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Presentations

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Abstract

Over the last decades an increasing fragmentation of production processes, driven by reductions in trade barriers and adoption of new technologies, has led to the emergence of the so-called global value chains. The phenomenon has involved both manufacturing and services industries.

However, the welfare gains from integration in an international value chain in terms of greater trade participation and upgrading in higher value-added activities may not be obvious and could differ among countries located at the core and at the edges of the global value chain. Traditional trade statistics have been revised in order to take account of value-added dispersion and to provide unambiguous assessments of the impact of trade on economic performance and job creation. In fact, official trade statistics measured in gross terms include multiple counted value-added of trade flows of intermediates which cross borders several times. This may provide a misleading perception of the impact of trade on GDP and employment (Koopman et al., 2010; 2014).

New metrics of trade in value-added can provide clearer insights about both job creation and growth. Decompositions of gross trade flows in value-added by origin highlight the direct and indirect effect of specific tasks, labor skills and capital to economic performance, employment and the environment. Moreover, removing all the pure double counted components, a deeper analysis would identify not only the country and sector of origin but also where the value-added is absorbed (Wang et al., 2013).

Despite the increased availability of data there is still little assessment of a dynamical map of global trade in value-added, sectoral interdependences and their impact on growth, employment and competitiveness (World Bank, 2017).

The objective of this thesis is to explain with empirical evidence heterogeneity in value-added economic outcomes at different levels of analysis (global, regional and firm-level) and across different sectors (both manufacturing and services), in the light of the increasingly

complex production processes, and to provide helpful insights for policy decisions about human capital and growth.

After an introduction in Chapter 1, Chapter 2 reviews the main novel indicators of trade in global value chains and investigates the effect of Central Eastern European counties accession to the European Union on new global value chain metrics of participation and positioning of the transport equipment sector. We find that bilateral joint adhesion to the European Union has a phased-in effect on participation to global value chains of the exporting country but does not affect its positioning along the value chain in a statistically significant way.

Chapter 3 assesses on a global scale the interaction between production choices, specialization trajectories and the quality of institution endowments, the latter being one of its long-term determinants. Our findings demonstrate that at a global scale there is some degree of substitutability between foreign and domestic intermediate input factors and between labor forces with high- and low-skills. Additionally, we find that the quality of financial and economic institutions positively affects value-added-based indicators of trade specialization, controlling for traditional Heckscher-Ohlin relative factor endowments.

Chapter 4 studies the internal and the external determinants of hotel companies' technical efficiency in the Italian administrative Region of Tuscany. The results emphasize the positive impact on technical efficiency scores of the relative share of intangible investments, the quality of human capital and location in well-renowned tourism destinations such as cities of art or seaside destinations.

Finally, Chapter 5 concludes.

Chapter 1

Introduction

Starting since the end of the nineteenth century, the so-called first unbundling of production, mainly driven by reduction in transportation costs, allowed the spatial separation between the production factories and final consumers. However, over the last decades the trade liberalization waves and the innovations in IT dramatically decreased coordination and communication costs, which led to a new phase of globalization, namely the second unbundling (Baldwin, 2006).

The technological revolution radically changed communication: it allowed coordinating production processes at greater distance and to offshore complex tasks to low-wage countries. In fact, this new phase of globalization has transformed the nature of trade flows, with massive transfers of knowledge and know-how from North and South of the world. However, while the first wave of globalization created a divergence between North and South, this second leap of globalization has produced a convergence of profit shares between most developed and developing countries, which have now access to international markets as key players (Baldwin, 2016).

The boost of trade in intermediate goods and services (Miroudot et al., 2009), know-how, managerial skills and workforce favoured the emergence of the so-called global value chains (Gereffi, 1994). Nowadays, production processes are fragmented globally across countries and global trade has benefited from this intensifies production sharing: firms are engaged in transactions across national borders both in manufacturing and in services sectors.

International production networks today revolve around three main regional areas (North America, Europe and Asia); therefore it makes sense to include the notion of regional value chains (Baldwin and Lopez-Gonzalez, 2015). In particular, some manufacturing industries such as automotive present a distinct regional structure of integration and a tendency to relocate the investments and tasks, such as the production of components and assembly, towards the peripheries of the main core areas, due to their lower labor costs and contiguity to final consumers markets (Sturgeon et al., 2008).

As discussed in Chapter 2 of this thesis, the benefits in terms of growth and job creation deriving from a greater involvement in global value chains could be different between countries engaged in higher value-added tasks and emerging and developing countries, mainly positioned in lower value-added activities. While the existing literature on this issue is limited but growing and usually deals with only one aspect of global value chains (Johnson, 2017), Chapter 2 attempts to improve our understanding on both country participation and positioning in global value chains with a unified framework in a manufacturing industry.

Also, services are a relevant share of countries' economies GDP and play a crucial role in value chains, being a prominent component of international trade flows (Low, 2013). However, the intangible, heterogeneous nature of services and their complementarity with other markets in supply chains render their analysis more complex with respect to manufacturing goods. Nevertheless, services represent a great opportunity for countries that wish to pursue upgrading strategies along value chains or improve their overall competitiveness.

In this regard, Chapter 3 deals with both manufacturing and service industries in order to provide a consistent assessment of global production and specialization, while Chapter 4 deals with a specific service sector (hospitality).

Researchers and policymakers are aware that it is necessary to complement traditional gross trade measurements with up-to-date metrics based on value-added flows across countries and sectors in order to measure the welfare and employment gains (or losses) of trade in global value chains (Koopman et al., 2010; 2014). Despite the increased availability of data, both at macro-level (such as inter-country input-output tables) and micro-level, there is still little assessment of a dynamical map of global trade in value-added, specialization trajectories and their interrelationships with socio-economic results. Chapter 3 adds on this strand of research with an empirical analysis, using the relatively unexploited gross trade decomposition frameworks (Wang et al., 2013).

A recent report by the World Bank (2017) highlights some key issues regarding the sustainability of globalization of trade along with development process. The access to international markets and global supply chains allowed developing countries to move into complex tasks and increase their productivity. In this sense, global value chains represent an efficient production environment. Nevertheless, too many areas and countries (in South Asia and Africa) are still excluded from the potential opportunities of globalization and have remained poor.

In developed countries, the benefits from increasing international trade and investments may favour capital-owners and destroy jobs in low-skill activities, amplifying income inequality.

In fact, international trade effects may not be equally distributed within and between countries involved in global value chains. The theoretical literature has identified several mechanisms through which trade policy affects wage inequality (Antràs et al., 2017). One is the change in relative demand for skilled workers. Trade liberalization and outsourcing activities from developed to developing countries increase the average skill intensity of production and the skill-premium in both countries, since the outsourced products are unskilled-labor intensive for the developed country but they are skilled-labor-intensive compared to domestic production of developing country (Goldberg and Pavcnik, 2007).

There is still only an imperfect knowledge about the strategies that can be pursued by countries, regions or firms to maintain or improve their positions and outcomes in the global economy. Nevertheless, it is not possible to assume that integration to global value chains automatically brings about economic upgrading or growth through technology or spill-overs. As a matter of fact, it is still unclear under what conditions, such as governance and trade arrangements, upgrading and growth are likely to occur.

Given the increasing relevance of the research challenges in these respects, this thesis has the objective to investigate empirically sectoral interdependences with economic outcomes, grounded on value-added measurements, at different detail of analysis (ranging from global country- and sector-level to regional firm-level), and their implications on welfare creation.

In all the Chapters, we make use of an inter-country input-output panel dataset at country-sector-level, the World Input Output Dataset (WIOD), which covers a time span of 15 years and also includes relatively unexploited information on input factors such as domestic and foreign intermediate inputs as well as labor by skill level. However, while the empirical macro-level analyses in Chapter 2 and Chapter 3 are based respectively on European and global country-sector level, the scope of the analysis in Chapter 4 is narrower, on a regional scale and with firm-level data. This differentiated geographical focus allows uncovering several aspects of the functioning of value chains and their effects on different economic outcomes. In particular, Chapter 2 addresses the relationship between trade and economic upgrading; Chapter 3 investigates the relationship between value-added in trade and growth, while, Chapter 4 looks at the endogenous and exogenous determinants of firm efficiency, measured in value-added.

Initially, in Chapter 2 the purpose is twofold. First, we review the main recent contributions on global value chain measurements, in particular on participation and positioning metrics, and their link with traditional gross trade statistics. Secondly, we exploit the comprehensive disaggregation framework proposed by Wang et al. (2013) to analyse the dynamics of trade in the transport equipment industry in European countries. The empirical tests through gravity models investigate the effect of the European Union integration on sectoral value chain indicators in Central Eastern European countries. We find that European Union adhesion to regional trade has a phased-in effect on country participation but does not contribute to significant changes of their positioning along the value chain.

In the light of the new geography of global trade flows revolving around regional blocs, trade agreements do have a positive role in favouring countries integration in global value chains. The econometric results suggest a positive correlation between accession to the European Union and countries' ability to boost their trade performance, in terms of traditional gross exports as well as of novel domestic value-added metrics. However, the analysis of global value chain positioning indicators points to the fact that adhesion to a regional trade agreement does not necessarily imply upgrading along the value chain. This puts countries at the peripheries of the regional value chain, specialized in lower value-added activities, in a position of dependence with respect to hub countries engaged in higher value-added tasks. It is necessary for country upgrading to operate not only within national industries but also within the regional trade bloc. It requires a shift from bilateral inter-regional trade relationships to a more developed form of labor division, incorporating more stages of the supply chain R&D to production, distribution and consumption.

Next, in Chapter 3, we aim to assess on a global scale the interaction between production choices, specialization trajectories and the quality of institution endowments. We do this by simultaneously estimating a global production function and the impact of economic and financial institutions as long-term sources of comparative advantage in value-added terms, along with the traditional Heckscher-Ohlin relative factor endowment determinants. We suggest that the level of international sourcing of intermediate inputs as well as educational attainments of labor force are key determinants of performance and should be the main factors to consider for policy implications. Moreover, our results point out that institutional quality does have a positive effect on the value-added based specialization pattern of a country-sector.

Global value chains offer a role to play for economies at different levels of development over time. Countries that have in place a supporting financial environment and well-functioning economic institutions can enhance their participation to international trade markets and fully exploit their competitive advantages in the global value chains.

However, the benefits of greater involvement in global value chains relative to growth may not be obvious and policymakers should be aware of potential risks related to them. Global value chains may bring about crowding-out effects of internationally-sourced intermediate input factors on domestic industries due to an easier access to foreign markets and to crowding-out of less educated workforce due to the job polarization and to an unbalanced workers skill distribution.

Finally, in Chapter 4, we analyse the hospitality sector, being a key node in the tourism value chains. In fact, the global value chain perspective has pervaded research not only in manufacturing but also in service sectors. Tourism is one of the largest and most composite sectors globally and tourism value chains are relevant for their forward and backward linkages with other industries and their impact on employment. First, we provide a descriptive overview of the hospitality sector performance in several countries using a value chain framework. Second, given the importance of hotel competitiveness on a narrower scale, we analyse the determinants of tourism firm-level value-added efficiency in one of the best-known Italian Regions as a tourism destination, Tuscany.

We estimate a stochastic frontier production function using a panel dataset of more than 1000 hotel companies in Tuscany over the period 2008-2016, and link firm technical efficiency to both hotel location and internal firm characteristics. Our results point out that hotels located in cities of art and on the seaside are found to be more efficient compared to hotels in other locations. In particular, cities of art are characterized by greater tourism opportunities and services, better infrastructure as well as a greater involvement in value chains and stronger links with the other sectors. Conversely, hotel efficiency in seaside destinations is favoured by large productive scale, which allows an easier access to better and cheaper inputs in intermediate markets. Additionally, hotel features such as intangible investments and the quality of human capital matter as determinants of hotel efficiency.

Policies for mergers and network creation seem possible solutions to enhance productive size of the hospitality sector in Italy, characterized by a majority of small businesses. The coordination of associative agencies or tourism networks can help reducing seasonality and contribute to increase human and immaterial capital which in turn can improve individual firm efficiency. Investments in innovation such as R&D subsidies as well as investments in human capital such as EU funded training programmes or development of tertiary education studies in tourism represent relevant instruments in supporting technological change, sustain employment and improve overall efficiency.

Chapter 2

Measuring Trade in Global Value Chains: an Analysis of the Transport Equipment Sector in the European Union

2.1 Introduction

Over the last decades, there have been relevant changes in the market dynamics due to the globalization process. Technological advancements, innovations and trade policies have favoured the fragmentation of production processes at a global scale (Jones and Kierzkowski, 2001) and have reduced cross-border transaction costs. Liberalisation waves have facilitated foreign direct investments and reduced trade barriers, in a way such that today most economies in the world experience a higher degree of openness compared to the past. The first phase of globalisation following reduction in transportation costs and liberalization waves brought about a local clusterization of production and a boost of trade in final goods across countries. The subsequent unbundling of production processes worldwide thanks to new technologies and reduction in coordination costs led to the fragmentation and internationalisation of the supply chains and therefore favoured a higher delocalisation of tasks, technologies, skills and know-how and, most importantly, the upsurge of trade in intermediate goods (Baldwin, 2006). Miroudot et al. (2009) estimate that trade in intermediate inputs represents 56% and 73% of total trade flows in goods and services respectively. Several global production networks emerged also as a consequence of trade agreements, with a few countries being the main hubs and other developing economies which improve their industrialization processes simply by joining these global supply networks (Baldwin, 2012). Today, international trade patterns show a distinct mark of regionalization around three main areas: North America, Europe and Asia (Baldwin and Lopez-Gonzalez, 2015).

Academics and policymakers have analysed the welfare gains and the shortcomings of the globalization phenomenon under different respects. However, only recently the global value chain (GVC) framework has allowed to delve deeper into some relevant issues such as the emergence of BRIC countries as crucial player in GVCs, the key drivers of success and competitiveness for exporting countries and industries, the economic and skill upgrading, the environmental impact of fragmented production processes. There is a growing interest and attention towards GVCs by public bodies in order to reformulate policy advice in the sense of assessing the impact of trade on growth in value-added and employment creation. (Gereffi and Korzeniewicz, 1994; Mayer and Gereffi, 2010; Gereffi 2016).

Accession to a GVC may bring about benefits in terms of poverty reduction, job creation, skill acquisitions and growth. However, these welfare gains are tightly related to the degree of competitiveness and the level of integration within the GVC itself. Therefore, GVC participation per se is not enough in order to reap the economic gains, since also the *quality* of GVC integration matters. While more developed countries focus on higher-value added activities in the pre-production (such as R&D) or post-production phases (such as customer service and marketing), less developed countries are usually engaged in lower-value added stages, like the assembling of components and manufacturing. Researchers developed the notion of "smile curve" in the context of GVCs, starting from the intuition of Shih (1996), to represent this relationship existing between positioning of developed and developing countries and the creation and distribution of value-added along a GVC (Rungi and Del Prete, 2018). Economic agents adopt upgrading strategies to maintain or improve their positions along the GVC. One of the main objectives of developing countries in GVCs is to limit the imported content of value-added and maximise the domestic content of export in order to climb the value-chain ladder. In general, upgrading has the objective to shift production to more beneficial tasks, in terms of higher value added contribution, profits or security (Gereffi, 2005).

Manufacturing industries such as automotive, electronics, apparel and consumer goods have been strongly affected by trade and investment liberalisations through free trade agreements over the last three decades. The automotive sector is one of the most dynamic and internationally fragmented industries, with a variety of production stages performed in several countries (Amighini and Gorgoni, 2014). Due to the importance of the interconnectedness among countries, several researchers have highlighted the role of large disruptive events in affecting global production networks in the automotive sector (MacKenzie et al., 2012; Arto et al., 2015). The industry has a key role in economies due to its size and relevance for employment. It accounts for almost 6% of EU employment (Head and Mayer, 2017). While total car production in OECD countries has remained relatively stable over the decade 2000-2010, despite the economic crisis in 2008, total production in non-OECD countries has increased steadily, driven by the upsurge of domestic demands in emerging countries such as China and India. Over the years 2000s, the global car industry has been characterized by large waves of offshoring activities from large developed economies towards the peripheral countries of the hub producers. Automotive multinational companies have the advantage of sourcing cheaper mechanical and electronic components from low-cost countries, while carrying out design and assembling close to final markets (Bailey et al., 2010).With this respect, the role of suppliers located in emerging Asian economies as well as in Central Eastern Europe is increasing (Rhys, 2004; Lefilleur, 2008). Abundance of low labor costs and a lax regulation have represented the main trade advantage of industrialising countries. However, cheap labor is not the only driver of the complex geography of trade flows in GVCs. Proximity to end markets as well as transportation costs still matter in the location choice of multinational firms and their offshore activities. (Navaretti and Ottaviano, 2014). For these reasons, the global automotive industry presents a distinct regional structure of integration and a tendency to relocate the investments and activities, such as the production of components and assembly, towards the peripheries of the main core areas, in order to exploit scale economies related to transportation and diversification costs to end markets (Sturgeon et al., 2008).

In fact, Central Eastern Europe has experienced an increase in the share of world production, despite a slow-moving growth in domestic demand, combined with a boost of exports and re-exports of foreign cars. To cite a few examples, Italian Fiat purchased a plant in Tychy, Poland, operating with full capacity starting from 1992, while Slovenia has become the exporting and offshoring platform of French Renault.

Previous studies of international trade tend to claim that regional trade agreements are one of the main drivers of the emergence of regional trade blocs (Baldwin and Lopez-Gonzalez, 2015). However, this claim is often based on the mere observation of more increasing intermediate input flows within regional trade areas.

