higher than the level reported by official statistics. Therefore it was broadly in line with that observed in other economies of the region at similar development stage.

Figure 2. Relationship between private consumption and per capita income in Asian economies

(percentage values)



Source: Penn World Table and FMI-WEO

2.2 The Chinese consumption structure and the future evolution of demand

In the next few years, the expansion of the medium and medium-high income classes will trigger a reallocation of consumption from basic products towards more sophisticated goods and services (Kharas, 2010; Marianera, 2012; Barton e al. 2013).

During the last twenty years the composition of Chinese consumption already experienced remarkable changes. In 2011 the share of essential goods, such as agricultural and food products, fell to about 17 per cent, from 40 per cent in the mid-1990s. In addition, the share of consumer goods in traditional sectors, such as clothing and footwear, decreased while durable goods rose to over 10 per cent of the total. The shift towards consumer services was another noticeable trend: the share of expenditures in social services, health and education rose by more than 10 points, reaching about one quarter of total household and government spending (Table 1).

Table 1. Sectoral composition of China's consumption

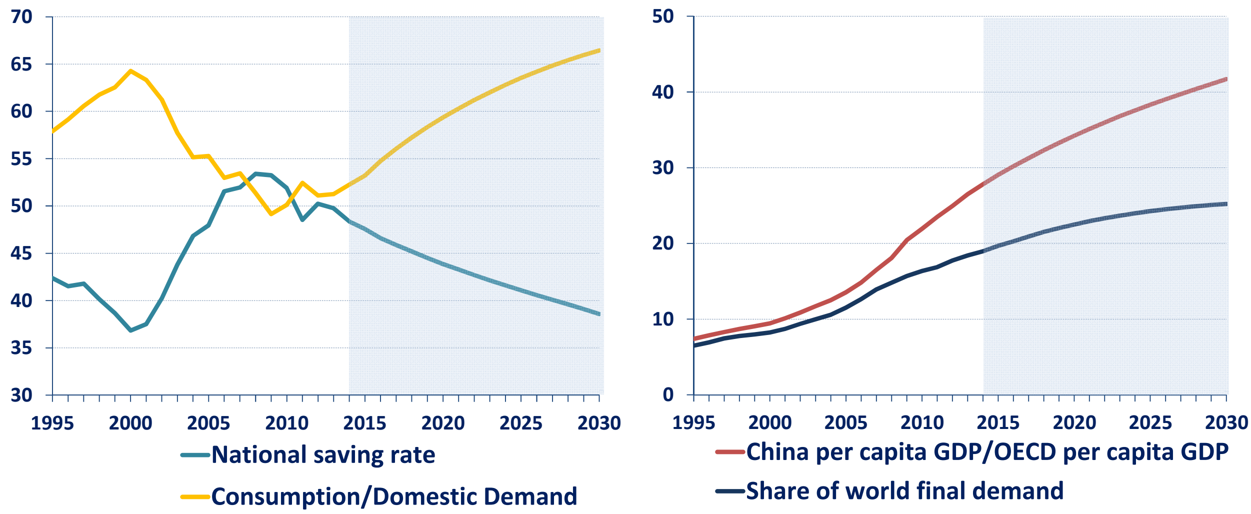
(percentage points)

	1995	2000	2005	2011	Δ(2011-1995)
Agriculture	24.0	18.5	13.3	9.6	-14.4
Food, Beverages and Tobacco	16.1	13.8	13.3	13.5	-2.6
Traditional	8.2	8.6	5.3	5.5	-2.6
Machinery, Electrical and Optical Equipment	3.8	4.0	2.8	2.6	-1.2
Transport Equipment	6.6	5.1	9.9	10.5	3.9
Other Manufacturing	3.6	3.1	2.2	1.8	-1.9
Fuel, Gas and Electricity	1.3	2.1	1.9	1.3	0.0
Real Estate Services and Construction	4.7	5.8	6.3	7.4	2.8
Wholesale, Retail and Other Business	8.9	10.0	9.5	10.9	2.1
Hotels and Restaurants	4.3	4.2	4.7	4.4	0.1
Tansport and Telecommunications	3.0	5.0	5.6	5.2	2.2
Financial Intermediation	2.7	2.2	2.3	3.5	0.8
Education	5.8	7.9	10.0	10.2	4.4
Health and Social Services	7.2	9.7	12.7	13.5	6.3

Source: WIOD

Figure 3. Projections of consumption rates, savings rates and China's share in the world economy

(percentage values)



Source: OECD, long-term baseline projections 2014.

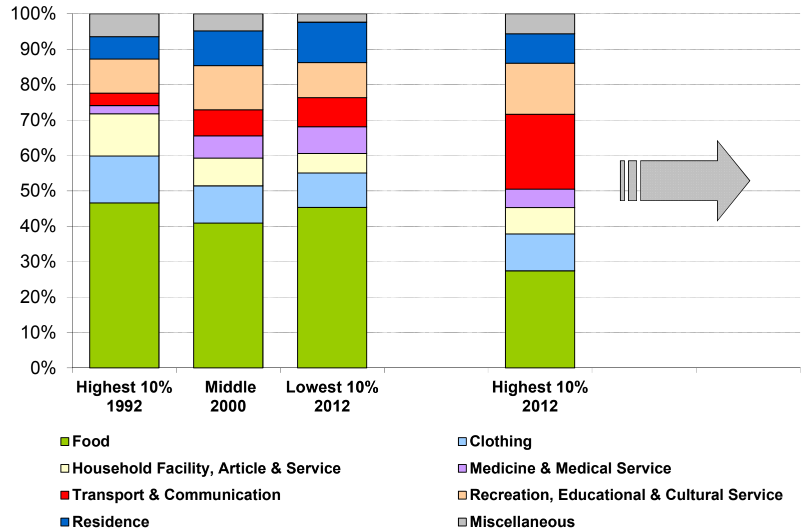
In China the future evolution of demand will be affected by changes in household disposable income and by the development strategies that the government will implement. Projections by private analysts (Huang e al., 2013; Towson and Woetzel, 2015) and by international institutions suggest that the share of total consumption should rise by about 15 points, exceeding 65 per cent in 2030 according to the OECD. On the contrary, the investment share and the overall saving rate should decrease significantly (Figure 3). Although Chinese domestic demand is expanding at a slower pace compared to previous decades, its share of global demand should keep rising, reaching approximately 25 per cent in 2030. At the same time, the per capita income gap with respect to advanced economies will narrow further.

The increase in household spending power in the next 15-20 years will probably affect consumption more than it has so far. Several studies show that the transition to a middle income group (ranging between 10 and 100 dollars of income per day) provides a special impulse to certain types of consumption with non-linear effects on expenditure.[6] Moreover, Murphy et al. (1989) show how reaching a critical mass of consumers with adequate spending power is even more crucial for foreign firms since they have to bear higher fixed costs to enter the market compared with their domestic competitors.

Past trends in household consumption classified by income class provide some preliminary insights into their future trajectory. Consumption by households in the top ten percent of the income distribution at the beginning of the 1990s is similar to that of the median family in the early 2000s and to the bottom ten percent in recent years (left hand side of Figure 4). Projections on income distribution (Kharas, 2010) confirm that the composition of China's total consumption in 10-15 years can be reasonably *proxied* by the current consumption of households in the top ten percent of the income distribution (Figure A1 in appendix). In 2012 it was characterized by a relatively low share of basic necessities, while the shares of consumer categories like transport and telecommunications were significantly above the average (right hand side of Figure 4).

Figure 4. Composition of consumption of Chinese families by income class

(percentage values)



Source: National Bureau of Statistics of China

The relationship between disposable income and the allocation of expenditure among different goods and services (Engel's law) is confirmed by a cross-country comparison: for products such as food and traditional goods the share of total consumption decreases as the per capita income increases, while for others categories, such as education and financial services, there is a clear positive relationship with per

[6] For some types of goods and services (durable goods and financial services) a discontinuity in the relationship between disposable income and consumption has been detected (the so-called Engel curve), with income elasticity rising well above one (Nomura, 2009).

capita income (Figure A2 in appendix). Thus we exploit this non-homotheticity of consumer preferences to project the future composition of total Chinese consumption.

For each year between 1995 and 2011 we combine data for the sectoral demand of 34 countries with a set of structural economic variables provided by the OECD.[7] Then we estimate the coefficients of the following relationship separately for each of the 15 end-use consumer categories (s) :

$$Cons_{c,t}^{s} = \alpha_s + \rho_s Cons_{c,t-1}^{s} + \beta_s GDPpc_{c,t} + \gamma_s TotCons_{c,t} + \theta_s saving\ rate_{c,t} + \varepsilon_{c,t}$$

where $Cons^{s}_{c,t}$ e $Cons^{s}_{c,t-1}$ are the consumption (current dollars) in the sector s of the country c, in the year t and $t-1$ respectively; $GDPpc_{c,t}$ is the per capita income of the country c; $TotCons_{c,t}$ is the total consumption per country and reference year; and $saving\ rate_{c,t}$ is the country's total saving rate.

On the basis of the estimated parameters and of the OECD long-term projections it is possible to assess the annual evolution of consumption in each country and sector between 2012 and 2030. As expected the estimates predict that the shares of primary goods will decrease in favor of an across the board increase in services. Among the latter, health and social services are expected to grow faster than the others, along with retail commerce, financial intermediation, transport and telecommunications. Overall, we expect that the share of durable goods in total consumption expenditures will remain roughly constant (Table 2).

Table 2. Sectoral composition of China's consumption: projections

(percentage points)

	2011	2020	2030	Δ(2030-2011)
Agriculture	10.2	6.4	4.3	-6.0
Food, Beverages and Tobacco	14.3	11.9	9.9	-4.5
Traditional	5.9	4.7	3.7	-2.2
Machinery, Electrical and Optical Equipment	2.8	3.3	3.4	0.5
Transport Equipment	4.9	4.5	4.1	-0.7
Other Manufacturing	1.9	1.6	1.5	-0.3
Fuel, Gas and Electricity	1.4	1.9	2.5	1.2
Real Estate Services and Construction	7.9	8.4	8.6	0.7
Wholesale, Retail and Other Business	11.6	13.4	14.5	2.9
Hotels and Restaurants	4.7	4.0	3.7	-0.9
Tansport and Telecommunications	5.5	6.6	7.0	1.5
Financial Intermediation	3.7	4.6	5.1	1.3
Education	10.9	12.1	12.5	1.6
Health and Social Services	14.3	16.7	19.2	4.9

Source: own calculation on WIOD and OECD data

In the following analysis, these projections are employed to assess the effects of these changes on the largest euro area economies. In particular, (real) growth estimates for aggregate consumption and investment are drawn directly from the OECD, as well as the future reallocation of demand across these two macro-components. The future evolution of sectoral consumption follows Table 2, while the composition of investment is assumed to remain unchanged with respect to the 2011 structure. Indeed investment composition is related to the specific sectoral specialization of each country; moreover adequate estimates

[7] OECD, 2014, 'Long-term baseline projections, No. 95', OECD Economic Outlook: Statistics and Projections (database).

for some key variables necessary to predict their evolution in time (e.g. the composition of capital stocks by industry) are rarely available.

3. Value added composition of production activated by Chinese final demand

There are two main reasons why the description of China's role in world trade through traditional trade statistics, i.e. gross flows of imports and exports, is not sufficient.

Firstly, not everything that is exported to China is destined for its domestic market. A remarkable share of imports to China is processed and then re-exported owing to China's status as 'final assembler' within *Factory Asia*[8] and the substantial weight of processing trade on Chinese exports.[9]

Secondly, a share of the foreign products destined for the Chinese market arrives there only indirectly (for instance the components produced in Italy and embedded in the German cars sold by Germany in China).

More generally, a simple analysis of a country's imports provides an incomplete picture of its interconnectedness with other economies from both a geographical and a sectoral point of view. With the diffusion of value chains the linkages between production and final demand have become more complex: the trade in intermediate goods for a given product has increased and the first destination of exports often does not coincide with the final market. So as to correctly identify the role of Chinese demand as an activator of foreign production it's important to first identify the share of value added produced by each country and embodied in China's imports; then, among them, distinguish between intermediate and final goods imported to meet the Chinese demand on one side and intermediate goods which will be transformed and re-exported on the other.

Using international input-output tables, like WIOD[10] (Timmer et al., 2015), and methodologies such as the one developed by Koopman et al. (2014) and extended by Borin and Mancini (2015) to the bilateral dimension,[11] it is possible to identify precisely the country of origin and the one of absorption of the value added produced in every economy, mapping out their paths along the international production chains. A first breakdown of Chinese final demand demonstrates that 18 per cent is met by value added produced in other countries (Table 3), a share lower than that recorded in the European Union (25 per cent), but higher than those of the US and Japan (13 and 12 per cent, respectively, Table 4). The share of foreign value added in Chinese final demand rises to 22 per cent when just investment is taken into account, which in 2011 represented nearly 50per cent of the final demand (40 per cent in 1995).

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[8] The integration of production activities has mainly occurred at a regional level, leading to the formation of three international 'poles': the so-called Asian *hub* (or *Factory Asia*, according to the terminology introduced by Baldwin and Lopez-Gonzales, 2013), *Factory Europe* and *Factory North America*.

[9] According to our estimates, based on the WIOD, in 2011 about one quarter of imported goods was re-exported to third markets.

[10] Alternatively, we can resort to the OECD-WTO TiVA database (*Trade in Value Added*).

[11] Koopman et al. (2014) propose a methodology for the breakdown of a country's total exports based on the origin and on the final absorption of the value added embodied in them. Such an approach encompasses the majority of those reported in the literature (for instance, Hummels et al., 2001; Daudin et al., 2009; and Johnson and Noguera, 2012), providing a rigorous accounting of the several components of the gross exports.

Table 3. Breakdown of Chinese final demand by origin of value added

(% of total Chinese demand, 2011)

		Share of aggregate demand …se …e …ed	Foreign Value Added	*Share on aggregate demand*
Aggregate demand	**1995**	83.8	16.2	*100*
	2011	82.0	18.0	*100*
Consumption	**1995**	87.6	12.4	*57.8*
	2011	86.1	13.9	*50.1*
Investment	**1995**	78.7	21.3	*42.2*
	2011	77.7	22.3	*49.9*

Source: own calculation based on WIOD data

Table 4. Breakdown of foreign value added

(% of total Chinese demand, 2011)

	Domestic Value Added	Foreign Value Added		Foreign Value Added in the domestic productions		Foreign Value Added in the foreign procutions
China	**82.0**	**18.0**	**=**	**13.8**	**+**	**4.3**
EU-27	75.1	24.9	=	11.9	+	13.0
France	80.3	19.7	=	9.4	+	10.3
Italy	78.7	21.3	=	12.2	+	9.2
Germany	74.5	25.5	=	10.7	+	14.8
United States	87.2	12.8	=	7.1	+	5.7
Japan	88.0	12.0	=	7.4	+	4.6
Emerging Asia (excluding China)	78.6	21.4	=	13.5	+	7.9
Other EMEs	82.3	17.7	=	8.1	+	9.6

Source: own calculation based on WIOD data

The foreign value added that is absorbed by Chinese final demand consists of both final goods that are imported directly, and intermediate goods used internally to produce final goods intended for the local market. This last category accounts for more than three quarters of the foreign value added absorbed by Chinese final demand (Table 4), a particularly high value, both in comparison with the other Asian countries (63 per cent) and, above all, compared to advanced economies such as the EU (48 per cent) and the US (55 per cent).

In sectoral terms, about two thirds of foreign value added destined for the Chinese market is concentrated in three sectors of consumption/investment: construction, machinery and transport equipment (Figure A5). The construction sector, which accounts for 34 per cent of Chinese demand, represents 30 per cent of the total foreign value added, notwithstanding the relatively low share of foreign goods per unit of final demand (16 per cent). Machinery and transport equipment are instead characterized by a foreign goods intensity of 40 per cent and more than 30 per cent, respectively. The highest share of foreign value added is in the chemical sector, which accounts for just 1 per cent of the total final demand. Conversely, food and agricultural products, destined to become less relevant to final demand (see section 2), are to a large extent produced internally.

Regarding the geographical composition, about 13 per cent of the foreign value added absorbed by China is generated in other Asian countries (Table 5), while the share of Chinese gross imports from these economies to total imports is significantly higher (19 per cent). The difference between the two statistics arises from the special role played by China in *Factory Asia*: only a small fraction of imported goods from the other countries in the region is destined for the Chinese market, while a significant share is re-exported. The value added generated in the EU and the US accounts for 22 per cent and 12 per cent, respectively, of the foreign value added consumed in China, more than the gross imports to China from these two areas. Despite processing trade representing a remarkable share of the exports from non-Asian countries to China, its weight is lower than the one observed for Asian countries.

Table 5. Geographical breakdown of the foreign value added in Chinese demand

(percentage values, 2011)

	Breakdown of foreign value added in Chinese demand	Breakdown of Chinese gross imports	Difference
EU-27	21.7	18.1	3.6
France	2.4	2.0	0.5
Italy	2.1	1.7	0.4
Germany	7.4	6.8	0.6
United States	11.7	9.8	1.9
Japan	10.4	10.0	0.3
Emerging Asia (ex. China)	12.9	18.9	-6.0
Altri emergenti	31.4	32.6	-1.3

Source: own calculation based on WIOD data

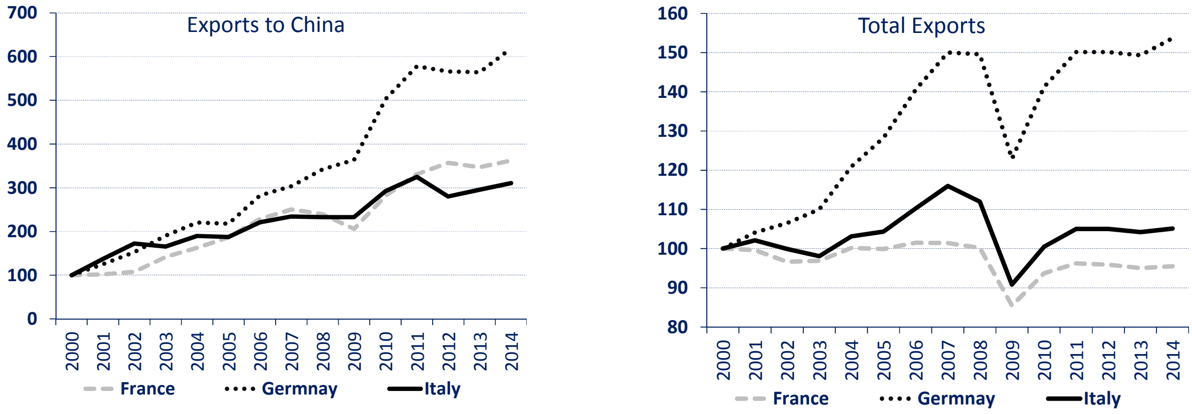
4. Chinese demand for the major euro area countries

4.1 Analysis of the direct and indirect links between the EA3 (France, Germany, Italy) and Chinese demand

China's share of Italian total exports tripled between 2000 and 2014, from 0.9 to 2.7 per cent, while in the same period China's share of German total exports grew fivefold, from 1.3 to 6.6 per cent. During the global financial crisis (2008-09) Italian total exports fell by more than 20 per cent. However, those towards China remained unchanged (Figure 5). After the crisis, Italian exports to China have grown more rapidly than those towards other markets (by 33 per cent, versus an overall growth of 16). However, they have not kept pace with French and German exports to China (70 and 76 per cent, respectively).

Figure 5. Exports to China and total exports

(export volumes, 2000=100)



Source: IMF-WEO

Capital and intermediate goods account for about three quarters of the EA3 exports to China. Nevertheless, over the last few years the share of exports absorbed by household demand has increased: above all, cars from Germany and other consumer goods from France and Italy (Figure A6).

Chinese final demand activates the production activities of the three European countries not only directly, but also through the sale of intermediate goods embedded into the exports of third countries (especially other EU members). Therefore, export shares in gross terms tend to underestimate the actual importance of the Chinese market for the euro area countries. In terms of value added, China's share of Italian and French exports rose by one point, while in the case of Germany it rose slightly less (Table 6).[12]

Table 6. China as a destination market of EA3 exports (nominal and percentage values, 2011) [a]

	France	Italy	Germany
Gross exports to China (million of US$)	19,361	15,513	91,370
share of total exports	2.8%	2.6%	5.7%
VA absorbed in China (million of US$)	16,996	13,811	70,574
share of total GDP exported	3.8%	3.6%	6.5%
GDP EXP / GROSS EXP	87.8%	89.0%	77.2%

Source: own calculation based on Eurostat and WIOD data

a) input-output WIOD tables are available until 2011.

[12] The WIOD data differ from the official statistics. As underlined by Timmer et al. (2014) the construction of these tables requires a reconciliation of the national input-output data with the trade statistics and a harmonization procedure for the bilateral exchanges (*mirror statistics*) in order to obtain a single trade flow within a given sector between two countries. This could explain some of the differences between the various sources. Therefore, we have chosen to correct China's share of EA3 total exports through a revision of the relative sizes based on Eurostat gross exports data.

Through the breakdown of bilateral exports, following Borin and Mancini's (2015) methodology,[13] it is possible to disentangle how the value added produced in a given country reaches the Chinese market, both directly and indirectly. For example, it is well known that Italian firms supply intermediate inputs for the production of German cars destined for the Chinese market: this value added is generated in Italy, embedded into German goods and absorbed by China, but in the traditional statistics these production activities are recorded as exports from Italy to Germany. Only a portion of domestic value added which meets Chinese demand is embedded in the direct trade flow to China. In fact, about 30 per cent of the value added produced by Italy and France and absorbed by China reaches Asian country thanks to the intermediation of other countries (Table 7). In particular, half of it is exported by other European countries, and about one fifth by Germany alone, the center of the *Factory Europe* hub-and-spokes system, as pointed out in Baldwin and Lopez-Gonzalez (2013).

The share of Italian value added in bilateral exports to China is the highest (77.6 per cent), more than 5 percentage points higher than Germany and 3 percentage points higher than France.

On average, just one quarter of the value added exported by these three countries and absorbed in China is activated by Chinese final demand in the same sector which has produced the value added in the country of origin (diagonal elements in Tables A2, A3, A4).[14] More than 60 per cent of Chinese final demand met by the production activities of EA3 countries is concentrated in three final consumption/investment sectors: machinery and electronic equipment, transport equipment and construction. Instead, if we look at the sectors of origin where the value added produced in the EA3 and destined for the Chinese market is generated, services account for more than half of the total.[15] Regarding Italy, value added produced in several Italian sectors is absorbed by four main components of Chinese final demand: machinery and construction, absorbing almost 50 per cent, traditional consumer goods (clothing, footwear, etc.) and transport equipment.

[13] Thanks to this methodology it is possible to determine, within any bilateral flow, the share of value added produced in the exporting country and the share of value added generated elsewhere, singling out the so-called *double counting*, that arises when intermediate inputs cross the borders of a given country several times during the various processing stages (Cappariello and Felettigh, 2015).

[14] Tables A2-A4 in the appendix link the value added generated in a given sector of the EA3 countries with the category of Chinese final demand where it is absorbed. Therefore in the main diagonal of each table the share of value added which is absorbed in the same sector that produced it is reported (for instance, the value added generated in the German automotive sector which is activated by Chinese households' and firms' final demand of cars).

[15] This share exceeds 60 per cent in France, 50 per cent in Italy, and is slightly lower than 40 per cent in Germany.

Table 7. Geographical composition of the value added absorbed in China

(share on total value added absorbed by China, 2011)

	France	Italy	Germany
direct to China	**70.7**	**71.2**	**77.5**
through other countries	29.3	28.8	22.5
share of VA exported to China through a third country			
EU-27	*49.4*	*50.7*	*40.2*
France		*7.6*	*6.9*
Italy	*4.9*		*4.0*
Germany	*20.4*	*22.1*	
United States	*3.7*	*3.5*	*3.9*
Japan	*2.2*	*1.3*	*2.0*
Emerging Asia (excluding China)	*8.9*	*6.6*	*10.4*
Others	*35.7*	*38.0*	*43.4*

Source: elaboration based on WIOD data

Nevertheless, the value added activated by Chinese final demand is produced in a large number of Italian sectors; the most relevant are business services and, within the manufacturing sector, machinery, in both cases accounting for around 20 per cent of the total. This picture diverges from the traditional analysis of trade flows: in terms of gross exports from Italy to China, machinery accounts for more than 40 per cent of the total and traditional consumer goods (clothing, footwear, etc.) for about 16 per cent (Figure A7). Although Chinese demand for Italian products from the traditional sectors is not negligible, the value added embodied in these goods is generated mostly in other sectors. This phenomenon is even more clear in the case of transport equipment: this category of final goods accounts for about 10 per cent of the Italian value added activated by Chinese demand, but only one tenth of it is generated in the transport equipment sector in Italy.

Germany is undoubtedly the country with the strongest manufacturing industry. German value added is concentrated in an even more limited number of Chinese absorbing sectors: machinery alone accounts for 30 per cent, and transport equipment 20 per cent. These sectors absorb a significant share of German products from other sectors as well; however, unlike Italy, more than half of the value added absorbed by the Chinese transport equipment sector originates in the same German sector.

France is more specialized in the service sectors: in particular, business services and transport and telecommunications services together generate around 40 per cent of the French value added absorbed by China. Another peculiarity is represented by the role of Chinese demand in the food sector, which absorbs nearly 10 per cent of the total French value added, a share twice as high as Italy's.

The idiosyncratic features of each country described above are a fundamental tool for analyzing how the evolution of Chinese demand in each sector may affect production in Italy, Germany and France. With a traditional analysis, which disregards the relationships detailed above, this would not be possible. In the next section the structure described here will provide a basis for a forward-looking assessment of how Chinese demand may affect the main economies of the euro area, identifying those sectors and countries which could benefit the most from China's transition to a new economic model.

4.2 A look at future developments

In order to assess the effects of the rebalancing of China's demand towards private consumption and the reallocation across sectors stemming from the increase in household purchasing power, we look at the estimate for China's future demand (section 2) and the relationships between Chinese final demand and the countries/sectors of origin of the exported product and services, highlighted in the previous section. In this forecasting scenario we assume that these connections remain unchanged at 2011 levels.[16] From 2011 to 2020 Chinese final demand will grow in real terms by 71 per cent, and by 148 per cent in 2030. Consumption, the most dynamic component, will increase by 94 per cent in 2020 and by 215 per cent in 2030.[17] Imports will grow on average by 4.4 per cent per year and their composition will reflect domestic demand.