Traditional concepts based on trade in final goods are not enough to capture the complexity of the phenomenon and there is still ambiguity on the countries' benefits of GVC integration, in terms of qualitative upgrading of their exports.

Policymakers and researchers have recognized some major problems associated with traditional trade metrics. First, the relevance of trade flows of some products may be overestimated due to multiple counting across borders. Secondly, the increasing importance of trade in intermediates renders the contribution of each production stage more difficult to identify. There is an increasing recognition that traditional trade measurements provide an ambiguous point of view on the impact of trade to economic performance, employment and income. This issue has raised awareness among scholars about the need to integrate existing conventional trade statistics with novel value chain metrics taking into account the complexity of global production chains, fragmented across several sectors and countries.

Taking into account the GVC perspective is crucial to achieve more effective qualitative and quantitative analyses of different policy-sensitive issues such as the impact of trade barriers, the cross-border propagation of shocks, trade balances and specialization patterns (Johnson, 2014). In particular, trade barriers such as tariffs and anti-dumping rights may have a detrimental effect on domestic production due to the highly fragmented nature of global production networks and to the fact intermediate imported goods and services may encompass domestic value-added.

Financial shocks as well as currency fluctuations and natural disasters may have a huge impact on market demand and trade flows due to the propagation of shocks through global supply networks. The so-called "bullwhip effects" refer to fluctuations in terms of trade elasticities by value chains (Altomonte et al., 2012). This means that a drop in demand for downstream firms can convert into a reduction in supply from more upstream companies. Recent studies relying on input-output tables find that negative shocks may propagate through inter-sectoral linkages to both downstream and upstream companies (Acemoglu et al., 2012; Caliendo et al., 2014; Di Giovanni and Levchenko, 2010). Further studies employing micro-level data investigate the impact of natural disasters on financial performance and production of firms directly or indirectly linked to those firms damaged (Barrot and Sauvagnat, 2016; Carvalho et al., 2014; Todo et al., 2015; Lu et al., 2017). Trade in value-added measures can give a better picture of how shocks are transmitted along global production chains so that improved policy decisions can be made to overcome the impact of macro-economic shocks.

However, even novel metrics of trade flows based on value-added may not take into consideration all the aspects of a global production chain. Competitiveness in global production networks has shifted from country-level to a firm-level. Multinational firms are undergoing fragmentation of their production processes and distribution of value-added between affiliate and parent companies worldwide. Sector analyses may overlook the fact that the main players in GVCs are firms. In particular, value-added trade measures are subject to a number of limitations. First, they are highly dependent on the reliability of the underlying data sources such as Input-Output tables, so that small errors may be amplified in the manipulation of the data framework. Moreover, the use of country-sector aggregate information in the input-output tables may be misleading in a context where the main actors in global production networks are firms. Second, value-added metrics are not able to assess track the physical movements of goods and services, nor to detect the actual location of the production processes. With this respect, value-added metrics are distant from real world trade exchanges. In fact, bilateral trade in value-added flows skip the all indirect transactions and the trade relationships highlight only the origin of the value-added and where it is finally consumed, even though there is no direct transaction between the source and final demand countries. It would be necessary to enrich the information with the value-added trade flows through all the countries involved in the value chains and not only the source and consumer countries. Third, further limitations are tightly linked to the quality of the dataset, its coverage and cross-sectional and time comparability. The value-added trade (as well as the gross trade) measures should not be considered as observed measures but only as mere indicators of the scope and diffusion of trade in GVCs.

Against this background, in this chapter we go through the key contributions on the recent literature on GVC measurements (De Backer and Miroudot, 2013; Amador and Cabral, 2016). Johnson (2017) reviews the main contributions on GVC measurements under the macro- and the micro-approaches. The study emphasizes that research on GVC analysis employing the macro-perspective mostly exploits Multi-Regional Input-Output Tables to measure trade in value added and positioning along the value chains (Johnson, 2012; Timmer et al., 2015; Koopman et al., 2014; Antràs et al., 2012). Conversely, the micro-perspective studies the organization of international production networks of multinational companies and their sourcing decisions, using firm-level data (Rungi and Del Prete, 2018).

While Johnson (2017) puts to light to two strands based on micro- and macro approaches, the focus of this chapter is mainly on the macro-approach of GVC measurements. In particular, the emphasis is on points of contact between two crucial GVC dimensions, participation and positioning, in value added in trade literature, which relies on decomposition frameworks of gross trade flows. We detect the connections between the terms of decomposed trade flows and previous vertical specialization metrics as well as upstreamness.

With respect to previous surveys in this field (De Backer and Miroudot, 2013; Amador and Cabral, 2016), we provide an extensive overview of previous research efforts along with technical details and construction methodologies of the different metrics. Our aim is to assess a link between these different concepts and allow for a comparison between value-added and gross metrics in order to provide a comprehensive framework.

Furthermore, we exploit the generalized decomposition framework by Wang et al. (2013) to analyse dynamically the transport equipment sector in EU countries, being one of the most fragmented sectors internationally and with a clear regional core-periphery structure.

These features and the specific year coverage of the dataset employed (the WIOD) allow us to investigate the effect of country accession to the regional trade agreement, namely the EU, on GVC dimensions and traditional trade statistics. By estimation of gravity models, we find that country-pair joint adhesion to the EU has a phased-in effect on GVC participation, but does not contribute to statistically significant changes of positioning along the value chain.

The remainder of this chapter is structured as follows. Section 2.2 and section 2.3 review the most relevant research efforts on GVC participation and positioning metrics, respectively. Section 2.4 presents the main Inter-Country Input-Output Tables. The descriptive analysis of the transport equipment sector in EU countries is presented in section 2.5 and the empirical model and the results in section 2.6. Finally, section 2.7 concludes.

2.2 Global Value Chain Participation Metrics

There is an ample literature on the phenomenon of cross-border fragmentation of production processes, the boost of trade flows in intermediate inputs and the emergence of the so-called GVCs (Feenstra, 1998). Starting from the paper by Hummels et al. (2001) on vertical trade measures, a branch of research has focused on value added trade (or factor content of trade), the development of input-output methodologies and measures of country participation into GVCs. (Daudin et al., 2011; Johnson and Noguera, 2012; Koopman et al., 2010).

Leontief (1936) seminal work is at the base of the all the value-added literature on vertical trade measures and decomposition techniques. According to his work, Inter-country Input-output tables are crucial tools in the estimation of input requirements for the production of one unit of output. The information on links between sectors and countries in input-output tables helps to trace each unit of final product back to the amount and the type of intermediate goods and services. Given an economic system of C countries and G sectors, the main input-output relationship is:

$$x = Ax + f = Lf \tag{2.1}$$

where x is a CG vector of gross output; A is a CG x CG matrix of technical input-output coefficients; f is a CG x 1 vector of final demand; L is equal to $(I - A)^{-1}$ where I is the identity matrix and represents the so-called Leontief inverse. The Leontief inverse or total requirement matrix indicates how much gross output is needed in order to increase final demand by one unit.

2.2.1 Vertical Specialization and Value-Added Exports

The concept of vertical specialization (VS) emphasized by Hummels et al. (2001) refers to the use of intermediate inputs sourced internationally to produce goods and services for exports. They develop two key measures of VS. The first sector-level measure of VS can be interpreted as either the foreign value-added in exports or the imported input content of exports. For any country c and sector g, it is computed as the product of the share of intermediate inputs in gross output and exports:

$$VS = \left(\frac{imported\ intermediates}{gross\ output}\right) \cdot exports = \left(\frac{exports}{gross\ output}\right) \cdot imported\ intermediates \tag{2.2}$$

The country-level VS measure is simply the sum across sectors. It coincides with the concept of Importing to Export (I2E), which encompasses all the foreign intermediates used for products which are then exported. However, this notion includes multiple counting of the same value-added components in the gross trade measures. I2E is a subset of Importing to Produce (I2P) notion, which embeds all the intermediate factors imported from abroad and used for domestic production. This metrics is still relevant to detect where the production industries are located globally (Baldwin and Lopez-Gonzalez, 2015). Given n sectors, in matrix notation:

$$VS = A^M(I - A^D)^{-1}E \tag{2.3}$$

where A^M is the n x n imported coefficient matrix (each element corresponds to the imported inputs from sector i used to produce one unit of sector j), I is the identity matrix, A^D is the n x n domestic coefficient matrix, E is an n x 1 vector of exports.

The second measure of VS (VS1) refers to the country exports used as inputs in another country's production of exports. In other words, it is the value of intermediate goods exported indirectly to final destinations through third countries. Hummels et al. (2001) do not provide a mathematical representation of this concept due to data limitations, since it requires matching input-output tables to bilateral trade flows.

Two main assumptions are embodied in the notion of Hummels et al. (2001) VS: first, the imports are sourced completely from abroad, and there is no possibility of circular trade, hence of re-importing of processed exports; secondly, the imported inputs intensity of use is fixed both for domestic production and exports.

Starting from the pioneering paper by Hummels et al. (2001), further research on VS tries to overcome its limitations. Several authors discuss the links of their works and their suggested improvements with the concept by Hummels et al. (2001) and others provide generalized frameworks of decomposition of gross exports. Johnson and Noguera (2012) generalize the notion of Hummels et al. (2001) by relaxing one of the assumptions and allowing for two-way trade in intermediates, that is for country export intermediates to be further processed and finally consumed domestically. They propose the measure of value-added exports, which is the value-added produced in the origin sector i and absorbed in the destination sector j.

$$va_{ij} = r_i y_{ij} \tag{2.4}$$

where r_i is the sector-level value-added share of output and y_{ij} is the S x 1 vector of output from sector i and absorbed in sector j, obtained using the Leontief inverse matrix. Moreover, they provide the ratio of value added export to gross exports, so-called VAX ratio.

$$VAX_{ij} = \frac{va_{ij}}{x_{ij}} \tag{2.5}$$

with x_{ij} being the gross bilateral exports. They find that aggregate VAX ratios differ significantly across countries and sectors, with manufacturing showing lower VAX ratios. Discrepancies between bilateral gross statistics and value added exports measures are due to multilateral production sharing (circular or triangular trade).

While Hummels et al. (2001)'s VS measure is interpreted as the foreign (or import) content of exports, the VAX ratio by Johnson and Noguera (2012) is instead a measure of domestic content of exports. Johnson and Noguera (2012) demonstrate that in a two-country model, the two measures are complementary under the restrictive assumption that there is no two-way trade in intermediates. If there is no possibility for exports to be reimported and consumed in the home country, the VS overestimates the actual foreign content of exports, as it also incorporates part of value-added that eventually returns home for final absorption.

According to Wang et al. (2013), the VAX ratio reveals a couple of limitations. Firstly, the VAX ratio is not upper-bounded and it can provide misleading results, since it can take the value of infinity if countries have small or no direct exports. Secondly, the VAX ratio is a forward-linkage based measure and does not behave well at any level of analysis (sectoral or bilateral or both) apart from the country level. This metrics is not sufficient to determine the position along the GVCs of different country-sectors which may possibly share the same VAX ratios. A major shortcoming is that it does not take into account the value added that is initially exported and ultimately reimported to be consumed domestically. In particular, this is the case of more developed economies, located in the more upstream industries. Some of their value-added is initially exported and after further processing in more downstream stages, it is finally re-imported and absorbed domestically. In other words, the VAX ratio does not allow to qualitatively distinguish between upstream industries exports (part of which is finally reimported for domestic consumption) and more downstream industries exports, which are mainly absorbed abroad.

2.2.2 Value added in trade: decomposition methodologies of gross exports

Stehrer (2012) provides clear and distinguished definitions of trade in value added and value added in trade. On one hand, trade in value added refers to the value added content of one country embodied in the final consumption of another country. The VAX ratio refers to this strand of analysis. On the other hand, value added in trade is the value added content of one country embedded in the gross trade flows (import or export) with other countries. With respect to this concept, there are several attempts related to VS literature that decompose gross trade flows into various components at several level of detail.

In particular, Koopman et al. (2010) and Koopman et al. (2014) elaborate general frameworks that bind the previous research efforts on VS with the literature on value added in trade. Their accounting systems identify a clear link between traditional trade metrics and value-added measures. In fact, they demonstrate that measures like the value added exports and the several variations of VS are linear combinations of the value-added terms identified by their new decomposition methods of aggregate gross exports at country level. The simultaneous analysis of gross and value-added trade flows allows to better detect the patterns of international production sharing in terms of specialization and bilateral trade balances.

Koopman et al. (2010) provide a methodology to fully decompose a country's gross exports into a foreign and a domestic component.

$$E_r = V_r B_{rr} \sum_{s \neq r} Y_{rs} + V_r B_{rr} \sum_{s \neq r} A_{rs} X_{ss} + V_r B_{rr} \sum_{s \neq r} \sum_{t \neq r,s} A_{rs} X_{st} + V_r B_{rr} \sum_{s \neq r} A_{rs} X_{sr} + FV_r \quad (2.6)$$

E_r represents export of country r , V_r is the direct value-added coefficient matrix, B_{rr} is the Leontief inverse matrix, Y_{rs} is the final demand vector, A_{rs} is the input-output coefficient matrix and X_s is gross output of country s used to produce goods absorbed in country s, r and t. The first four elements are parts of domestic value added. The last term FV_r is foreign value added embodied in gross exports.

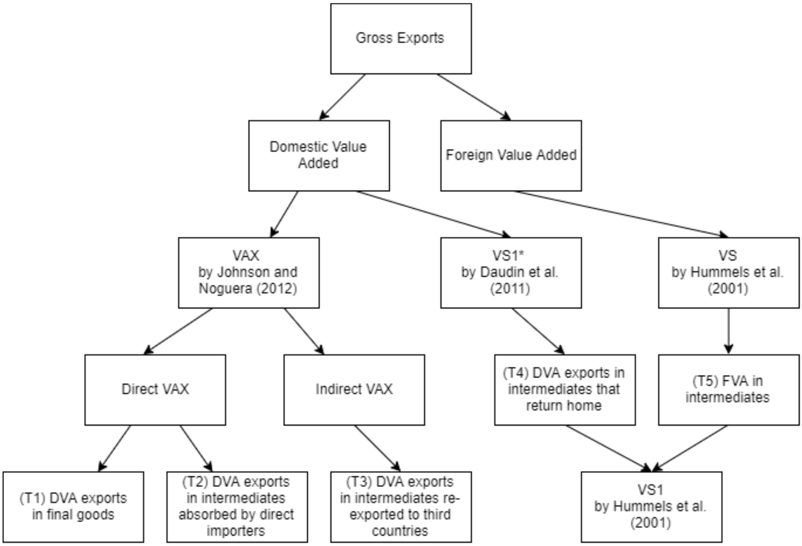
Table 2.1 summarizes the five terms of this decomposition methodology. More specifically, the foreign component is equivalent to the VS notion by Hummels et al. (2001) and the domestic component is broken down into four terms, according to use by the direct importer (absorption of final exports, production for direct importer consumption, for re-exporting to third countries, for re-exporting to home country). Koopman et al. (2010) pinpoint the foreign component and the part of domestic value-added returning home as the sources of double counted terms in trade statistics, since both elements cross borders more than once, but they do not provide a classification of these terms. A better representation of the relationship between the five components and the existing measures of VS is depicted in Figure 2.1.

Table 2.1: Decomposition of gross exports in 5 terms

Term	Description	Origin	Type	Absorption
T1	DVA exported in final goods	Domestic	Final	Direct importer
T2	DVA exported in intermediates absorbed by direct importers	Domestic	Intermediate	Direct importer
T3	DVA exported in intermediates re-exported to third countries	Domestic	Intermediate	Third countries
T4	DVA exported in intermediates that return home	Domestic	Intermediate	Domestic
T5	FVA in intermediates	Foreign	Intermediate	Foreign

Source: own elaboration based on Koopman et al. (2010)

Figure 2.1: Decomposition of gross exports (Koopman et al., 2010)

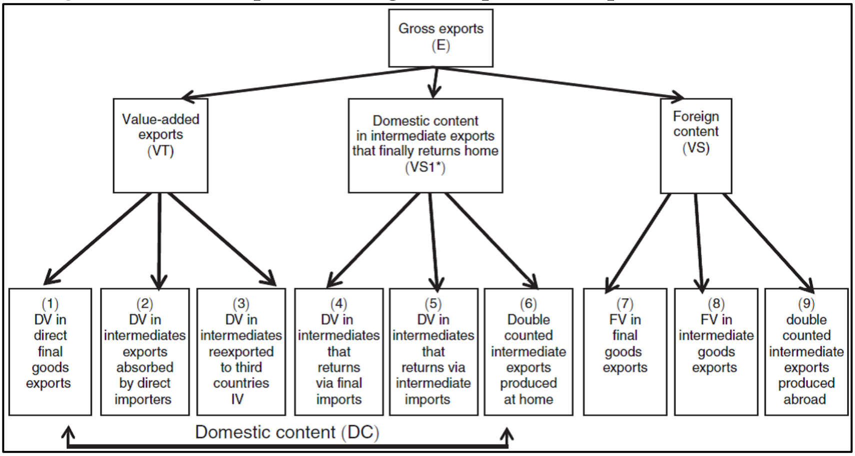


Note: Adapted from Figure 1 –Koopman et al. (2010)

The proposed methodology by Koopman et al. (2014) is the first attempt that tries to categorize also the double counted parts of gross exports. It decomposes gross exports into nine terms, that can be grouped into four sets of elements: first, value added exports consumed abroad equivalent to the VAX by Johnson and Noguera (2012); secondly, domestic value added exports that are first exported and finally re-imported to be consumed home; thirdly, foreign value added used in the production of exports and consumed abroad; finally, pure double counted terms, which are partly domestically generated and partly due to the multiple crossing of intermediate goods and services across borders.

Figure 2.2 shows the relationships between decomposition terms and the already discussed measures of vertical trade. Table 2.2 presents the decomposition of gross exports into nine terms according to Koopman et al. (2014) framework and highlights the country of origin and absorption of value-added and the use of the exports. This decomposition does not trace the number of stages that imported intermediates go through in the domestic market. Therefore, it holds at the country-sector aggregate level but not at the bilateral level.

Figure 2.2: Decomposition of gross exports (Koopman et al., 2014)



Source: Koopman et al. (2014)

Table 2.2: Decomposition of gross exports in 9 terms

Term	Description	Origin	Type	Absorption
T1	DV in direct final goods exports	Domestic	Final	Direct importer
T2	DV in intermediates exports absorbed by direct importers	Domestic	Intermediate	Direct importer
T3	DV in intermediates re-exported to third countries IV	Domestic	Intermediate	Third countries
T4	DV in intermediates that returns via final imports	Domestic	Intermediate	Domestic
T5	DV in intermediates that returns via intermediate imports	Domestic	Intermediate	Domestic
T6	Double counted intermediate exports produced at home	Domestic	Intermediate	Domestic
T7	FV in final goods exports	Foreign	Final	Foreign
T8	FV in intermediate goods exports	Foreign	Intermediate	Foreign
T9	Double counted intermediate exports produced abroad	Foreign	Intermediate	Foreign

Source: own elaboration based on Koopman et al. (2014)

2.2.3 Value added in trade: decomposition methodologies of bilateral gross exports

Further efforts on value added in trade are focused on disaggregation methodologies of gross trade flows at finer levels of detail. Wang et al. (2013) provide a generalization of all the previous efforts in the research area of gross trade decomposition at different levels of disaggregation. This novel accounting framework improves some methodological techniques and gives relevant information about cross-country production sharing and sector location in GVCs. The goal of their framework is to decompose trade flows in intermediate inputs by separating the value added contribution from the double counted terms, at both sector and bilateral level.

Wang et al. (2013) attempt to go beyond the application of the well-known Leontief (1936) methodology. While gross exports in final goods and services can be easily decomposed into foreign and domestic value-added terms applying the Leontief insight, the same cannot be replicated for intermediate exports because it would not take into account the double counted terms. The use of the local Leontief inverse allows to decompose intermediate inputs according to countries' final demand and to the country of absorption.

At aggregate country level, forward-linkage and backward-linkage based value-added measures coincide. The bilateral sector computation is particularly challenging due to the fact that gross exports can be decomposed either from a forward-linkage perspective, which is from the production point of view, or from a backward-linkage based perspective, that is the consumers' point of view. In fact, domestic value added on sector may also be exported indirectly through other domestic or foreign sectors and domestic value added of one country included in total gross exports may include value-added stemming from other sectors. The perspective adopted for domestic content is based on backward-linkage. In Wang et al. (2013) framework, bilateral gross exports can be decomposed in sixteen components, summarized in Table 2.3.

Table 2.3: Decomposition of gross exports in 16 terms

Term	Name	Description	Origin	Type	Absorption
T1	DVA_FIN	DVA exports in final goods exports	Domestic	Final	Direct importer
T2	DVA_INT	DVA in intermediate exports to the direct importer and is absorbed there	Domestic	Intermediate	Direct importer
T3	DVA_INTrexI1	DVA in intermediate exports used by the direct importer to produce intermediate exports for production of third countries' domestic used final goods	Domestic	Intermediate	Third countries
T4	DVA_INTrexF	DVA in Intermediate exports used by the direct importer producing final exports to third countries	Domestic	Intermediate	Third countries
T5	DVA_INTrexI2	DVA in Intermediate exports used by the direct importer producing intermediate exports to third countries	Domestic	Intermediate	Third countries
T6	RDV_FIN	Returned DVA in final goods imports -from the direct importer	Domestic	Final	Domestic
T7	RDV_FIN2	Returned DVA in final goods imports -via third countries	Domestic	Final	Domestic
T8	RDV_INT	Returned DVA in intermediate imports	Domestic	Intermediate	Domestic

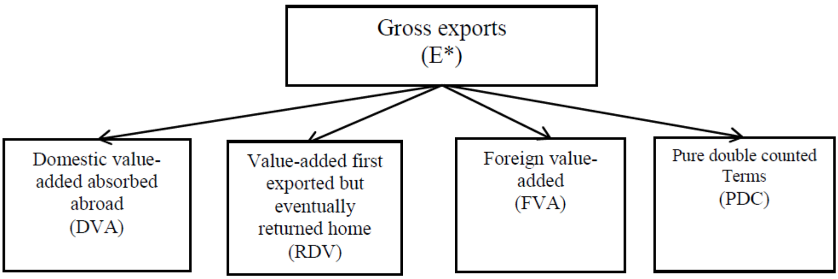
T9	DDC_FIN	Double counted DVA used to produce final goods exports	Domestic	Final	Double counted
T10	DDC_INT	Double counted DVA used to produce intermediate exports	Domestic	Intermediate	Double counted
T11	MVA_FIN	Direct importer’s VA in source country’s final goods exports	Foreign	Final	Foreign
T12	OVA_FIN	Direct importer’s VA in source country’s intermediate goods exports	Foreign	Intermediate	Foreign
T13	MVA_INT	Direct importer’s VA double counted in exports	Foreign	-	Double counted
T14	OVA_INT	Third countries’ VA in final goods exports	Foreign	Final	Foreign
T15	MDC	Third countries’ countries’ VA in intermediate goods exports	Foreign	Intermediate	Foreign
T16	ODC	Third countries’ VA double counted in exports production	Foreign	-	Double counted

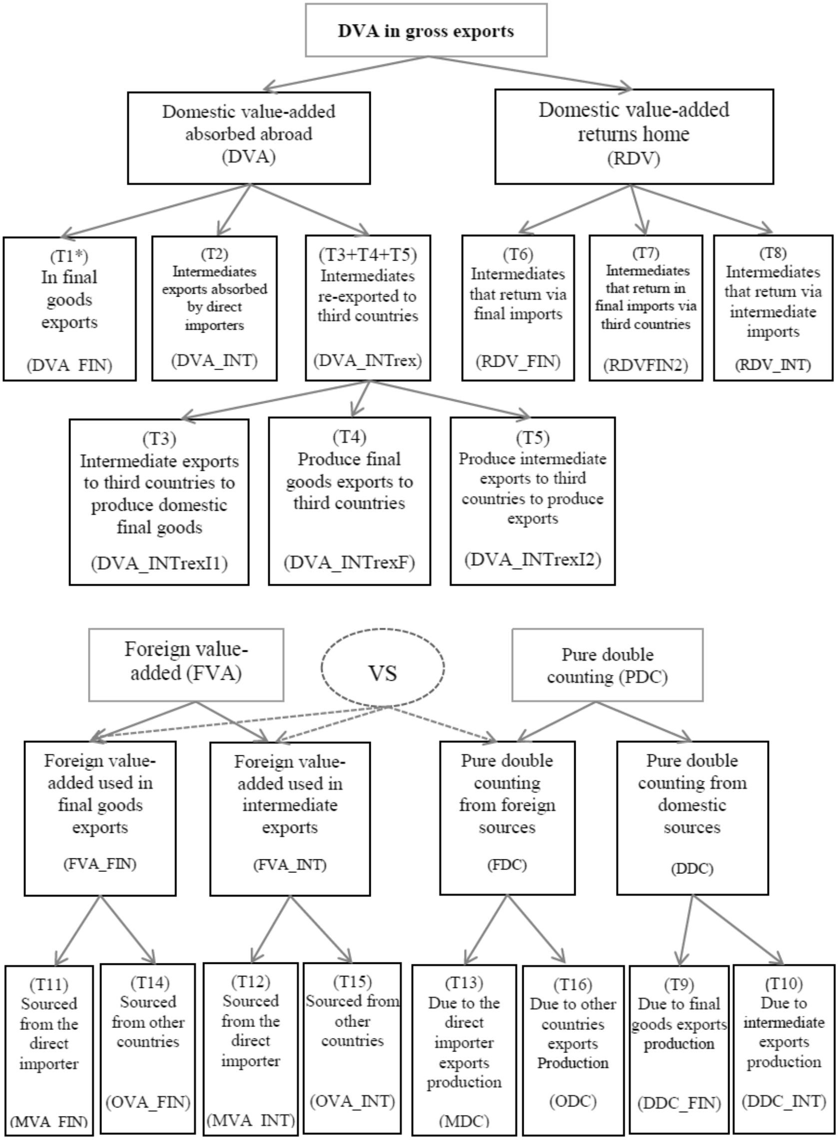
Note: adapted from Table J1 – Wang et al. (2013)

This advanced disaggregation carried out by Wang et al. (2013) has two main benefits: all the components are consistent with each other, so that their sum is equal to the gross term, and it is a generalization of the already discussed decomposition by Koopman et al. (2014). The sixteen components can be clustered into four major groups: Domestic Value Added (DVA), that is finally consumed abroad; Returned Domestic Value (RDV), which is domestic value added, that is initially exported and returns to the home country through reimported intermediate inputs for ultimate consumption; Foreign Value Added (FVA), which is value-added generated abroad; Pure Double Counted (PDC) components, which are due to the multiple flows of intermediate inputs across countries.

While Johnson and Noguera (2012)'s VAX measures the domestic value added exported and consumed abroad and generated only in the sector, DVA as defined by Wang et al. (2013) takes also into account of domestic value added generated in all the other domestic sectors which is exported through the sector under consideration. Wang et al. (2013) suggest to use the share of domestic value added absorbed abroad as an inverse metrics of VS. This measure is based on backward linkages, bounded between 0 and 1 and defined at bilateral sector level. This measure is equivalent to the forward- and backward-linkage based VAX ratio, which holds only at aggregate level. The disaggregation in four main sets and the link of the elements with VS is diagrammed in Figure 2.3. With respect to previous works, VS differs from FVA, as it includes also part of multiple counted terms.

Figure 2.3: Decomposition of gross exports (Wang et al., 2013)





Source: Wang et al. (2013)

Additional contributions on the research of bilateral trade flows decomposition come from more recent works. Nagengast and Stehrer (2014) carry out a deeper investigation on the factors underlying the discrepancies between bilateral value added and gross trade metrics. More specifically, they provide two different frameworks for the decomposition of value added in bilateral trade relationships. One approach is source-based or forward-linkage based, meaning that it is based on the perspective of the origin country where the value added stems from by tracking the first time that value added is recorded in international trade statistics; the second approach is sink-based or backward-linkage based, considering the perspective of the destination country where the value added is finally absorbed. Nevertheless, neither methodology is able to entirely explain the domestic value added component in bilateral trade flows. Borin and Mancini (2015) argue that in both approaches, some domestic value added terms are misestimated, so that the sum of all the components does not equal the total gross exports.

Starting from Koopman et al. (2014), Borin and Mancini (2015) extend the framework and decompose gross exports at the bilateral level using both perspectives, the source-based and the sink-based perspectives, accounting for domestic value added as well as multiple counted terms and better distinguishing between value added absorbed by direct importers and by third countries. Similarly to Wang et al. (2013), the decomposition results in a generalization of the Koopman et al. (2014) framework with a total of sixteen terms of gross exports and it can isolate the value added by country of absorption (direct importer or third countries). They provide a more detailed definition of direct absorption, which is the value added that is exported only once to the importing country and directly absorbed, without further stages of production abroad. Therefore, their source-based GVC indicator takes into account also value added generated in the source country and absorbed by the destination country, indirectly after other processing stages in third countries. The measure used to assess the international fragmentation in GVCs is the complementary of the share of direct absorption in gross exports. The measure of direct absorption includes all the domestic value added absorbed from the direct importer. Unlike in Koopman et al. (2014), it makes the use of the local Leontief inverse matrix, which is more appropriate to capture circular trade flows. Borin and Mancini (2015) argue that Wang et al. (2013) adopt a sink-based perspective for domestic value added in direct exports of final goods while for the other components, it is adopted a source-based perspective. For these reasons, it is not possible to compare the items of the decomposition among each other. Furthermore, they argue that Wang et al. (2013) make use of different ways to treat trade in final goods and in intermediates. This renders the comparison and the analysis of trade flows inappropriate.

2.3 Global Value Chain Positioning Metrics

Starting from the concept of average propagation length, proposed by Dietzenbacher et al. (2005), which measures the number of production stages in production networks necessary for a shock to propagate from one industry to another, there is an increasing number of researches which focus their analysis on GVC positioning metrics and revolve around the notions of vertical fragmentation (Fally, 2012) and downstreamness or upstreamness (Antràs and Chor, 2013; Antràs et al., 2012; Alfaro et al., 2017).

2.3.1 Vertical Fragmentation and Downstreamness

The notion of vertical fragmentation and downstreamness are related. The first refers to the number of sequential stages and sectors involved in a production process. The concept of downstreamness (or upstreamness) refers to the proximity (or distance) between production and final consumption.

The already cited studies on VS mainly consider cross-border transactions. Therefore, the perspective proposed by Johnson and Noguera (2012) on VS and the ratio of Hummels et al. (2001)'s VS to VS1 as a proxy of downstreamness are based at country-level.

Conversely, measures of vertical fragmentation are devised for analysis at the sector level. Fally (2012) provides three measures of cross-sectoral vertical fragmentation of production processes across different stages of the value chain, specifically N_i, D_i and H_i. Antràs and Chor (2013) build two measures of downstreamness (*DUse_TUse* and

DownMeasure) making use of input-output methodology at the sector level. A later study by Antràs et al. (2012) shows that the two measures of vertical fragmentation and downstreamness coincide.

The first measure proposed by Fally (2012), N_i, identifies the number of sectors necessary to produce a good or service and is computed as a weighted average of the number of sectors where the weight is the value-added contribution. N_i is the average number of stages that enter the sequential production process. It can also be computed as the weighted average number of stages where the weight is the relative value added contribution of each stage. The measure does not distinguish between foreign and domestic stages of production. N_i is equal to the gross-output-value-added ratio in the case that N_i is equal for all the products. The ratio between gross output and value added has been previously employed as a measure of sector-level vertical fragmentation (Adelman, 1995; Woodrow, 1979; Macchiavello, 2012). The measure is calculated as follows:

$$N_i = \sum_{n=1}^{\infty} n \, v_i^{(n)} \tag{2.7}$$

where n is the stage number (with 1, being the most downstream) and $v_i^{(n)}$ is the fraction of output value of sector i crossing n stages.

The second measure by Fally (2012) D_i is the average number of stages between production and final consumption. D_i is the weighted average number of stages between production and final consumption. It expresses the distance between producer and final demand. It ranges from 1 and infinity. It depends on the share of production used as intermediate inputs in downstream industries. The index is equivalent to the weighted average of the number of production stages between producer and final consumer, where the weight is represented by the sector output share:

$$D_i = \sum_{n=1}^{\infty} n \, s_i^{(n)} \tag{2.8}$$

where $s_i^{(n)}$ is the share of output of sector i value crossing n stages before reaching final demand. Fally (2012)'s estimate relies on the fact that vertical positioning of one sector is dependent on the level of upstreamness in the closest downstream sector. In order to better account for the degree of dispersion of sequential production along the value chain, Fally (2012) proposes a third measure of vertical fragmentation H_i, similar to the Herfindal Index, which assesses the level of concentration of value added across sectors. The index is computed as follows:

$$H_i = \frac{1}{\sum_{n=1}^{\infty} n \left(v_i^{(n)}\right)^2} \quad (2.9)$$

and is equal to 1 if the source of value added is unique or larger values if the origin of value added is more dispersed.

The first downstreamness measure by Antràs and Chor (2013), *DUse_TUse*, is computed dividing the aggregate direct use by the aggregate total use of output at the sector level. For a pair of sectors i and j, the direct use is the amount of output from sector i directly used by sector j to produce final goods. The total use is the amount of output from sector *i* used directly or indirectly through other upstream sectors in the production of sector j for final use. The index ranges from 0 to 1. For lower values of *DUse_TUse*, the contribution of a sector input to the production chain takes place mostly indirectly, that is in more upstream phases. A higher value of the index indicates that the contribution of a sector input is mostly direct in the production of sector *j* output.

The second measure of downstreamness by Antràs and Chor (2013), *DownMeasure*, is a weighted average of the position where the output is used, with the shares of use in that stage of the sector output being the weights. This index complements the first by providing additional information on the indirect use of output in more upstream stages. The construction of the index can be simply expressed as a function of the elements of a Leontief inverse matrix. For each industry *i*, *DownMeausre* is the *i-th* entry of $[I-D]^{-2}F$ normalized by total output, where D is the direct requirement matrix and F is the final use vector. *DownMeasure* ranges from 0 to 1 and measures the distance from final demand. Its reciprocal is equivalent to an upstreamness measure, which takes values equal or greater than 1. The index ranges from 1, for the most downstream sector, to larger values, for more upstream sectors. The measure takes into account all the amounts of one sector's output needed to produce one value unit of the immediate downstream industry's output. It highlights the length of the value chains in terms of number of stages between the input production in sector *i* and final use in sector j and it can be seen as a forward-linkage measure of cost-push effects, considering a supply-side perspective. It assesses the impact of value added variations in sector i on all the other sectors' output in the economy.

Antràs et al. (2012) review the measures of sector distance from final consumer (that is upstreamness) and demonstrate that the upstream version of Antràs and Chor (2013) *DownMeasure* equals Fally's (2012), measure of distance D_i. This upstreamness measure also corresponds exactly to the row sum of the so-called Ghosh inverse matrix $[I-\Delta]^{-1}$ (Ghosh, 1958), a forward linkage based measures of trade from input-output analysis.