We provide a general assessment of the effects of the growth in Chinese demand on EA3 output assuming that import shares and cross-border supply relationships activated by each sectoral component of Chinese final demand[18] will remain unchanged (at 2011 levels). According to these hypotheses, the value added of EA3 countries destined for the Chinese market increase on average by 65 per cent in 2020 and 130 per cent in 2030, compared to 2011, in line with the aggregate growth of Chinese demand (Table 9). For Italy, this corresponds to an average increase in GDP of nearly 0.1 percentage point per year, one third more than the average contribution of Chinese final demand in the 1995-2011 period; for France the increase is slightly lower (0.08), while for Germany it is about twice as high (0.20). These contributions are sizable, especially considering that the estimates do not take into account the indirect effects of the growth in Chinese demand.[19] For Italy, the estimated effects imply a 2 percentage-point increase in GDP by 2020, 3 percentage points by 2030. After all, even during the recent financial crisis Chinese final demand played a crucial role: between 2009 and 2011 it provided a positive contribution to Italian GDP of more than half a percentage point (in cumulative terms), whereas the aggregate Italian GDP contracted by 3.3 per cent in the same period.[20]

[16] Even though we control for both the direct effects on the demand of final goods and for spillover effects on the supply of intermediate goods, other indirect effects generated by changes in Chinese demand, such as possible increases in investment levels induced by the growth in the production of a particular sector of origin, are not taken into account.
[17] The investments are expected to increase by 46 per cent between 2011 and 2020 and by 75 per cent between 2011 and 2030.
[18] Therefore the estimate of these effects does not take into account the possible changes in China's domestic production structure or in the international value chains; moreover the possible variations in the mix between domestic production and foreign imports (or between the countries of origin of the imports) activated by a given category of Chinese final demand are not taken into account (i.e. import substitution).
[19] The estimates do not take into account the indirect effects such as the investments needed to expand the production capacity in the countries of origin, or the second round effects on income and domestic demand in the countries of production.
[20] If we consider only the Italian value added activated by the foreign demand, which in the aggregate in 2011 fell by 4.4 per cent compared to the pre-crisis level of 2008, the cumulative contribution of China was equal to +2.3 per cent.

Table 9. Value added absorbed by China's growth in demand, by sector of origin

(percentage changes compared to 2011, constant prices)

	2020			2030		
	France	Italy	Germany	France	Italy	Germany
Agriculture	54.8	58.4	61.9	106	115	123
Food etc.	60	61	62	116	119	123
Traditional	59	58	64	114	113	127
Machinery, Elec. and Optical Equip.	60	58	59	113	109	111
Transport Equipment	59	70	76	114	145	161
Chemical & plastic prod.	66	65	67	142	138	141
Basic Metals and Fabricated Metal	60	60	61	116	115	119
Fuel, Gas and Electricity	67	63	67	139	126	137
Real Estate Serv. & Construction	66	68	66	134	138	134
Wholesale, Retail & Restaurants	62	64	65	124	129	132
Renting of M&Eq & Oth. Business	69	72	69	142	150	140
Tansport and Telecommun.	73	66	69	153	134	141
Financial Intermediation	66	65	67	135	130	136
Educ., Health and Social Services	69	64	68	145	127	138
Public Admin	79	77	70	172	167	145
TOTAL	66	64	65	133	129	131

Source: elaboration based on WIOD and OECD data

Among the sectors of origin, services lead the overall growth, especially for the longer term horizon. In the manufacturing sectors, the chemical industry in the three countries and the Italian and German transport equipment sectors grow much faster than the total value added exported to China, above all in the case of Germany. Italy seems to have the highest growth rates in the business services sector, higher than those recorded for Germany and France. Instead, in the health and social services sector Italy seems to benefit less than the other two countries.

As already explained, this is the joint effect of the overall increase in Chinese final demand and of the reallocation among sectors. In order to disentangle the effect of the new composition of demand on the sectors of origin, we have repeated the same exercise subtracting the overall growth trend from each sector's growth. The reduction in the growth rate of Chinese investments compared to consumption could disadvantage some sectors: in particular, according to our analyses, the machinery and metals sectors (Table 10) might decline with respect to the others. The change in China's consumption patterns could also harm the traditional sectors and the food sectors, especially for France and Italy, although this effect might be at least partly offset by the potential increase in Chinese demand for higher quality goods.

Table 10. Effect of the reallocation of Chinese demand on sectors of origin

(percentage changes compared to 2011 excluding the total change in the final demand, constant prices)

	2020			2030		
	France	Italy	Germany	France	Italy	Germany
Agriculture	-6.0	-4.7	-3.4	-12.1	-9.6	-7.2
Food etc.	-4.2	-3.9	-3.3	-9.4	-8.5	-7.3
Traditional	-4.6	-4.8	-2.7	-9.8	-10.2	-6.2
Machinery, Elec. and Optical Equip.	-4.3	-4.9	-4.6	-10.1	-11.4	-10.7
Transport Equipment	-4.3	-0.3	1.8	-10.0	-0.8	3.7
Chemical & plastic prod.	-1.8	-2.1	-1.5	-1.8	-2.9	-2.1
Basic Metals and Fabricated Metal	-4.0	-4.2	-3.6	-9.2	-9.6	-8.5
Fuel, Gas and Electricity	-1.5	-2.9	-1.6	-2.7	-6.3	-3.4
Real Estate Serv. & Construction	-1.8	-1.2	-1.8	-4.0	-2.9	-4.2
Wholesale, Retail & Restaurants	-3.2	-2.5	-2.1	-7.0	-5.6	-4.8
Renting of M&Eq & Oth. Business	-0.8	0.3	-0.9	-1.8	0.4	-2.3
Tansport and Telecommun.	0.8	-1.8	-0.8	1.4	-4.3	-2.1
Financial Intermediation	-1.8	-2.3	-1.5	-3.9	-5.3	-3.4
Educ., Health and Social Services	-0.6	-2.7	-1.2	-1.0	-6.2	-2.9
Public Admin	2.8	2.1	-0.5	6.9	5.3	-1.0
TOTAL	-2.0	-2.5	-2.1	-4.5	-5.6	-4.9

Source: elaboration based on WIOD and OECD data

5. Conclusion

The relevance of China on global demand has become fairly significant, reaching a share similar to that of the euro area. In the next few years the Chinese economy, despite slowing down, will probably keep on outpacing the advanced economies, increasing its share of world demand.

The export-led growth model followed by China in the last several decades has involved a relative reduction in domestic consumption. Several factors, such as the level of economic development reached and China's new public policy stance , suggest that China can no longer postpone changing its growth model. The structure of Chinese demand will see a reduction in the investment-to-output ratio and a reallocation of the consumption pattern across sectors. Our estimates, based on OECD projections and on long run structural relationships, foresee a reduction in the relative weight of primary goods (food and traditional sectors) for the next 15 years, and a relative increase in the demand for services, while purchases of transport equipment and durable consumer goods will continue to expand at a fast pace, albeit in line with the average for Chinese demand.

These changes will certainly have important effects on the partner economies, including the European ones. However, the magnitude of these effects can only be evaluated by taking into account all the connections linking Chinese final demand with production in third countries. This analysis has become increasingly complex owing to the spread of global value chains; nevertheless, WIOD tables and new analysis tools allow us to identify with greater precision the connections between production and Chinese final demand.

Already today 18 per cent of Chinese final demand is met by value added generated abroad, a share higher than that of other large economies such as the US and Japan. About 22 per cent of the foreign value added absorbed by Chinese final demand is generated in EU countries, nearly 4 percentage points more than the share calculated on the basis of traditional international trade statistics. The share of foreign value added in Chinese demand is higher for investment than consumption and shows a strong sectoral concentration.

About one third of the Italian value added destined for the Chinese market reaches it only indirectly, embedded into intermediate goods exported from Italy to other countries, in particular Germany.

In value added terms, for France, Germany and Italy (EA3), the role of the service sectors as sectors able to satisfy Chinese final demand is much more prominent than the one inferred from traditional export flows. On the contrary, some manufacturing sectors, such as machinery and transport equipment, turn out to be much less relevant.

Among the categories of Chinese final demand satisfied by EA3 production activities, the share represented by the real estate and construction sector is only slightly lower than the machinery sector. For the machinery sector, the demand for capital goods activates more than one fifth of the entire EA3 production destined for the Chinese market, with spillovers on almost all the sectors of origin both in the manufacturing and services sectors.

We estimate that the evolution of Chinese demand should increase output by nearly 0.1 percentage points in Italy and France, and by 0.2 percentage points in Germany. The effects across EA3 sectors are certainly positive, but heterogeneous. Services, especially those provided to firms, would lead the overall growth, particularly for Italy. In the manufacturing sector, the chemical and transport equipment sectors in Germany and, to a lesser extent, in Italy, would benefit the most. On the contrary, the machinery and metals sectors would display a more limited expansion, suffering from the lower growth rate of investments in China.

Two issues still need to be addressed: (1) in the analysis described above the growth in demand of higher quality goods by Chinese consumers is not taken into account; a relative increase in this demand could provide sizable benefits to other sectors, such as the food and traditional goods sectors in France and Italy; (2) the greater difficulties faced by Italian firms when trying to directly reach the most dynamic extra-European markets, such as the Chinese market, could limit their ability to fully seize the opportunities that these economies will generate.

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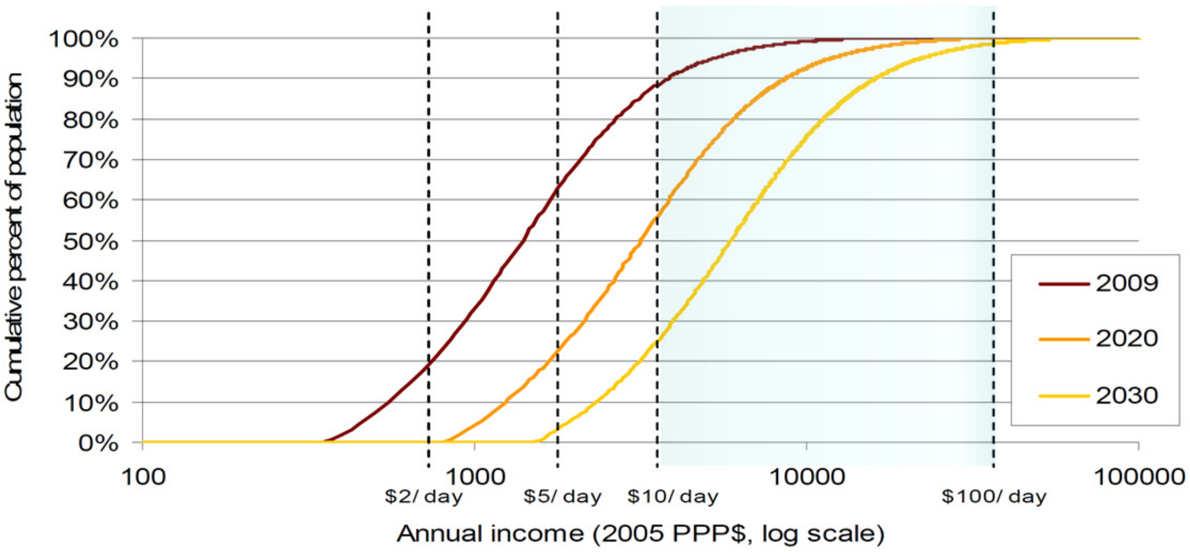
Appendix: tables and figures

Figure A1

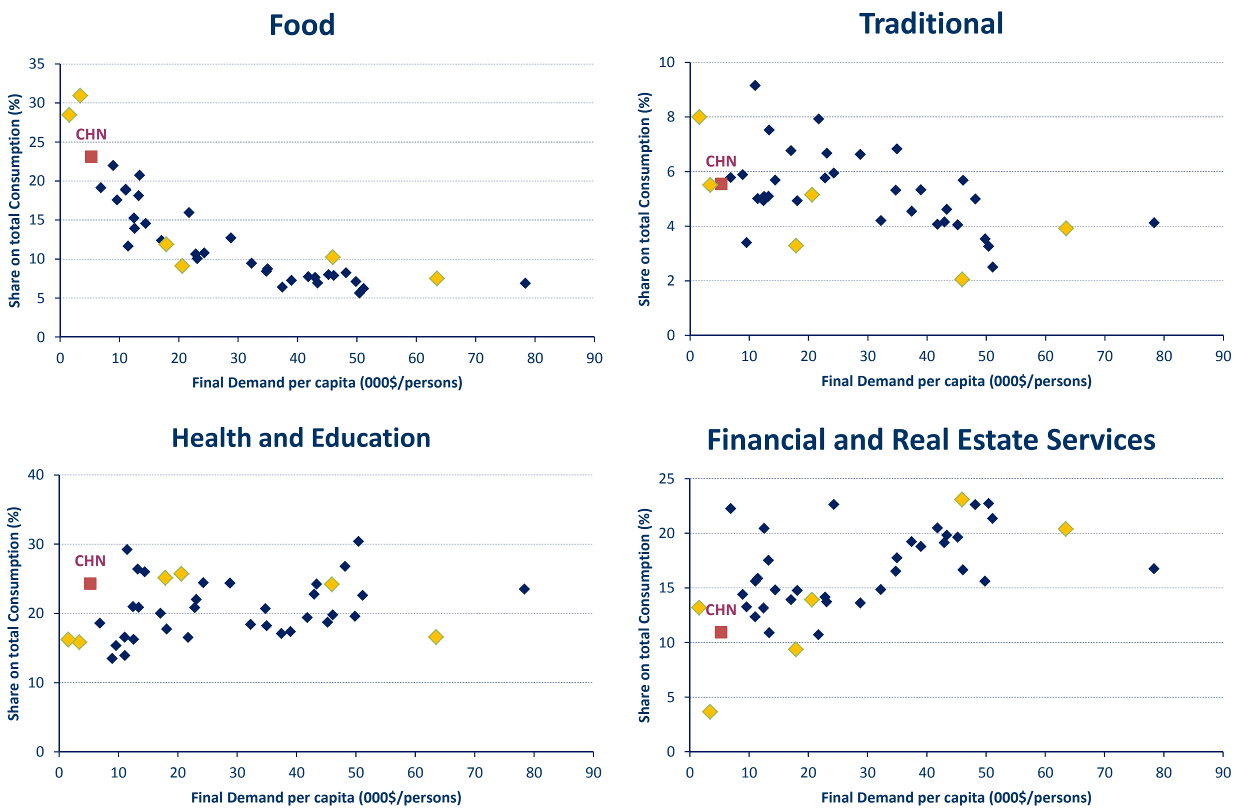
Projections of the cumulative distribution of Chinese income
(percentage values)



Source: Kharas, 2010

Figure A2

Share of the sectors in total consumption and per capita income level[a]
(percentage values, year 2011)

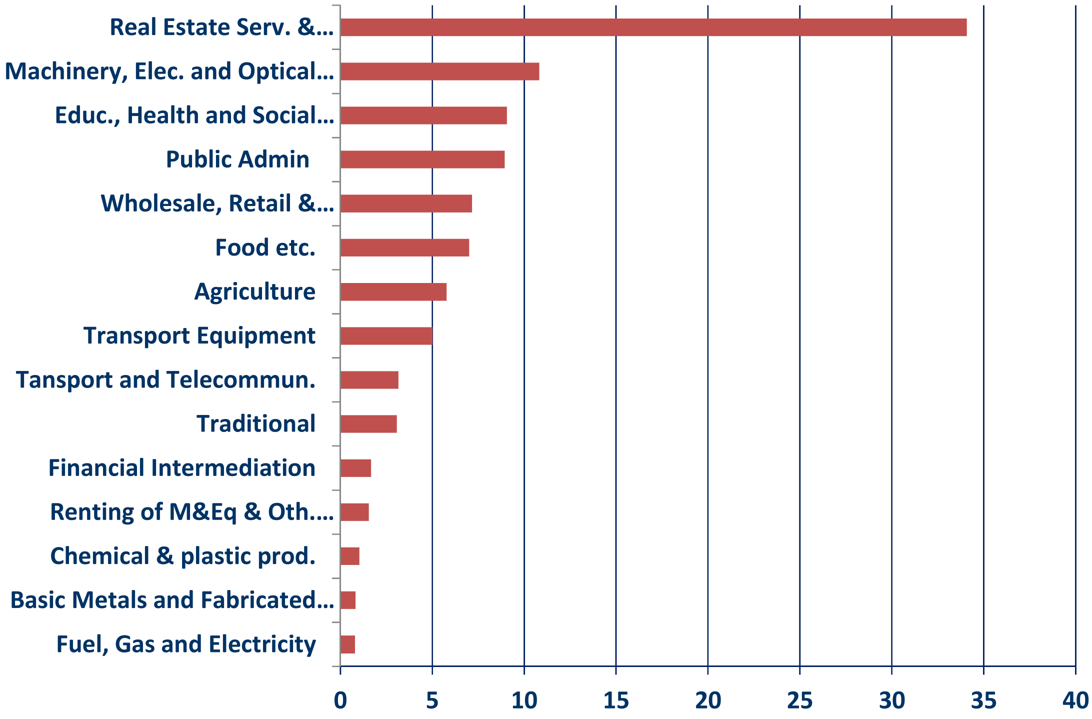


Source: WIOD e FMI WEO

a) Emerging Asian countries are in yellow, China in red.

Figure A3

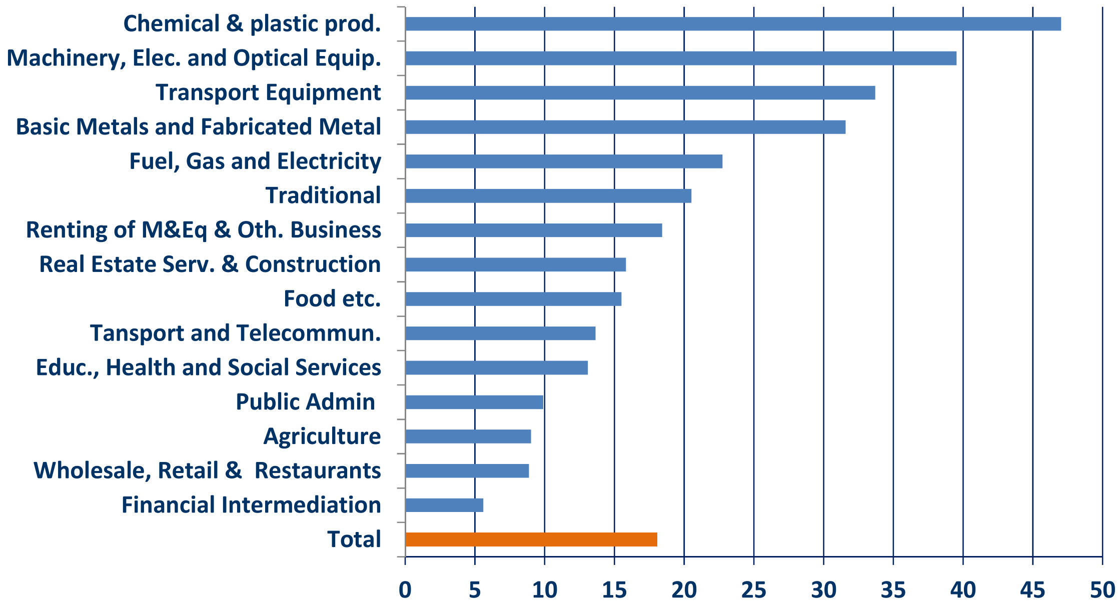
Share of each sector in Chinese total final demand
(percentage values, 2011)



Source: own calculation based on WIOD data

Figure A4

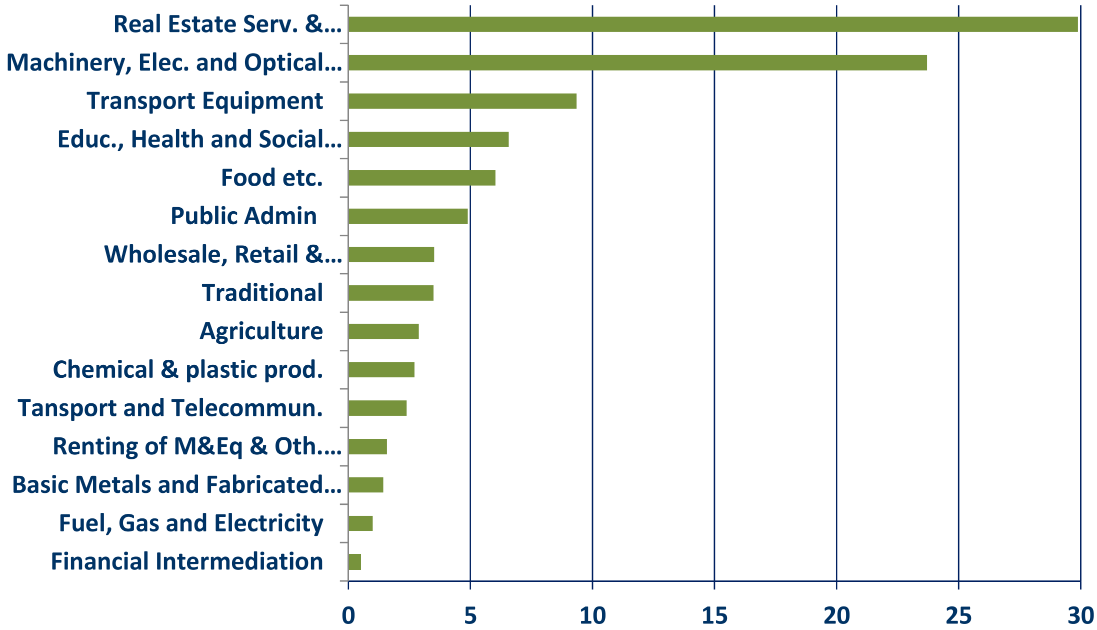
Share of foreign value added activated by Chinese final demand, by sector of activation
(percentage values, 2011)



Source: own calculation based on WIOD data

Figure A5

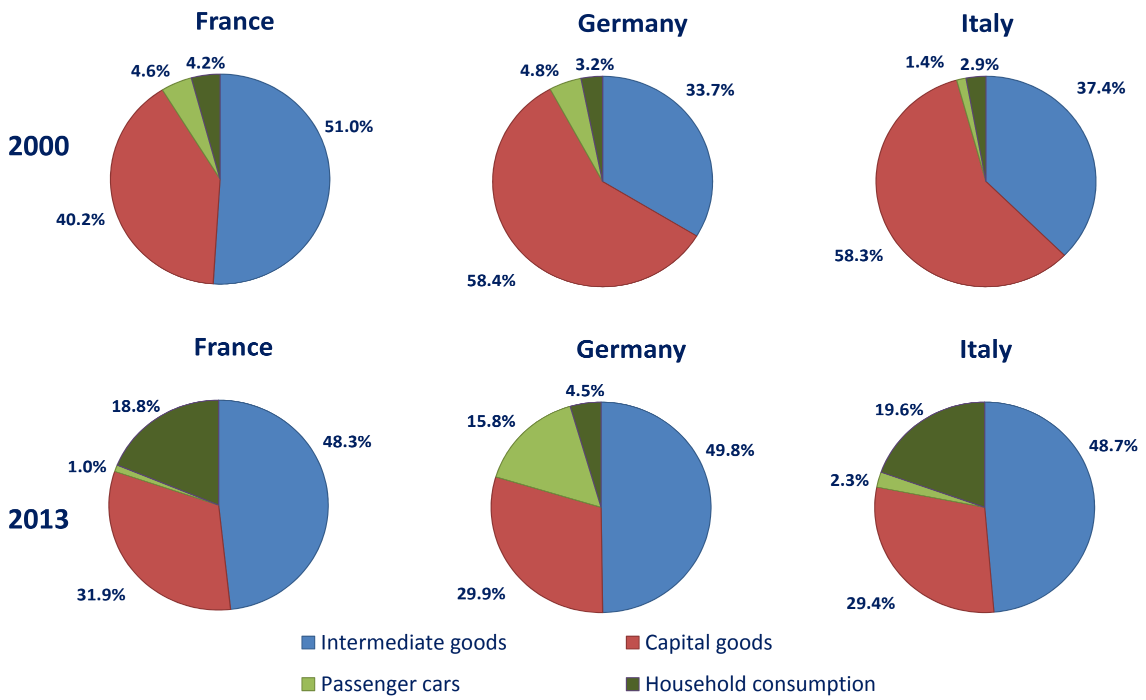
Sectoral foreign value added on total foreign value added absorbed
(percentage values, 2011)



Source: own calculation based on WIOD data

Figure A6

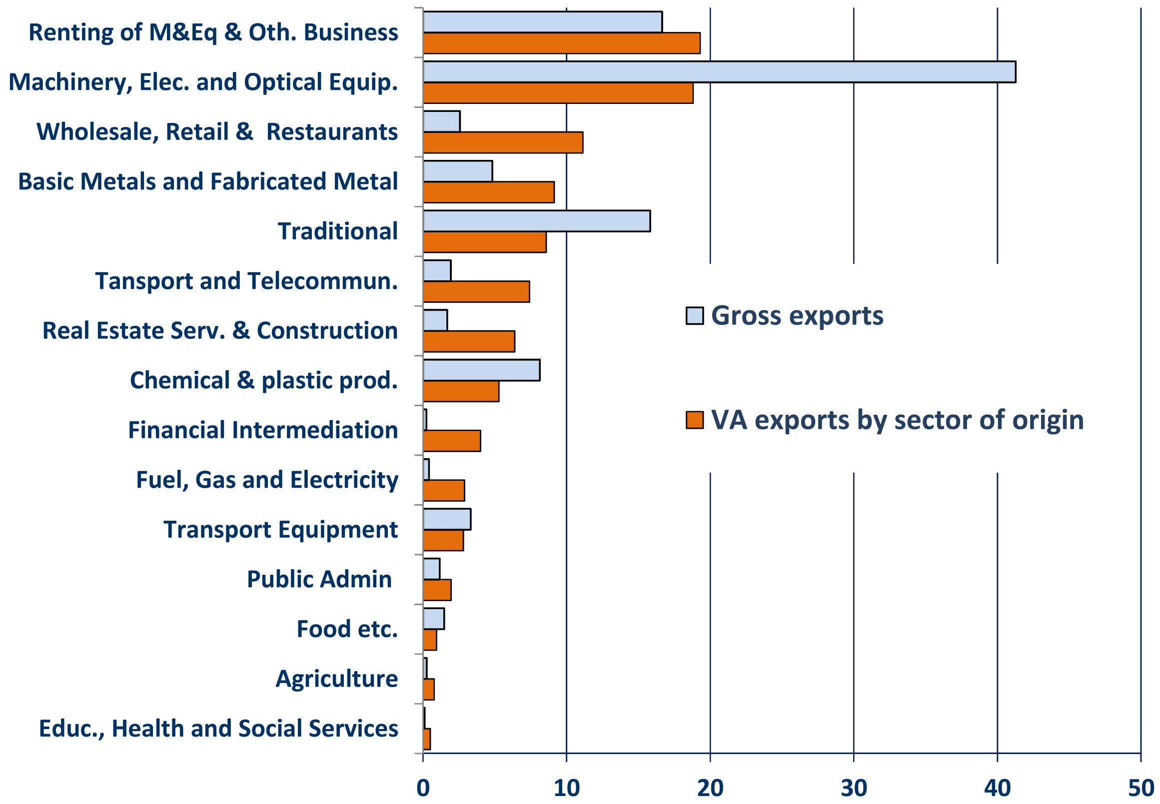
Composition of EA3 exports to China
(percentage values)



Source: own calculation based on OECD data

Figure A7

Composition of Italian exports to China
(percentage values)



Source*:* own calculation based on WIOD data

Table A2

Italian value added by sector of origin and absorption category in Chinese final demand

(percentage share, 2011)

ABSORPTION in CHINA → / ↓ ORIGIN IN ITALY	Agriculture	Food etc.	Traditional	Machinery, Elec. and Optical Equip.	Transport Equipment	Chemical & plastic prod.	Metal prod.	Fuel, Gas and Electricity	Real Estate Serv. & Construction	Wholesale, Retail & Restaurants	Renting of M&Eq & Oth. Business	Tansport and Teleco.	Financial Intermed.	Educ., Health and Social Services	Public Admin	TOTAL
Agriculture	0.08	0.23	0.12	0.09	0.04	0.02	0.00	0.00	0.10	0.03	0.01	0.01	0.00	0.03	0.02	**0.8**
Food etc.	0.02	0.43	0.15	0.09	0.04	0.03	0.00	0.00	0.09	0.03	0.01	0.01	0.00	0.03	0.02	**0.9**
Traditional	0.07	0.17	4.77	0.87	0.49	0.14	0.05	0.02	1.16	0.16	0.07	0.07	0.02	0.26	0.27	**8.6**
Machinery, Elec. and Optical Equip.	0.19	0.32	0.29	9.92	1.54	0.15	0.13	0.11	4.03	0.30	0.18	0.25	0.04	0.89	0.47	**18.8**
Transport Equipment	0.03	0.08	0.18	0.47	1.17	0.06	0.02	0.01	0.43	0.07	0.03	0.04	0.01	0.10	0.09	**2.8**
Chemical & plastic prod.	0.13	0.21	0.29	0.89	0.44	1.40	0.04	0.02	1.05	0.12	0.05	0.06	0.01	0.39	0.18	**5.3**
Basic Metals and Fabricated Metal	0.10	0.19	0.24	3.22	1.31	0.11	0.52	0.05	2.38	0.16	0.09	0.12	0.02	0.38	0.25	**9.1**
Fuel, Gas and Electricity	0.05	0.12	0.28	0.74	0.28	0.16	0.04	0.05	0.72	0.10	0.04	0.05	0.01	0.16	0.11	**2.9**
Real Estate Serv. & Construction	0.09	0.24	0.67	1.46	0.52	0.19	0.07	0.03	1.68	0.37	0.15	0.12	0.05	0.40	0.32	**6.4**
Wholesale, Retail & Restaurants	0.15	0.43	1.48	2.95	1.09	0.44	0.14	0.05	2.16	1.00	0.15	0.16	0.04	0.53	0.37	**11.1**
Renting of M&Eq & Oth. Business	0.38	0.97	1.29	3.63	1.46	0.45	0.18	0.10	4.55	1.64	1.38	0.47	0.30	1.46	1.05	**19.3**
Tansport and Telecommun.	0.12	0.32	0.78	1.80	0.68	0.27	0.09	0.04	1.70	0.31	0.14	0.33	0.05	0.43	0.36	**7.4**
Financial Intermediation	0.07	0.16	0.37	1.11	0.37	0.13	0.06	0.02	0.91	0.17	0.08	0.08	0.07	0.22	0.17	**4.0**
Educ., Health and Social Services	0.01	0.02	0.04	0.13	0.05	0.01	0.01	0.00	0.11	0.02	0.01	0.01	0.00	0.07	0.02	**0.5**
Public Admin	0.03	0.07	0.17	0.34	0.14	0.06	0.02	0.01	0.38	0.09	0.03	0.03	0.02	0.12	0.45	**2.0**
TOTAL	**1.5**	**4.0**	**11.1**	**27.7**	**9.6**	**3.6**	**1.4**	**0.5**	**21.5**	**4.6**	**2.4**	**1.8**	**0.7**	**5.5**	**4.1**	**100**

Source: own calculation based on WIOD and IMF data

Table A3

German value added by sector of origin and absorption category in Chinese final demand
(percentage share, 2011)

ABSORPTION in CHINA → / ↓ ORIGIN IN GERMANY	Agriculture	Food etc.	Traditional	Machinery, Elec. and Optical Equip.	Transport Equipment	Chemical & plastic prod.	Metal prod.	Fuel, Gas and Electricity	Real Estate Serv. & Construction	Wholesale, Retail & Restaurants	Renting of M&Eq & Oth. Business	Tansport and Teleco.	Financial Intermed.	Educ., Health and Social Services	Public Admin	TOTAL
Agriculture	0.02	0.11	0.01	0.04	0.02	0.01	0.00	0.00	0.06	0.01	0.00	0.00	0.00	0.02	0.01	**0.3**
Food etc.	0.01	0.26	0.01	0.03	0.02	0.01	0.00	0.00	0.04	0.01	0.00	0.00	0.00	0.02	0.01	**0.4**
Traditional	0.04	0.11	0.38	0.47	0.29	0.06	0.02	0.01	0.75	0.07	0.04	0.04	0.01	0.15	0.13	**2.6**
Machinery, Elec. and Optical Equip.	0.27	0.44	0.31	15.25	2.39	0.17	0.17	0.18	6.02	0.45	0.30	0.40	0.07	1.39	0.73	**28.5**
Transport Equipment	0.08	0.13	0.08	0.73	7.92	0.06	0.03	0.03	1.01	0.17	0.07	0.13	0.02	0.23	0.28	**11.0**
Chemical & plastic prod.	0.22	0.32	0.26	1.08	0.65	1.34	0.04	0.03	1.59	0.17	0.08	0.09	0.02	0.67	0.28	**6.8**
Basic Metals and Fabricated Metal	0.09	0.16	0.12	2.50	1.57	0.09	0.36	0.04	2.43	0.14	0.08	0.11	0.02	0.33	0.23	**8.3**
Fuel, Gas and Electricity	0.05	0.10	0.07	0.66	0.47	0.11	0.03	0.14	0.64	0.07	0.03	0.05	0.01	0.16	0.10	**2.7**
Real Estate Serv. & Construction	0.06	0.14	0.09	1.18	0.97	0.12	0.04	0.03	1.09	0.12	0.07	0.09	0.02	0.24	0.16	**4.4**
Wholesale, Retail & Restaurants	0.09	0.21	0.16	1.82	1.48	0.21	0.06	0.05	1.30	0.32	0.07	0.10	0.02	0.33	0.21	**6.4**
Renting of M&Eq & Oth. Business	0.40	0.79	0.42	4.34	2.88	0.52	0.14	0.13	4.49	0.87	0.83	0.37	0.16	1.20	0.78	**18.3**
Tansport and Telecommun.	0.10	0.21	0.12	1.25	0.85	0.14	0.05	0.04	1.41	0.19	0.07	0.35	0.04	0.35	0.31	**5.5**
Financial Intermediation	0.03	0.07	0.04	0.51	0.37	0.06	0.02	0.02	0.44	0.05	0.03	0.04	0.04	0.10	0.08	**1.9**
Educ., Health and Social Services	0.01	0.02	0.01	0.13	0.13	0.02	0.00	0.00	0.12	0.02	0.01	0.01	0.00	0.03	0.02	**0.5**
Public Admin	0.04	0.09	0.05	0.52	0.43	0.10	0.02	0.02	0.50	0.07	0.05	0.04	0.01	0.14	0.21	**2.3**
TOTAL	**1.5**	**3.1**	**2.2**	**30.5**	**20.4**	**3.0**	**1.0**	**0.7**	**21.9**	**2.7**	**1.7**	**1.8**	**0.4**	**5.4**	**3.5**	**100**

Source: own calculation based on WIOD and IMF data

Table A4

French value added by sector of origin and absorption category in Chinese final demand
(percentage share, 2011)

↓ ORIGIN IN FRANCE / ABSORPTION in CHINA →	Agriculture	Food etc.	Traditional	Machinery, Elec. and Optical Equip.	Transport Equipment	Chemical & plastic prod.	Metal prod.	Fuel, Gas and Electricity	Real Estate Serv. & Construction	Wholesale, Retail & Restaurants	Renting of M&Eq & Oth. Business	Tansport and Teleco.	Financial Intermed.	Educ., Health and Social Services	Public Admin	TOTAL
Agriculture	0.40	1.09	0.10	0.10	0.06	0.04	0.01	0.00	0.23	0.06	0.01	0.01	0.00	0.06	0.05	**2.2**
Food etc.	0.03	1.72	0.04	0.04	0.02	0.03	0.00	0.00	0.06	0.02	0.00	0.01	0.00	0.02	0.02	**2.0**
Traditional	0.05	0.19	2.45	0.55	0.37	0.12	0.02	0.01	0.77	0.09	0.05	0.05	0.02	0.17	0.15	**5.1**
Machinery, Elec. and Optical Equip.	0.11	0.21	0.14	5.53	0.97	0.09	0.06	0.07	2.28	0.19	0.13	0.18	0.03	0.53	0.31	**10.8**
Transport Equipment	0.06	0.18	0.10	0.43	3.69	0.09	0.02	0.02	0.55	0.09	0.04	0.08	0.01	0.13	0.16	**5.6**
Chemical & plastic prod.	0.16	0.25	0.22	0.79	0.49	1.96	0.03	0.02	1.10	0.12	0.05	0.07	0.01	0.47	0.20	**5.9**
Basic Metals and Fabricated Metal	0.07	0.17	0.13	1.90	1.13	0.11	0.13	0.03	1.59	0.11	0.06	0.09	0.02	0.25	0.17	**5.9**
Fuel, Gas and Electricity	0.07	0.26	0.13	0.50	0.30	0.28	0.02	0.06	0.60	0.08	0.04	0.07	0.01	0.18	0.13	**2.7**
Real Estate Serv. & Construction	0.07	0.32	0.21	0.76	0.51	0.25	0.02	0.02	0.76	0.13	0.09	0.10	0.03	0.22	0.19	**3.7**
Wholesale, Retail & Restaurants	0.19	1.12	0.65	2.08	1.70	0.73	0.06	0.05	1.69	0.22	0.12	0.16	0.03	0.47	0.33	**9.6**
Renting of M&Eq & Oth. Business	0.58	2.06	1.14	4.88	3.17	1.33	0.16	0.15	5.98	1.52	1.29	0.68	0.30	1.82	1.33	**26.4**
Tansport and Telecommun.	0.23	0.72	0.41	1.71	0.93	0.39	0.07	0.06	2.91	0.51	0.20	1.15	0.12	0.95	1.06	**11.4**
Financial Intermediation	0.11	0.45	0.27	0.95	0.55	0.26	0.03	0.03	0.97	0.15	0.09	0.13	0.10	0.26	0.22	**4.6**
Educ., Health and Social Services	0.02	0.09	0.05	0.23	0.16	0.06	0.01	0.01	0.22	0.04	0.02	0.03	0.01	0.15	0.06	**1.2**
Public Admin	0.04	0.16	0.12	0.37	0.22	0.11	0.01	0.01	0.54	0.13	0.05	0.06	0.03	0.19	0.65	**2.7**
TOTAL	**2.2**	**9.0**	**6.2**	**20.8**	**14.3**	**5.9**	**0.7**	**0.5**	**20.2**	**3.5**	**2.3**	**2.9**	**0.7**	**5.9**	**5.0**	**100**

Source: own calculation based on WIOD and IMF data

Regional employment patterns in a globalizing world: a tale of four Italies

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May 2015

Abstract

The past decades have witnessed a rapid globalisation of economic activity: production, trade and investments have been increasingly organised within "global value chains" (GVCs). Recently, a number of GVC-studies explore how regional clusters are embedded into global production systems and how changes in this involvement affected development of these clusters. Usually these studies analyse single products or sectors, mainly from a qualitative viewpoint; as a consequence, they cannot be generalised. This paper follows a macro-oriented approach, introducing the results of a first attempt to integrate sub-national input-output tables for Italy into the World Input-Output Database (WIOD), in order to assess the effects of changes in the structure of value chains on regional employment patterns. From this viewpoint, Italy is an interesting country to study at a regional level, since it is characterized by high heterogeneity that is likely to influence the degree to which regional production systems contribute to different value chains. Using the new value chain metrics introduced by Timmer et al. (2013), the "integrated" database allows us investigating to what extent different industries in four Italian macroregions (Northwest, Northeast, Centre and South and Islands) captured stages in "manufactures value chains" in the years 1995 and 2006, and analyzing the effects on employment of different types of workers. We find that employment in GVCs increased across all regions, but in the South levels are still much lower than in the other three regions. Moreover, the South seems to participate in GVCs which grow relatively slowly. In the period studied, low-skilled workers are the category that lost most in every region, and especially in the South, while the value chain demand for high-skilled jobs rose intensely across regions.

Keywords: world input-output tables, regional input-output tables, global value chains, demand for skills, intra-regional differentiation.
JEL Classifications: C67, F16, F66, R11, R15.

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We wish to thank Alberto Felettigh, Rita Cappariello, Erik Dietzembacher, Anna Giunta, Renato Paniccià, the participants in the 2015 Bank of Italy's Workshop "Global Value Chains: New Evidence and Implications" in Rome, in the 2013 ERSA Conference "Regional Integration" in Palermo and in the 2012 Final WIOD Conference "Causes and Consequences of Globalization" in Groningen. The views expressed in this paper are those of the authors and do not necessarily reflect those of the Bank of Italy. All the remaining errors are ours.

1. Introduction

Italy is known to be a country in which regions vary much in terms of their economic performance. Income levels, unemployment rates and sector structures in the South are quite different from those in the North, which performs best. Several studies have been studying both the regional differences in levels and the dynamics of these over time, analysing the roles of several potential drivers of growth (or stagnation). In this paper, we aim at providing novel insights, by linking the economic performance of four "Italies", that is the four Italian macro-regions (Northwest, Northeast, Centre, and South, which includes the islands Sardinia and Sicily), to the extent to which these are integrated in value chains that span several regions and countries.

Improvements in information and communication technology have allowed firms to locate some of the stages of their production processes to distant places. Communication via e-mail and video-conferencing, alongside with opportunities for sharing the management of databases to control inventories and deliveries have led to situations in which comparative advantages of regions and countries can be deployed to a much larger extent than before. As a consequence, production processes have become much more internationally fragmented and "Global Value Chain" (GVC) has become a buzzword. The emergence of GVCs has also affected regions as defined at the subnational level. Most probably, the best-known example of a region that was heavily affected by the emergence of GVCs is Guangdong province in the Southeast of China. Many Western electronics firms relocated their assembly activities to this region, to benefit from the low-cost labour (Linden et al., 2010). Research & Development and design activities remained in Western countries, while the production of components was largely offshored to other Asian countries, like Japan and South Korea.

Regional policies aimed at development should take the consequences of the international fragmentation of production processes into account. Governments should not only focus on advancing the role of their regions as export platforms, but also create the facilities to import intermediate inputs, for example. Humphrey and Schmitz (2002) give a taxonomy of four types of regional upgrading in and across value chains, stressing the way in which industrial cluster policies can be adapted fruitfully to achieve this goal.

Until recently, GVC studies were almost exclusively case studies. This has changed with the construction of a number of global input-output tables, which basically give a quantitative summary of the world production structure. Using the World Input-Output Database (see Dietzenbacher et al., 2013; Timmer et al., 2015), Timmer et al. (2013; 2014) and Baldwin and Lopez-Gonzalez (2014) have provided studies with a more macroeconomic flavour, identifying patterns and trends regarding the consequences of international fragmentation of production processes. Johnson and Noguera (2012) and Koopman et al. (2014) did the same, but based on global input-output tables constructed on the basis of GTAP data.

In this paper, we follow the more macro-oriented approach, but with a specific focus on the Italian macro-regions. To this end, we incorporated regional supply and use matrices and trade data (both among Italian regions and between Italian regions and other countries) into the WIOD framework. In a sense, the four macro-regions can be considered as countries within WIOD. We constructed these data for 1995 and 2006. We link these extended global input-output tables to data on employment by educational attainment level, by country and industry. This allows us to address the overarching research question is "To what extent can GVCs explain the differences and dynamics in employment patterns across Italian macro-regions?"

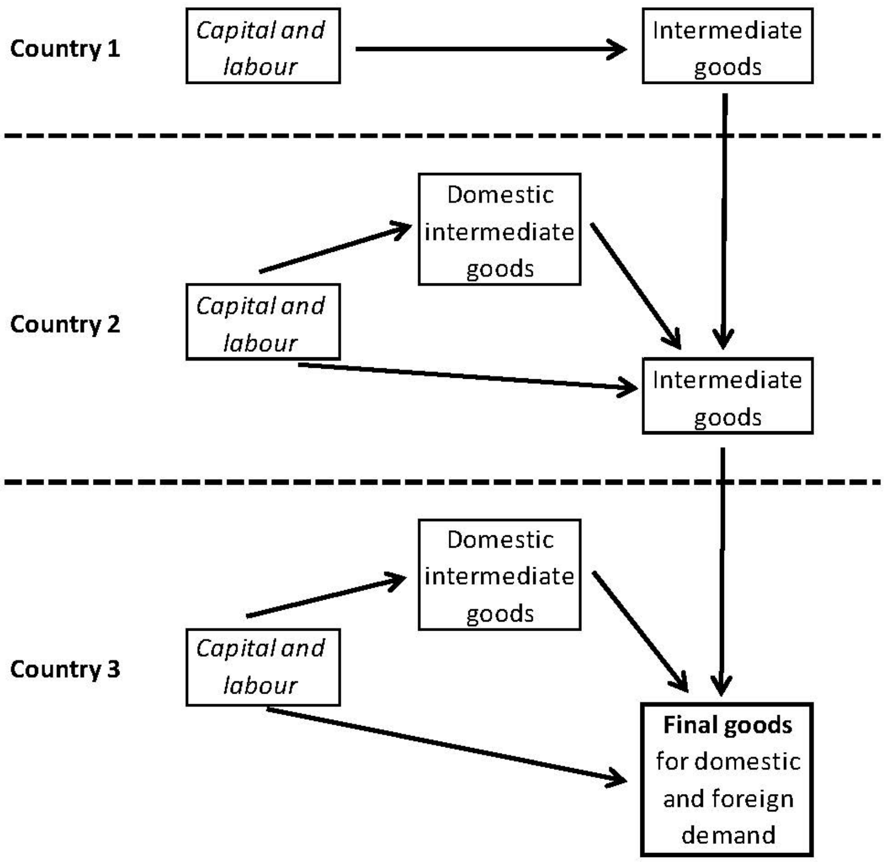
The organization of the paper is as follows. In the next section (Section 2), we will outline the way in which international input-output tables have been used in the recent past to quantify the role of countries in GVCs, and the changes in these roles. The GVC-approach as advocated by Los et al. (2013) will be the focus of this exposition. Section 3 is devoted to a description of the data, in particular the WIOD-tables with Italy split into four regions. Section 4 presents the empirical results and Section 5 concludes.

2. Global Value Chains and (Regional) Development

Due to advances in information and communication technology, reductions in transportation costs and the continuing removal of trade barriers, companies have experienced increasing opportunities to relocate part of their production processes to countries where the availability and costs of the production factors are most favourable for these specific activities (Baldwin, 2006). As is stressed in the case study literature (e.g. Dedrick et al., 2010), these relocations can be governed within the firm (by means of FDI) or by agreeing on contracts with specialised foreign suppliers. No matter what form is chosen, such relocation decisions have consequences for the distribution of demand for jobs (of different types) in the geographic areas involved.

To measure the changes in employment across regions and countries as a consequence of this phenomenon, we use an indicator introduced by Timmer et al. (2013) called "value chain (VC) jobs". The VC of a final manufactured product (used for consumption purposes or as a capital good) can be defined as the set of all activities that are directly and indirectly needed to produce it.[1] We identify a VC by the region/country and industry in which the last stage of production takes place: examples are the VC for Chinese electrical equipment, and the VC for Northwest Italian transport equipment.

Figure 1 – Stylised representation of a Value Chain



Source: Los et al. (2015)

[1] Concepts like "global supply chains" or "international production chains" typically refer only to the physical production stages, whereas the "value chain" concept refers to a broader set of activities both in the pre- and post-production phases including research and development, software, design, branding, finance, logistics, after-sales services and system integration activities. The VC-jobs measure will take account of the value added in all these activities.

Figure 1 refers to a simplified world economy consisting of three countries (where "country" can be interpreted as a nation or a region) and depicts a value chain of a final product (e.g. a car) for which the last stage of production takes place in country 3. We call this the "country-of-completion", i.e. the country where a product is finished before it is shipped to wholesalers, retailers or directly to consumers. Both domestic and foreign demand for country 3's cars will require labour (and other production factors) in 3's car industry itself. It will also generate employment in upstream industries in country 3 itself, for example because the car manufacturer needs intermediate inputs from the domestic business services industry. Next to domestically sourced intermediate inputs, other intermediate inputs (metal products, for example) are imported from country 2. The manufacturing of these metal products require labour inputs as well and the metal products manufacturers in their turn also need intermediate inputs, partly produced in country 2 and partly in country 1. Due to demand for final products completed in country 3, value added and jobs are created in all three countries. Based on information of the various production linkages in the production of the final product considered, employment in industries in countries 1, 2 and 3 due to demand for country 3's cars can be calculated.[2]

Using well-established techniques from the field of input-output analysis (see Miller and Blair, 2009), information contained in World Input-Output Tables can be deployed to estimate the (gross) output levels of all industries in each of the countries, required to meet final demand for a specific product group with a specific "country-of-completion". After these output levels are determined, information about the labour requirements per unit of output can be combined with the output levels to arrive at an estimate for the employment levels associated with the specific final demand level studied. If the employment levels associated with final demand for all products with all "countries-of-completion" are estimated in this way, these will exactly sum to actual labour inputs in each of the industries and in each of the countries where labour inputs are located. In our empirical application we will study the changes in distribution of jobs, across geographic areas (countries/regions), economic sectors and different types of labour. A somewhat more technical exposition of such VC decompositions can be found in Timmer et al. (2013).

More formally, using matrix algebra we can write:[3]

$$e_{st} = \mathbf{u'}_{ij}\mathbf{E}_{st}\mathbf{x}_t \quad [1]$$

in which e_{st} is the number of workers of skill type s in year t in the aggregate of all industries and countries of interest; $\mathbf{E}_{st}$ is an (MNxMN) diagonal matrix containing quantities of labour requirements of skill type s per unit of (gross) output in each of the N industries in each of the M countries, in year t; $\mathbf{x}_t$ is the MN vector of (gross) output levels in each of the N industries and M countries, in year t; and $\mathbf{u}$ is an MN "selection vector" which contains ones in the cells associated with particular industries of interest located in specific countries of interest, and zero elsewhere. If the selection vector contains only ones, e_{st} refers to employment of skill level s in year t in the global economy. If we would be interested in, for example, employment in services industries in the Northwest of Italy and nothing else, only the cells corresponding to these industries should equal one, and all other cells should contain zeros.

Gross output levels in $\mathbf{x}_t$ are the result of the interplay between final demand levels (for final consumer products and capital goods) and the intermediate inputs required to produce these final goods (Miller and Blair, 2009). The product market clearing condition can be written as:

$$\mathbf{x}_t = \mathbf{A}_t\mathbf{x}_t + \mathbf{f}_t \quad [2]$$

in which $\mathbf{A}_t$ is an (MNxMN) matrix whose elements $a_{ij,hk}$ are the input-output coefficients, describing the output from industry i in country j used as intermediate input by industry h in country k

[2] However, it is important to note that the fact that a product is completed in a particular "country-of-completion" 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. For more on governance in global value chain production see Gereffi (1999), our analysis deals with the location of workers.

[3] This exposition is based on Timmer et al. (2013) and Los et al. (2015).

as a share of output in the latter sector and $\mathbf{f}_t$ is an MN vector of final demand levels for products produced in all industries and all countries. Rearranging, we arrive at the fundamental input-output identity:

$$\mathbf{x}_t = (\mathbf{I} - \mathbf{A}_t)^{-1}\, \mathbf{f}_t \qquad [3]$$

in which $\mathbf{I}$ is an (MNxMN) identity matrix and $(\mathbf{I} - \mathbf{A}_t)^{-1} \equiv \mathbf{L}_t$ is the famous "Leontief inverse", the elements $l_{ij,hk}$ of which give the output of industry i in country j needed to produce one unit of final output of sector h in country k. We can now rewrite equation [1] as:

$$e_{st} = \mathbf{u'}_{ij}\mathbf{E}_{st}\mathbf{L}_t\mathbf{f}_t \qquad [4]$$

Equation [4] shows that the use of labour inputs is driven by final demand for each of the N industries delivered by each of the M countries. If we apply [4] for specific parts of the actual final demand vector $\mathbf{f}_t$, we can attribute parts of actual employment to these. We can, for example, choose the hypothetical demand vector such that it only contains demand for German cars and set all other elements of it to zero. The left hand side of [4] will then give the number of workers of skill type s in year t in the set of industries of interest active in the VC for German cars.

Since we consider VC jobs from a regional (rather than a national) perspective in this paper, we need to introduce some new terminology. We will attribute employment (total, or of a particular skill level) in each Italian macro-region to three kinds of value chains, plus a residual not related to VCs. If VC jobs are due to final manufactured products with a non-Italian country-of-completion, we will label these as global value chain jobs (GVC jobs). If VC jobs can be attributed to final manufactured products completed in one of the three other Italian macro-regions, we will denote such jobs as interregional value chain jobs (IRVC jobs).[4] Employment linked to the production of manufactured final products in the macro-region itself will be dubbed local value chain jobs (LVC jobs). The remaining employment can be attributed to non-manufactured final products, most often services. These are most often much harder to contest in an international or interregional sense.

We should emphasize that we consider number of jobs on a "domestic", rather than a "national", basis: it includes activities carried out on the regional territory disregarding the region or country of which workers are citizens. We expect differences to be small, although interregional migration is more common than international labour migration.

We would like to stress that the decomposition methodology outlined above is basically an accounting framework, rather than a fully specified economic model. It starts from exogenously given final demand and traces the value added (and related jobs) generated at the various stages of production in an international input-output model, without explicitly modelling the interaction of prices and quantities like in Computable General Equilibrium models.

The proportions (and changes therein) of GVC, IRVC and LVC employment give insights into the extent to which regions are integrated in production networks spanning various countries and regions. As we will see, these proportions vary considerably over the four Italian macro-regions analysed.

3. Data

The World Input-Output Database (WIOD) is the result of a project sponsored by the European Commission, carried out by a consortium of 12 research institutes between 2009 and 2012. The database provides annual time-series of world input-output tables (WIOTs) from 1995 to 2011, including 35 industries and 59 products. It covers 27 of the European Union (EU) countries and 13

[4] We will label GVCs and IRVCs taken together as "external" VCs.

other major advanced and emerging economies, plus a “rest of world” region, which accounts for the remaining non-covered part of the economy. WIOD is publicly and free of charge available (www.wiod.org). An accessible description of the database including discussions of opportunities and pitfalls has been published as Timmer et al. (2015).

WIOD combines detailed information on national production activities and on international trade, according to a clear conceptual framework on the basis of official data that are publicly available (a detailed description of construction issues can be found in Dietzenbacher et al., 2013). A key feature of the WIOTs is that they are fully benchmarked on National Accounts Statistics (NAS) and bilaterally balanced according to the available statistics of international trade in goods and services. National Supply and Use Tables (SUTs) are the building blocks for the construction of the WIOTs. SUTs are the core statistical sources from which National Statistical Institutes derive national symmetric input-output tables (IOTs), but they allow for secondary production in the same industry. Obtaining “international SUTs”, by linking SUTs with international trade data, which are typically product based, becomes more straightforward and accurate.