A limitation of this upstreamness measure is that distance between sectors is fixed to one and does not depend on the amount of trade flows because they consider a closed-economy setting with no imports and exports. It can be shown that the two measures still coincide in an open economy setting if we assume that, consistently with countries' choice to specialize in different stages of the value chains, given two sectors i and j, the share of sector's i exports used by sector j's producers is equal to the share of sector i output used in sector j.

While upstreamness by Fally (2012) and Antràs et al. (2012) reflects the average positioning of an industry i with respect to final consumption and investment, Alfaro et al. (2017) provide an alternative measure of upstreamness $upst_{ij}$ on the base of input-output tables, which provides industry-pair specific information about the vertical location of input i relatively to production in sector j. In this sense, it can be seen either as an extension at the bilateral sector level of the previous measure developed by Fally (2012) and Antràs et al. (2012) or as an average propagation length à la Dietzenbacher et al. (2005). This measure, $upst_{ij}$, is based on the values that enter directly (in one stage) the production of the relative downstream sector. In matrix notation, it is the ratio between the *ij*-th entry of $[I-D]^{-2} D$ and the total requirement coefficient, that is the *ij*-th entry of $[I-D]^{-1} D$, where I is the identity matrix, D is the direct requirement matrix, $[I-D]^{-1}$ is the Leontief inverse matrix. In other words, the total requirement coefficient is the total value of i used to produce one value unit of output j and it gives information about the relative importance of i for sector j. The measure of upstreamness of i in the production of j can be seen as a weighted average of the number of stages necessary for sector i to access the production of j and the weights are represented by the share of total requirement coefficient to the relative upstream stage. It takes the lowest value, that is 1, if all the input use of i accrues to output j in one stage only. Larger values of the measure correspond to greater relative input use value of i in the total output of j. The measure is not upper-bounded, it is more appropriate to the firm-level analysis. Furthermore, Alfaro et al. (2017) construct an additional variable called ratio-upstreamness which measures the level of upstreamness of a firm's integrated inputs relative to its non-integrated inputs.

A more recent work by Antràs and Chor (2018) provides an overview of the several metrics of upstreamness and document their dynamics, making use of the WIOD.

2.3.2 Relationship with Participation Metrics

A full comprehension of the growing complexity of GVCs requires novel measures that can capture not only the degree of country participation but also the relative positioning in the production process and the distance between economic agents (countries, industries or single firms). For instance, countries may have the same degree of vertical integration (i.e. value added export ratios) but may have a different positioning along GVCs. Quantifying and classifying the double counted components from decomposition frameworks can provide significant insights about the position of countries in GVCs as well. Koopman et al. (2014) argue that the ratio of foreign value added to returned value added is a proxy of downstreamness.

The foreign value added share indicates the share of a country's exports that consist of inputs produced in other countries and thus does not add to the GDP of the country of interest. It is therefore likely to be higher if a country is involved in downstream production processes. The indirect value added exports share is the share of a country's value added exports embodied as intermediate inputs in other countries' exports (i.e. forward integration), and it represents the contribution of the domestic sector to the exports of other countries, thus indicating the extent of GVC participation for relatively upstream sectors.

Koopman et al. (2010) provide an application of the value-added measures and link them with positioning. In their work, they construct two indexes (*GVCPosition* and *GVCParticipation*) to measure both the country-sector participation and upstreamness based on indirect value added and foreign value added in exports, which are two of the five terms composing gross exports.

$$GVCPosition_{ir} = \ln\left(1 + \frac{IV_{ir}}{E_{ir}}\right) - \ln\left(1 + \frac{FV_{ir}}{E_{ir}}\right) \quad (2.10)$$

$$GVCParticipation_{ir} = \frac{IV_{ir}+FV_{ir}}{E_{ir}} \quad (2.11)$$

An alternative index of positioning in GVCs is the ratio between indirect value added and foreign value added. If the index is larger than 1, the country is located in a relatively upstream position with respect to other countries, in the sense that it provides more value-added than it receives. Conversely, an index between 0 and 1 indicates a position of downstreamness. This index is similar to the ratio between VS1 and VS proposed by Daudin et al. (2011), but it emphasizes the role of domestic indirect exports.

Considering both the dimensions of participation and positioning, Wang et al. (2013) refined decomposition technique helps to reconcile all the previous measures of VS and provides a more detailed disaggregation of all the bilateral trade components. With respect to the foreign value added defined by Wang et. al (2013), the VS measure (Hummels et al., 2001) includes a pure multiple counted component as a result of multiple crossing of intermediate inputs across countries. The VS measure can be decomposed into three parts, identified by Wang et al. (2013), each with a different economic interpretation. In this way, it is possible to analyse the different structure of VS of country-sectors and extrapolate information on the positioning along GVCs: foreign value added in final exports (FVA_FIN), foreign value added in intermediate exports (FVA_INT), pure double counted component in foreign value added exports (FDC). First, countries engaged in final assembling of foreign intermediate components, located at the bottom of the global supply chains, are expected to have a relative higher share of FVA_FIN in gross exports. Secondly, countries which are not positioned at the lower end of the value chain are supposed to produce and export an increasing share of intermediate inputs, which is FVA_INT, relative to gross exports to third countries for final production and consumption. Finally, Wang et al. (2013) indicate the FDC component as a measure of depth of international production sharing, that is frequency of multiple crossing of intermediate inputs in trade flows, or the length of the global supply chains. We consider the disaggregation framework proposed by Wang et al. (2013) a comprehensive tool that integrates the perspective of participation and positioning in GVCs and will be useful for the purpose of our analysis in the empirical section of this chapter.

2.4 The Inter Country Input-Output Databases

The objective of decomposing trade flows by country and sectoral value-added components has raised the need of inter-country input-output tables taking into account and harmonizing trade flows of intermediate inputs. While the role of national institutes of statistics is crucial for collecting and providing these tables, there is the need to harmonize and coordinate the single national efforts and provide a unique multi-regional dataset. The main issue with the construction of an international input-output table is the identification of the link between the selling industry and the purchasing industry, domestically or abroad, for final or intermediate consumption. Frequently, data do not provide clear information whether the usage in one stage is the final consumption or an intermediate processing.

Researchers have tried to tackle this issue of uncertain usage exploiting customs classification, even though the same products can be used as intermediates or final goods. Some countries provide information on special customs regimes for processing trade, for instance intermediates which are later processed and re-exported (Koopman et al., 2008). One of the most common techniques to address the issue of intermediate usage is the use of input-output tables, where the information is aggregated at country- or sector-level.

2.4.1. The World Input-Output Database

The World Input-Output Database (WIOD) consists of a time series of inter-country input-output (ICIO) tables, which is freely available since 2012. It was created by a consortium of 11 European research institutions and financially supported by the European Commission. Timmer et al. (2012) provide an extensive description of the WIOD database, its strengths and weaknesses, construction methods and sources. The dataset ranges from 1995 to 2011, it covers 40 countries worldwide and 35 sectors. The latest release (2016) covers 43 countries, 56 sectors for the period from 2000 to 2014. It exploits supply-use tables (SUT) from single country's national accounts and combines them with bilateral trade statistics to obtain a final symmetric global input-output table. It connects SUT data with product-based trade statistics and sectoral employment and value-added data. It also avoids error inherent in the assumptions imposed when transferring SUTs to symmetric input-output tables before the reconciliation process starts. The WIOD is closely linked to EU KLEMS and World KLEMS; it improves the allocation of inputs by end use category and provides a better decomposition of capital types and labor skill categories. One of the major shortcomings of the WIOD is that exports to the rest of the world are derived residually, therefore they may become negative as well. Moreover, contrary to EORA, there is no reconciliation procedure based on constrained optimization and data reliability. Country coverage is skewed toward developed countries and several developing countries are neglected.

2.4.2 OECD Inter-Country Input-Output database

Similarly to WIOD, the OECD ICIO database is based on OECD harmonized single national input-output tables. It is used as the main source for the first OECD-WTO public database on Trade in Value Added (TiVA), which provides indicators for all the years over the period 1995-2001, across 63 countries and 34 industries. The OECD has the objective to improve the quality, the time and country coverage of the tables in the future. The key sources for the construction of the OECD project are the national bilateral input-output tables such as National Accounts, Supply and Use tables, and the bilateral trade coefficients.

2.4.3 European Union KLEMS

The European Union KLEMS has the objective to "create a database on measures of economic growth, productivity, employment creation, capital formation and technological change at the industry level for all European Union member states starting from 1970. This project provides an important contribution to policy evaluation, in particular for the measurement of the goals concerning competitiveness and economic growth potential as established by the Lisbon and Barcelona summit goals. The database facilitates the production of high quality statistics using the methodologies of national accounts and input-output analysis. The input measures include various categories of capital, labour, energy, material and service inputs. Productivity measures are developed with growth accounting methodologies. Several measures on knowledge creation are constructed. Substantial methodological and data research on these measures has been carried out to improve international comparability. There is an ample attention for the development of a flexible database structure, and for the progressive implementation of the database in official statistics over the course of the project. The database will be used for analytical and policy-related purposes, in particular to study the relationship between skill formation, technological progress and innovation on the one hand, and productivity, among the others. The balance in academic, statistical and policy input in this project is realised by the participation of 15 organisations from across the EU, representing a mix of academic institutions and national economic policy research institutes and with the support from various statistical offices and the OECD. The EU KLEMS project ran from 2003 until 2008 and will not be updated anymore. It was funded by the European Commission." (European Commission, http://www.euklems.net/project_site.html.).

2.4.4 EORA-Multi Regional Input-Output database

EORA is a Multi-Regional Input-Output (ICIO) database with matching environmental and social satellite accounts for 187 countries, covering a 26 sectors over the period 1990-2012, freely available on the internet. All raw data are stored and processed together in one single balancing and optimization procedure. Lenzen et al. (2013) describe the procedures and the results of the project. It is characterized by a high level of standardisation, automation and data organisation. EORA has some key features: it represents all countries at a detailed sectoral level, it allows constant updating, provides information on data reliability and also contains information expressed in basic prices. In particular, EORA provides a methodology to estimate the standard errors for each unit of the ICIO table to measure the level of reliability and uncertainty using constraint violation and discrepancy indicators between the final dataset and the initial unbalanced dataset. UNCTAD (2013) has exploited the EORA dataset to produce an alternative set of indicators of Trade in Value Added to the OECD-WTO TiVA.

2.4.5 Others

There are several other projects aimed at constructing international and multiregional Input-output dataset. The Center of Global Trade Analysis at Purdue University has developed and maintains the Global Trade Analysis Project (GTAP) database, covering 114 countries in 20 regions, 57 industries. GTAP is based and reconciled with official trade statistics which guarantee its reliability (Gehlhar, 1996). Demand data of single countries and sectoral supply data may be subject to large differences compared to the national accounts, as GTAP uses only adjusted trade statistics as benchmark. Also, there is no time reconciliation such that intertemporal comparisons of different versions of the dataset are inconsistent. There is no distinction between intermediate and final good trade flows in the data, because the GTAP database relies on the literature on the ICIO table. In order to obtain ICIO tables from the GTAP database, it is necessary to transform the data (Tsigas et al., 2012; Greenville et al., 2017). The Asian Development Bank (ADB) Multi Regional Input-Output database has included more Asian countries in the WIOD in order to facilitate research related to the Asia and the Pacific Region. Bangladesh, Malaysia, Philippines, Thailand and Vietnam have been added for the years 2000, 2005-2008, and 2011. The ADB-ICIOs do not exactly match with the WIOTs since during the construction process, the values for other countries were adjusted such that the tables were still balanced. EXIOBASE is a global, detailed Multi-regional Environmentally Extended Supply and Use / Input Output database. The Institute of Developing Economies, Japan

External Trade Organization (IDE-JETRO) has been producing international input-output tables with a focus on Asia-Pacific countries since 1975, namely the Asian International Input-Output Tables (AIIOTs), covering the period 1985-2005.

2.4.6 Comparison between Inter-Country Input-Output Tables

Inter-Country Input-Output Tables represent the baseline framework for the analysis of trade activity at a global scale and the development of both economic and environmental measures of trade in value-added. Due to their great repercussions on policy recommendations, it is necessary to provide an assessment of the quality of these datasets. Steen-Olsen et al. (2016) compare the differences between three Inter-Country Input-Output (ICIO) tables, that is the WIOD, the EORA and the GTAP databases, in the same year (2007) and find that at a global scale there are no major discrepancies. However, significant differences arise when accounting for country and sector level of detail. With the unbundling of supply chains in different locations, the production process is increasingly more separated from the consumption phase. Within this context, the creation of Inter-Country Input-Output Tables helped the reconciliation between trade flow statistics and factor use and consumption analysis and environmental impact. Value added in trade as well as environmental footprint of trade are the most relevant and widespread applications of the ICIO tables. Murray and Lenzen (2013) provide a summary of the recently developed ICIO tables. The emergence of several different ICIO tables poses a certain number of issues about their reliability, reproducibility as well as their comparability in terms of interpretation of the results and policy implications. Recently, a number of researchers (Inomata and Owen, 2014; Moran and Wood, 2014; Owen et al., 2014; Arto et al., 2014) have focused their efforts in assessing the differences across datasets of environmental impact of factor use. Steen-Olsen et al. (2016)'s comparison focus on the value added in trade in order to analyse the production- and consumption-based points of view at a global, country and sectoral scale. They prefer to exclude the environmental factors in order to avoid including additional data consisting of physical and not economic quantities.

The authors classify the differences among the tables in four main categories: the source, which can be the national input output accounts, bilateral trade flow statistics and environmental accounts; country and sector coverage; the different use of supply use tables or symmetric input-output tables, the methodologies to ensure balanced data, to surmount missing information and the methodologies to harmonize inconsistent data. The first step in order to allow for comparison of dissimilar ICIO tables is the harmonization based on the principle of greatest common factor to obtain a common classification system of countries and sectors. The final system resulted in a set of 40 countries and 17 sectors. Since there is not a single and univocal accurate statistical test for matrix correspondence (Butterfield and Mules, 1980), the authors use a set of metrics in order to assess the similarity of the ICIO tables. The similarity tests share the key feature of commutativity, that is the similarity results remain the same if the matrices are interchanged. The authors choose six statistical tests. Three are considered distance measures (the mean absolute deviation, from Harrigan et al., 1980, the mean squared deviation and the Isard-Romanoff similarity index). They are based on the absolute or relative differences between the elements of the matrices. The other three tests (the absolute psi statistic, the absolute entropy distance, both based on the information gain statistic by Kullback and Leibler (1951) and the R-squared) are all scale-invariant, that is the indicators do not change if the matrix is multiplied by a scalar. The first results are based on the aggregate global value added. Although the accounts are based on different sources, the comparisons show results close to each other, ranging from 52.7 trillion USD of EORA to 53.6 trillion USD of GTAP. At a common classification sectoral level of detail, the comparison of global value-added accounts both from a consumption-based and production-based perspective shows homogeneity across ICIOs, with a weighted average relative standard deviation at 7%.

Table 2.4: Main Inter-Country Input-Output Tables

	Institution	Sources	Number of countries	Number of industries	Available years
World Input-Output Database (2013 and 2016)	Consortium of 11 institutions, University of Groningen	National accounts (supply use tables)	43 + Rest of the World	56	From 1995 to 2014 (yearly)
OECD Inter-Country Input-Output database	OECD	National I-O and supply-use tables and National Accounts	63	34	From 1995 to 2011(yearly)
European Union KLEMS	15 research institutes led by University of Groningen	National accounts and national Input-Output tables	EU countries (between 15 and 25)	71	1970-2005
EORA-Multi Regional Input-Output database	University of Sydney	National accounts and national Input-Output tables	187	26	From 1990 to 2012 (yearly)

2.5 Descriptive Statistics

In this section, we analyse the evolution of the transport equipment industry exports in EU countries and emphasize the trade dynamics between core countries, such as Germany, and peripheries, that is Central Eastern European (CEE) countries. We apply the disaggregation framework of sector and bilateral gross exports proposed by Wang et al. (2013), which allows us to highlight both the degree of country participation and relative positioning to the international value chains, in terms of value added components and VS. We make use of the WIOD and consider sector 15 "Transport Equipment".

Table A.1 in the Appendix A displays the main exporter countries in the European Union (EU), considering the group of 27 countries belonging to the EU in 2011[1], over the period 1995-2011. All the trade figures are reported in millions of dollars at current price.

The top 5 countries, such as Germany, France the UK, Spain and Italy, are all developed and older members of the EU, they have maintained a position of leadership in exports and still represent almost three quarters of the total EU exports in this sector. However the relevance of other countries has increased considerably. We group seven CEE countries which accessed European Union in the 2000s: Czech Republic, Hungary, Poland, Slovakia, Slovenia in 2004 and Bulgaria and Romania in 2007. The export share of this group increased from 2.4 % to more than 11 % in 2011, with two countries, Poland and Czech Republic being two of the 10 main exporters.

Tables in the Appendix A (from Table A.2 to Table A.6) present the decompositions of Transport equipment gross exports of Germany, France, the UK and Italy and CEE countries over the period 1995-2011.

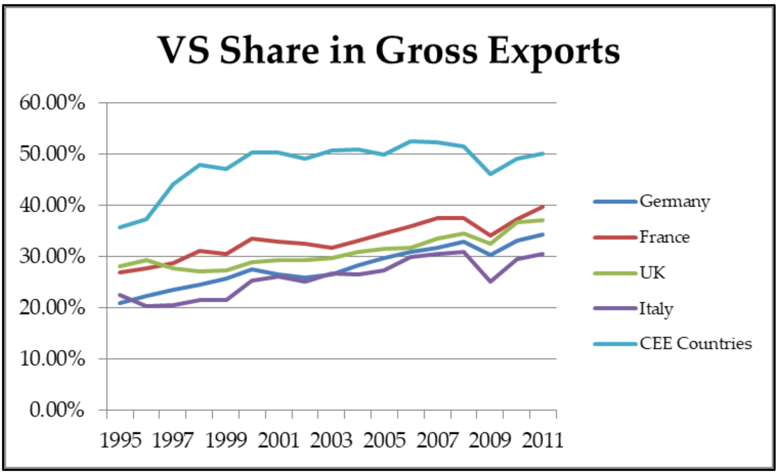
Similar considerations can be made concerning the trends of exports components in the four countries under analysis. In particular, the share of domestic value added (DVA) has decreased in all four countries and it represents the highest share in Italy in 2011 (68.3 %). The foreign value added (FVA) part is on average low (between 1 and 2%) and has remained relatively constant over time. Conversely, the

[1] We refer you to Table A.12 in Appendix A for the full list of countries

combined shares of returned domestic value (RDV) and pure double counted (PDC) have increased in all countries ranging between 31% in Italy and 40% in France in 2011. The patterns of the gross exports components in Transport Equipment industry of the CEE countries considered altogether seems close to those of Western European Countries. The reduction in DVA was sharp from 64 % in 1995 to slightly less than 50 % in 2011, the share of FVA has remained negligible over time, but the joint shares of RDV and PDC have increased considerably representing more than half of total exports in 2011.

Figure 2.4 shows the time series of VS shares of total gross exports in the set of countries under analysis. In all the countries, the trend is positive and the share is significantly higher in CEE countries, signalling a greater dependence of these countries' exports on the foreign markets of the value chain. VS in transport equipment sectors increased in all the Western countries analysed by almost 11% on average (from a mean value of 24.7% in 1995 to 35.5% in 2011). Similarly, in the group of CEE countries, the foreign content of exports increased by a larger magnitude compared to the other countries (14.5% over 17 years), representing more than half of the total exports (50.2%) in 2011.

Figure 2.4: Vertical Specialization Share in Gross exports in Transport Equipment Industry (WIOD 15)



According to Wang et al.'s (2013) framework, VS can be further decomposed in three of the sixteen components of the total gross exports, each of these having a specific economic interpretation with respect to the trends of international production sharing. The three components are foreign value added in exports of final goods (FVA_FIN), foreign value added in intermediate inputs exports (FVA_INT) and the pure double counted component in foreign value added exports (FDC). Additionally, decomposing VS can provide information about the relative importance of each term and discover main drivers of VS variations over time. We present the decomposition of VS in the EU countries under consideration in the Appendix A, from Table A.7 to Table A.11.

FVA_FIN is expected to be high in the countries which are at the end of the GVCs, that is at the lower bottom of the production processes (mainly final assembling of imported intermediates). The share of FVA_FIN in VS ranges between 50 and 60%. The share is relatively high (almost 60%) and stable over time in Germany, it has decreased in France and Italy and in the CEE countries, while it increased in the UK. The share of FVA_INT may represent the engagement in activities upper in the global supply chains. A large share of exports of intermediated inputs abroad, which may be possibly further re-exported to third countries for final production and consumption, signal that there is an upgrade in the positioning of the industry along the GVC. The share of FDC in VS is a measure of the length of the global supply chain, as it increased with the frequency of multiple cross-border flows of intermediate inputs. The FDC share of VS increased in all the countries over the time span under analysis. In Germany, the FDC component increased from 14.4% to 19.6% in 2011. In the other Western economies, the FDC share raised from a mean value of 15.1% to 19.7%. The CEE countries as a group shows a relatively higher share of FDC in VS compared to other EU countries, ranging from 18.8% at the beginning of the period, to 32.1% in 2005, and reaching 28.5% in 2011. The dynamics of the VS components show that its variations are mainly driven by the increase in FDC. This points to the fact that the increase in the foreign content of gross exports in the transport equipment sector is due to the increased deepening of cross-country production relationships and a greater volume of back and forth trade in intermediates. Despite similar trends in the composition of VS structure, there is some degree of heterogeneity across the group of countries in terms of magnitude. In particular, the CEE countries experienced a larger increase with respect to other countries relatively to both the VS share of total exports and the FDC share of VS. Furthermore, the overall incidence of FDC on total gross exports of CEE countries in 2011 is 14.3%, twice as much as the mean value for Western countries (6.9%). In order to delve deeper in the production sharing within the European region, we analyse the bilateral trade exchanges between Germany and the CEE countries in the transport equipment sector. Over time, Germany has remained steadily the main exporter, being the hub of the European Region Factory, while CEE economies have witnessed an upsurge in trade flows, with a few countries (Poland and Czech Republic) gaining a crucial role in the regional production sharing. Table 2.5 provides a decomposition of total bilateral gross exports for years 1995, 2003 and 2011. Column (1) shows the total gross exports for both bilateral exchanges. The numbers indicate that Germany had a trade surplus in gross terms in 1995, but the trade balance is reversed in 2011 with Germany having a trade deficit of almost 7 billion (dollars) with respect to CEE countries. Column (2) and (3) distinguish between gross exports in final and intermediates and bring to light the boom of trade in intermediate inputs. While in 1995 the share of exports in final goods was larger (57.6% for German exports and 51.7% of CEE exports), in 2011 bilateral trade flows consist mainly of exports in intermediate goods (62.7% for Germany and 64.2% for CEE countries).Decomposition of gross exports in several components in columns (4), (8), (9), (10) and (11) gives us information on the structure of bilateral trade flows. Additionally, domestic value added can be further decomposed in three parts, shown in columns (5), (6) and (7). Overall the structure of the gross exports are similar in both trade partners: the share of domestic value added is the largest component but it has decreased over time; the share of foreign value added has remained relatively stable, while the pure double counted term has increased to almost one fifth of the overall trade flow.

Table 2.5: Germany-CEE Countries Bilateral Trade in Transport Equipment (WIOD 15)

Germany-CEE countries exports

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
year		**texp**	**texpfd**	**texpint**	**dva**	**dva_fin**	**dva_int**	**dva_intrex**	**rdv**	**mva**	**ova**	**pdc**
1995	Value	2337.2	1347.3	989.9	1729.5	1064.6	402.1	262.8	88.2	5.1	385.8	128.4
	Share	100	57.6	42.4	74.0	45.6	17.2	11.2	3.8	0.2	16.5	5.5
2003	Value	11946.6	5695.4	6251.1	7158.8	4188.2	1205.3	1765.3	1139.4	56.1	1895.7	1696.4
	Share	100	47.7	52.3	59.9	35.1	10.1	14.8	9.5	0.5	15.9	14.2
2011	Value	23700.2	8834.2	14866.0	13286.7	5792.6	2329.1	5165.1	1337.3	133.6	4171.1	4771.5
	Share	100	37.3	62.7	56.1	24.4	9.8	21.8	5.6	0.6	17.6	20.1

CEE countries-Germany exports

year		**texp**	**texpfd**	**texpint**	**dva**	**dva_fin**	**dva_int**	**dva_intrex**	**rdv**	**mva**	**ova**	**pdc**
1995	Value	2221.6	1149.2	1072.4	1451.3	774.9	317.3	359.1	1.8	153.9	399.8	214.8
	Share	100	51.7	48.3	65.3	34.9	14.3	16.2	0.1	6.9	18.0	9.7
2003	Value	16503.0	7161.9	9341.1	7818.0	3265.8	1401.1	3151.1	34.1	1866.6	3419.4	3365.0
	Share	100	43.4	56.6	47.4	19.8	8.5	19.1	0.2	11.3	20.7	20.4
2011	Value	30100.9	10765.2	19335.6	14581.2	5267.5	2977.1	6336.5	77.1	2281.0	6254.4	6907.1
	Share	100	35.8	64.2	48.4	17.5	9.9	21.1	0.3	7.6	20.8	22.9

Despite similarities, there are some major differences among exporters, which provide insights about their different degrees of participation and positioning in the international value chain over time. First, the difference between shares of domestic value added is due to the domestic value added in final goods, which is larger for Germany.

Secondly, the share of returned domestic value added is negligible for CEE countries, while it has increased in Germany (5.6% in 2011). RDV can be considered a proxy of upstreamness: part of German value added exported to CEE countries is finally reimported through further stages and finally absorbed domestically.

Thirdly, the share of foreign value added which comes from the direct importing country (MVA, column 9) is trivial for Germany, but it is relevant for CEE countries (7.6% in 2011). This underlines a more downstream location of CEE countries in the value chain and their role of dependence on German value added to produce exports.

2.6 Empirical Model and Results

In this section, our aim is to empirically assess the impact of trade agreements, being one of the main drivers of the emergence of regional trade bloc, on country GVC participation and positioning. In particular, our focus is on the effect of country-pair adhesion to the EU on trade in value-added metrics proposed by Wang et al. (2013) in the transport equipment sector. With respect to gross trade metrics, the use of these novel measures allows us to estimate the impact of EU accession on relatively unexplored aspects of GVCs, such as country upstreamness apart from involvement in the GVC itself.

Starting from the seminal paper by Tinbergen (1962), gravity equations have been a common empirical tool to investigate bilateral international trade flows. We take as a reference point the baseline equation for the estimation of international trade gravity models (Baier and Bergstrand, 2007):

$$lnY_{ijt} = \beta_o + \beta_1 lnGDP_{it} + \beta_2 lnGDP_{jt} + \beta_3 lnDIST_{ij} + \beta_4 CONTIG_{ij} + \beta_5 COMLANG_{ij} + \beta_6 EU_{ijt} + \varepsilon_{ijt} \quad (2.12)$$

where Y_{ijt} is Wang et al. (2013) domestic value-added (DVA) measure of trade flow from the transportation equipment sector of the exporting country i to the importing country j. In particular, we make use of DVA as a proxy for GVC participation, as it entails all the portion of gross exports which is generated domestically and is absorbed abroad, either in the direct importing country or third countries. Zero trade flows represent less than 3% of the total sample and we control for them by adding 1 to the dependent variables.

On the right hand side, we include the most commonly used gravity controls, sourced from the CEPII gravity dataset (see Head et al., 2010; Head and Mayer, 2014): GDP_{it} and GDP_{it} are the gross domestic products in current US dollars of respectively country i and j (they are not deflated in accordance with the trade flow variable), $DIST_{ij}$ is the population-weighted great circle distance between large cities of the two countries, $COMLANG_{ij}$ is a dummy variable which takes value 1 if countries i and j share a common official or primary language, $CONTIG_{ij}$ is a dummy variable which takes value 1 if the two countries are contiguous. Our independent variable of interest is EU_{ijt}, which is a dichotomic variable which takes value 1 if at time t both country i and j belong to the European Union and 0 if only one country or none of them belongs to the European Union. ε_{ijt} is the log-normally distributed error term.

Since our focus of our analysis is on regional trade and the role of EU bilateral adhesion as a regional trade agreement, our panel dataset considers the 27 EU countries in 2011 and consists of 11934 observations (that is 27x26 bilateral relationships[2] over 17 years, between 1995 and 2011)[3].The use of panel data is motivated by the widely agreed view among econometricians it is a valid option to estimate treatment effect in the presence of potential endogeneity bias due to unobserved heterogeneity (Wooldridge, 2000).

Starting with Santos Silva and Tenreyro (2006), a large number of recent papers deal with econometric problems resulting from heteroskedastic residuals in log-linear gravity equations and the prevalence of zero bilateral trade flows by estimating non-linear Poisson pseudo-maximum likelihood (PPML) estimators. Head and

[2] The inclusion in the sample of gross intra-national flows (computed as the difference between total output and gross exports) is not feasible as the empirical analysis relies on value-added components of bilateral exports.

[3] We refer you to Tables A.12 and A.13 in Appendix A for the full list of countries and date of accession and the descriptive statistics of the variables used in the estimations.

Mayer (2014) suggest to use the PPML estimators in combination with others, in order to check robustness of the results

Following Baier and Bergstrand (2007), we provide different specifications, alternative to the baseline gravity equation, in order to address the issue of endogeneity of our variable of interest, EU_{ijt}. In the first two sets, we present the results relative to estimation with fixed effects. In particular, in the second specification, we introduce lagged variables. In the third set of estimations, we use first differences.

The first estimation in Table 2.6 shows the results for different specifications of gravity equation 2.12 using panel data with domestic value added as dependent variable, EU_{ijt} as the main binary independent variable, with and without time and bilateral fixed effects.

Column (1) provides the results of the baseline estimation without any fixed effects for the whole time span considered. The coefficients of the GDPs of exporting and importing countries are positive, the coefficients of distance and contiguity are consistent with the expectations, respectively negative and positive. The coefficient relative to common language is not significant. The coefficient of the EU dummy variables in this first estimation is negative (-0.40). Column (2) adds time-specific dummies in the estimation, that however do not solve the issue of endogeneity with respect to the countries' EU participation. The results relative to the time variables are not shown for brevity. The coefficient for EU is still negative (-0.09) but smaller and not statistically significant. Column (3) gives information about the estimation with bilateral fixed effects, therefore time-invariant controls such as distance, contiguity and common language are excluded. The EU coefficient becomes positive (0.18) and statistically significant, consistently with our expectations. Column (4) refers to results of the estimation with both types of fixed effects, time-specific and bilateral. The EU coefficient increases to 0.24 which corresponds to a 27% increase in domestic value added if both trade partners belong to the EU.

Table 2.6: Panel gravity equations in levels using various specifications

Variable	(1)	(2)	(3)	(4)
ln GDP_{it}	0.962***	0.959***	0.466***	0.305***
	(0.024)	(0.024)	(0.077)	(0.099)
ln GDP_{jt}	0.657***	0.653***	0.353***	0.192*
	(0.026)	(0.026)	(0.076)	(0.110)
ln $DIST_{ij}$	-0.854***	-0.855***		
	(0.081)	(0.082)		
$CONTIG_{ij}$	0.758***	0.747***		
	(0.167)	(0.165)		
$COMLANG_{ij}$	-0.103	-0.184		
	(0.218)	(0.222)		
EU_{ijt}	-0.401***	-0.0915	0.179***	0.241***
	(0.058)	(0.091)	(0.036)	(0.043)
Constant	-32.568***	-32.48***	-18.42***	-10.53***
	(1.137)	(1.145)	(1.066)	(3.799)
Observations	11,934	11,934	11,934	11,934
R-squared	0.768	0.774	0.340	0.360
Time fixed effects	No	Yes	No	Yes
Bilateral fixed effects	No	No	Yes	Yes

Clustered standard errors in parentheses - *** p<0.01, ** p<0.05, * p<0.1

Summing up, the first two specifications provide results inconsistent with our expectations and they do not account for the presence of unobserved time-invariant heterogeneity. The introduction of bilateral and time-varying fixed effects renders the coefficient of EU positive and statistically significant. However, it is necessary to provide other specifications which better account for biases due to omission of country time-varying factors (such as multilateral resistance terms) and also the possibility of phasing-in effects of EU participation.

Previous specifications may subject to omitted variable bias due to the lack of time-specific variables which take into account variations of time-variant terms. With this respect, bilateral fixed effects are not sufficient. In this specification, the introduction of bilateral fixed effects render the constant controls (distance, contiguity and common language) superfluous, while the addition of country-time fixed effects accounts for country-specific variables changing over time (in this context, GDP and the other omitted variables). The estimation should be unbiased. The first two columns in Table 2.7 provide the result for the estimation with bilateral fixed effects as well as country-time-specific fixed effects. To allow for a direct comparison, the dependent variable is gross exports in Column (1) and DVA in Column (2). The effect of the EU_{ijt} dummy variable is higher on total exports than on DVA, consistently with the expectation that gross statistics tend to overestimate the economic impact of trade agreements.

Table 2.7: Panel gravity equations with country-time and bilateral fixed effects

Variable	(1)	(2)	(3)	(4)	(5)
EU_{ijt}	0.500***	0.487***	0.199**	0.155*	0.009
	(0.0919)	(0.0849)	(0.0831)	(0.0807)	(0.0686)
$EU_{ij,t-1}$			0.293***	0.025	0.024
			(0.0749)	(0.0668)	(0.0668)
$EU_{ij,t-2}$				0.313***	0.297***
				(0.0780)	(0.0781)
$EU_{it,t+1}$					0.170**
					(0.0695)
Constant	2.928***	2.520***	2.517***	2.515***	2.452***
	(0.092)	(0.085)	(0.088)	(0.090)	(0.095)
Observations	11,934	11,934	11,232	10,530	9,828
R-squared	0.586	0.568	0.555	0.543	0.542

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In Column (2), the coefficient for EU_{ijt} is 0.49 and corresponds to an average 63% increase in trade for EU partners ($e^{0.49}$ = 1.63 or 63% increase). We overlook estimations with restrictions on income elasticities, as Baier and Bergstrand (2007) show that it does not affect the free-trade agreement coefficient. The dichotomic variable EU_{ijt} is created according to the date of accession, however it is believed that accession to trade agreements as well as the integration within an economic union is executed gradually over a longer time span than one year. The economic impact of country integration in the EU may be delayed after the formal year of accession. We know from literature on international economics that the conditions and the volumes of bilateral trade may be altered even after a longer period from the economic integration. With these respects, it makes sense to add lagged variables of EU dummy in the estimation. Column (3) and (4) provide the information about the coefficients of the one-year-lag and the two-year-lag variables respectively. Both coefficients are positive and significant. The average treatment effect (ATE) is the sum of the statistically significant coefficient of the EU dummy variables. The cumulative ATEs are 0.49 and 0.47 in the two estimations. The results suggest that the EU country-pair participation increases bilateral domestic value added trade by 60% after two years ($e^{0.47}$ = 1.60 or 60% increase). Moreover, in all countries joining the EU huge institutional adjustments must have taken place already before the final accession date. What follows is that some of the effects on trade might have become visible already in the pre-accession period.