In addition, the WIOTs are linked and fully consistent to satellite accounts on the inputs of production factors (labour and capital) at the industry level, extending the scope of potential applications. Labour data are constructed for most advanced countries by extending and updating the EU KLEMS database (www.euklems.org) using the methodologies described in O’Mahoney and Timmer (2009), while for the other countries additional data have been collected, according to the same principles, mainly from national labour force surveys (LFS). Together, these features make WIOD suitable for addressing issues related to globalization of production processes, competitiveness of countries and related socio-economic variables dynamic.

Despite its informative contents, WIOD does not give insights at a sub-national level. Increasing the database detail to a regional level can offer macro-economic perspectives on the heterogeneous results reported by some case-studies and a deeper knowledge of the geographical nature of linkages (Timmer et al., 2015). In this paper, we introduce a regional disaggregation of the Italian part of WIOD’s tables. Four regions have been considered: Northwest, Northeast, Centre and South and Islands (henceforth simply South). For these regions, Interregional Supply and Use tables (IRSUTs), which can be made compatible with WIOD, are available for the years 1995, 2001 and 2006 (see Appendix 1 for a description of the various steps needed to build the Italian IRSUTs). The approach adopted to integrate the Italian IRSUTs into the WIOD system of international SUTs was to replace the tables for Italy as a whole by 4 Supply and 4 Use tables, a couple for each region (the “Four Italies”). As a result the final database, where each of the “Four Italies” is a country itself, has 44 countries (comprehensive of the “rest of the world”) instead of the original 41.

The new SUTs have been linked to each other and to the other tables of the WIOD through trade flows, both interregional and between each of the macro-regions and the countries in WIOD.[5] In order to cope with this “more detailed world”, some adjustments were needed to conform the Italian IRSUT to the WIOD format; also the original WIOD tables, and particularly the Use tables, had to be modified to take the four distinct origins of imports from Italy into account.

As far as the IRSUTs are concerned, a first change to the original data was related to some “extra-regional” values – that is, values which are not strictly attributable to any regions but are included in the national SUTs for Italy as a whole – which had to be attributed to regions. These concern the mining sector (mainly offshore rigs) and public administration (mainly embassies and military bases abroad). They have been attributed, respectively, to South (by proximity criteria) and to the Centre (where the central offices of the public administration are located). Parts of these values are also included in the interregional trade flows through re-exports to other regions. They have been adjusted accordingly.

[5] Similar results are obtained for purchases abroad by residents and purchases on the country’s territory by non-residents.

The most relevant difference is that the international WIOD Use tables separate domestically sourced and imported goods and services, while the multi-regional Use tables contain aggregated imported and domestic values. Moreover, there's no information about the country of origin of imports. A three-step procedure has been used to adjust the four Use tables. Firstly, for each product the interregional imports and imports from abroad have been divided into intermediate, consumption and capital use of goods and services, according to the proportions observed for the imports in the international Use for Italy as a whole.[6] Secondly, intermediate use has been distributed among industries, final use into final consumption categories and capital use into gross fixed capital formation categories, according to the regional proportions in each use group, as observed in the IRSUT. Thirdly, imports from abroad have been split by country of origin:[7] for each product the regional share of imports has been calculated on the basis of ISTAT trade statistics (available by product, region and country of origin); since for services there are no trade statistics available, the WIOD national share of imports (by service and country of origin) has been applied uniformly to every region.

The international transport margins (ITMs) of each of the 4 regions when trading goods with foreign countries, as they result from the international WIOD tables, have been distributed according to the proportion of the total regional imports from abroad of each product, as they result from the multi-regional Supply tables. Since in WIOD the "domestic" ITMs for Italy as a whole are obviously zero, the ITMs for each product between pairs of macro regions have been put to 0. The CIF/FOB adjustments pertaining to each region have been calculated consequently.

When necessary, further adjustments for negative values in intermediate and final use categories have been performed.[8] As for the international Use tables for all the other countries, the corrections are solely concerned with the imports from Italy, which now have to be split into imports from the four regions; in this case the sum of these values must be equal to the Italian national exports to that country.

Imports of Italian products by a country have been split by region according to the regional shares of exports, calculated for products on the basis of ISTAT trade statistics (available by product, region and country of destination) and for services on the basis of the regional shares of exports observed in the IRSUT, supposed to be equal for any country of destination for the same service.[9] Country's ITMs with the regions have been adjusted accordingly.

As already mentioned, a defining characteristic of WIOD is the availability of employment data, which can be used in conjunction with the WIOTs. The limitation of these data, for the purpose of this work, is that they are only available at country level. In order to obtain regional data, the Italian Regional Accounts data and the Labour Force Survey (LFS) database has been used to split national employment data from EU KLEMS. The Regional Accounts employment data are consistent with EU KLEMS totals, but they only report the geographical distribution of total workers, without any other detail. On the other hand, LFS data are very detailed, but they are not fully consistent with EU KLEMS. The main differences between the two sources of labour data is due to the adoption of a slightly different definition of workers: EU KLEMS includes resident and non-resident (regular and irregular) workers in domestic firms only, while LFS accounts for resident (regular and irregular) workers everywhere.

Annual LFS data have been made consistent with EU KLEMS through the iterative proportional fitting procedure known as "RAS algorithm" (Bacharach, 1965), according to the

[6] For interregional imports some further amendments has been required in order to consider products not imported from abroad: "raw materials", "public administration", "health and social services", "private households". The last 3 products have been considered final, while "raw material" has been imputed in the same proportion to intermediate and final use.
[7] Interregional imports are available, by construction, in the MRSUT.
[8] In analogy with WIOD construction procedures, adjustments have been attributed to re-exports and all columns involved in the correction have been modified accordingly.
[9] Further corrections have been made when the shares turned to be null for every regions. In all these cases, proportions of purchases by non residents on the regional territory (not available for single products but only as a total amount) have been used.

marginal distributions of workers by type of job (employee or self-employed), economic sector (NACE rev. 1 classification) and regional distribution of total workers (from Regional Accounts).[10]

Workers are further classified by skill levels, which are proxied by the level of educational attainment, as defined in the International Standard Classification of Education (ISCED). Low-skilled (LS) workers are those with an education level in ISCED categories 1 and 2 (no formal qualifications), medium-skilled (MS) in ISCED 3 and 4 (higher education below degree, intermediate vocational plus advanced education, low intermediate) and high-skilled (HS) in ISCED 5 and 6 (university graduates). The definitions of high, medium and low education are consistent over time.[11]

4. Empirical Work

4.1 Regional employment patterns: descriptives

The share of a specific activity within the whole regional economy gives an idea as to in which sectors regions are specialized. Using the number of persons employed for the analysis, we find some significant disparities between the "Four Italies" in terms of the importance of different activities within their economies.

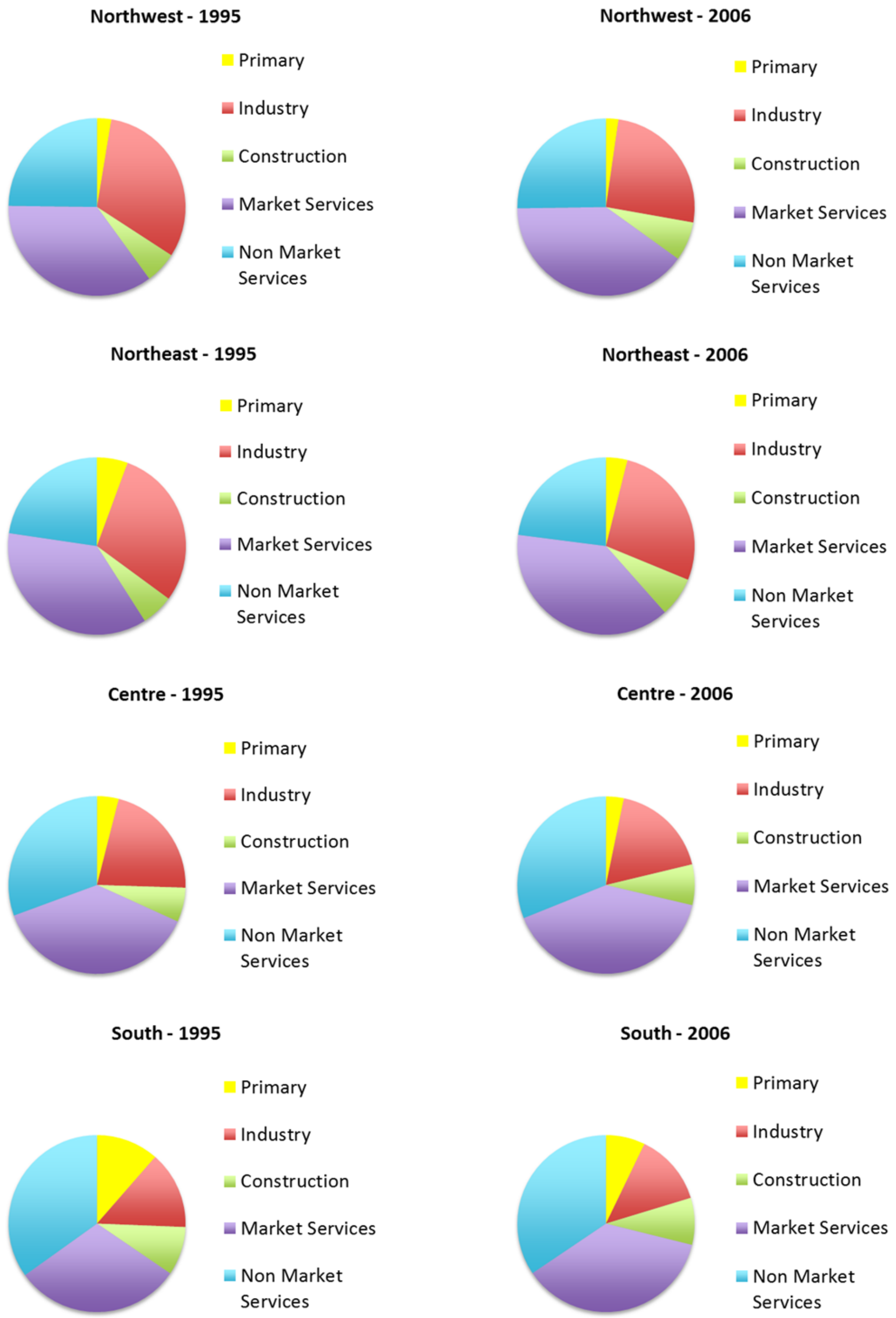
Figure 2 shows that in 1995 industrial activities were very important in the Northern regions (with a share of employment around 30%), but less important in the Centre (22%) and even less so in the South (14%). The share of market services exceeded that of industrial activities in all regions. Non-market services (mainly concerned with public administration, defence, education, etc.) were the most important employment sectors in the Centre (31%) and the South (35%).

The reasons for such specialization are varied and include: the availability of natural resources (for example, for mining and quarrying or forest-based manufacturing); access to skilled workforce (for example, for scientific research and development); the level of production costs (for example, wages and other labour costs, or the cost and availability of other inputs); adequate provisions of infrastructure (for example, transport or telecommunications); climatic and topographic conditions (particularly relevant for tourism activities); proximity or access to markets; and legislative constraints (Eurostat, 2013).

[10] Before applying the RAS algorithm some minor data adjustments have been performed (i.e. exclusion of NACE residual code "99", detailed classification of secondary jobs into economic sectors, etc.).

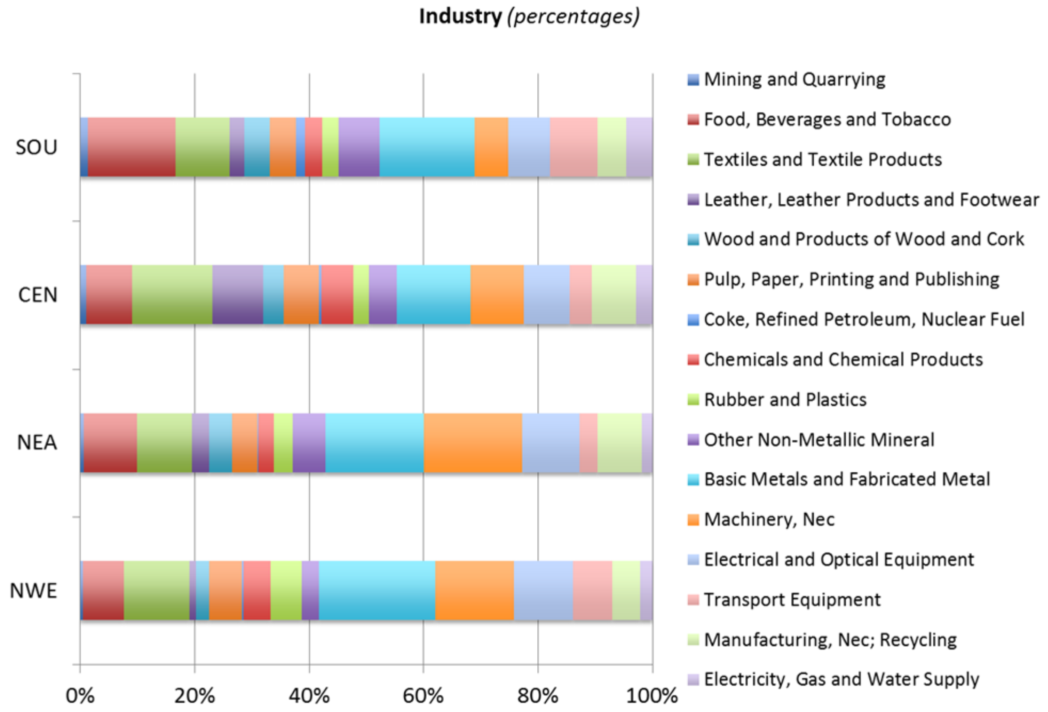
[11] The adopted classification might be too restrictive to ensure exact cross-country comparisons, given the differences in educational systems throughout the world, but it is fully time-consistent for a single country (O'Mahoney and Timmer, 2009).

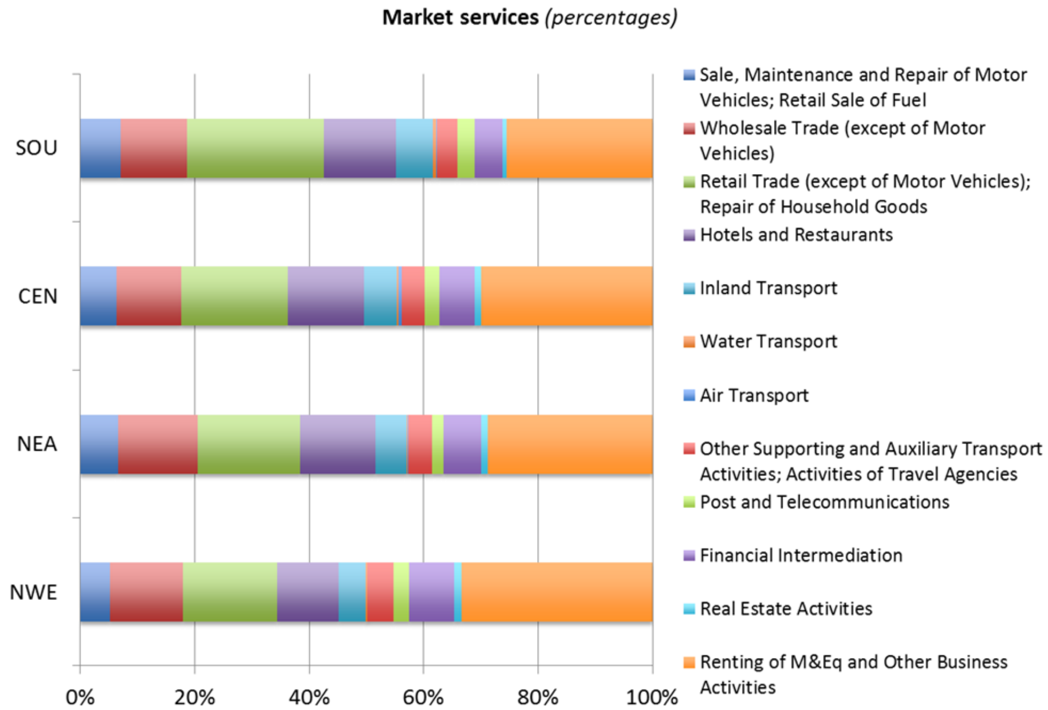
Figure 2: Regional Employment Structures (1995 and 2006)



Source: EU KLEMS, Istat

Figure 3: Industry Employment Patterns in Industry and Market Services (2006)





Source: EU KLEMS, Istat

Between 1995 and 2006 we observed a reduction of the disparities between Italian regions with respect to economic specialization patterns: primary and industrial activities became less important in each region, while the share of non-market services remained stable. Market services became the most important source of jobs in every region, with shares of 40% in the Northern and Central regions and of 37% in the South.

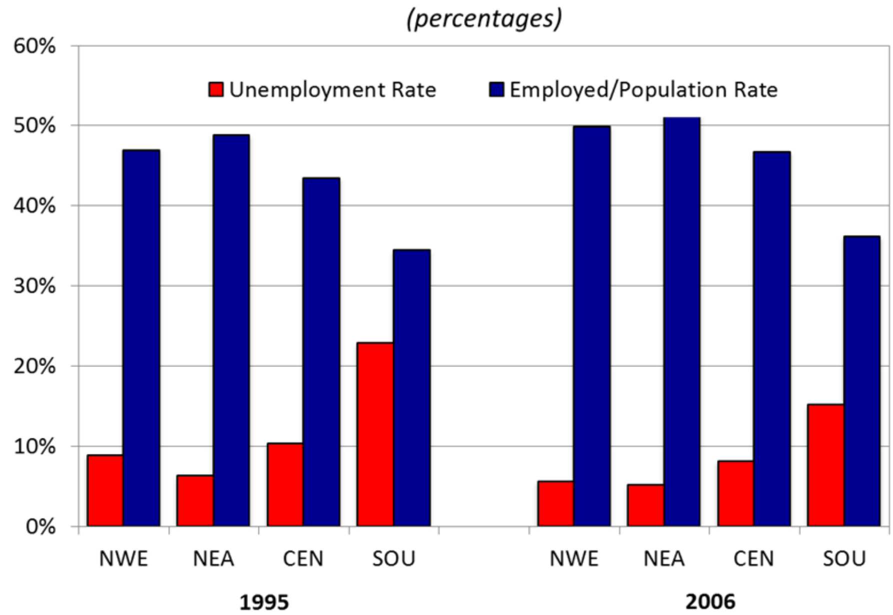
Figure 3 presents a more detailed analysis of the employment structures in industry and market services, for 2006. Since manufacturing activities that involve the primary processing stages of agricultural, and fishing products tend to be concentrated in areas close to the source of the raw materials, the most specialized region in food and beverage manufacturing (with 15% of industry workforce) was the South. In the Centre about 23% of the total employment was concentrated in textile, leather and related manufactures (the so-called "fashion sector"). Northern regions were most specialized in "heavy manufacturing" activities (machinery and transport equipment), which employed 20% of the industry workforce. Related activities, such as basic metal and fabricated metal production, were about equally important in these regions.

Distributive trade (wholesale and retail trade and related activities) accounted for more than one third of the total employment in market services across all regions, with a peak in the South (43%). Specialization in financial services, real estate activities, information and communication activities, professional scientific and technical activities and administrative and support services is often based on access to a critical mass of clients (enterprises and/or households) or to a specific knowledge base (i.e. qualified staff). In the Northwest and in the Centre – where main financial and administrative Italian centres are located – these sectors employed in 2006 45% and 40% of market service workforce, respectively.

The employment-to-population ratios increased by a few percentage points over the period 1995-2006 in all regions, but remained heterogeneous across regions: around 50% in the Northern regions, 45% in the Centre and 36% in the South (Figure 4). The unemployment rates decreased in all regions between 1995 and 2001, but grew again between 2001 and 2006 in all regions but the South (-5 percentage points). The latter result is due to a little increment in employment and, at the same time, a marked reduction of the total labour force in the region, mostly as a consequence of substantial migrations towards the Centre and North (where the labour force grew more than employment) observed in the period.[12]

These findings are quite different if skill-specific patterns are considered (Figure 5): in 2006 the employment-to-population rate of low-skilled workers was less than half that of high- and medium-skilled workers taken together, across all regions. Employment rates were consistently lower in the South than in the other regions, but the differences are most prominent for medium-skilled workers.

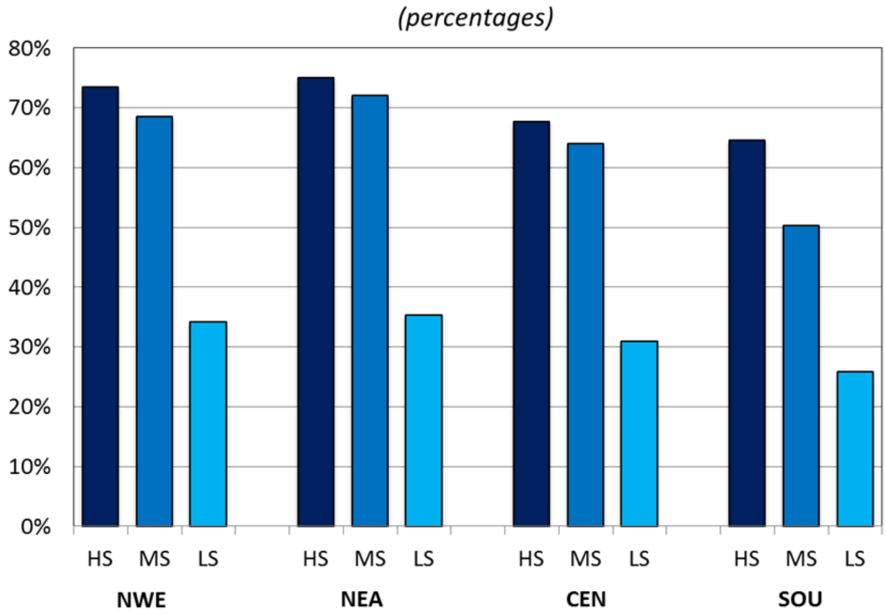
Figure 4: Aggregate Regional Employment and Unemployment Rates in 1995 and 2006



Source: Istat

[12] Between 1998 and 2006 over one million people, most of whom were young with an average to high level of education, transferred their legal residence from the South to the other Italian regions (especially to the Northwest). Regional net migration figures are also correlated with unemployment rates, reflecting the fact that workers tend to move to where income and employment opportunities are better (Bank of Italy, 2008).

Figure 5: Regional Employment Rates by Skill Category (2006)



Source: Istat

4.2 External dependence: Value Chain Analysis

We saw that in the period 1995-2006 total employment increased in all Italian regions, with a slight redistribution of workers from industry to services. This trend is occasionally linked to interregional or international production fragmentation and the associated offshoring of activities. It is thus useful to look at the structure of employment in value chains and analyse the changes in the characteristics of workers directly and indirectly involved in the production of final products.

We will mainly focus on activities which are directly and indirectly involved in the production of final manufacturing goods ("manufactures"), because they are particularly prone to production fragmentation as related activities have a high degree of contestability (Timmer et al., 2013). Conversely, most of final services are still less contestable, primarily dealing with local markets and mostly employing local workers (Jensen and Kletzer, 2010).[13] We also find support for this statement when considering Italian regions. The bottom part of Table 1 shows that the share of "external" VC-workers involved in the production of industrial final goods in Italy as a whole is around 43%, while in market services it is 20% and in non-market services it does not exceed 10%.

It is important to emphasize that VC-jobs of manufactures also include employment outside manufacturing, such as business services, finance and insurance, transport and communication services, extraction of raw materials and so on. These indirect contributions are explicitly taken into account through the modelling of input-output linkages across industries.

The upper panel of Figure 6 shows the magnitudes of the three types of manufactures VC-employment as defined above. The share of employment involved in activities whose final manufactures are completed in the same region (LVCs) in total manufacturing jobs was around 60% for the Northern regions and 50% for the others. IRVCs were still more important than GVCs in the Centre and, especially, in the South. The Northwest was clearly the region for which GVC-participation mattered most. In this region, the number of manufactures GVC-jobs exceeded that of manufactures IRVCs by 123 thousand.

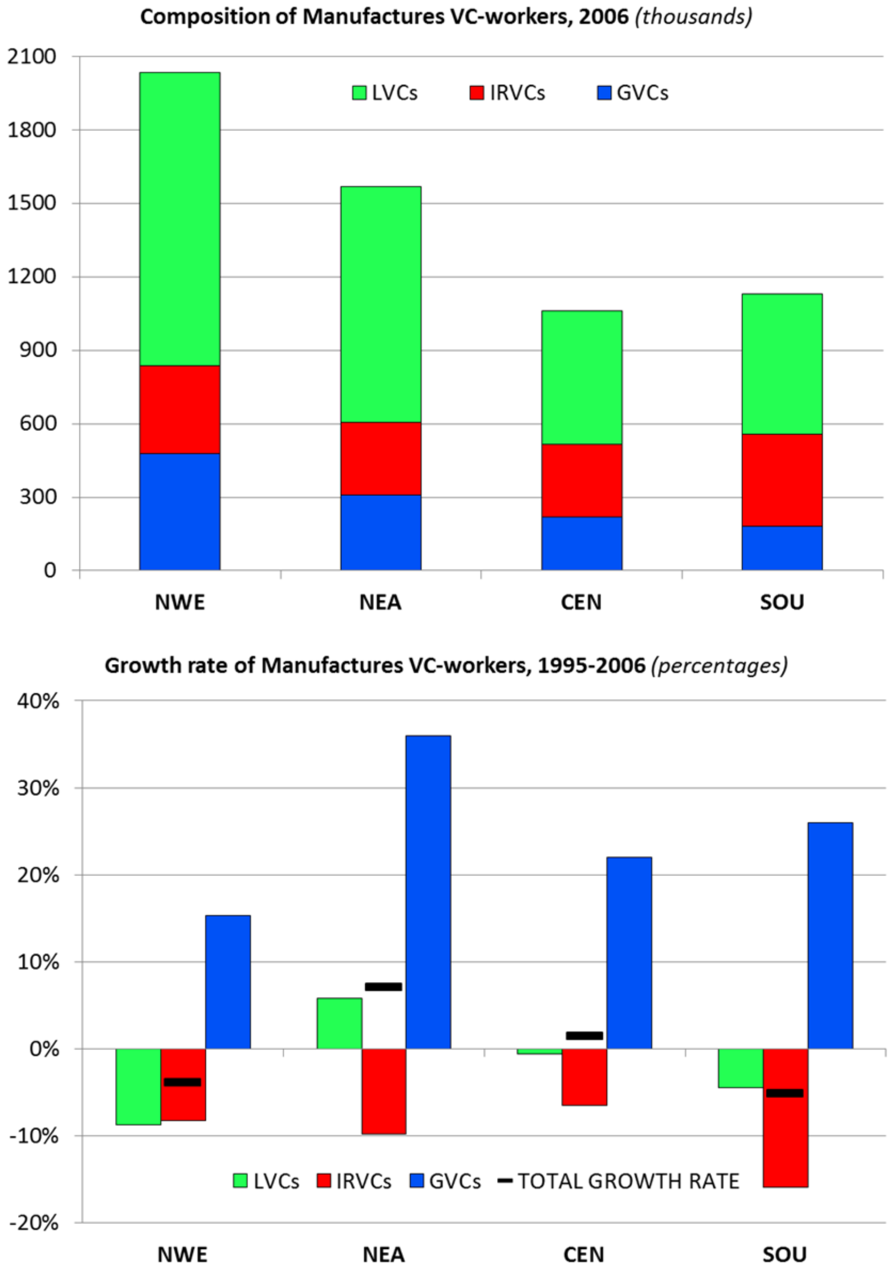
[13] We use the terms "jobs" and "workers" interchangeably, but the underlying data pertains to numbers of workers (i.e. numbers of "heads") rather than jobs.

Table 1: Attribution of Regional Employment to Sectors-of-Completion

Region/Country-of-employment	Value Chain type	Total VC workers (in thousands)		VC workers in 2006 by industry-of-completion as a share of regional total workers (in %)					Changes in VC workers between 1995 and 2006 by industry-of-completion (in %)				
		1995	2006	Primary	Industry	Construct.	Market services	Non-Market services	Primary	Industry	Construct.	Market services	Non-Market services
NWE	LVCs	4809,3	5413,4	54,8	58,7	65,3	77,7	87,7	16,6	-8,3	36,3	20,0	17,3
	IRVCs	831,7	875,4	14,8	17,5	13,5	12,9	4,6	2,8	-7,4	0,4	25,5	15,2
	GVCs	837,3	1063,9	30,3	23,7	21,3	9,4	7,7	-1,7	15,8	40,9	44,5	36,1
	Total	6478,2	7352,8	100,0	100,0	100,0	100,0	100,0	8,3	-3,3	30,9	22,6	18,4
NEA	LVCs	3522,9	4068,3	75,9	61,2	66,2	78,5	87,9	-2,2	5,9	38,6	13,1	20,4
	IRVCs	689,2	711,9	8,7	18,8	14,1	14,0	5,0	-15,1	-8,9	-7,8	25,4	24,9
	GVCs	507,0	693,6	15,4	19,9	19,7	7,4	7,1	9,1	36,2	28,0	45,5	46,1
	Total	4719,0	5473,8	100,0	100,0	100,0	100,0	100,0	-1,9	7,4	27,5	16,6	22,1
CEN	LVCs	3447,6	3995,9	71,5	51,6	67,6	78,8	90,4	9,4	-1,0	32,3	18,7	17,4
	IRVCs	683,3	739,7	13,3	27,8	16,8	14,6	4,6	-3,2	-5,7	6,5	26,7	24,4
	GVCs	382,6	523,2	15,2	20,6	15,5	6,6	5,0	7,5	22,8	37,9	59,0	56,8
	Total	4513,5	5258,8	100,0	100,0	100,0	100,0	100,0	7,3	1,7	27,9	21,8	19,2
SOU	LVCs	5015,2	5576,9	88,1	51,5	80,0	83,8	95,4	-19,1	-4,7	9,2	27,0	8,7
	IRVCs	820,8	818,9	6,8	32,7	11,5	12,7	2,4	-18,3	-15,2	46,5	11,8	25,5
	GVCs	294,4	392,8	5,1	15,8	8,5	3,5	2,3	-1,7	26,5	53,8	40,1	35,5
	Total	6130,4	6788,7	100,0	100,0	100,0	100,0	100,0	-18,3	-4,8	15,4	25,3	9,6
ITALY	LVCs	16795,0	19054,6	77,5	56,7	70,0	79,8	90,8	-9,1	-2,6	26,2	20,1	14,8
	IRVCs	3025,0	3145,9	9,5	22,8	13,7	13,5	4,0	-9,9	-9,7	7,3	21,9	21,7
	GVCs	2021,2	2673,6	13,0	20,6	16,2	6,7	5,2	2,5	23,5	37,9	46,9	42,6
	Total	21841,2	24874,1	100,0	100,0	100,0	100,0	100,0	-7,8	-0,1	24,9	21,8	16,3

Source: Author's calculations on WIOD data (November 2013 release)

Figure 6: The Relative Importance of Various Types of Value Chain Participation across Italian macro-regions

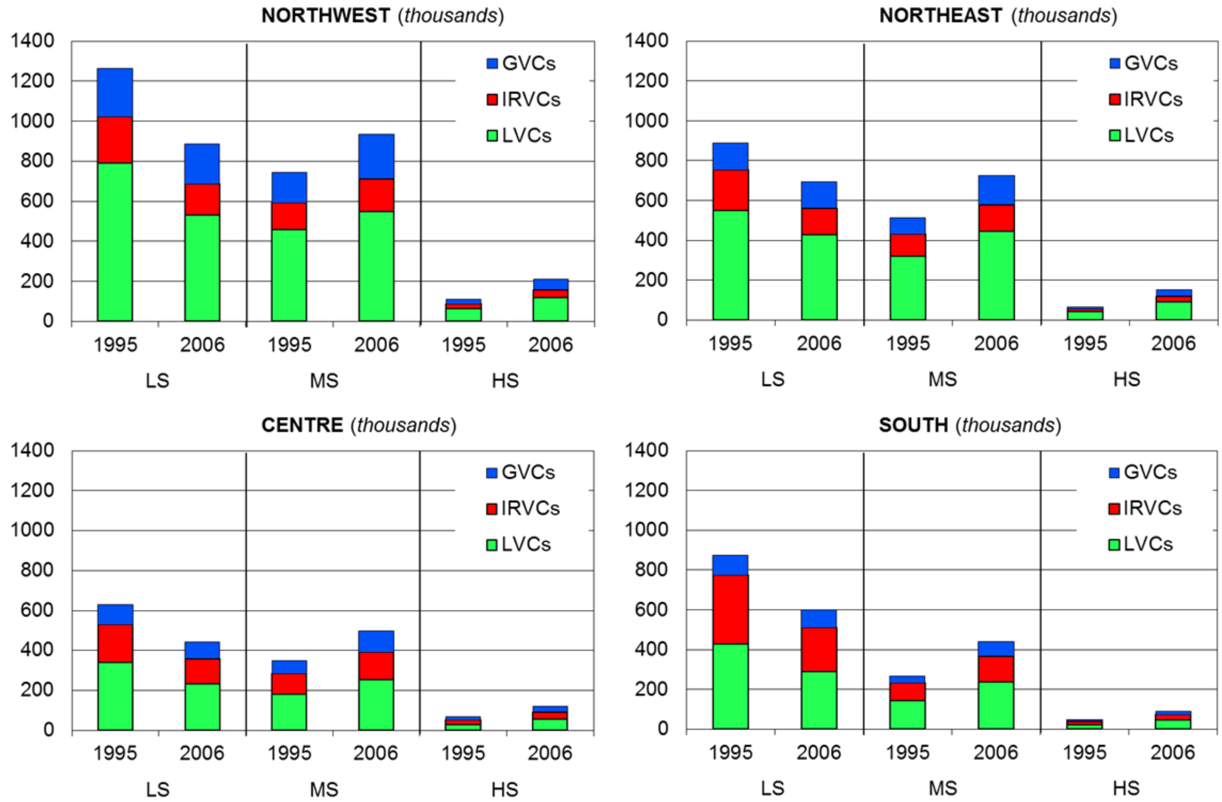


Source: Author's calculations on WIOD data (November 2013 release)

The lower panel of Figure 6 shows that the dependence on different types of manufactures VCs has changed in a quite uneven way in the period 1995-2006, for all four regions (see also the right panel of Table 1). The main finding is that the number of manufactures GVC-workers grew considerably, while employment in domestic manufacturing VCs dropped virtually everywhere. The increase of GVC-jobs was most prominent in the Northeast (36%). Employment in IRVCs declined much more in the South than elsewhere, by more than 15%. Manufactures LVC-workers increased only in the Northeast. Due to its sheer size, the contribution of the local component explained most of the overall regional dynamics, which were negative in the Northwest and in the South, positive in the Northeast and almost stationary in the Centre.

Trends in the structure of VC-workers by skill over the period from 1995 to 2006 are shown in Figure 7 and Table 2; details for VCs for specific types of products can be found in Appendix B.

Figure 7: Manufactures VC-jobs by Skill Category (1995 and 2006)



Source: Author's calculations on WIOD data (November 2013 release)

Figure 7 clearly reflects the declining number of LS manufacture VC-workers observed for virtually all advanced countries by Los et al. (2014). It dropped by about 30% in the Northwest, the Centre and the South, and by 22% in the Northeast. The graph also shows that LVCs were still important for manufactures LS and MS workers, although their weight decreased from 1995 to 2006. In 2006 IRVCs and especially GVCs had become fundamental for HS workers, but their importance had also grown for less skilled employment.

The columns in the first part of the table in Appendix B shows, for each region and skill level, the number of workers in "external" manufactures VC involved in more detailed industries-of-completion in 2006, when IRVCs and GVCs concerned in total about 2.5 million of workers. The second part of the table refers to the change over the period 1995-2006 for the same categories and shows that skill upgrading was widespread across regions (and especially in the Northern ones) and VCs for various types of products. Italian workers (especially those in the South, and including agricultural workers) were mostly active in external "Food, beverages and tobacco" VCs. This was also the only type of external VCs in which LS workers exceeded MS (and obviously HS) workers, despite the intense reduction of the former component and the growth of the others. Other important industries-of-completion for Italian workers participating in global and interregional VCs, especially from the Northern regions, were "Transport equipment" and "Machinery". The growth was particularly intense in the Northeast, and also slightly affected LS workers in the case of "Transport equipment" value chains.

Table 2 focuses on the GVC component of "external" VC-workers and gives the dimension of the phenomenon and its dynamics for different groups of foreign countries. Figures in the table indicate that the number of Italian workers involved in manufactures GVCs grew between 1995 and 2006 by 23% (from less than 1.0 million to almost 1.2 millions), with a shift from EU-15 GVCs (whose share of total GVC-workers decreased from 52% in 1995 to 45% in 2006) towards GVCs with other countries-of-completion.

Table 2: Italian Global Value Chain Jobs, by Location of Last Production Stage

Region/Country-of-employment	Country-of-completion	Total GVC workers (in thousands)		GVC workers in 2006 by skill as % share of regional GVC workers				Changes in GVC workers between 1995 and 2006 by skill (in %)			
		1995	2006	LS	MS	HS	Total	LS	MS	HS	Total
NWE	EU-15	225,4	220,5	46,4	45,8	45,6	46,0	-29,3	27,2	93,7	-2,2
	Other EU-27	15,7	36,8	7,9	7,6	7,1	7,7	75,1	200,3	332,2	134,7
	BRICs	22,7	47,7	9,9	9,9	10,1	10,0	51,2	171,1	326,4	109,9
	NAFTA	46,3	49,3	10,1	10,3	11,1	10,3	-20,8	33,2	80,7	6,6
	Rest of the World	105,7	125,0	25,7	26,4	26,2	26,1	-13,7	48,7	136,5	18,3
	Total	415,8	479,5	100,0	100,0	100,0	100,0	-16,0	47,7	123,6	15,3
NEA	EU-15	123,5	138,5	44,9	44,5	44,6	44,7	-19,7	46,1	158,8	12,1
	Other EU-27	10,4	27,3	9,0	8,7	8,5	8,8	90,1	241,0	514,4	162,7
	BRICs	11,7	29,7	9,6	9,6	9,5	9,6	82,1	228,3	499,2	154,2
	NAFTA	23,3	32,4	10,3	10,5	10,8	10,4	0,4	79,8	180,1	39,2
	Rest of the World	59,0	81,9	26,2	26,7	26,5	26,4	0,7	74,8	222,2	38,8
	Total	227,9	309,8	100,0	100,0	100,0	100,0	-2,2	75,3	209,6	35,9
CEN	EU-15	89,2	92,0	41,9	42,0	42,9	42,1	-31,4	42,2	79,1	3,1
	Other EU-27	6,9	16,2	7,9	7,3	6,4	7,4	66,2	222,1	258,8	135,3
	BRICs	9,9	22,9	10,4	10,5	10,7	10,5	54,6	217,4	295,4	131,1
	NAFTA	21,9	25,0	10,9	11,4	12,9	11,4	-19,5	44,5	70,4	14,1
	Rest of the World	51,2	62,5	28,9	28,8	27,2	28,6	-15,2	67,0	74,3	22,1
	Total	179,1	218,6	100,0	100,0	100,0	100,0	-16,8	66,0	93,9	22,0
SOU	EU-15	65,8	79,6	44,6	44,0	43,5	44,3	-14,8	105,0	126,2	21,0
	Other EU-27	5,4	13,3	7,5	7,4	7,2	7,4	74,6	311,2	358,9	146,8
	BRICs	7,8	15,1	8,3	8,5	8,5	8,4	35,4	210,3	326,4	93,0
	NAFTA	15,9	18,5	10,3	10,3	10,5	10,3	-16,3	83,4	117,9	16,6
	Rest of the World	47,9	53,3	29,3	29,9	30,4	29,6	-22,3	85,1	113,4	11,3
	Total	142,8	179,9	100,0	100,0	100,0	100,0	-11,4	109,6	139,2	26,0
ITALY	EU-15	504,0	530,7	44,9	44,5	44,5	44,7	-25,1	41,9	106,8	5,3
	Other EU-27	38,4	93,7	8,1	7,8	7,3	7,9	77,5	227,0	356,7	144,1
	BRICs	52,2	115,4	9,6	9,8	9,9	9,7	55,9	198,0	349,0	121,3
	NAFTA	107,3	125,2	10,3	10,6	11,3	10,5	-15,1	51,4	98,3	16,7
	Rest of the World	263,9	322,8	27,0	27,4	27,0	27,2	-12,7	63,3	129,6	22,3
	Total	965,7	1187,8	100,0	100,0	100,0	100,0	-12,1	64,6	133,7	23,0

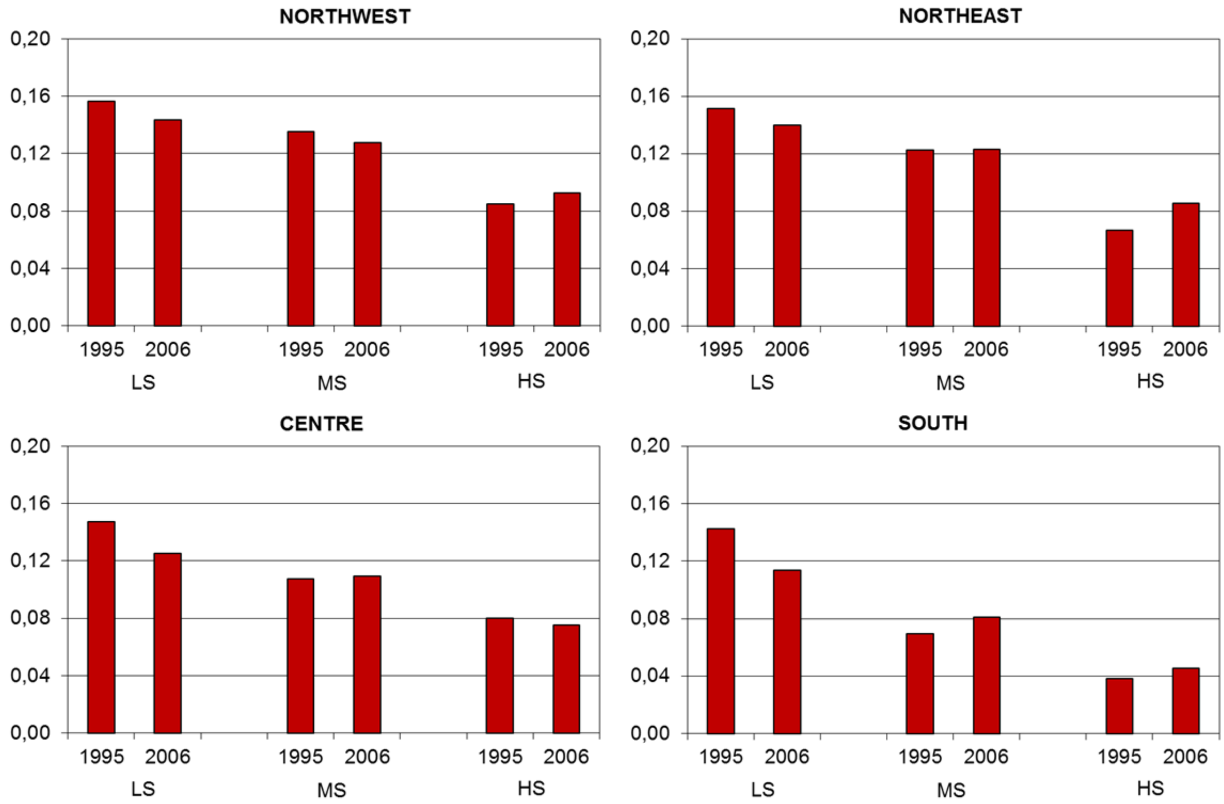
Source: Author's calculations on WIOD data (November 2013 release)

The growth was particularly intense for GVCs whose the final manufactures were completed in the new EU member states (the number of Italian workers involved more than doubled in all four regions), but GVCs with more distant countries-of-completion, such as BRICs (Brazil, Russia, India and China), also affected regional employment patterns in Italy. On average, the importance of BRIC-GVCs increased by 121%.

It is noteworthy that in 2006 activities directly and indirectly involved in final manufacturing products from the new EU member states and the BRICs required not only increasing amounts of MS and HS workers, but also more LS workers than in 1995, across all Italian regions. For all other GVCs (and especially those with EU-15 countries-of-completion), LS GVC-workers dropped in all regions, except for the Northeast. There, GVC-employment for low-skilled workers decreased for EU-15 GVCs, but remained stable for the Rest of the World-GVCs. Most probably, these results indicate that activities that are LS-intensive were largely relocated from Italian places to cheaper places in Eastern Europe or to other low-cost countries, like China. Relatively slow growth in demand for domestically produced final products in the old EU and the US led to reductions in Italian LS-employment in these GVCs, while the net effect in BRICs-GVCs and "other EU"-GVCs was positive as a consequence of rapid growth in demand for the products these generated (for example consumer electronics assembled in China and cars assembled in countries like the Slovak Republic).

A simple and concise index of participation in "external" VCs can be obtained by dividing the number of "external" manufacture VC-workers (by skill level) by the sum of the number of workers involved in LVCs and the number of non-VC workers (i.e., those workers who do not contribute to the production of final manufactured products), for the same skill category. We will label it the "External Dependence (ED) index". The higher the index, the more integrated a region is in production processes of manufactures that are ultimately sold by extra-regional producers. Figure 8 shows the regional ED indices for 1995 and 2006 by skill level.

Figure 8: Manufactures External Dependency, by Region and Skill Category (1995 and 2006)



Source: Author's calculations on WIOD data (November 2013 release)

For low-skilled workers, the dependency indices have been almost identical across macro-regions, both in 1995 and in 2006. For every 100 LS-jobs in local VCs or not participating in any VC, 15 or 16 LS-jobs were due to external VCs in 1995. This number declined to approximately 12 in 2006. For medium-skilled workers, we do not find such quite homogeneous results. In the Northwest the ED-index declined a bit, from about 0.13 to 0.12, but these levels are much higher than those in the South. There, the ED-index for MS-workers increased a bit, but the level in 2006 (0.08) was still considerably lower than elsewhere in Italy.[14] For high-skilled jobs, we find that the ED index increased in all regions apart from Centre, with the most prominent growth in the Northeast. In terms of levels, South is also lagging behind for HS-jobs. For every 100 HS-workers in the South working in local value chains or outside manufactures chains, only 4 contribute to external value chains. We consider this as a negative sign of the health of the Southern economy, since strong GVC-participation in high-skilled activities imply that competition from abroad can be faced with some confidence. Low-wage countries are not directly a threat for this type of GVC-participation.[15]

The differences in external dependency across regions as depicted in Figure 8 do not bode well with regard to regional equality in Italy. The most recent results we can report here refer to 2006, when the Global Crisis had not hit yet. Still, employment rates in the South were already considerably lower than elsewhere in Italy (see Figure 5). As a consequence, one might expect that the Crisis has led to relatively strong losses of purchasing power in the South. In view of its low external dependency, this will most likely have led to a situation in which local value chains did not grow much (or, most probably, even shrank), while the other regions had some opportunities to dampen the negative effects of the crisis by benefiting from the relatively modest effects of the Crisis as felt in other parts of the world. Most countries survived the Crisis more easily than Italy did, in particular the BRICs. Based on sustained domestic demand for final products, most value chains for final products from these countries continued growing. Table 1 showed that the share of GVC-workers in total workers was nowhere close to the low shares in South, while Table 2 indicated that the share of BRICs-GVC-employment in the total number of GVC-jobs was clearly lower in South than in the other macro-regions.

5. Conclusions

Italy is a country marked by a lot of geographic heterogeneity. The North of the country has high employment rates and has an industry specialization in which manufacturing plays an important role, while the South has much more unemployment and has a stronger specialization in primary industry and non-market services. Over the period 1995-2006 these geographical differences declined somewhat, but they are still considerable. In this paper, we investigated to what extent such differences (both in terms of levels and in terms of growth rates) can be attributed to differences in the extent to which the four Italian macro-regions participate in value chains for manufactured final products. We focused on the positions of these regions in three types of value chains, (i) those that yield to final goods of which the last stage of production takes place in the region itself (we provisionally labelled these "local value chains", LVCs), (ii) those that produce final products of which the last stage of production takes place in one of the other three Italian regions ("interregional value chains", IRVCs), and (iii) those for final products with the last stage of production outside Italy ("global value chains", GVCs).

We find that employment in GVCs has increased in all four regions in the period studied, but that the levels in the South are still much lower than in the other three regions. Employment in IRVCs has dropped much more in the South than elsewhere. Southern low-skilled workers are the category that lost most, in all three types of value chains. The South does not only lag the other regions (in

[14] One might rightfully argue that the ED-index tends to be larger for small regions than for large regions. Size differences cannot be held responsible for the differences in levels across regions as reported in Figure 8. As Table 1 indicates, the numbers of jobs in the four regions were contained in the relatively narrow range between 5.3 million and 7.4 million in 2006. South was the second largest.

[15] For a discussion on the positioning in GVCs, see for example Baldwin and Lopez-Gonzales (2014) and, for Italy, Accetturo et al. (2011).

particular the Northern regions) in terms of GVC-participation, but is also participating in GVCs that grow relatively slowly. The share in total GVC-employment of GVCs for products completed in the emerging new EU-countries and in the fast-growing BRICs is considerably lower than in other regions, and employment growth rates for low-skilled labour were also lower over 1995-2006. The low external dependency of the South also does not bode well for the effects of the crisis, by which Italy was hit much harder than many other countries.

This paper is the first to integrate data at sub-national regional level into global input-output tables. Much more work is needed to make comparative analysis across regions possible. With regard to Italian data, an update should have the highest priority, in particular because observed trends for 1995-2006 cannot be easily extrapolated to more times, because the Global Crisis made things anything but "business as usual". Within the framework of the EC-sponsored FP7-project "Smart Specialization for Regional Innovation" efforts are underway to regionalize the EU-part of the WIOD-database. The assumptions that have to be made to attain a regional disaggregation are more heroic for several countries, since regional supply and use tables are not always available. Nevertheless, data on interregional trade and sector composition of output and employment will allow for the construction of data that can be meaningfully used for analyses of regional competitiveness in value chains spanning regions in several countries.

Appendix A

The MRSUT of the four Italian regions

The accounting structure of the Italian IRSUTs is made up by two sets of accounts: 20 regional SUTs (one for each NUTS 2 region) and a multi-regional trade flow matrix.

Initial data are mainly taken from the national and regional accounts statistics (published by the Italian National Institute of Statistics, ISTAT) or from the competent Institutes and Authorities. Data which are not available at regional level (e.g. foreign exports of services) or not significantly linked to the regional demand (e.g. imports from abroad) are imputed according to the local industry mix. Few of them are gathered through ad hoc surveys; in particular, sample data about the regional distribution of total turnover were taken from Bank of Italy’s survey of industrial and service firms (Bank of Italy, 2010).

For each regional SUT two identities provide a link between the use and resources account and that of the formation and destination of industry output, that is:

$$\mathbf{q} + \mathbf{mr} + \mathbf{mw} \equiv \mathbf{U} \cdot \mathbf{i} + \mathbf{df} \cdot \mathbf{i} + \mathbf{er} + \mathbf{ew} \qquad \text{[A1]}$$

$$\mathbf{x} \equiv \mathbf{i'} \cdot \mathbf{U} + \mathbf{i'} \cdot \mathbf{Y} \qquad \text{[A2]}$$

in which: **U** = Use matrix; **df** = domestic final demand; **er** = interregional export of products; **ew** = foreign export of products; **q**= product output; **mr**= interregional import of products; **mw** = foreign import of products; **x** = sector output; **Y** = industry value added matrix.

For each j-th product there is a trade matrix among the 20 Italian regions. The estimation of the multi-regional trade flows – a key issue for the building of any IRSUT – is carried out through a gravity model using an ad hoc survey sampling data. The sum of the off-diagonal elements by row (export) and column (import) link the matrix T flows to the regional SUTs. At multi regional level the identity [1] becomes:

$$\mathbf{q} + \mathbf{i'} \cdot \check{\mathbf{R}} + \mathbf{mw} \equiv \mathbf{U} \cdot \mathbf{i} + \mathbf{df} \cdot \mathbf{i} + \check{\mathbf{R}} \cdot \mathbf{i} + \mathbf{ew} \qquad \text{[A3]}$$

in which $\mathbf{R} \equiv \Theta \cdot vec(\mathbf{T})$

The IRSUT is estimated through a GLS estimator proposed by Stone, Champernowne and Meade in Stone et al. (1942), later developed by Byron (1978). The balancing structure of the multi-regional table is specified according to according to four groups of constraints:

i. at regional level, both supply and demand of products and formation and use of output must be consistent;
ii. constraints stemming from regional accounts statistics must be fulfilled;
iii. interregional flows of imports must be equal to interregional flows of exports at national level for each product;
iv. the sum of the regional SUT must be equal to the national one except for interregional trade.

The estimated IRSUT for the 20 Italian regions have been aggregated into 4 macro areas according to the NUTS 1 classification: Northwest, Northeast, Centre and South and islands.

The final result is an IRSUT with 4 regions, 59 products (CPA classification) and 35 industries (NACE rev. 1 classification). IRSUTs are available for the years 1995, 2001 and 2006. All the resulting tables are at basic prices and expressed at current prices (euro); values have been converted to US dollars using the same fixed exchange rates used in WIOD.