We try to capture partially potential pre-accession effect with the introduction of a lead variable[4]. Column (5) refers to the estimation with a lead, that is one-year subsequent to the EU country-pair participation, in addition to the two lags.

The coefficient of the future level is positive, significant but smaller than the other coefficients in the other estimations. We cannot exclude the possibility of feedback effects between domestic value added trade and EU country-pair participation and from an econometric standpoint, we rule out strict exogeneity of EU variable change to trade flow variations.

Furthermore, this result may indicate that the anticipation of common participation to the EU may lead to increase in domestic value added due to redirection of costs. To check for robustness of the OLS estimations, a re-estimation of Table 2.7 using PPML is included in the Appendix A and the main results are confirmed.

The fixed effects specifications of columns (2) and (3) can eliminate the effects of unobserved heterogeneity for time-invariant country pair factors, but they cannot account for any bilateral factors that are time-varying. Hence, coefficient estimates of the variables of interests may still be biased by omitted country pair-specific variables that are time-

[4] Given the time span and the variables considered, we are aware that there may be further pre-accession effects or effects concerning country accessions before 1995.

varying.[5] Estimation using fixed effects gets more biased if the time dimension of the panel dataset is large.

Estimation with first-differences provides more accurate results compared to previous specification, as it can solve "the spurious regression problem" which derives from employing fixed effects with a large T panel dataset (Wooldridge, 2000).

We still employ country-time specific fixed effects to deal with potential biases from non-constant country-specific omitted variables.

Apart from these advantages, the use of first difference is also a way to check the robustness of the other estimations.

$$dlnY_{ij,t-(t-1)} = \beta_6 dEU_{ij,t-(t-1)} + \beta_{i,t-(t-1)} Dum_{i,t-(t-1)} + + \beta_{j,t-(t-1)} Dum_{j,t-(t-1)} + \omega_{ij,t-(t-1)} \quad (2.13)$$

The estimation of equation 2.13 covers a period of 14 years and all the trade relationships in the sample. Given the time span considered from 1995 until 2011, the first difference of the EU dummy variable takes the value 1 for all the bilateral trade relationships of countries which accessed EU in 2004 and 2007, and mainly consist of CEE countries (see Table A.12 in Appendix A).

The country-and time dummies account for variations in countries' specific variables. Table 2.8 provides the results of the estimation of equation 2.13 with different lags of the change in EU joint participation.

Column (1) and (2) show the specification with zero-lag and one lag as explanatory variable. The coefficients of both estimations are small and not significant. Column (3) introduces the result for the estimation with a two-year lag of the first-differenced key variable. The ATE is 0.13 and statistically significant. It means that domestic value added of exporting country increases by almost 14% if the country pair belong to the EU ($e^{0.13}$ = 1.14 or 14% increase). These figures are lower compared to previous estimations. Column (4) provides the estimation with future change in the EU bilateral participation. This term can indicate a potential anticipation effect on trade flows of the enforcement of the EU joint participation. It does not have a significant impact on domestic value added variations. However, the ATE is 0.13, confirming the

[5] Inclusion of an *ijt* fixed effect is not feasible because it would perfectly explain trade flows. Bergstrand et al. (2015) propose for a theoretically motivated specification, the additional inclusion of countrypair fixed effects interacted with a time trend

results of column (3). Economic integration with trade partners has a positive impact on the domestic value added changes of the exporting country, and the impact is significant with a two-year delay.

Table 2.8: First-differenced panel gravity equations with country-time effects

Variable	(1)	(2)	(3)	(4)
$dEU_{ij,t-(t-1)}$	0.00938	0.00938	0.00938	0.00938
	(0.0688)	(0.0682)	(0.0688)	(0.0688)
$dEU_{ij,(t-1)-(t-2)}$		0.0245	0.0245	0.0245
		(0.0669)	(0.0670)	(0.0670)
$dEU_{ij,(t-2)-(t-3)}$			0.134**	0.132**
			(0.0626)	(0.0621)
$dEU_{ij,(t+1)-t}$				-0.0874
				(0.0659)
Observations	11,232	10,530	9,828	9,126
R-squared	0.243	0.247	0.243	0.248

Clustered standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Given the econometric advantages of first-differenced data and in order to account for possible delayed economic effects of bilateral adhesion to the EU on trade volumes, we replicate the estimations with different trade in value-added regressands using as a reference model equation 2.13 on the full panel of trade relationships. The use of additional decomposition terms allows us to investigate further GVC dimensions of bilateral trade, such as positioning and depth. In particular, we adopt the last estimation shown in Table 2.8, with the lagged variables and the lead variable. Results are shown in Table 2.9. In order to allow for easier comparisons, column (1) replicates the results of the last column in Table 2.8. Column (2), (3) and (4) provide the results for estimations with the other gross export decomposition terms as dependent variables, namely returned domestic value added (RDV), foreign value added (FVA) and pure double counted (PDC) components. As already discussed, RDV can be interpreted as a proxy for upstreamness, FVA as a measure of VS in GVC, while PDC is a measure of depth of cross-country sharing. Additionally, we provide the results for the estimations with FVA from direct importing countries (MVA), FVA from third countries (OVA), and direct RDV respectively in columns (5), (6) and (7). Finally, the estimation with total gross exports in column (8) helps to supplement the analysis with a comparison with gross trade statistics.

Interestingly, the coefficients are positive and significant only for some estimations and only for one lagged variables. The results indicate that the change in country-pair participation to the EU has a statistically significant phased-in effect on some value-added trade variables after two years.

In particular, the ATE ranges from 0.13 on domestic value added in column (1) to 0.15 on total gross exports in column (8). The ATE on domestic and foreign value added is in line with the ATE on total gross exports.

However, the ATE is not statistically significant on some value-added components of gross exports, that are tightly correlated to the positioning of the country in the value chains. Specifically, the ATE is not statistically significant on RDV, MVA and PDC. Returned value added is a component of gross exports which approximates the degree of upstreamness, while PDC is a measure of depth of international production sharing, as it increases with multiple cross-border transactions.

The estimation in Colum (7) with the direct RDV as dependent variable, given by the sum of T6 and T8 of Wang et al. (2013), provides results qualitatively similar to those of Column (2) of Table 2.9, and thus not statistically significant.

The estimation with MVA and with the direct RDV allow to isolate the dyadic relationship of the country-pair flows, excluding the influence of third countries and are robust to potential dyadic error correlation (Cameron and Miller, 2014; Baliè et al., 2017).

Overall, the empirical findings point out that EU membership positively affects bilateral trade flows in gross terms, as well as it increases GVC participation due to its positive effect on both domestic and foreign value added components of total exports.

Table 2.9: First-differenced panel gravity equations with country-time effects

Dependent variables	DVA	RDV	FVA	PDC	MVA	OVA	Direct RDV	Tot. Exports
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables								
$dEU_{ij,t-(t-1)}$	0.009	-0.005	-0.011	-0.041	-0.030	-0.011	-0.005	0.009
	(0.0688)	(0.0159)	(0.0638)	(0.0568)	(0.0205)	(0.0635)	(0.0154)	(0.0782)
$dEU_{ij,(t-1)-(t-2)}$	0.025	0.003	-0.004	0.023	0.015	-0.004	0.003	0.022
	(0.0670)	(0.0165)	(0.0592)	(0.0500)	(0.0207)	(0.0589)	(0.0162)	(0.0761)
$dEU_{ij,(t-2)-(t-3)}$	0.132**	0.000	0.143**	0.061	0.018	0.143**	0.000	0.146**
	(0.0621)	(0.0176)	(0.0592)	(0.0472)	(0.0240)	(0.0589)	(0.0180)	(0.0699)
$dEU_{ij,(t+1)-t}$	-0.087	-0.002	-0.067	-0.005	-0.030	-0.066	-0.009	-0.100
	(0.0659)	(0.0168)	(0.0587)	(0.0398)	(0.0193)	(0.0584)	(0.0162)	(0.0750)
Observations	9,126	9,126	9,126	9,126	9,126	9,126	9,126	9,126
R-squared	0.248	0.283	0.291	0.340	0.285	0.292	0.259	0.258

Clustered standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Nevertheless, the impact of EU bilateral participation on measures of value chain positioning and depth does not emerge, as the coefficients are not statistically different from zero.

We consider the effect of EU participation on two different components of foreign value added, that is MVA and OVA. On one hand, the estimation in column (5) with MVA as dependent variable provides statistically insignificant coefficients. On the other hand, the estimation in column (6) with OVA as dependent variable provides an ATE in line with that of total FVA in column (3), that is 0.14. These results may indicate that the effect of EU joint participation has an impact on FVA only through the OVA component, that is the part of foreign value added which stems from third countries. Conversely, the EU bilateral participation does not seem to affect significantly the part of foreign value added coming from the direct importing countries. These findings corroborates the idea that while country-pair EU participation enhances the exporting country-sector's involvement in value chains internationally thanks to increase both in greater domestic value added and in sourcing of foreign value added, it does not seem to impact the bilateral relationship and the sourcing of value added from the direct importing country. In this sense, the participation of the exporters in transport equipment value chain increases but its relative positioning both in the international and in the bilateral trade sharing is not affected in a statistically significant way.

2.7 Conclusions

Over the last decades, the increasing fragmentation of production processes worldwide has led to the emergence of the so-called GVCs. The main drivers of the significant diffusion of GVCs are to be found in the rapid technological advancements as well as in the dramatic fall of political and trade barriers. GVCs have received considerable attention by researchers due to its innovative perspective which can provide novel information on economic players (countries, industries and firms) and can support policymakers in decision concerning economic performance, employment and development. In the light of the upsurge of trade in intermediates due to a rapid globalization, researchers and policymakers are aware that traditional gross trade flow measurements need to be complemented with up-to-date value-added metrics, which better assess the degree of participation and location along the GVCs.

We review two main strands of research on GVC metrics under the macro-perspective. The first strand relates to GVC metrics of participation, that is the extent to which economic agents are involved in the vertically fragmented production. The seminal concept of VS (Hummels et al., 2001) equals the import content of export and is at the base of the development of other measures, such as the value added exports by Johnson and Noguera (2012) which also takes into account circular trade and reimport of exports, and the decomposition frameworks of gross trade flows at aggregate level (Koopman et al., 2010; 2014) and bilateral level (Wang et al., 2013; Nagengast and Stehrer, 2014; Borin and Mancini, 2015). The second strand has the objective to identify the relative location of economic players along GVCs and to develop positioning metrics. In particular, vertical fragmentation (Fally, 2012) highlights the length of value chains, in terms of number of sequential stages, and corresponds to the notion of downstreamness (Antràs et al., 2012; Antràs and Chor, 2013; Alfaro et al., 2017), which depend on the distance from final demand and, more generally, from its specialization along the so-called smile curve.

In the analysis of exports of the transport equipment industry in European countries, we highlight the evolution of trade flows and the decomposition of gross exports, the trade relationship between and Germany and CEE countries and the impact of EU joint participation to measures of trade in value added. In gross terms, CEE countries have experienced an upsurge over the years, with Poland and Czech Republic being two of the main exporters in the Europe area. The decomposition of total gross exports reveals that domestic value added share has decreased while the foreign and pure double counted components have increased in all the countries. The share of VS in gross exports has increased and is particularly relevant in CEE countries, where the increase is mostly driven by the pure double counted term in foreign value added. Considering the bilateral trade exchanges between hub and peripheries of the European area, the trade balance in gross terms has reversed over the years and CEE countries have a trade surplus with respect to the main partner. However, considering only gross trade figures provides a partial picture of the changes in trade patterns within Europe. In fact, Germany has a more upstream position in the value chain, with larger value added exports in final goods and reimported value added. Conversely, CEE countries are located in a more downstream position, with little returned domestic value added and a large portion of foreign value added coming directly from the exporter itself.

In our empirical analysis on the impact of EU participation on transport equipment trade flows in value-added, we find that EU bilateral participation has a positive impact on total gross exports as well as on domestic value added and foreign value added. We find that the effect is phased-in with a two-year delay after bilateral status change. However, no significant effect was found on other gross export components such as returned domestic value and pure double counted, which indicate country positioning and GVC depth.

Although trade agreements are important determinants of trade in regional blocs, in this sector analysis we find that the joint participation to the EU positively affects country participation in the regional production process but does not affect significantly positioning and depth. While trade agreements are widely accepted as one of the main drivers of the emergence of trade in GVCs, our findings suggest that their phased-in effect is mostly quantitative, in terms of greater involvement in domestic and foreign sharing. Yet, bilateral EU adhesion has no significant impact on the exporters' positioning (upstreamness), and in the depth of the cross-border production sharing. In this case, we may argue that EU accession has been a determinant factors for greater involvement of countries in the regional production exchanges, but it has not represented a driver of upgrading along the value chain. The findings seem to suggest that especially for countries located at the peripheries of production networks, greater participation to GVCs alone is not enough in order for them to reap the benefits of global trade, in terms of higher value-added generation and a lower degree of dependence on the hub countries of the GVCs.

The transition to the enlarged European Union has contributed to an upsurge in foreign investments and to the reorganization of the automobile sector in Central Eastern Europe. Although several CEE countries have successfully integrated in the regional trade network, the automobile sector could see the role of the hub country, Germany, reinforced in the long-run. For these reasons, policymakers should be cautious in the assessment of economic performance and the effectiveness of trade policies, relying on traditional gross statistics only. As a matter of fact, over the time span considered the trade flow increase in CEE countries was mainly driven by foreign value added and multiple counted components due to re-exports of intermediates. The impact of the upsurge of foreign direct investments on growth and employment needs to be re-assessed taking into account the degree of downstreamness. This would reflect the level of dependence between the CEE countries and the hub countries as well as the risks related to potential propagation of shocks.

Chapter 3

Catching-up Trajectories over Global Value Chains

3.1 Introduction

In the recent years, global production sharing has increased and has boosted trade in intermediate inputs (Miroudot et al., 2009; Baldwin and Robert-Nicoud, 2014). Researchers have focused their efforts in trying to develop new measures of trade, consistent with these changes (De Backer and Miroudot, 2013; Amador and Cabral, 2016). Another strand of research has started to consider persistent factors which are interconnected with output and trade performance, such as institutional quality (Beck, 2003; Nunn, 2007; Levchenko, 2007; Manova, 2008).

In this chapter, we aim at providing an empirical contribution on these subjects, by trying to interpret the interdependence between production, input choices and specialization pattern. For this purpose, we stress the role of international sourcing of intermediates and labor force educational attainments on output performance. Moreover, we include economic and financial institutional quality along with traditional Heckscher-Ohlin factor endowments as sources of comparative advantage.

In the light of the internationalization of trade and the emergence of global value chains, the objective of this chapter is to investigate at a global scale the relationship between input factors and growth and to detect long-term sources of specialization, measured in value-added terms.

We find that there is a certain degree of substitutability between domestic and international sourcing of intermediate inputs as well as between labor forces with different skill levels. These findings suggest that the potential benefits of greater involvement in global supply chains may not be obvious. Moreover, consistently with recent empirical studies (Nunn, 2007; Levchenko, 2007; Chor, 2010), we find that there is a strong positive effect of both economic and financial institutions on specialization, controlling for traditional Heckscher-Ohlin determinants.

This chapter is organised as follows. Section 3.2 reviews the literature on the subject and the motivation related to this chapter. Section 3.3 introduces the dataset. Section 3.4 describes the empirical specification and presents the findings and section 3.5 adds some robustness checks. Finally, section 3.6 concludes.

3.2 Motivation and Literature Review

This chapter adds to the recently growing literature on the emergence of global value chains, in the light of the boost of trade in intermediate inputs and the traditional and long-term sources of specialization in international trade theory.

The theoretical literature has highlighted the relationship of interdependence between agents along a sequential production process and their specialization within the stage of the value chain (Costinot, 2012; Costinot et al., 2012; Antràs and Chor, 2013; Antràs and de Gortari, 2017) and the impact of global trade in terms of welfare gains (Fally and Sayre, 2017). Empirical contributions on the organization of global value chains and integration choices at firm-level include Alfaro et al. (2017) and Del Prete and Rungi (2017).

In this chapter, we exploit these insights in two ways. First, we estimate country-sector production function, by considering a shared common technology. Our objective is to emphasize the contribution of factor endowments and in particular that of international sourcing of intermediate inputs and of different labor skills. Then, we assess the interdependence of production and specialization pattern, considering the (economic and financial) institutional component. Hence, we attempt to generalize the interdependences between specialization patterns and production performances in a Heckscher-Ohlin framework with a globally common technology and emphasize the role of institutional quality as a determinant of comparative advantage.

With respect to previous empirical studies, our focus is at the macro-level. We do this by making use of a novel panel dataset at country-sector level and employing new appropriate measures of comparative advantage (Wang et al., 2013) to encompass the phenomena of global supply chains and trade in value-added[6]. Our findings point out that at a global scale there is some substitutability between foreign and domestic intermediate inputs as well as between different groups of workforce by skill level. Moreover, our results confirm the relationship of dependence between specialization and production and the role of both economic and financial institutions as determinants of comparative advantage.

There are at least two strands of literature related to this chapter. First, we explore this subject in the light of the growing interest of academics on the role of global value chains and the upsurge of trade in intermediate inputs and trade in value-added. Secondly, this chapter relates to the recently growing empirical and theoretical literature on the institutions as sources of comparative advantage.