Appendix B

Industry-of-completion	Northwest LS	Northwest MS	Northwest HS	Northeast LS	Northeast MS	Northeast HS	Centre LS	Centre MS	Centre HS	South LS	South MS	South HS
Manufacture "external" VC workers in 2006 by industry-of-completion (in thousands)												
Food, Beverages and Tobacco	57,7	55,7	13,5	58,4	46,1	8,9	49,4	45,2	12,0	118,6	46,3	8,3
Textiles and Textile Products	42,4	44,6	9,9	22,7	23,8	5,6	26,2	30,0	6,7	23,6	18,3	4,1
Leather, Leather and Footwear	13,0	14,9	3,7	11,4	12,3	2,7	10,4	11,1	2,6	15,9	11,0	2,2
Wood and Products of Wood and Cork	2,3	2,5	0,7	2,3	2,6	0,5	1,7	2,1	0,4	2,5	1,8	0,3
Pulp, Paper, Paper , Printing and Publis	8,2	9,8	2,6	7,1	7,8	1,8	6,0	7,5	2,3	6,3	5,8	1,5
Coke, Refined Petroleum and Nuclear F	5,4	6,5	1,7	4,1	4,7	1,1	3,0	4,0	1,3	3,3	2,9	0,8
Chemicals and Chemical Products	15,0	17,5	4,6	11,2	12,5	2,9	9,1	11,8	3,5	10,7	8,9	2,2
Rubber and Plastics	4,7	5,3	1,3	3,2	3,6	0,8	2,7	3,4	1,0	3,0	2,6	0,6
Other Non-Metallic Mineral	1,9	2,3	0,6	1,6	1,9	0,4	1,3	1,6	0,5	1,5	1,3	0,3
Basic Metals and Fabricated Metal	16,4	18,3	4,1	10,9	12,5	2,9	8,2	10,6	2,8	11,5	9,2	2,3
Machinery, Nec	57,8	63,9	14,6	40,1	45,3	10,4	27,4	35,4	9,8	35,9	29,9	7,5
Electrical and Optical Equipment	34,8	39,6	9,6	24,6	27,3	6,2	17,2	22,7	6,5	18,6	16,3	4,1
Transport Equipment	71,6	79,2	18,6	50,5	57,3	13,2	30,8	39,2	10,8	39,0	34,2	7,9
Manufacturing, Nec; Recycling	24,6	27,3	6,8	17,7	19,9	4,2	15,0	18,5	4,4	19,5	15,4	3,3
TOTAL	*356,0*	*387,3*	*92,3*	*265,9*	*277,5*	*61,6*	*208,4*	*243,3*	*64,6*	*309,8*	*203,7*	*45,4*
Growth rates of "external" VC workers between 1995 and 2006 by industry-of-completion (in %)												
Food, Beverages and Tobacco	-40,4	2,2	79,3	-29,3	18,9	115,8	-31,3	44,1	87,4	-36,7	45,1	52,1
Textiles and Textile Products	-41,2	17,4	95,4	-46,7	-0,6	110,1	-44,5	17,5	10,2	-52,8	16,5	54,9
Leather, Leather and Footwear	-27,0	12,1	91,2	-45,9	-6,1	71,7	-45,8	-0,6	8,5	-47,2	15,2	41,3
Wood and Products of Wood	-34,9	17,3	59,8	-18,3	55,3	287,8	-25,0	73,7	51,5	-26,9	37,8	75,0
Pulp, Paper, Paper , Printing	16,8	103,6	210,9	-27,9	23,0	114,2	-28,4	26,8	88,1	-32,0	67,3	93,8
Coke, Refined Petroleum and Nuclear	-20,9	44,0	119,0	26,2	115,2	285,4	24,8	123,1	173,1	10,2	130,8	168,8
Chemicals and Chemical Products	-25,1	36,3	110,9	-19,2	42,1	148,3	-22,3	57,1	103,9	-17,0	86,1	113,7
Rubber and Plastics	-37,8	17,2	54,5	-20,1	37,9	146,7	-26,7	46,0	77,9	-21,1	81,9	100,1
Other Non-Metallic Mineral	-10,0	62,9	112,4	-46,6	-1,1	63,1	-42,6	11,4	44,6	-27,5	31,8	56,9
Basic Metals and Fabricated Metal	-16,9	48,4	92,7	-1,1	75,8	248,4	-15,1	70,1	106,9	11,6	127,4	161,3
Machinery, Nec	-20,7	37,7	90,7	-4,9	70,2	221,0	-21,3	55,2	94,5	-10,5	89,9	105,7
Electrical and Optical Equipment	-13,5	50,6	133,8	-15,5	57,1	185,0	-16,8	58,2	94,2	-19,0	76,1	99,4
Transport Equipment	-32,5	14,2	78,0	3,4	90,0	211,2	-12,1	70,0	109,8	1,7	159,7	160,8
Manufacturing, Nec; Recycling	-5,7	70,7	149,2	-22,2	42,1	155,3	-34,5	36,8	48,9	-37,3	28,0	58,8
TOTAL	*-23,9*	*35,7*	*102,6*	*-20,6*	*43,7*	*164,2*	*-28,1*	*45,5*	*75,1*	*-29,8*	*64,9*	*90,1*

Source: Author's calculations on WIOD data (Novembre 2013 release)

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Value Chains and the Great Recession: evidence from Italian and German firms

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April 2015

Abstract

Global Value Chains (GVCs) have been one of the main transmission mechanisms of 2009 the Great Trade Collapse. Our paper provides a description of the effects of the crisis from a perspective that is both country-comparative (Germany and Italy) and on firm level. Two are the main conclusions: i) intermediate firms were hit by the crisis more than final firms; ii) firms' position in GVCs and their strategies explain part of the performance gap between Italian and German firms.

Keywords: global value chains, Germany, Italy, industrial firms, firm organization, world trade.

JEL Classifications: D230, L220, F140, F230.

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The Authors wish to thank Salvatore Rossi for insightful discussions and suggestions; Mariarosaria Agostino, Giorgio Barba Navaretti, Matteo Bugamelli, Marianna Mantuano, Enrico Marvasi, Marcello Pagnini, Annamaria Simonazzi, Domenico Scalera, Robert Stehrer, Francesco Trivieri, and all the participants to the CompNet meeting (Frankfurt, 2013); International Trade Study Group Conference (Cagliari, 2014); the SASE Conference (University of Chicago, 2014), the 55th Annual Società Italiana degli Economisti Conference (Trento, 2014) for useful comments on a previous version of the paper. The views expressed in the paper are those of the authors and do not necessarily correspond to those of the Bank of Italy

1 Introduction

A sizeable body of literature over the past twenty five years considers that a structural change in the productive economy has occurred as a further consequence of the ICT revolution, the steady lowering of trade barriers and transport costs (Feenstra, 1998), and the changing nature of multinational enterprises (Saliola and Zanfei, 2009).[1] The outcome is a new international division of labor in which the production of final products is fragmented in Global Value Chains (GVCs henceforth). Under this interpretation (Gereffi and Fernandez-Stark, 2011, for an overview of GVCs), one may consider the production process for any given good as a continuum of tasks assigned to the various productive units; these tasks can be performed in several different places around the world. The organization of production varies continually, with each task offshored to the country where the production and international transaction costs are lowest.

In the face of the 2008-09 great recession, the systemic importance of GVCs proved to be significant. According to several studies, GVCs acted, throughout different channels, for the rapid transmission of real and financial shocks, thus amplifying the national fluctuations of demand for final goods. Baldwin (2009) holds that the synchrony of the collapse in world trade was precisely caused by the input-output linkages in GVCs.

What happened to firms operating inside the value chains? Did firms' position in the value chain play a role in their performance during the crisis? Were firms' individual characteristics and firms' strategies relevant determinants of their resilience? The aim of this paper is to answer to these questions by taking a look at the firm level evidence.

Exploiting the dataset coming from the EU-EFIGE/Bruegel-UniCredit survey (henceforth EFIGE), we first outline which are firms' main modes of participating to a GVC. We then assess the interactions between firms' position in the value chains and their performances, by looking at sales dynamics during the 2008-09 crisis.

In this study we concentrate on the German and Italian part of the EFIGE dataset. Germany and Italy are somewhat paradigmatic countries and provide to be an interesting area of analysis for several reasons. They are both highly industrialized countries and leaders in EU manufacturing exports; industrial firms of both countries are substantially involved in and affected by globalization; a large share of firms (higher in the Italian industry) work exclusively as intermediate firms, a key factor in our analyses to explain heterogeneous resilience to the crisis.

The 2008-09 crisis is a particularly interesting case. First, it was quite unexpected and originated from the US financial crisis of the summer of 2007. This implies that it can be considered exogenous to the German and Italian economic conditions. Second, the downturn was particularly severe. German and Italian GDP fell by, respectively, 4 and 7 per cent in two years; in this light, the crisis can be considered as a serious “stress test” for firm’s strategic decisions.

This paper contributes to the literature under at least three points of view. First, unlike developing countries in which intermediate firms prevail, advanced economies are characterized by the coexistence of both final and intermediate firms; this implies that they are on the verge to become either a “headquarter” or a “factory economy” (Baldwin, 2011). By analyzing firm performance during a great economic shock, we are able to understand which is the “best” specialization of a country under “extreme” economic conditions. Second, as heterogeneity matters, the analysis of the micro dynamics at firm level is particularly relevant in terms of strategies and their ability to face a major macroeconomic shock. It is also important from a policy maker point of view as it can be learnt which typology of firms are more vulnerable to crisis. This is a truly under-researched issue as there are only two papers that analyze this topic under a different perspective (Altomonte et al., 2012; Bekes et al., 2011; see next section of a literature review). Third, we make a cross-country analysis of two developed and highly industrialized economies; this is an important issue since most of the existing literature focuses on emerging markets firms and their chances to access GVCs.

The structure of the paper is as follows. Sections 2 analyzes the very recent debate on the role of GVCs as transmission mechanisms of the 2008-09 financial crisis and the firm level impact and makes a comparison between Italy and Germany in terms of differences, similarities and firms' involvement in GVCs; Section 3 presents the data. Section 4 is dedicated to the descriptive analysis. Section 5 analyzes the performance of the firms during the crisis by setting up the estimation methods and presenting the main results. Section 6 concludes.

2 Firms in GVCs, facing the great recession

2.1 Literature review

"World trade experienced a sudden, severe, and synchronized collapse in late 2008 – the sharpest in recorded history and deepest since WWII" (Baldwin, 2009). World trade in manufactures fell by about 30 per cent between the first half of 2008 and the first half of 2009 (WTO, 2009). The fall in trade during the crisis has also been quite homogeneous across all countries: more than 90 per cent of OECD countries have exhibited simultaneously a decline in exports and imports exceeding 10 per cent (Martins and Araújo, 2009). European Union countries were severely affected both in terms of decrease of industrial production and merchandise trade.

According to the recent work of several researchers, GVCs played a leading role in the transmission of the shocks in the 2008-09 crisis, causing the Great Trade Collapse. Why were GCVs regarded as the main propagation of the global downturn? Which were the transmission mechanisms? According to Freund (2009) and Cheung and Guichard (2009), this has happened because the share of intermediate products in international trade has greatly increased over recent decades. In this vein, the main idea is that vertical specialization and links among firms have determined a reduction of the intermediate demand that was sharper than the one that would be implied by the "standard trade channel" (Bems *et al*., 2010). In Yi (2009), this happened because the same component might be exchanged several times (and crosses several national borders) before it is finally incorporated in the final product.

Alessandria *et al*. (2011) test another likely channel of transmission based on the inventory adjustments firms adopt to face a demand reduction. As a consequence of a reduction in the final demand, final firms decreased orders across GVCs firms, the decrease will be amplified for firms located far away from the final customer. Such an adjustment inventories mechanism resembles the well-known bullwhip effect (Forrester, 1961). While Altomonte *et al*. (2012), working on a firm level, confirm that inventory adjustments along GVCs greatly contributed to the great trade decrease. Escaith *et al*. (2010) only partially agree on the role played by the "inventory effect", underlying that other factors might also be at work.

Being the GVCs a transmission mechanism of the great crisis, the next important questions become: what happened inside the GVCs? Which type of firms involved in the GVCs were the most hit? To what extent their position (intermediate or final) along GVCs and their individual characteristics (such as size) and strategies (innovation, imports, human capital) played a role in their performance during the crisis? Surprisingly enough given the relevance of the matter even from a policy making perspective, here the evidence is very scant, as there are very few studies based on firm level analysis.

In particular, we can recall just two contributions. Altomonte *et al*. (2012) introduce a peculiar modes of organization of inter-firm linkages as a key factor to explain firms' different resilience during the crisis. In their analyses, based on a representative sample of French firms, they single out two organizational modes: the first one pursued by multinational firms that entail trade among related parties; according to the second one, the relationship between buyer and supplier is carried out by arm's length trade. They found that trade originated within hierarchies of firms (i.e. transactions among firms belonging to a group) reacted faster to the negative demand shock, but also recovered faster in the following months than arm's length trade: "our explanatory hypothesis is that the internalization of activities within the boundary of a group allows for a better management of information flows coming from the bottom of the value chain so that production and inventories can be more swiftly adjusted to demand shocks" (Altomonte *et al*., 2012: 22).

Békés *et al*. (2011), in a highly comprehensive report on European firms, shed some more light on the link between firms' heterogeneity and their reaction to the crisis. One of their key findings is that firm's positioning in GVCs do matter. On the basis of the EFIGE dataset they show that, on average, intermediate firms suffered the most in terms of greater sales reduction, while outsourcers mitigate the effects of the crisis. Firms' characteristics also played a role as large and controlling firms fared better.

2.2 Italian and German firms in the GVCs

From a static point of view, Germany and Italy are similar under many respects.[2] Manufacturing is prominent in both countries: in 2010, in Germany equals to 25.3 per cent of total value added and in Italy 23.3 per cent. Both countries exhibit high levels of manufacturing exports, share of exports to German GDP is 39.9 per cent, in Italy 23.4 per cent. The organization of production structure is quite similar as well: family-owned German firms represent almost 90 per cent of total firms, 86 per cent in Italy (Bugamelli *et al.,* 2012).

A starker difference is, instead, represented by the size of the firms: the average number of employees in Italian firms was 9 in 2009, while in Germany was 37. As highlighted by Barba Navaretti *et al*. (2011), such structural dimensional difference, industry invariant, represents a strong advantage of Germany, in terms of productivity, internationalization, innovation strategies.

Both countries share a great involvement in GVCs. Largely as outward processing trade, the global operation of firms started quite early in Germany (Helg and Tajoli, 2005) and accelerated around the 1990's, after the unification process, with the increasing commercial integration with Poland, Slovakia, Czech Republic, and Hungary. Foreign outsourcing started somewhat later in Italy (in the second half of the '90s) as a firms' reaction strategy to shocks such as: stronger competitive pressure from Eastern European and Asian producers; exchange rate constraints before the introduction of the single European currency; and the development and spread of ICTs (Giunta *et al*., 2012).

As underlined by Breda and Cappariello (2012), if the direct and indirect import content of the production of goods and services is taken as an indicator of international outsourcing, we can appreciate another similarity between the two countries. In 2007, such indicator was around 17 per cent for both the Italian and the German economies: “on this basis and from a static viewpoint, also Italy could be defined as a «bazaar economy»” (Breda and Cappariello, 2012: 133).[3] Further proof of both countries involvement in GVCs operations comes from the participation index (Oecd, 2012):[4] Italy index participation value in 2009 appear to be slight below the German one. The important question also concerns whether Germany and Italy also share the same position in the value chain, in fact a country can be upstream or downstream according to its specialization. Here the evidence is not a conclusive one, as a country’s position considerably varies according to the data used. However, some hints come from the firm level analysis on which we turn.

3 Data and descriptive statistics

3.1 The EFIGE dataset

For the comparative analysis of firms in the GVCs between Germany and Italy, we use the EFIGE survey. The data have been collected within the EFIGE project – European firms in a global economy: internal policies for external competitiveness – supported by the Research Directorate General of the European Commission. The EFIGE survey was conducted in 2009. The sample includes around 3,000 firms for France, Germany, Italy and Spain, more than 2,200 firms for UK, and 500 firms for Austria and Hungary.

Sampling design follows a stratification by sector and firm size, that induces an oversampling for large firms.

The survey questionnaire contains both qualitative and quantitative data on firms’ characteristics and activities, split into six sections providing different pieces of information on: structure of the firm; workforce; investment; technological innovation and R&D; internationalization; finance; market and pricing.[5] Data from the survey was then matched with balance sheet information from Amadeus (Bureau Van Dijk).[6]

As this paper focuses on the two major industrial economies of the Euro area, we make use of the Italian and German firm data. This should leave us with slightly less than 6,000 observations. However, the number of firms actually used in the analysis is much lower (slightly more than 4,000, roughly 2,000 for each country) due to the presence of several missing values in the balance sheet data.

3.2 Variables and descriptive statistics

In order to analyze the impact of the participation to a Value chain on firm performance during the crisis, we first have to qualify how to measure a firm participation.

Finding a firm-level proxy for the participation to a Value chain is not an easy task. In principle, we should exploit a dataset that contains information on all firm-to-firms linkages including the type of products bought and sold by each firm. At the best of our knowledge, these kind of data are not available for European countries;[7] therefore, by using our firm level dataset, we proxy the participation to a Value chain with two variables.

The first variable indicates whether a firm participates to a Value chain as a supplier (i.e. in an upstream position). We use the information contained in the share of total turnover made up by sales of produced-to-order goods to other firms (Share of produced-to-order, SPTO henceforth). Produced-to-order strategies allow customers to purchase products that are specific to their needs. This is likely to approximate in the best way the strict vertical relationships that are usually established in a VC. In the paper we use a discretized version of SPTO, that is a dummy variable equal to one if the firm is fully intermediate (INT, henceforth; SPTO equal to 100). There are three reasons for this. The first is that it allows to easily interpret the coefficient when we interact it with other dummy variables. The second one is that other available measures on the positioning in the GVCs are discrete and this would create an undesired asymmetry between the measurement of upstreamness and downstreamness. Third, discretizing SPTO does not generate a very large loss of information. The distribution of SPTO is bimodal, with a mass of firms on zero and another mass on 100.[8]

EFIGE data also allow to detect whether the main customers of the produced-to-order goods reside within the national borders or abroad; in the first case the firm participates to a national Value chain (INT-DMC); in the second to a GVC (INT-FMC). As we will see, these types of firms present relevant differences in terms of strategies and characteristics.

The second variable proxies firm participation to GVC as a purchaser (i.e. in a downstream position). We use a dummy equal to one if the firm buys from abroad customized intermediate goods (Customized purchases of intermediaries, CPI henceforth), that is components which are exclusively manufactured for the firm.

Descriptive statistics are reported in table 1.

First of all it should be noted that the average number of employees is 55; this means that the EFIGE dataset is, as already mentioned, representative of medium and large firms. In the face of the crisis, sales displayed on average a dramatic drop (-17.9 per cent); however the standard deviation is also quite high, thus reflecting a large heterogeneity in firm performance. Table 1 also shows that SPTO is quite large. On average, more than three-fourth of a firm's sales is made up of selling of customized intermediate goods to other firms. The share of fully intermediate firms (INT) is quite high (50.3 per cent) and quite equally split between those with national main customers (INT-DMC) and foreign main customers (INT-FMC). Conversely, only a small portion of firms (5.6 per cent) purchases customized intermediaries (CPI); this means that the actual number of firms in a downstream position is very limited in the dataset.

A small share of intermediate firms (4.8 per cent) are also engaged in the purchase of specialized intermediaries (INT&CPI): these are a group of intermediate companies (INT) that, apparently, succeeded in organizing their own supply chain.

4 Descriptive analysis

4.1 How do Italian and German firms participate to Value chains?

Table 2 shows the sample size for each category of firms in the dataset and allows a comparison between Italian and German firms. As a reference group of the analyses, we use firms which operate outside a Value chain, that is they do not buy customized intermediaries and do not sell produced-to-order goods. We label these firms as "generic" firms.

Turning to the comparison between Italian and German firms, table 2 shows the different positioning of German and Italian firms along the Value chains. The share of fully intermediate (INT) firms skims the 60 per cent in Italy, while it is much lower (35 per cent) in Germany. CPI or INT&CPI firms are instead relatively more frequent in Germany, hinting at the fact that German firms are more structured, thus able to organize their own Value chains and are, on average, located more downstream on the Value chains.[9]

Such a positioning is confirmed by the analysis shown in table 3, that highlights the difference in the frequency of each type of firm controlling for the industry composition. This is done by regressing a dummy equal to one for each type of firms over a country dummy (Italy) and a set of industry dummies (2-digit Nace). Italy's relative specialization in intermediate firms is confirmed: within each sector the probability to observe an Italian firm in an intermediate position in the GVC is on average 21.8 percentage points larger than for a German firm. Similarly, controlling for sector, German firms in a downstream position are 4.2 percentage points more frequent that Italian firms in the same position.

4.2 Firms in the Value chains: characteristics and performance

Table 4 reports some descriptive statistics of firms' characteristics and performance. Each dependent variable (reported at the top of the table) is regressed over a set of dummies for each type of firm. The constant (at the bottom of each boxed table) is represented by "generic" firm, not involved in vertical linkages. Intermediate (INT) firms in the dataset are smaller in terms of both sales and employment; in the period 2008-09, they also accumulated a larger decrease in total sales compared with "generic" companies. Firms that purchases specialized intermediate goods (CPI) and, less strikingly, firms that are both INT and CPI are, instead, larger and their performance in the period 2008-09 was somewhat comparable with the reference group.

Yet the set of fully intermediate firms is far from being homogeneous. Compared with intermediate firms whose main customer is domestic (INT-DMC), the INT companies with a foreign main customer (INT-FMC) are larger both in terms of sales and employment. Notwithstanding such a heterogeneity, their performances during the crisis are instead quite similar.

These patterns are also roughly confirmed within each country. The discount in terms of size and performance is less dramatic for the INT group in Germany; the premium for CPI firms is also slightly smaller. In both country, the ranking between INT-FMC and INT-DMC is also preserved.

The cross-country comparison also highlights the weaknesses of the Italian productive structure and its disappointing performance in the crisis period (Brandolini and Bugamelli, 2009). The gap is particularly wide in terms of employees and, in our dataset, in the differential in the 2008-09 performance.[10]

4.3 Detecting heterogeneity

So far, the EFIGE dataset has shown that intermediate firms are usually smaller and, during the recent crisis, they also experienced a more dramatic fall in sales.

However, a recent stream of literature has highlighted the heterogeneous nature of both suppliers and final firms (Accetturo *et al*., 2011, 2012; Agostino *et al*., 2014; Giovannetti *et al*., 2014). Companies operating along the GVCs tend to differ from each other in terms of strategic choices to better compete in the markets.

In order to deduce different characteristics, we start by analyzing firm's choices in terms of innovation, internationalization and human capital accumulation.

We consider five variables:

- share of employees with a university degree;
- share of employees in training activities;
- dummy for the introduction of product innovation;
- dummy for the introduction of process innovation;
- exports share over total turnover.

Table 5 presents some descriptive statistics according to the positioning in the GVC; the table has the same structure of table 4 and presents the regression result of each characteristic over a set of dummy variables for each type of firms. Intermediate firms (INT) have less human capital and tend to be engaged more frequently in process rather than product innovations. More downstream firms (CPI) have a statistically significant higher level of human capital, product and process innovation and international exposure. Once again the group of intermediate firms (INT) presents relevant internal differences especially in terms of innovation and international projection. INT companies with a foreign main customer (INT-FMC) tend to be engaged more often in process innovation and have a share of exported sales comparable to the one registered for CPI.

These patterns are also confirmed within each country.

5 Econometric analysis

5.1 Performance during the crisis

We now look at the relationship between firm performance and its positioning in GVCs. We estimate the following equation:

(1) $$\Delta y_i = \alpha + \beta_1 INT_i + \beta_2 CPI_i + \beta_3 INT_i \,\&\, CPI_i + \gamma X_i + \phi_1 D_s + \phi_2 D_c + \phi_3 D_g + \varepsilon_i$$

Where Δy_i is the cumulated growth rate (in log scale) of sales between 2007 and 2009 for firm *i*. INT_i is a dummy variable equal to one if SPTO sales is 100 per cent and the firm does not buy customized intermediaries. CPI_i is a dummy equal to one if the firm purchased customized intermediaries and has a SPTO sales lower than 100 per cent.

$INT_i \& CPI_i$ is a dummy equal to one if the firm is both intermediate and purchased customized intermediaries from abroad. By construction, INT_i, CPI_i, and $INT_i \& CPI_i$ are mutually exclusive. This implies that β_3 can be interpreted as the discount (premium) in growth rate for $INT_i \& CPI_i$ firms, without other manipulations.

X_i is a set of covariates aimed at capturing firms' heterogeneity; it includes a control for the initial (log) level of sales and the number of employees both measured in 2007; it also includes the variables described in section 4.2 (human capital and innovation) aimed at detecting heterogeneous behaviours of the firms and the share of the purchases of both total and imported intermediaries over turnover.[11] D_s and D_c are sets of, respectively, sector and country dummies. D_g are set of dummies equal to one if the firm belongs to a national or foreign group.

The coefficients of interest are β_1, β_2, and β_3. β_1 captures the correlation between the performance during the crisis and the intermediate status of a firm in a GVC. β_2 indicates the influence of the downstream positioning in a GVC of a firm on the dynamics of sales in the period 2008-09. β_3 is the effect of being an intermediate firm buying customized intermediaries, that is the effects of an intermediate that has organized its own Value chain.

Equation (1) is estimated by OLS, standard errors are robust to take into account the heteroskedasticity concerns. We also exclude from the regressions the first and the 99th percentile of the dependent variable to minimize the impact of outliers.

Before showing the results a cautionary note is worth making. Coefficients β_1, β_2, and β_3 cannot be interpreted in causal way but, rather, as conditioned statistical associations. This is due to the possible presence of endogeneity problems: there can be a number of omitted variables (such as entrepreneur's ability) that affect both the firm's decisions (to be an intermediate or a final firm) and its performance during a period of crisis. Unfortunately, this problem cannot be easily solved; there are not obvious instruments that correlate with companies' positioning in the GVC but not with its performance. For this reason, we should consider the estimates of equation (1) as multivariate stylized facts on the microeconomics of GVCs.

Results are shown in table 6.

Column (1) reports a simple specification with just INT, CPI, and INT&CPI with country and sector dummies. The coefficient of INT is negative and significant, thus confirming that being intermediate is associated with a negative performance during the crisis. Intermediate firms witnessed, on average, an additional fall in sales by 3.1 percentage point (in log scale). The coefficients of CPI and INT&CPI are, instead, positive; their point estimates indicate that firms engaged in the purchase of customized intermediaries (i.e. in a downstream position in a GVC) succeeded in limiting the drop in sales during the crisis by 1.7-2.2 percentage points (in log scale). However, standard errors look pretty large (probably due to small sample size in these groups) and this cannot rule out the possibility that the performance of this kind of firms is statistically different from the one of the reference group (generic firms).

Column (2) adds firm-level controls: the initial period (log) levels of sales and employment, the share of total and imported intermediaries over sales, and group dummies. The initial levels of sales and employment aim at controlling for the possible presence of mean reversion or scale effects in firm growth; the share of total and imported intermediaries over sales control for the structure of firm purchases that may, in principle, affect the downstream status of the firm; group affiliation proved instead particularly relevant in the face of the crisis (Altomonte *et al*., 2012). The coefficient for 2007 turnover is negative and significant thus showing a process of mean reversion; larger firms (measured in employment) attenuated instead the fall in sales during the crisis. The coefficients of INT is now slightly larger in modulus, while the positive but not significant estimates for β_2 and β_3 are confirmed.

In column (3) we insert controls for firm strategies and characteristics. While the three coefficient of interest confirm the previous results, human capital and product innovation variables turn out to be positive and significant. This implies that, controlling for sector, country, firms' characteristics and positioning in the GVC, having a qualified workforce or introducing new products attenuated the negative effect of the crisis.

For all specifications, the country dummy for Italy is larger than 20 percentage points and highly significant; this implies that the performance gap between Italian and German firms was huge. We analyze the issue in section 5.3.

5.2 Heterogeneous effects

As we have seen in section 4, intermediate firms (INT) display a very relevant heterogeneity when we look at the type of main customers. Intermediate firms with a foreign main customer (INT-FMC) are generally larger and more innovative than those with a domestic main customer (INT-DMC). We now investigate whether these characteristics had an impact on firm performance during the crisis. This is done by allowing different coefficients for INT-DMC and INT-FMC:

$$\begin{aligned} &\Delta y_i = \alpha + \beta_{1F} INT-FMC_i + \beta_{1D} INT-DMC \\ &+ \beta_2 CPI_i + \gamma X_i + \phi_1 D_s + \phi_2 D_c + \phi_3 D_g + \varepsilon_i \end{aligned} \quad (2)$$

Results are displayed in table 7.

The first column reports the coefficients for the most parsimonious specification without firm level controls. It is apparent that intermediate firms were hit during the crisis in a similar way, regardless the geographical location of the main customer. Both β_{1D} and β_{1F} are negative and statistically significance and their point estimates are also quite similar. Downstream firms (CPI) confirm their positive coefficient even if, once again, standard errors are too large to reject their difference from zero.

The second column reports the results when we insert all firm-level controls, with results much in line with the previous estimate.

5.3 Do GVCs explain the Italy-Germany performance gap?

As clearly shown so far, both in the descriptive and econometric analyses, during the 2008-09 crisis Italian and German firms presented divergent dynamics as sales growth for Italian firms was more than 20 percentage points lower than the one registered by German companies.

The Italian structural problems are well known (see Brandolini and Bugamelli, 2009, for a comprehensive review; Federico, 2012) and they range from the small size of the firms to backward labor market institutions, and include inefficiencies of public administration as well as rigidities in the service markets.

In the descriptive statistics of the paper, we have also shown that, contrary to Germany, Italian industry is characterized by a very large number of small fully intermediate firms that performed very badly during the crisis, while the share of firms engaged in the purchase of customized intermediaries is comparatively small.

In this section, we try to understand whether the high number of intermediate firms in Italy contributed to the relevant firms' performance gap.

To do so, we proceed as follows. We calculate how much of the Italy-Germany firms' performance gap is explained by our econometric models and then we compute the contribution of each set of regressors to the explained gap.

In practice we run following five regressions:

$$\Delta y_i = \alpha_1 + \kappa_1 D_{Italy} + \varepsilon_i^1$$

$$\Delta y_i = \alpha_2 + \kappa_2 D_{Italy} + \text{Sectors} + \varepsilon_i^2$$

$$\Delta y_i = \alpha_3 + \kappa_3 D_{Italy} + \text{Sectors} + \text{Firm characteristics} + \varepsilon_i^3$$

$$\Delta y_i = \alpha_4 + \kappa_4 D_{Italy} + \text{Sectors} + \text{Firm characteristics} + \text{Strategies} + \varepsilon_i^4$$

$$\Delta y_i = \alpha_5 + \kappa_5 D_{Italy} + \text{Sectors} + \text{Firm characteristics} + \text{Strategies} + \text{Positioning} + \varepsilon_i^5$$

The total *explained* performance gap between German and Italian firms is given by $\kappa_5 - \kappa_1$.

The accounting is made by comparing κ_j with κ_{j+1}, with j=1,…,4. If $\kappa_{j+1} - \kappa_j$ is positive, part of the performance gap between Germany and Italy is explained by the variables added in the *j+1th* regression. Percentage contributions to the total explained gap is computed as $\frac{\kappa_{j+1} - \kappa_j}{\kappa_5 - \kappa_1}$.

Table 8 reports the results for these estimates.

First we should observe that most of the Italy-Germany performance gap is left unexplained by the model. In the best specification (number 5), the performance gap remains still huge (-21 per cent). The explained performance gap is just the 13 per cent of the total gap ((24.25-21)/24.25 = 13 per cent). We concentrate on the explained part having in mind that this still represents a minority of the total difference.

Most of the total explained performance gap (70 per cent) is attributable to firm characteristics such as size, human capital or innovative activity. However, different positioning in the GVC plays an important role as it explains almost one-fifth of the gap. This is not a small number, considering that this kind of explanation of the Italy-Germany firms' performance gap has been so far overlooked both by analysts and policy makers.

6 Concluding remarks

According to recent papers (Baldwin, 2011, 2009,; Bems *et al*., 2010; Yi, 2009), GVCs have been one of the main transmission mechanisms of the Great Trade Collapse that severely and simultaneously hit all OECD countries in 2009, thus amplifying the national fluctuations of demand for final goods. Notwithstanding the severity, to the best of our knowledge there is very scant evidence on the micro impact of the crisis on firms involved in GVCs. The aim of this paper is to remedy to this gap by exploiting a rich and novel dataset, EFIGE, that contains both qualitative and quantitative data on firms' characteristics and activities; the data have been matched with balance sheet information from Amadeus (Bureau Van Dijk). We perform our analysis by comparing German and Italian industrial firms. As previously underlined, these two countries provide to be an interesting area of application for several reasons, the first of it being German and Italian firms great involvement in GVCs.

We investigate whether firms' position along the GVCs – whether intermediate or final firms – as well as some firms' strategies – to increase the level of human capital, innovation propensity and foreign markets penetration – play a significant role in their performance in 2008-09.

The descriptive investigation shows that, within each country, intermediate firms are smaller than final ones in terms of both sales and employment. Their strategies are also somewhat less ambitious in terms of human capital accumulation and innovation. They are also highly heterogeneous as intermediate firms with foreign main customers are generally much larger and more innovative that intermediate companies mostly involved in national Value chains.

The relevance of firms' position in the GVCs is furthermore confirmed by our econometric analysis. The latter shows that the crisis hit firms in GVCs in an asymmetric way. Intermediate firm observed a more severe contraction of sales, while firms in a more downstream position (i.e. purchasers of specialized intermediaries) registered a less critical turnover reduction. The reduction for intermediate firm was similar in magnitude for both domestic and international suppliers.

Going to the cross-country's comparison, we find that firms' position within the GVC and their characteristics help in explaining part of the difference in performance between German and Italian firms.

In comparison with German firms, a higher percentage of Italian industrial firms are fully intermediate; German firms are instead more frequently in the purchase of customized intermediaries, thus hinting at the fact that those companies are usually located in a downstream position in the GVCs.

The cross-country comparison sheds some more light on the well-known weaknesses of the Italian industry in terms of average firms' size and strategies. Firms' strategies are constrained by firms' small size. The latter severely undermines a successful participation in the GVCs, thus casting a shadow over Italy’s role in the current and future international division of labor as Italy risks to become a “factory country”, to use Baldwin (2011) taxonomy. On the contrary, the higher share of final firms, the larger firms’ size, partly explain German firms’ capacity to face the crisis and to recover.

While some limitations in the methodology of this paper have to be addressed in our future research agenda, the correlation we found between firms’ position in the GVCs, their strategy and the ability to face the crisis have relevant implications on countries’ competitiveness. Implications that seem, so far, overlooked by policy makers.

[1] For a survey of GVCs drivers, see Amador and Cabral (2014).

[2] For an overview that compares structural similarities and differences between Italy and Germany, see Arrighetti and Ninni (2012). Here we report 2010 data. However, because of the prolonged economic crisis in Italy, differences among the two countries have since then widened.

[3] The label “bazaar economy” comes from Sinn (2003), suggesting that Germany sells products that were not produced in the country.

[4] The participation index is proposed by Koopman *et al*. (2010),it is expressed as a percentage of gross exports and indicates the share of foreign input (backward participation) and domestically produced inputs used in third countries’ exports (forward participation), see also De Backer and Miroudot (2014).

[5] The questionnaire can be found at the website www.efige.org.

[6] We consider all the manufacturing firms, food and beverages excluded, due to the countercyclical nature of these industries.

[7] Carvalho et al. (2014) uses a proprietary dataset on transactions among Japanese firms to analyze the macroeconomic effects of the Fukushima earthquake.

[8] In the EFIGE dataset, almost 70 per cent of firms has an SPTO equal to either 100 or zero.

[9] On the greater chances for lead firms to capture more value along the Value chain, see Dedrick et al. (2010).

[10] According to Eurostat, Industry and Trade Statistics, between 2007 and 2009, industrial production fell by 22.2 per cent in Italy and 16.9 per cent in Germany. This hints that the EFIGE dataset for Germany is skewed toward more successful firms.

[11] We have excluded the export share as it is highly collinear with INT-FMC and CPI.

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Table 1

DESCRIPTIVE STATISTICS

	Type of variable	No. Obs.	Mean	Standard Deviation
SPTO	Continuous (0-100)	4,117	73.2	38.9
INT	Binary (0-1)	4,117	0.503	0.500
Foreign main customer (INT-FMC)	*Binary (0-1)*	*4,117*	*0.242*	*0.428*
Domestic main customer (INT-DMC)	*Binary (0-1)*	*4,117*	*0.261*	*0.439*
CPI	Binary (0-1)	4,117	0.056	0.231
INT&CPI	Binary (0-1)	4,117	0.048	0.214
Sales in 2007 (1)	Continuous	4,117	11,282	87,288
Employees in 2007	Continuous	4,117	55.2	194.1
Log percentage change of sales 2008-09 (X100)	Continuous	4,117	-17.9	34.5

Source: Authors' calculations on EFIGE dataset. Weighted averages according to the sample design.
SPTO: share of produced-to-order sales; INT: dummy equal to one if SPTO=100; INT-FMC: dummy equal to one if an INT firm has its main customer outside the country (INT-FMC+INT-DMC=INT); INT-DMC: dummy equal to one if an INT firm has its main customer inside the country (INT-FMC+INT-DMC=INT); CPI: dummy equal to one if the firm buys a customized intermediate good from abroad; INT&CPI: dummy equal to one if an intermediate firm buys a customized intermediary from abroad. Sales in 2007: value of sales in thousands of euros in 2007; Employees in 2007: number of employees in 2007; Log percentage change of sales 2008-09: difference between the log of sales in 2009 and the log of sales in 2007.
INT, CPI, and INT&CPI are mutually exclusive.

Table 2

ITALIAN AND GERMAN FIRMS IN GVCS

	Total sample	Italy	Germany
INT	1,996	1,358	638
	(48.5%)	(58.7%)	(35.4%)
INT-FMC	*991*	*688*	*303*
	(24.1%)	*(29.7%)*	*(16.8%)*
INT-DMC	*1,005*	*670*	*335*
	(24.4%)	*(29.0%)*	*(18.6%)*
CPI	264	105	159
	(6.4%)	(4.5%)	(8.8%)
INT&CPI	212	104	108
	(5.1%)	(4.5%)	(6.0%)
Generic	1,645	746	899
	(40.0%)	(32.2%)	(49.8%)
Total	4,117	2,313	1,804
	(100%)	(100%)	(100%)

Source: Authors' calculations on EFIGE dataset.
INT: dummy equal to one if SPTO=100; INT-FMC: dummy equal to one if an INT firm has its main customer outside the country (INT-FMC+INT-DMC=INT); INT-DMC: dummy equal to one if an INT firm has its main customer inside the country (INT-FMC+INT-DMC=INT); CPI: dummy equal to one if the firm buys a customized intermediate good from abroad; INT&CPI: dummy equal to one if an intermediate firm buys a customized intermediary from abroad; Generic: residual class.
INT, CPI, and INT&CPI are mutually exclusive.

Table 3

ITALIAN AND GERMAN FIRMS IN GVCS (CONTROLLING FOR SECTORS)

	Value for the dummy: Italy
INT	0.218***
	(0.015)
INT-FMC	*0.118****
	(0.013)
INT-DMC	*0.100****
	(0.013)
CPI	-0.042***
	(0.007)
INT&CPI	-0.012*
	(0.007)
Generic	-0.164***
	(0.015)

Source: Authors' calculations on EFIGE dataset. Weighted regressions according to the sample design.
OLS regression. Dependent variables are on rows.
Explanatory variables: industry and country dummies.
INT: dummy equal to one if SPTO=100; INT-FMC: dummy equal to one if an INT firm has its main customer outside the country (INT-FMC+INT-DMC=INT); INT-DMC: dummy equal to one if an INT firm has its main customer inside the country (INT-FMC+INT-DMC=INT); CPI: dummy equal to one if the firm buys a customized intermediate good from abroad; INT&CPI: dummy equal to one if an intermediate firm buys a customized intermediary from abroad; Generic: residual class.
INT, CPI, and INT&CPI are mutually exclusive.

Table 4

CHARACTERISTICS OF THE FIRMS

	Log sales in 2007	Log empl. in 2007	Log percentage change of sales 2008-09 (X100)
		Total sample	
INT	-0.134***	-0.125***	-9.380***
	(0.036)	(0.026)	(1.132)
INT-FMC	*0.171****	*0.016*	*-10.347****
	(0.042)	*(0.032)*	*(1.373)*
INT-DMC	*-0.417****	*-0.256****	*-8.483****
	(0.041)	*(0.031)*	*(1.343)*
CPI	0.531***	0.386***	2.928
	(0.075)	(0.083)	(2.390)
INT&CPI	0.332***	0.225***	-0.052
	(0.081)	(0.061)	(2.568)
Generic (constant)	8.373***	3.454***	-13.363***
	(0.027)	(0.020)	(0.849)
		Italy	
INT	-0.156***	-0.075**	-4.788**
	(0.046)	(0.030)	(1.601)
INT-FMC	*0.141***	*0.044*	*-4.624***
	(0.052)	*(0.034)*	*(1.864)*
INT-DMC	*-0.446****	*-0.190****	*-4.948***
	(0.052)	*(0.035)*	*(1.852)*
CPI	0.626***	0.437***	1.727
	(0.111)	(0.072)	(3.859)
INT&CPI	0.299**	0.269***	3.835
	(0.109)	(0.061)	(3.808)
Generic (constant)	8.367***	3.292***	-24.957***
	(0.037)	(0.024)	(1.294)
		Germany	
INT	-0.068	0.002	-2.786**
	(0.060)	(0.050)	(1.414)
INT-FMC	*0.266***	*0.232****	*-5.197****
	(0.078)	*(0.064)*	*(1.849)*
INT-DMC	*-0.342****	*-0.187***	*-0.807*
	(0.073)	*(0.059)*	*(1.718)*
CPI	0.460***	0.315***	1.444
	(0.105)	(0.086)	(2.446)
INT&CPI	0.347***	0.197**	-2.801
	(0.122)	(0.099)	(2.835)
Generic (constant)	8.378***	3.608***	-2.308**
	(0.039)	(0.032)	(0.912)

Source: Authors' calculations on EFIGE dataset.
OLS weighted estimates according to sample design. Dependent variables are in columns. Explanatory variables: INT: dummy equal to one if SPTO=100; INT-FMC: dummy equal to one if an INT firm has its main customer outside the country (INT-FMC+INT-DMC=INT); INT-DMC: dummy equal to one if an INT firm has its main customer inside the country (INT-FMC+INT-DMC=INT); CPI: dummy equal to one if the firm buys a customized intermediate good from abroad; INT&CPI: dummy equal to one if an intermediate firm buys a customized intermediary from abroad; Generic: residual class.
INT, CPI, and INT&CPI are mutually exclusive. * significant at 10%, ** significant at 5%, *** significant at 1%.

Table 5

HETEROGENEITY ACROSS FIRMS

	Share w/ univ. Degree	Share in training	Product innovation	Process innovation	Export share
			Total sample		
INT	-4.252***	-4.026***	-0.078***	0.056**	1.042
	(0.404)	(0.838)	(0.016)	(0.016)	(0.869)
INT-FMC	*-3.103****	*-5.064****	*0.036**	*0.099****	*16.331****
	(0.489)	*(1.017)*	*(0.019)*	*(0.019)*	*(0.958)*
INT-DMC	*-5.319****	*-3.063***	*-0.185****	*0.017*	*-13.147****
	(0.478)	*(0.994)*	*(0.019)*	*(0.019)*	*(0.937)*
CPI	1.894**	4.138**	0.282***	0.134***	16.630***
	(0.853)	(1.770)	(0.034)	(0.034)	(1.834)
INT&CPI	0.833	1.990	0.142***	0.168***	14.821***
	(0.916)	(1.902)	(0.037)	(0.037)	(1.971)
Generic (constant)	10.388***	17.765***	0.496***	0.379***	17.906***
	(0.303)	(0.629)	(0.012)	(0.012)	(0.652)
			Italy		
INT	-2.337***	-0.903	-0.079***	0.048**	-2.150*
	(0.436)	(1.009)	(0.022)	(0.022)	(1.272)
INT-FMC	*-1.269***	*-1.534*	*0.049**	*0.088***	*14.695****
	(0.507)	*(1.175)*	*(0.026)*	*(0.026)*	*(1.302)*
INT-DMC	*-3.377****	*-0.289*	*-0.206****	*0.008*	*-18.565****
	(0.503)	*(1.167)*	*(0.025)*	*(0.026)*	*(1.293)*
CPI	3.492**	4.648*	0.284***	0.138**	15.217***
	(1.152)	(2.434)	(0.054)	(0.054)	(3.067)
INT&CPI	2.648**	4.644*	0.143**	0.103*	14.610***
	(1.039)	(2.402)	(0.053)	(0.053)	(3.027)
Generic (constant)	7.298***	11.150***	0.501***	0.393***	23.323***
	(0.353)	(0.816)	(0.018)	(0.018)	(1.028)
			Germany		
INT	-4.237***	-1.528	-0.084***	0.055**	0.599
	(0.763)	(1.434)	(0.025)	(0.025)	(1.149)
INT-FMC	*-2.580***	*-2.854*	*0.012*	*0.100***	*11.057****
	(0.996)	*(1.877)*	*(0.032)*	*(0.032)*	*(1.443)*
INT-DMC	*-5.596****	*-0.441*	*-0.134****	*0.017*	*-7.979****
	(0.926)	*(1.745)*	*(0.030)*	*(0.030)*	*(1.342)*
CPI	0.063	2.397	0.281***	0.135***	18.801***
	(1.320)	(2.482)	(0.043)	(0.043)	(1.988)
INT&CPI	-0.738	-0.048	0.140**	0.235***	14.375***
	(1.529)	(2.877)	(0.050)	(0.050)	(2.304)
Generic (constant)	13.334***	24.074***	0.491***	0.365***	12.740***
	(0.492)	(0.925)	(0.016)	(0.016)	(0.741)

Source: Authors' calculations on EFIGE dataset.
OLS weighted estimates according to sample design. Dependent variables are in columns. Explanatory variables: INT: dummy equal to one if SPTO=100; INT-FMC: dummy equal to one if an INT firm has its main customer outside the country (INT-FMC+INT-DMC=INT); INT-DMC: dummy equal to one if an INT firm has its main customer inside the country (INT-FMC+INT-DMC=INT); CPI: dummy equal to one if the firm buys a customized intermediate good from abroad; INT&CPI: dummy equal to one if an intermediate firm buys a customized intermediary from abroad; Generic: residual class.
INT, CPI, and INT&CPI are mutually exclusive. * significant at 10%, ** significant at 5%, *** significant at 1%.

Table 6

POSITIONING IN THE GVC AND FIRMS PERFORMANCE IN 2008-09

	(1)	(2)	(3)
INT	-3.051**	-3.496**	-3.071**
	(1.098)	(1.111)	(1.111)
CPI	2.212	3.430	2.924
	(2.244)	(2.306)	(2.318)
INT&CPI	1.701	2.360	2.172
	(2.582)	(2.615)	(2.618)
Log(employment)-2007	-	4.486***	4.603***
		(1.085)	(1.089)
Log(sales)-2007	-	-4.677***	-4.996***
		(0.881)	(0.901)
Share of intermediaries over		0.032	0.030
turnover (sh_int)		(0.027)	(0.027)
Share of intermediaries from		-0.085	-0.089
abroad (sh_int_abr)		(0.075)	(0.074)
Share w/ university degree	-	-	0.113**
			(0.040)
Share in training	-	-	0.070***
			(0.020)
Product innovation	-	-	1.776*
			(1.061)
Process innovation	-	-	-0.439
			(1.048)
National Group	-	-0.374	-1.222
		(2.048)	(2.045)
Foreign Group	-	-0.994	-1.916
		(2.542)	(2.550)
No. industry dummies	21	21	21
Country dummy: Italy	-23.218***	-22.236***	-20.998***
	(1.588)	(1.179)	(1.215)
Constant	-1.341	21.548***	20.852***
	(2.217)	(1.179)	(5.182)
R^2	0.15	0.17	0.17
No. Obs.	4,117	4,117	4,117

Source: Authors' calculations on EFIGE dataset.
OLS weighted estimates according to sample design. See eq. (1). Dependent variable: percentage change in sales in the period 2008-09. All estimates exclude the 1st and the 99th percentile of the dependent variable. White-robust standard errors in parenthesis. * significant at 10%, ** significant at 5%, *** significant at 1%.
INT: dummy equal to one if SPTO=100; CPI: dummy equal to one if the firm buys a customized intermediate good from abroad; INT&CPI: dummy equal to one if an intermediate firm buys a customized intermediary from abroad; log(employment) – 2007: log of employment in 2007; log(sales) – 2007: log of sales in 2007; sh_int: share of the purchase of intermediaries over total sales; sh_int_abr: share of the purchase of intermediaries from abroad over total sales; share w/ university degree: share of employees with a university degree; share in training: share of employees in training; product innovation: dummy equal to one if the firm carried out product innovations; process innovation: dummy equal to one if the firm carried out process innovations; National group: dummy equal to one if the firms belongs to a national group; Foreign group: dummy equal to one if the firms belongs to a foreign group.

Table 7

GLOBAL OR LOCAL VALUE CHAINS?

	(1)	(2)
INT-FMC	-3.429**	-2.861**
	(1.365)	(1.375)
INT-DMC	-2.710**	-3.271**
	(1.300)	(1.319)
CPI	2.204	2.957
	(2.245)	(2.322)
INT&CPI	1.691	2.195
	(2.582)	(2.621)
Log(employment)-2007	-	4.606***
		(1.090)
Log(sales)-2007	-	-5.019***
		(0.906)
Share of intermediaries over turnover (sh_int)	-	0.029
		(0.027)
Share of intermediaries from abroad (sh_int_abr)	-	-0.088
		(0.074)
Share w/ university degree	-	0.112**
		(0.040)
Share in training	-	0.070***
		(0.019)
Product innovation	-	1.743
		(1.059)
Process innovation	-	-0.448
		(1.049)
National Group	-	-1.218
		(2.046)
Foreign Group	-	-1.897
		(2.548)
No. industry dummies	21	21
Country dummy: Italy	-23.209***	-20.999***
	(1.058)	(1.215)
Constant	-1.290	21.031***
	(2.216)	(5.211)
R^2	0.16	0.17
No. Obs.	4,117	4,117

Source: Authors' calculations on EFIGE dataset.
OLS weighted estimates according to sample design. See eq. (1). Dependent variable: percentage change in sales in the period 2008-09. All estimates exclude the 1st and the 99th percentile of the dependent variable. White-robust standard errors in parenthesis. * significant at 10%, ** significant at 5%, *** significant at 1%.
INT-FMC: dummy equal to one if an INT firm has its main customer outside the country (INT-FMC+INT-DMC=INT); INT-DMC: dummy equal to one if an INT firm has its main customer inside the country (INT-FMC+INT-DMC=INT); CPI: dummy equal to one if the firm buys a customized intermediate good from abroad; log(employment) – 2007: log of employment in 2007; log(sales) – 2007: log of sales in 2007; sh_int: share of the purchase of intermediaries over total sales; sh_int_abr: share of the purchase of

intermediaries from abroad over total sales; share w/ university degree: share of employees with a university degree; share in training: share of employees in training; product innovation: dummy equal to one if the firm carried out product innovations; process innovation: dummy equal to one if the firm carried out process innovations; National group: dummy equal to one if the firms belongs to a national group; Foreign group: dummy equal to one if the firms belongs to a foreign group.

Table 8

DECOMPOSITION OF ITALIAN-GERMAN FIRMS' PERFORMANCE

	Dummy Italy	Total performance gap explained (in %)
Overall difference	-24.25	
Sectors	-24.02	7%
Characteristics	-22.79	38%
Strategies	-21.69	34%
Positioning	-21.00	21%

Source: Authors' calculations on the EFIGE dataset.
The column "Dummy Italy" reports the point estimate of the country dummy for Italy in each regression after inserting each set of variables. OLS weighted estimates (according to sample design). Dependent variable: percentage change in sales in the period 2008-09. All estimates exclude the 1st and the 99th percentile of the dependent variable. List of regressors. *Overall difference*: Dummy Italy. *Sectors*: Dummy Italy, Sector dummies. *Characteristics*: Dummy Italy, Sector dummies, log employment and log sales in 2007. *Strategies*: Dummy Italy, Sector dummies, log employment and log sales in 2007, sh_int, sh_abr, share of workers with tertiary education, share of workers in training programs, dummy for process and product innovation group dummies. *Positioning*: see strategies + INT, CPI, INT&CPI.

Legal enforcement and global value chains: micro-evidence from Italian manufacturing firms

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September 2015

Abstract

A growing literature suggests that institutional quality is an important determinant of trade flows. Theoretical models of international trade with incomplete contracts predict that firms will not source intermediate inputs signing arm's length contract if ex-post they cannot enforce the contract. Contract enforcement ultimately depend on the quality of institution. Prior empirical evidence support this idea using cross country data. We study how institutional quality at the local level influences the ability of firms to become international subcontractors using firm-level data. Using a sample of Italian firms and the trial length of civil disputes to proxy for contract enforcement, we find that firms located in courts with higher trial length have a lower probability to supply customized intermediate inputs to foreign firms.

Keywords: global value chains, Italy, manufacturing firms.
JEL Classifications: F10, F14, L14.

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The views expressed herein are those of the authors and are not necessarily those of the Bank of Italy. All the remaining errors are our own.

1 Introduction

Over the past twenty five years structural change in the global economy has occurred as a consequence of the ICT revolution, the steady lowering of trade barriers and transport costs, and the changing nature of multinational enterprises (Feenstra [1998]). The outcome is a new international division of labor in which the production of final products is fragmented in Global Value Chains (GVC henceforth). Under this new production paradigm, the production process for any given good can be split in tasks assigned to various productive units performed in several places around the world.