The first strand of literature related to this chapter originates from the intensification of trade in intermediate goods, both among developed and less developed economies, due to the fragmentation and increase in complexity of production chains globally. Over 10 years, between 1995 and 2006, trade in intermediate goods and services increased 6.2 % yearly while intermediated services increased 7% on a yearly average. Miroudot et al. (2009) find that more than half of international trade is represented by intermediate goods and services, that are not consumed directly but are used as inputs in the subsequent production process. The growth rate of trade in intermediate is the same as that of trade in final goods. Therefore the shares of intermediate and final goods and services have remained basically constant. In the age of globalisation and increasing fragmentation of production processes worldwide, this stable ratio between trade in intermediates and final goods may be explained by the fact that the internationalisation of trade has boosted both flows at the same pace. However, the boost in intermediate trade renders standard trade statistics and measures less reliable and there is therefore need of a new

[6] The concepts of trade in value added and value added in trade are made clear by Stehrer (2012)

framework which can capture the value flows embodied in trade (Koopman et al., 2010; Johnson and Noguera, 2012; Timmer et al., 2015).

This novel approach has, of course, several implications like on the assessment of the comparative advantage, based on traditional gross trade figures. (Wang et al., 2013; Koopman et al.; 2014). In this chapter, Wang et al. (2013)'s new revealed comparative advantage represents the main point of specialization pattern at country-sector level.

Johnson (2017) reviews the main contributions on global value chain measurements under the macro- and the micro-approaches. Research on global value chain analysis employing the macro-perspective mostly exploits multi-regional input-output tables to measure trade in value added and positioning along the value chains (Johnson, 2012; Timmer et al., 2015; Koopman et al. ,2014; Antràs et al., 2012). The micro-approach investigates organization of global production networks revolving around multinational companies, using firm-level data (Rungi and Del Prete, 2018).

This chapter is linked to the broader branch of research linking trade and development (Taglioni and Winkler, 2016; Zi, 2014) and research on the static and dynamic gains from trade through access to new imported intermediate goods (Romer ,1987; Rivera-Batiz and Romer, 1991). There are different ways how intermediate imports can affect economic outcomes (complementarity channel, input cost effect and learning spillovers). Complementarity stems from imperfect substitutability among intermediate inputs as in the love-of-variety model of Krugman (1979) and refers to the idea that the combination of different intermediate inputs can create gains that are larger than the sum of the parts (Halpern et al., 2015). Empirical studies such as those of Fenstra (1994) and Broda and Weinstein (2006) document the gains from trade deriving from new imported varieties in the total volume of trade. Jones (2011) provides a theoretical contribution to explain how intermediate inputs are relevant for economic development and how they can drive large income differences across countries. The author supports a long-standing approach in development economics that complementarities effect along different stages of the supply chain are crucial driver for output and economic growth (Hirschman, 1958).

Skill and factor biased technological change and international outsourcing, that is import of intermediate inputs from abroad, are seen as major factors contributing to labor demand shifts in favor of more educated workers (among others see Feenstra and Hanson, 1996; Acemoglu and Autor, 2011). They are also considered to play a central role in reshaping the job structure towards the so-called polarization trend. Job polarization refers to the phenomenon of decline in middle-skill employment in favour of higher- and lower skill positions (Autor et al., 2006). Horgos (2011) underlines the role of elasticity of substitution among labor force with different skills in the relationship between outsourcing and labor demand shifts: the higher it is, the larger the effect of outsourcing, similarly to technological progress, on employment disruptions. These static labor-labor relationships with growth may be harmful for employment creation if, for instance, substitutability between high and low skill workers means that a smaller number of workers is necessary to produce the same amount of output.

With respect to previous studies, this chapter estimates at a global scale the degree of substitutability/complementarity between different types of labour inputs (high-skilled, medium-skilled and low-skilled) and to differentiate between foreign and domestic intermediary inputs used in the production processes.

The second strand of literature related to this chapter relates to the interdependence between institutional quality and specialization pattern. The first empirical works on the impact of contracting institutions on comparative advantage are by Nunn (2007), which focuses on the hold-up problem, and by Levchenko (2007), which includes property rights in the definition of institutions. Levchenko (2007) provides a general equilibrium model in which contract incompleteness (Grossman and Hart, 1986; Williamson, 1985) is considered as an institutional characteristic which varies across countries and sectors. High quality contracting institutions are a source of comparative advantage in countries and sectors where the risk of hold-up is more prominent, that is where the relationship-specific investments are higher. Nunn (2007) is the first to define and measure contract intensities that is the relationship-specific investment intensities of goods. Similarly, Acemoglu et al. (2007) imply that differences in contracting institutions generate differences in comparative advantages and offers a mechanism (technology adoption) through which this effect may take place. While many empirical studies focus on the impact of contracting institutions on horizontal specialization (across sectors), some study its impact on vertical specialization (Essaji and Fujiwara, 2012)[7].

To sum up, there is already broad evidence that contracting institutions have an impact on trade and are a source of comparative advantage. Nunn and Trefler (2014) provide a rather extensive review of the empirical and theoretical literature on the relationship between institutions as a source of comparative advantage and international trade. The authors cite studies on different types of institutions affecting comparative advantage: contracting institutions, financial development institutions (Beck, 2003; Manova, 2008) and labor market institutions (Costinot, 2009).

The empirical studies control for methodological problems such as omitted-variables bias and reverse causality. In order to avoid the omitted-variables bias, the already cited empirical studies include fixed effects as well as country-sector interaction terms and Heckscher-Ohlin factor endowments. Nunn (2007) addresses the issue of reverse causality between institutional quality and country specialization in specific sectors with the use of legal origins as instrumental variable.

Financial environment can affect the specialization pattern of a country in several ways. Beck (2002) finds that countries with better developed financial systems have a comparative advantage in sectors where fixed costs are higher, such as manufacturing. Chor (2010) examines all the institutional explanations of previous studies simultaneously and finds that, despite the effect of each institutional explanatory variable on trade pattern is small, all the determinants are significant. The institutional determinants employed by Levchenko (2007) and Nunn (2007) are particularly relevant, even after controlling for traditional sources of comparative advantage in a Heckscher-Ohlin setup such as relative factor endowments.

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[7] The notion of vertical specialization proposed by Essaji and Fujiwara (2012) does not correspond to the one discussed in Chapter 2.

In this chapter, we investigate the relationship between two dimension of institutional quality and an appropriate value-added based measure of comparative advantage, in a GVC framework.

3.3 Data and Descriptive Statistics

In this chapter, we mainly use three data sources for analysis: the World Input-Output Database (WIOD) which represents our basis, the Worldwide Governance Indicators (WGI) by Kaufmann et al. (2009) and the Financial Development Indexes by the International Monetary Fund, where we source respectively economic and financial institution variables.

Firstly, we exploit the World Input-Output Database (WIOD). Timmer et al. (2012) provide an extensive description of the database. In an additional section called Socio-Economic Account, the WIOD also includes information on prices and quantities of factor inputs with country-industry data on employment (number of workers, wages and educational attainment), capital stocks, gross output and value added at current and constant prices at the industry level. The country-industry employment levels are broken up into three skill categories (high, medium and low) which follow the educational attainment classification of the International Standard Classification of Education (ISCED). Following Wang et al. (2013), we calculate a new measure of trade specialization, in the light of a higher fragmentation of production processes. While Balassa's (1965) revealed comparative advantage (RCA) index is based on total gross exports, Wang et al.'s (2013) propose a new measure of revealed comparative advantage (NRCA, for short) which substitutes total gross exports with a forward-looking measure of domestic value added, derived from their disaggregated decomposition method of the WIOD gross exports[8]. Due to a large number of missing values, we consider only 39 countries and years up to 2009[9].

Secondly, we make use of the Worldwide Governance Indicators by Kaufmann et al. (2009) employed by previous empirical studies as

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[8] A broader description of RCA and NRCA is provided in Appendix B.

[9] We exclude Taiwan as different sources do not always distinguish between China and Taiwan or do not have data specifically on Taiwan.

measures for institutional quality (Antràs and Chor, 2010; Acemoglu et al., 2014). The WGI is a panel dataset covering more than 200 countries since 1996 of six indicators of several dimensions of governance such as Voice and Accountability, Political Stability, Government Effectiveness, Regulatory Quality, Rule of Law and Control of Corruption. For the purpose of our analysis, we focus on one of the areas of WGI, that is the respect of citizens and the state for the institutions, and consider one specific variable, Rule of Law as a proxy for the quality of economic institutions. In particular, it measures perceptions of the agents with respect to contract enforcement, property rights, police, courts and the probability of violence and crime. For an extensive analysis of the construction of the indexes and the potential bias related to survey data, we refer you to Kaufman et al. (2011).

Thirdly, we include a recently developed dataset by the International Monetary Fund on financial development indicators covering 176 countries over the period between 1980 and 2013 (Sahay et al., 2015). We focus on financial institutions only, including both bank and nonbank institutions such as insurance firms, mutual and pension funds and other organizations. The financial institution index is constructed on the basis of twelve measures, grouped into three categories, depth, access and efficiency. Each index is normalized between zero and one. We refer you to Sahay et al. (2015) for deeper analysis of the construction methods of the index.

To sum up, our empirical study combines several still relatively unexploited data sources in the light of increasing importance of global value chains. The whole sample consists of 39 countries, 35 sectors over a time span of 15 years from 1995 to 2009. A more ample description of the data sourced from the WIOD and the construction of the variables are provided in the Appendix B.

3.3.1 Descriptive statistics

Table 3.1 provides summary statistics for the variables employed in the empirical analysis. Different country and year coverage are the reason why database sample sizes of the variables differ[10]. There is considerable cross-country variation over the period considered and

[10] A more detailed description of the variables construction is given in the Appendix B.

this is measured by the within-standard-deviation. The mean values reflect the fact that the sample consists mainly of developed economies, since the WIOD includes mostly European countries.

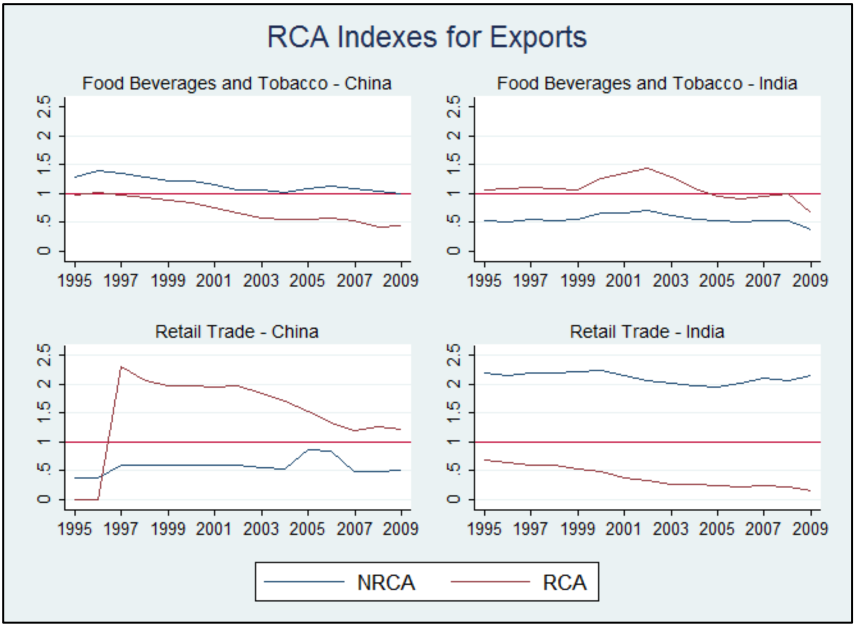
Table 3.1: Summary Statistics

Variable	Obs	Mean	Std. Dev.	Std. Dev. Within	Min	Max
Real Gross Output	20235	414.69	1302.37	318.68	0.00	22525.65
Capital	18950	66642.95	448422.20	78515.06	0.00	14100000.00
High-Skill Labor	20340	299.31	1192.33	337.78	0.00	32592.52
Medium-Skill Labor	20340	1068.23	5324.48	823.36	0.00	139872.40
Low-Skill Labor	20340	1447.83	18016.14	968.67	0.00	518911.20
Foreign Inputs	19905	29.52	106.66	67.99	0.00	7771.90
Domestic Inputs	19905	178.33	577.22	206.29	0.00	14104.41
Economic Institutions	15015	0.88	0.82	0.11	-1.13	2.00
Economic Institutions (distance from the mean)	15015	0.00	0.82	0.11	-1.97	1.11
Financial Institutions	20475	0.60	0.20	0.10	0.05	0.97
Financial Institutions (distance from the mean)	20475	0.00	0.18	0.06	-0.42	0.31

We compare the traditional Balassa's RCA and the NRCA based on the value-added decomposition by Wang et al. (2013) of the WIOD. Following Wang et al. (2013), we provide two examples in two large Asian emerging economies such as China and India of how traditional and value-added measures of RCA can differ and lead to misleading conclusion. While China has benefited a greater engagement in GVCs and has experienced an upsurge in domestic content in exports, the same does not seem to hold for India. The food, beverages and tobacco sector in China presents a comparative disadvantage over the time span considered while, in India, the sector shows a comparative advantage. Using the novel index with forward-looking value-added measures, the revealed comparative export position of the two countries is reversed: China has a comparative advantage and India does not. Conversely, the analysis of the NRCAs in sector of retail trade gives a brighter picture of the Indian market with respect to the Chinese market, while the old RCAs follow opposite path. Figure 3.1

provides a clear representation of the dynamics of the indexes of the sectors in the two Asian countries.

Figure 3.1: RCA and NRCA Indexes for Selected Sectors



Source: own calculation using the WIOD, Sector 3 (Food Beverages and Tobacco) and Sector 21 (Retail Trade).

The data presented in Table 3.2 shows in detail a comparison between RCA and NRCA in all the Chinese and Indian sectors. The first column provides the average difference between RCA and NRCA along all the available years. Despite the magnitude of these indexes is not readily interpretable, the average difference is nevertheless an indicator of the distance between the two measurements. The second column shows the level of correlation between the two. In most cases the correlation is high, but there are several exceptions of negative correlation, signalling different trends in specialization measured in gross trade with respect to domestic value-added. Figure B.1 and B.2 in the Appendix B section provide a better visual representation of the clusters of improvements (or deteriorations) of both indexes and their dynamics in the industries of the two selected countries.

Table 3.2: Comparison between RCA and NRCA in China and India

	China		**India**	
Sector	**Average Difference**	**Correlation**	**Average Difference**	**Correlation**
1	*1.530*	*0.860*	*0.820*	*0.980*
2	0.438	*0.898*	0.229	0.388
3	0.437	*0.937*	*0.513*	*0.950*
4	0.175	*0.961*	*0.851*	*0.984*
5	*0.621*	*0.989*	0.292	*0.989*
6	0.443	0.663	0.271	0.527
7	0.445	-0.565	0.161	*0.950*
8	*0.579*	*0.788*	0.278	*0.953*
9	0.489	*0.771*	0.079	*0.892*
10	0.184	*0.776*	0.354	-0.078
11	0.427	*0.939*	*1.456*	*0.995*
12	0.207	-0.663	0.203	0.624
13	0.194	*0.980*	0.039	*0.839*
14	0.462	*0.970*	0.034	*0.993*
15	0.127	*0.969*	0.017	*0.996*
16	0.064	*0.946*	*2.057*	*0.953*
17	*0.950*	-0.627	*1.358*	-0.785
18	*0.897*	0.103	*1.600*	-0.135
19	n.a.	n.a.	0.472	-0.670
20	0.435	*0.896*	0.466	-0.903
21	*1.243*	0.477	*1.740*	0.062
22	0.435	*0.953*	*2.733*	*0.971*
23	*0.566*	0.468	0.328	*0.812*
24	*0.583*	*0.910*	0.123	*0.941*
25	0.198	0.470	0.174	0.351
26	0.328	*0.982*	0.198	*0.902*
27	0.181	0.032	*0.546*	*0.857*
28	*0.671*	0.733	*0.916*	*0.897*
29	*0.508*	-0.012	*3.435*	*0.983*
30	0.206	*0.916*	*1.009*	*0.992*
31	0.160	0.019	n.a.	n.a.
32	0.244	0.328	0.228	-0.218
33	*0.664*	-0.300	n.a.	n.a.
34	*1.011*	0.717	*0.916*	-0.107
35	n.a.	n.a.	*37.917*	-0.120

Source: own calculation using the WIOD. List of sectors is provided in Table B.3 in Appendix B.

Table 3.3: Comparison between RCA and NRCA

	NRCA<1	NRCA≥1	Total
RCA<1	51.92	10.55	62.47
RCA≥1	5.06	32.46	37.53
Total	56.98	43.02	100.00

Source: own calculation using the WIOD – (39 countries, 35 sectors, 15 years)

We will skip all the considerations about the magnitudes and the quantitative significance of both indexes but we will focus instead only on the qualitative property of signalling a revealed comparative advantage or disadvantage. As shown in Table 3.3, in more than 80 percent of the country-sectors over the time period under consideration, both measures are consistent with each other, that is either they both reveal a comparative advantage or a comparative disadvantage in the exporting sector of the country. However, the NRCA seems to overestimate more often a comparative advantage rather than underestimate a comparative disadvantage with respect to the traditional RCA. In fact, the share of observations when the NRCA is greater than 1 while the RCA is lower than 1 is almost twice the share of the opposite case (10.6 percent compared to 5.1 percent).

3.4 Empirical Strategy

3.4.1 Baseline Results

Our aim is to analyse the effect on a global scale of trade in intermediate inputs on output at country-sector level and how international sourcing of input factor interacts with specialization.