GVC are characterized by contractual relationships between producers of intermediate goods and assemblers. In this context contract incompleteness may be pervasive (Antras [2003]; Antràs and Helpman [2004]), thus resulting into hold-up problems and intermediate producers' misbehavior. As for the second aspect (that is the focus of this paper) all final firms face the risk that once the contract is signed the foreign supplier has an incentive to reduce its costs and deliver a good that does not satisfy the contractual obligations. Any product incompatibilities or delivery delay can substantially reduce the buyer's profit. Under this perspective contract enforceability plays a relevant role; high quality judiciary institutions might deter intermediate firms' misbehavior: this ultimately is likely to increase intermediate firm participation to GVC, especially when contracts (and products) between are complexity is particularly high.

In this paper we aim at providing evidence that judiciary efficiency may influence participation to GVC, by using firm-level data of the Bank of Italy's "Survey of Industrial and Service Firms". We show that firms located in courts with higher trial length in civil disputes, which is our measure of contract enforcement, are less likely to supply customized inputs to foreign firms. The effect is stronger in contact-intensive sectors. Our work is the first, to our knowledge, that looks at the impact of contract incompleteness at the local level from the perspective of the exporting firm misbehavior using firm-level data within the same country.

Institutional quality is often assumed to be country specific. Several empirical studies show how contract incompleteness determines trade flows across countries and the pattern of comparative advantages (Anderson and

Marcouiller [2002]; Nunn [2007]). In a recent paper, Acemoglu and Dell [2009] show that institutions at the local level are a strong determinant of productivity differences within countries. Local institutions can vary greatly in countries with federal systems or within countries where national laws must be enforced by local authorities that influence *de facto* institutions.

By analyzing the Italian case we take advantage of three important characteristics of the Italian legal system. First, law determines the courts for disputes, that corresponds to the court where the plant is located. This implies that there is no room for the choice of an alternative (more efficient) court when the contract is signed. Second, Italy is characterized by a huge heterogeneity in the quality of local institutions. North-South Italian divide includes financial development (Guiso et al. [2004]), political accountability (Nannicini et al. [2013]), workplace productivity (Ichino and Maggi [2000]), and schooling quality (Angrist et al. [2014]). Judiciary efficiency is no exception, despite the fact that law should be uniformly applied over the country. Third, the Italian law codifies a specific contract type for the supply of customised intermediate inputs ("*contratto di subfornitura*"). This contract is widely used in the Italian context (Lazerson [1999]). In our data, firms report if they supply intermediate inputs to foreign customers under this type of contract, and we use it to measure firm-to-firms relations in a GVC.

Empirically, we are able to document that firms located in inefficient courts have a lower probability to supply intermediate inputs abroad. The effect is driven by firms that operate in industries that are contract intensive. For each industry we measure contract intensity as the share of products that are not sold on organized markets according to the Rauch [1999] classification (following Nunn [2007]). We find that a one-year increase in trial length decreases the probability to supply customised inputs by 1.7 to 3.0 percentage points in industries at the 25th and 75th percentile of contract intensity, respectively.

This is, to our knowledge, among the few studies that provides firm-level evidence supporting the predictions of theoretical models of contract enforcement and international trade (see Antràs and Yeaple [2014] for a review of theoretical models). In these models, contract incompleteness shape international trade among firms because of the hold up problem. Driven by the richness of our data, our main focus is on exporting misbehavior. Suppose that two firms located in different countries decide to sign a cash-in-advance contract for the supply of a specialised intermediate input (see Antràs [2014] pp. 78–82 for a detailed discussion). After the contract is signed, and the payment is received, the exporter can increase its profits by reducing production costs. In the extreme case, the exporter maximizes its ex post profits if no production takes place at all. The exporter incentive to deviate from its contractual obligations depends on the punishment it will incur if the importer recurs to a court to enforce the contract. When the exporter is punished with certainty, it has no incentive to deviate, otherwise the importer faces ex-ante contract insecurity. In this particular setting, the quality of institutions that matters is the one of the exporter country. This is true even when the contract specifies a *choice-of-law* clause. Local courts may be unwilling to enforce a contract signed between residents of two countries, particularly if unfavorable to the local firms.

The bulk of the empirical literature on contract incompleteness and international trade (see Nunn and Trefler [2013] for a detailed review of the empirical literature) uses cross country data. Anderson and Marcouiller [2002] show that contract incompleteness can be an important determinate of international trade. Nunn [2007] and Levchenko [2007], further develop this idea and show that countries with better institutional quality have a comparative advantage in the production of goods that are contract intensive. Helpman et al. [2008] estimate a gravity equation to show that countries that share the same legal institutions have a higher probability of establish trade relationships. The use of cross country data can be problematic because there two possible sources of institutional quality heterogeneity. Countries have different legal system and they differ in institutional enforcement. Our focus on a single country has the advantage of keeping the legal system fixed, while allowing us to focus on the impact of *de facto* institutions within country in the level of law enforcement.

Few other works explore the relationship between the quality of institution and international trade using firm-level data. Using data from 28 developing countries, Ma et al. [2010] show that firms located in areas with better institutional quality export more goods that are contract intensive. They results replicates Nunn [2007] finding using firm level data. Araujo et al. [2012] show that the importer country's institutional quality affects the export of Belgian firms. In a similar approach, Aeberhardt et al. [2014] use French firm-level data to show that better institutional quality improves the persistence of trade relationship for firms operating in industries with severe contracting problems. All these studies, although from different perspectives, assume that institutional quality is country specific.

Our paper also contributes the the literature on the importance of institutions in determining economic outcomes (Acemoglu et al. [2001];Acemoglu et al. [2005]). Acemoglu and Dell [2009] document substantial within-country income per capita and productivity differences and show that local institutional quality is an important determinant of such differences. In our paper, we show that local institutions are a determinant of exporting behavior.

The reminder of the paper is organised as follows. In section 2, we introduce the Italian legal system. In section 3 and 4, we describe the data and the identification strategy. Section 5 discusses the results.

2 Background and the Italian legal framework

To see exactly how contract enforcement in the exporter country can affect the supply of customized intermediate inputs, consider a simple cash in advance contract (Antràs [2014]). At t_0 an exporter F agrees to ship q_{ij} at price s_{ij}, to be be paid at t_0. The following period, at t_1, the goods are shipped from country i to country j where the importer M sells the goods and collects revenues $q_{ij}p_{ij}$.[1] With contractual frictions the exporter can increase profits deviating from the contract by producing a lower quality output, by delaying the delivery of the goods or, in an extreme case, by not delivering the good at all. The incentive to deviate from the contract will depend on the probability to be sued and lose (λ_{ij}^{exp}) and the damage

[1] In this particular setting, without contractual frictions the amount to be paid in the first period is equal to the collected revenues $s_{ij} = q_{ij}p_{ij}$ and all surplus goes to the exporter.

to be paid (d_{ij}^{exp}), which both depend on the *quality of institutions* in the exporter country. When the cost from deviating is lower than the value of the contract $d_{ij}^{exp}\lambda_{ij}^{exp} < s_{ij}$ the exporter will deviate and generate profit losses to the importer.

Contract enforcement varies extensively also within countries. Suppose that in country i there are two firms located in different areas c and c' which differs in the level of contract enforcement $\lambda_{ijc}^{exp} > \lambda_{i'jc'}^{exp}$. Because it is easiest to enforce a contract in c than in c', the importer finds more risky to sign a contract with a firm located in court c'. To overcome this problem, the rules of international private law allow the parties to agree on either a tribunal or an arbitration court and to empower it to judge on any controversy arising from the contract. Such courts must not necessarily be located within the jurisdiction of either the buyer's or the supplier's tribunal. Once a verdict is issued, however, the local court of the supplier may still play a role in enforcing the sentence, in particular, local courts might be reluctant to damage a domestic business in favor of a foreign firms.

In this study we will focus on the case of Italy which provide a perfect empirical setting. First, in the Italian system the enforcement of the sentence is carried out by the local court and there is no *choice-of-law* clause. Article 26 of the Italian Code of Civil Procedure states that the court responsible for enforcement is the one where the majority of the firm's properties are located, i.e. the court in charge of enforcement is determined by the location of the supplier. If that court is inefficient, the buyer may foresee a substantial reduction of its profits, arising from both the incentive of the supplier to deviate from the contract and the delayed compensation in case of controversy. Second, Italy has 165 tribunal jurisdiction areas, whose boundaries has been set in 1865 after the italian unification, and that display large differences in contract enforcement. According to doing business, the average Italy city ranks 155 out of 185 countries measured by doing business in terms of contract enforcement, and there is substantial variation between courts: it might take form 855 days in Turin to more than 2,022 days in Bari to enforce a contract. Finally, in our data, firms report if they supply intermediate inputs to foreign customers under the so called "*contratto di subfornitura*", which is a specific contract codified by the Italian law and widely used in the Italian context (Lazerson [1999]) for the supply of customised intermediate inputs.

3 Data description

In our empirical exercise, we merge the firm-level data of the Bank of Italy's "Survey of Industrial and Service Firms" (Invind, henceforth), and the information on the efficiency of civil justice provided by the Italian Ministry of Justice.

Invind is a survey of industrial and service firms with at least 20 employees, and contains a wide range of information on nationality, location, age, sector of activity, ownership structure, employment (annual average), investment (realised and planned) and sales (domestic and foreign).[2] Invind data are merged with the Cerved Group database to recover information on the firm's value added.

We use the 2007 wave of the survey, which collects detailed data on the exporting behaviour of 2,878 firms; in particular, we are able to observe whether a firm has supplied customised intermediate inputs to foreign companies (we will label these firms as "international subcontractors" in what follows).[3] If the firm belongs to a foreign group, the survey also records if the majority of these supplies were realised on behalf of other firms of the group. Our database contains 225 firms engaged in international subcontracting; out of these, 187 realise their sales out of the group's boundaries.

Data on the actual duration of civil proceedings are not directly available. Following Giacomelli and Menon [2013], we build a proxy of the average civil trial length in 2002, using the caseflow data provided by the Ministry of Justice. For each of the 165 Italian judicial districts, we calculate the index as follows:

$$D_{2002} = \frac{P_{2002} + P_{2003}}{E_{2002} + F_{2002}} \tag{1}$$

[2]Data are available upon request through the BIRD system at `http://www.bancaditalia.it/statistiche/indcamp/sondaggio/bird`.

[3]One limitation of our data is that we do not observe the content of the contract, the value of the transaction and the identity of the partners. We are only able to identify, among exporters, those that supply customised inputs abroad.

where P are pending cases at the beginning of the year, F are the new cases filed throughout the year, and E are the cases ended with a judicial decision or withdrawn by the parties during the year. The data only refer to ordinary civil proceedings and are expressed in years.

Since we expect the effect of local courts' efficiency on the probability of engaging in international subcontracting to scale up with the contract intensity of the goods provided, we interact the index of trial duration with a sectoral index of relationship specificity derived from the Rauch's classification [Rauch, 1999]. We measure the contract intensity as the share of differentiated products produced within each sector, using both the liberal and the conservative classification.

Table 1 contains some basic statistics on our sample of firms. The average size in terms of employees is 248, while average revenues and exports amount to roughly 98 and 39 million Euros; it is apparent, though, that these statistics are inflated by the presence of some large firms in our sample. The distribution of productivity, roughly proxied by value added per worker, is more symmetric, though still being skewed to the right. The 79% of the firms in our sample are exporters, and the average firm exports 30% of its revenues.

In table 2, we show how firm characteristics vary with the exporting status. In line with the theory, domestic firms are on average smaller and less productive, while pure exporters, which are the more numerous category in our sample, are characterised by the largest average size (both in terms of employees and revenues) and by the highest value added per worker. International subcontractors, instead, are smaller and significantly less productive than pure exporters, though outdoing domestic producers on all dimensions; moreover, the share of revenues arising from exports is slightly higher for international subcontractors than for pure exporters. Most interestingly for our purposes, domestic producers are on average located in judicial districts characterised by a higher length of civil proceedings, hinting at a potential role played by local court efficiency on the exporting behaviour of a firm.

To further explore this point, Figure 1 displays two maps highlighting the geographical distribution of subcontractors and the duration of civil proceedings by judicial district. The comparison of the two panels reveals a relevant negative correlation between the two variables. Subcontracting is more frequent in the North and the Centre, and is limited to very narrow zones of the South, which is instead characterised by a longer duration of civil trials. Both the data on subcontracting and trial length, however, display a large amount of variation even within the same macroregion.

4 Identification Strategy

We estimate the following equation:

$$y_{isc} = \alpha + \beta Trial - Len_c * CI_s + \gamma_1 D_c + \gamma_2 D_s + \gamma_3 X_{isc} + \varepsilon_{isc} \quad (2)$$

where y_{isc} is a dummy indicating whether firm i, located in area (court) c, and operating in sector s has engaged in international subcontracting. $Trial-len_c$ is a measure of quality of law enforcement (trial length) in court c; the higher $Trial - len_c$ the more inefficient is the court. CI_s proxies for the contract intensity of sector s, as computed by Rauch [1999]. D_c and D_s are a set of area and sector dummies, while X_{isc} is a matrix containing firm level controls.

In this equation the access to GVC is explained by the interaction between an industry characteristic with an area characteristic. This resembles the empirical specification used by Rajan and Zingales [1998] to test the relationship between financial development and dependence on external financing, and by Nunn [2007] in his study on law enforcement as a source of country level comparative advantages.

We expect $\beta \leq 0$ if court inefficiency (long trial length) negatively impacts the probability of a firm to engage in international subcontracting in contract-intensive sectors, holding fixed all other characteristics. These characteristics include industry and area features and a bunch of firm level controls (size, productivity, and whether the firm already sold produced-to-order goods and belongs to a group).

For a number of reasons, we have to be quite cautious in interpreting β as a causal parameter. The first relates to omitted variables that may influence both trial length and the access to GVC. For example contract intensive sectors are generally more skilled-labor intensive, that is a crucial determinant for the access to international markets and, in Italy, is concentrated in areas in where the law enforcement is more efficient; this may create a downward bias in the estimate of β. For this reasons, we control for other determinants of international subcontracting like size, productivity and share of total exports over sales.

The second one relates to reverse causality issues. Areas in which international sourcing is very diffuse may successfully lobby the Italian Ministry of Justice to maintain a good contracting environment by keeping there the most efficient judges, court officers and clerks, thus negatively affecting β. While we cannot exclude this occurrence, this issue looks much more relevant in cross-country analyses rather than in within country regressions. The reason is that, in Italy, decisions on the composition of local courts are made by the High Council of the Judiciary (HCJ);[4] HJC decides according to the dispositions of two major laws: the first is the Royal Decree n. 12 issued on January 30th, 1941, the second is Law 195, published on March 24th, 1958. Both laws were issued in a completely different economic setting, well before problems related to international sourcing could even arise. To be sure, HCJ still retains some discretionary powers in the assignment of judges; yet HCJ is an extremely independent body, its autonomy is warranted by the Constitution and jealously defended by its components.

The third is relative to the problems of sorting or self-selection. Firms with an intense international contracting activities might be induced to relocate in areas in which courts are more efficient. This would generate a negative bias in β. We can test this issue by checking whether areas with a better quality of law enforcement tend to be more specialized in contract-intensive sectors. Figure 2 plots the average contract intensity at court level against the average trial length.[5] We use both liberal and conservative definition of contract intensity as defined by Rauch [1999]. It is apparent that the correlation between the two measures is zero thus rejecting the sorting hypothesis.

[4]Two-thirds of the HJC are made by judged, which are elected by all Italian judges. One-third is instead elected by the Parliament among University Professors of Law or Lawyers.

[5]Similar results, available upon request, can be obtained by using the median or the highest contract intensity in the area.

5 Results

Baseline results are reported in Table 3. The first two columns report the estimates by using the liberal definition of contract intensity proposed by Rauch [1999]. Third and fourth columns use instead the conservative one. Column (1) reports the estimates of equation 2 for the most parsimonious specification that includes the interaction between trial length and contract intensity and the full set of sector and area dummies only. The coefficient of interest is negative and significant thus implying that firms in contract-intensive sectors have a lower probability to operate in a GVC as suppliers when they happen to be located in areas in which courts are particularly inefficient.

This result is confirmed when we insert other firm level controls. These include a measure of size (log of employees) and productivity (log of sales per worker); these aim to control for firm productivity that is a crucial variable to understand the role of firms in international markets. We also control for a dummy equal to one if the firm has operated as a specialised supplier either home or abroad as a control for the self-selection in to the supplier status; the last explanatory variable is a dummy equal to one when sales in the GVC mostly occur within the same group. As expected, size positively correlates with the probability to be engaged in international subcontracting; similarly having signed a contract of (domestic or international) *subfornitura* and group membership also positively impact on the participation to a GVC. Despite the statistical significance of these controls, the point estimate of the interaction of interest remains very similar to the parsimonious specification.

Similar results are obtained when we look at the conservative Rauch classification. Point estimates now are slightly larger (in modulus), even if confidence intervals largely overlap.

As for the magnitude of the coefficients, a one-year increase in trial length reduces the probability to operate as an international subcontractor by 1.7 percentage points for firms belonging to sectors at the 25th percentile of the (liberal) Rauch classification; the fall is almost double (-3.0 percentage points) for industries at the 75th percentile. A similar magnitude can be obtained when we look at the conservative definition; in this case a one-year increase in trial length reduces the participation to GVC by 2 percentage points for sectors at the 25th percentile of the (conservative) contract intensity and by 3.3 percentage points in sectors at the 75th. These are not negligible effects as average participation to GVC is 8%.

Table 4 presents the first set of robustness checks. Dependent variable in equation 2 equals to one if the firm is an international subcontractor; zero is instead attributed to both domestic firms and exporters which do not operate in a GVC. A possible concern relates to the fact that the negative coefficient found in Table 4 actually depends on the self-selection into the exporter status, thus detecting a mere Nunn [2007] effect. In order to reject this hypothesis we re-run equation 2 on the exporters only. Results in Table 4 actually reject this concern. The coefficient of the interaction remains negative and significant with a point estimate very close to the previous results.

Another possible concern relates to the presence of multi-plant firms. In section 2 we have discussed that in that case the court in charge of the execution may vary according to the relative size of the firm's assets across plants. Invind database is collected at firm level, while production activity (and participation to GVC) might be influenced by the quality of law enforcement at plant level. This would generate an attenuation bias in the estimates. In order to rule out this hypothesis, we make use of an information in the Invind dataset on the geographical distribution of employees across Italian macroregions.[6] We discard all companies reporting this information as (with certainty) multi-plant firms. Before showing the results two cautionary notes should be considered. The first is that multi-plant firms can also have all establishments within the same macroregion and, in our analysis, they would be incorrectly coded as single-plant. We interpret our measure of multi-localization as a simple lower bound of the true variable. The second is that this information is available for larger firms only (with more than 49 employees); we have decided to discard all firms between 20 and 49 employees despite the fact that their probability to be multi-plant is indeed quite low.

Results are presented in Table 5. Columns (1) and (3) report the esti-

[6] Italy is made of four (NUTS1) macroregion: North-West, North-East, Center, and South.

mates of equation 2 for the sub-sample of firms with at least 50 employees; columns (2) and (4) report the results by excluding firms with (certainly) other plants outside the macroregion. Estimates confirm the attenuation bias due to measurement error. Point estimates for both definitions of contract intensity are larger (in modulus) even if the standard error for the liberal partition has more than doubled. For the conservative definition, instead, the point estimate has become almost twice the baseline one.

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Tables

Table 1: Summary statistics about the sample

	mean	sd	p25	p50	p75
employees	248	834	38	72	178
revenues	97990	546089	6500	15836	51000
export	38501	246095	70	3000	15994
VApw	65.87	117.59	39.73	53.50	73.92
dummy exporter	0.79	0.41	1.00	1.00	1.00
share exported revenues	0.30	0.30	0.01	0.20	0.55

Source: Survey of Industrial and Service Firms (Invind), Bank of Italy.

Table 2: Summary statistics by firm status

	#	empl	revs	export	VApw	share exp. revs	trial length
Domestic	599	89	23587	0	53.02	0.00	3.23
Exporting	2018	289	122916	49591	70.22	0.38	2.65
Subcontr.	187	263	61036	32751	58.14	0.44	2.70
Total	2804	244	97570	37874	65.87	0.30	2.78

Source: Survey of Industrial and Service Firms (Invind), Bank of Italy; data on trial length provided by the Italian Ministry of Justice. Firms belonging to a foreign group are excluded from the computation of these statistics. The first column shown the numerosity of each group, while all the other statistics are group averages. The last column displays the average trial length in the judicial districts where the firms are located.

Table 3: Baseline regressions

	(1)	(2)	(3)	(4)
interact liberal	-0.0317**	-0.0330***		
	[0.0147]	[0.0125]		
interact conserv.			-0.0357**	-0.0348***
			[0.0153]	[0.0130]
log employees		0.0105**		0.0104**
		[0.0050]		[0.0049]
log revenues		0.0114		0.0114
		[0.0076]		[0.0076]
dummy subcontr.		0.3957***		0.3958***
		[0.0220]		[0.0220]
group subcontr.		0.1072*		0.1064*
		[0.0590]		[0.0590]
R^2	0.184	0.470	0.184	0.470
N	2720	2720	2720	2720

Robust standard error in parentheses.

Table 4: Regression on the subsample of exporters

	(1)	(2)	(3)	(4)
interact liberal	-0.0354	-0.0372**		
	[0.0223]	[0.0171]		
interact conserv.			-0.0395*	-0.0390**
			[0.0236]	[0.0181]
log employees		0.0116**		0.0115**
		[0.0056]		[0.0056]
log revenues		-0.0044		-0.0044
		[0.0093]		[0.0093]
dummy subcontr.		0.5252***		0.5252***
		[0.0270]		[0.0270]
group subcontr.		0.0811		0.0807
		[0.0659]		[0.0659]
R^2	0.202	0.578	0.202	0.578
N	2132	2132	2132	2132

Robust standard error in parentheses.

Table 5: Regressions controlling for multi-plant firms

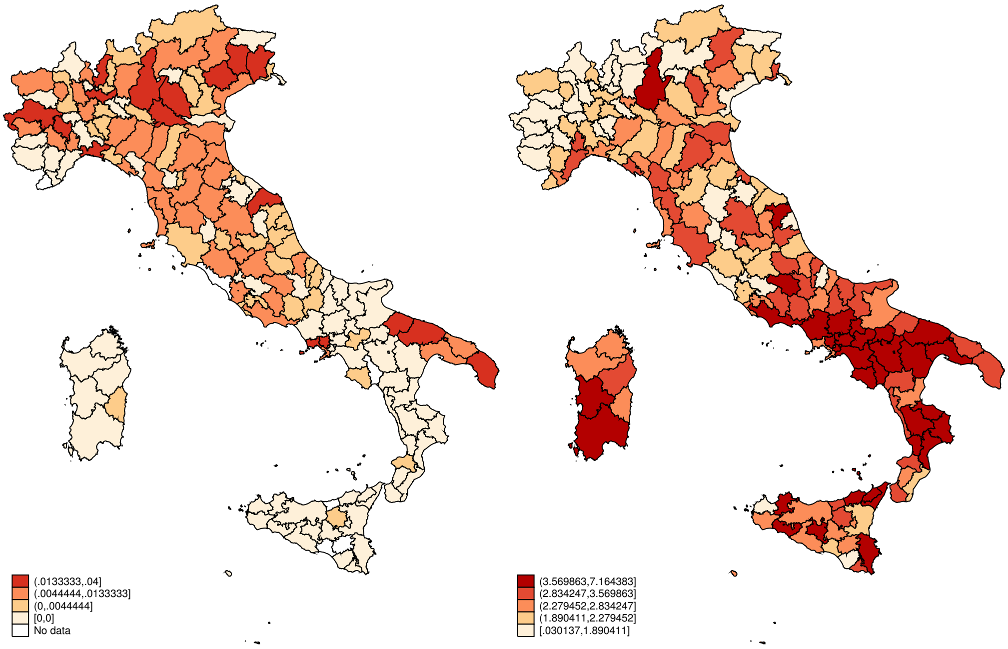
	(1)	(2)	(3)	(4)
interact liberal	-0.0358	-0.0516		
	[0.0259]	[0.0323]		
interact conserv.			-0.0452*	-0.0668**
			[0.0257]	[0.0321]
R^2	0.229	0.286	0.230	0.287
N	1654	1285	1654	1285

Robust standard error in parentheses.

Figures

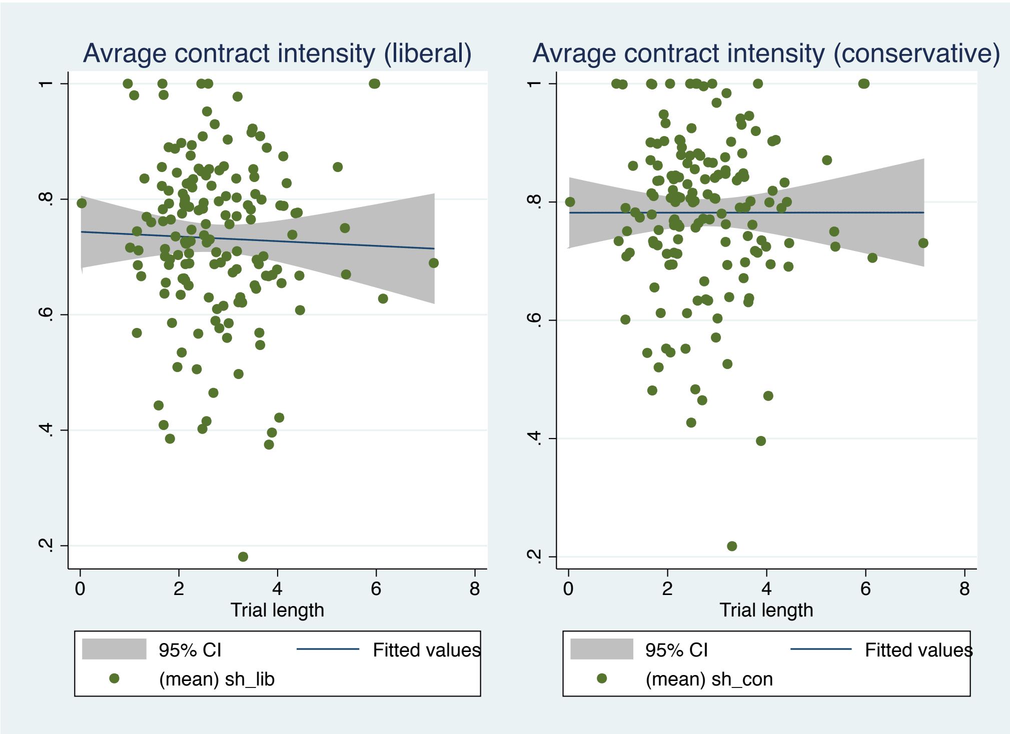
Figure 1: The geography of subcontracting and judiciary efficiency

(a) Share of subcontractors *(b) Average trial length*



Source: Survey of Industrial and Service Firms (Invind), Bank of Italy, and Italian Ministry of Justice. The left panel shows the share of firms involved in international subcontracting within each judicial district.

Figure 2: Controlling for sorting



Source: Italian Ministry of Justice.