For the purpose of our analysis, we adopt a production function as a starting point since it is both the basis of modern growth accounting and a straightforward way to link the simultaneous impact of multiple inputs to the industry aggregate output level. Among all the different functional forms, we choose the transcendental logarithmic (translog) production function as the most appropriate for our objective. The translog function can be interpreted as a generalization of the Cobb-Douglas production function and has been widely used empirically for its simplicity and great flexibility (Berndt and Christensen, 1973; Christensen et al., 1973). This functional form allows us to estimate the effect of several input factors on the aggregate industry output level, assuming a homogenous technology common to all countries and sectors, still with a high degree of approximation.

The form of the translog function is the following:

$$ln\,Y_{ckt} = \alpha_0 + \sum_i \alpha_i \, ln\, X^i_{ckt} + \delta_T T + \frac{1}{2}\sum_i \sum_j \beta_{ij}\, lnX^i_{ckt}\, ln\, X^j_{ckt} + \sum_i \gamma_{iT}\, ln\, X^i_{ckt} T + \frac{1}{2}\delta_{TT} T^2 + \varepsilon_{ckt} \quad (3.1)$$

where Y_{ckt} is the real value of gross output, $X^{i,j}_{ckt}$ are factors of production and T is the time trend adopted for the identification of technical change. The subscripts, c, k and t, identify respectively the country, the sector and the year while the superscripts, i and j, identifies the several input factor covariates. We are considering: real capital (K), total hours worked by three skill categories of labor force (high, H, medium M and low-skill workers, L), domestic (D) and foreign intermediates (F). Finally, ε_{ckt} represents the error term. We include intermediate inputs, divided into domestic and foreign, among the production factors. Domestic intermediate inputs are generated by the trade among industries within the same country while foreign intermediate inputs are all the imported production factors.

The latter are relevant because they capture offshoring and outsourcing activities and represent the connection with international trade as a driver of growth.

We test the static relationship between trade in intermediates and growth by estimating the nonlinear separable and joint effects of domestic and imported intermediates on output in a flexible way. Our focus is on the complementarity channel between internationally sourced and domestically produced inputs and the mechanisms already described in literature (love of variety; technological spillover, access to cheaper inputs).

The specification of three different levels of skills for labor as explanatory variables allows the detection of nonlinear relationships with output and complementarity or substitutability among the labor cohorts. Despite many models based on Cobb-Douglas production function assume perfect labor-labor substitutability, empirical evidence, such as in the work by Autor et al. (1998), suggests that workers with different skill levels are less than perfect substitutes.

The translog production allows to analyze both the direct and indirect effects of explanatory variables through the quadratic and interaction terms. More specifically, the presence of quadratic terms allows for non-linear relationship between the input factors and the output level while the interaction terms also allow for analysis of substitutability and complementarity. According to the equation 3.1, the model consists of 36 explanatory variables: apart from the intercept and the 7 linear covariates, we have a set of 21 interacted variable terms and 7 quadratic terms. The first results of the worldwide translog production function with a panel fixed effect estimation are shown in Table 3.4, column 1. Out of 36 coefficients, 27 are statistically significant. The variables of capital and its interactions with high and low-skill workers, the interaction terms between labor groups and intermediate inputs with the exception of that between medium-skill-labor and domestic intermediate input are all non-significant.[11]

Table 3.4: Estimation Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
α_K	-0.0125	-0.0163	0.00920	0.00922	-0.0154	-0.0152	0.00919
	(0.0135)	(0.0130)	(0.0142)	(0.0142)	(0.0130)	(0.0130)	(0.0142)
α_H	0.0305*	0.0415**	0.0285	0.0285	0.0411**	0.0411**	0.0285
	(0.0170)	(0.0161)	(0.0192)	(0.0192)	(0.0161)	(0.0161)	(0.0192)
α_M	-0.138***	-0.123***	-0.112***	-0.112***	-0.124***	-0.125***	-0.112***
	(0.0266)	(0.0260)	(0.0303)	(0.0303)	(0.0260)	(0.0260)	(0.0303)
α_L	0.0503**	0.0560**	0.0500*	0.0501*	0.0567**	0.0576***	0.0500*
	(0.0209)	(0.0223)	(0.0257)	(0.0257)	(0.0223)	(0.0222)	(0.0257)
α_D	0.877***	0.689***	0.702***	0.702***	0.687***	0.687***	0.702***
	(0.0309)	(0.0290)	(0.0344)	(0.0344)	(0.0290)	(0.0290)	(0.0344)
α_F	0.480***	0.521***	0.535***	0.535***	0.523***	0.524***	0.535***
	(0.0283)	(0.0263)	(0.0305)	(0.0305)	(0.0263)	(0.0263)	(0.0305)
δ_T	-0.0183***	-0.0344***	-0.0379***	-0.0379***	-0.0338***	-0.0338***	-0.0380***
	(0.00221)	(0.00250)	(0.00313)	(0.00313)	(0.00250)	(0.00250)	(0.00313)

[11] R^2 close to 1 in Column (1) is likely to be due to the *explosive* number of independent variables in the translog functional form. To support this guess, within R^2 for the fixed effect estimation of the Cobb-Douglas (not reported) equals 0.83.

Interaction terms: Substitutability and Complementarity Effects							
β_{KH}	-0.00248	-0.00498***	-0.00548***	-0.00548***	-0.00493***	-0.00490***	-0.00547***
	(0.00171)	(0.00168)	(0.00200)	(0.00200)	(0.00168)	(0.00168)	(0.00200)
β_{KM}	0.0404***	0.0299***	0.0318***	0.0318***	0.0299***	0.0300***	0.0318***
	(0.00206)	(0.00200)	(0.00239)	(0.00239)	(0.00200)	(0.00200)	(0.00239)
β_{KL}	-0.00115	-0.00731***	-0.00946***	-0.00947***	-0.00730***	-0.00733***	-0.00947***
	(0.00123)	(0.00120)	(0.00150)	(0.00150)	(0.00120)	(0.00120)	(0.00150)
β_{KD}	-0.0485***	-0.0235***	-0.0240***	-0.0240***	-0.0234***	-0.0234***	-0.0240***
	(0.00194)	(0.00218)	(0.00265)	(0.00265)	(0.00218)	(0.00218)	(0.00265)
β_{KF}	-0.0110***	-0.00806***	-0.00734***	-0.00733***	-0.00819***	-0.00822***	-0.00733***
	(0.00166)	(0.00162)	(0.00189)	(0.00189)	(0.00162)	(0.00162)	(0.00189)
γ_{KT}	-0.0017***	-0.00122***	-0.00127***	-0.00127***	-0.00122***	-0.00122***	-0.00127***
	(0.000174)	(0.000182)	(0.000225)	(0.000225)	(0.000182)	(0.000182)	(0.000225)
β_{HM}	0.00369***	0.00243*	0.000923	0.000925	0.00244*	0.00248*	0.000922
	(0.00139)	(0.00132)	(0.00149)	(0.00149)	(0.00131)	(0.00131)	(0.00149)
β_{HL}	-0.0040***	-0.00358***	-0.00261*	-0.00261*	-0.00358***	-0.00361***	-0.00261*
	(0.00124)	(0.00119)	(0.00135)	(0.00135)	(0.00119)	(0.00119)	(0.00135)
β_{HD}	0.00313	0.0119***	0.0138***	0.0138***	0.0118***	0.0118***	0.0138***
	(0.00234)	(0.00223)	(0.00260)	(0.00260)	(0.00222)	(0.00222)	(0.00260)
β_{HF}	-0.00280	-0.00843***	-0.00873***	-0.00872***	-0.00841***	-0.00840***	-0.00872***
	(0.00218)	(0.00202)	(0.00228)	(0.00228)	(0.00202)	(0.00202)	(0.00228)
γ_{HT}	-0.000654***	-0.000461***	-0.000421**	-0.000421**	-0.000456***	-0.000453***	-0.000421**
	(0.000145)	(0.000138)	(0.000165)	(0.000165)	(0.000138)	(0.000138)	(0.000165)
β_{ML}	0.00385**	0.00357**	0.00297	0.00297	0.00350**	0.00352**	0.00298
	(0.00182)	(0.00171)	(0.00194)	(0.00194)	(0.00170)	(0.00170)	(0.00194)
β_{MD}	-0.0332***	-0.0215***	-0.0254***	-0.0254***	-0.0214***	-0.0213***	-0.0254***
	(0.00329)	(0.00310)	(0.00375)	(0.00375)	(0.00310)	(0.00310)	(0.00375)
β_{MF}	-0.00289	0.00640**	0.00622**	0.00621**	0.00641**	0.00639**	0.00621**
	(0.00292)	(0.00265)	(0.00312)	(0.00312)	(0.00265)	(0.00265)	(0.00312)
γ_{MT}	0.00137***	0.00159***	0.00159***	0.00159***	0.00156***	0.00155***	0.00160***
	(0.000223)	(0.000213)	(0.000263)	(0.000263)	(0.000213)	(0.000213)	(0.000263)
β_{LD}	-0.00135	0.00522***	0.00860***	0.00860***	0.00527***	0.00527***	0.00860***
	(0.00209)	(0.00190)	(0.00233)	(0.00233)	(0.00190)	(0.00190)	(0.00233)
β_{LF}	-0.0000874	0.000688	0.0000219	0.0000231	0.000666	0.000665	0.0000272
	(0.00185)	(0.00167)	(0.00195)	(0.00195)	(0.00167)	(0.00167)	(0.00195)
γ_{LT}	-0.000502***	-0.000513***	-0.000509***	-0.000510***	-0.000496***	-0.000492***	-0.000511***
	(0.000149)	(0.000144)	(0.000178)	(0.000178)	(0.000144)	(0.000143)	(0.000178)
β_{DF}	-0.0901***	-0.103***	-0.104***	-0.104***	-0.103***	-0.103***	-0.104***
	(0.00249)	(0.00264)	(0.00301)	(0.00301)	(0.00264)	(0.00264)	(0.00301)
γ_{DT}	0.00101***	-0.000775**	-0.000625	-0.000625	-0.000765**	-0.000754**	-0.000626
	(0.000325)	(0.000326)	(0.000396)	(0.000396)	(0.000325)	(0.000325)	(0.000396)
γ_{FT}	0.00167***	0.00346***	0.00367***	0.00367***	0.00343***	0.00341***	0.00367***
	(0.000265)	(0.000260)	(0.000314)	(0.000314)	(0.000260)	(0.000260)	(0.000314)

Quadratic terms: Return to Scale Effects							
β_{KK}	0.0130***	0.00977***	0.00942***	0.00942***	0.00973***	0.00973***	0.00942***
	(0.000860)	(0.000877)	(0.00103)	(0.00103)	(0.000876)	(0.000876)	(0.00103)
β_{HH}	0.00202***	0.00186***	0.00216***	0.00216***	0.00186***	0.00185***	0.00216***
	(0.000376)	(0.000353)	(0.000408)	(0.000408)	(0.000353)	(0.000353)	(0.000408)
β_{MM}	-0.00955***	-0.0121***	-0.0107***	-0.0107***	-0.0120***	-0.0121***	-0.0107***
	(0.00179)	(0.00163)	(0.00187)	(0.00187)	(0.00163)	(0.00163)	(0.00187)
β_{LL}	0.000775***	0.00116***	0.00123***	0.00123***	0.00115***	0.00114***	0.00123***
	(0.000253)	(0.000233)	(0.000274)	(0.000274)	(0.000233)	(0.000233)	(0.000275)
β_{DD}	0.0800***	0.0615***	0.0607***	0.0607***	0.0614***	0.0614***	0.0607***
	(0.00156)	(0.00189)	(0.00216)	(0.00216)	(0.00189)	(0.00189)	(0.00216)
β_{FF}	0.0507***	0.0509***	0.0506***	0.0506***	0.0509***	0.0510***	0.0506***
	(0.00134)	(0.00138)	(0.00161)	(0.00161)	(0.00138)	(0.00138)	(0.00161)
δ_{TT}	0.000220***	0.000350***	0.000245***	0.000242***	0.000347***	0.000348***	0.000245***
	(0.0000534)	(0.0000523)	(0.0000642)	(0.0000642)	(0.0000523)	(0.0000522)	(0.0000643)
NRCA		-0.130***	-0.119***	-0.119***	-0.131***	-0.131***	-0.119***
		(0.00367)	(0.00445)	(0.00445)	(0.00366)	(0.00365)	(0.00445)
constant	-1.370***	-0.0132	-0.342**	-0.342**	-0.0200	-0.0156	-0.342**
	(0.100)	(0.144)	(0.168)	(0.168)	(0.145)	(0.145)	(0.168)
Treatment Equation (Dep. Variable: NRCA dummy)							
$\beta_1 KL_{ckt-1}$		0.0000233***	0.0000170**	0.0000170**	0.0000212***	0.0000203***	0.0000170**
		(0.00000591)	(0.00000712)	(0.00000712)	(0.00000588)	(0.00000587)	(0.00000712)
$\beta_2 HM_{ckt-1}$		-0.0164***	-0.0169***	-0.0168***	-0.0162***	-0.0157***	-0.0169***
		(0.00224)	(0.00258)	(0.00258)	(0.00223)	(0.00223)	(0.00258)
$\beta_3 HL_{ckt-1}$		-0.0398**	-0.0528**	-0.0529**	-0.0458***	-0.0483***	-0.0527**
		(0.0167)	(0.0209)	(0.0209)	(0.0168)	(0.0168)	(0.0209)
$\beta_4 FD_{ckt-1}$		-0.0129	-0.0290*	-0.0289*	-0.0167	-0.0171	-0.0290*
		(0.0111)	(0.0152)	(0.0152)	(0.0110)	(0.0109)	(0.0152)
$\beta_5 ER_{ckt-1}$		-0.0150***	-0.0244**	-0.0246**	-0.0133**	-0.0142**	-0.0246**
		(0.00583)	(0.0107)	(0.0107)	(0.00585)	(0.00584)	(0.0107)
$\beta_6 EI_{ckt-1}$			0.0929***				0.0953***
			(0.0139)				(0.0188)
$\beta_7 EID_{ckt-1}$				0.0933***			
				(0.0139)			
$\beta_8 FI_{ckt-1}$					0.195***		-0.0146
					(0.0452)		(0.0753)
$\beta_9 FID_{ckt-1}$						0.278***	
						(0.0483)	
Constant		-0.0935***	-0.155***	-0.0741***	-0.204***	-0.0885***	-0.148***
		(0.0136)	(0.0198)	(0.0182)	(0.0289)	(0.0137)	(0.0407)
Obs.	18881	17458	12175	12175	17458	17458	12175
adj. R-sq	0.998						
/athrho		1.227***	1.150***	1.150***	1.231***	1.233***	1.150***
		(0.0234)	(0.0291)	(0.0291)	(0.0233)	(0.0232)	(0.0291)
/lnsigma		-2.155***	-2.226***	-2.226***	-2.154***	-2.154***	-2.226***
		(0.00946)	(0.0118)	(0.0118)	(0.00942)	(0.00939)	(0.0118)
Wald Test Ind. Eq	0	0	0	0	0	0	0

Standard errors in parentheses - *p<.1; **p<.05; ***p<0.01- Source: WIOD, Worldwide Governance Indicators (WGI), IMF Financial Development Indexes

The coefficients of the sets of variables describe three main effects. The sign and magnitude of the input coefficients show the linear effect on the dependent variable, that is real gross output. The interaction terms depict the existence of a substitution effect or a complementary effect among the variables taken in consideration and in accordance with the sign of the coefficient, respectively negative or positive. Finally, the quadratic variables coefficients suggest the existence of a non-linear effect on output, either increasing or decreasing depending on the sign, respectively positive or negative.

We focus our analysis on the results regarding the joint effects of the intermediate input variables and the labor cohorts by skill level.

The reason of our focus on intermediate inputs is due to the fact that a larger endowment of foreign inputs reveals a greater involvement in global value chains. The negative coefficient of the interaction term between imported and domestic intermediates indicates the presence of a substitution in input effects on growth. Ignoring the direct effects of the inputs and their interactions with other production factors, the combined impact of foreign sourced and domestic intermediates is negative on output. This result adds up to the findings on complementarity channels of trade in intermediates and economic performance. This means that an increase in the import of foreign intermediates, due to a greater participation to global value chain (for instance, international outsourcing and offshoring activities), generates a reduction in output through the interaction with those sourced from the domestic market. Static and dynamic complementarities deriving from combing imperfectly substitutable domestic and foreign input varieties in production may be more than counterbalanced by economic gains due to replacement of cheaper and higher quality intermediate inputs from abroad and shared supplier spillovers from domestic firms (Kee, 2015).

All the parameters of the interaction terms among the three different skill levels are highly statistically significant. The coefficients of the interaction between the high-skill and low-skill labor force is negative while the parameters relative to the interactions of the medium-skill labor with the other two labor groups are positive. Overlooking the impact of the other parameters, substitution between workforces with high and low educational attainments is consistent with some degree of imperfect interchangeability among the groups. The estimates of joint labor variable terms imply that the workers skill distribution affects economic growth. The acceleration during recession of phenomena in the global labor market such as job polarization (that is the decline of middle-skill occupations in favour of higher and lower skill employment) and crowding-out of less educated are consistent with the signs of the coefficients in our estimation. This finding supports policies with the intent to counteract the downsides of unequal skill distribution and its impact on employment and economic growth.

Additionally, all of the quadratic terms coefficients are positive, demonstrating, therefore, the presence of positive nonlinear relationship between factor inputs and output. This means that the increase in one of the inputs, ceteris paribus, leads to an increase of the marginal outputs. Irrespectively of the level of other factor endowments of a country, an increase of one of the input, such as capital, will generate an increase of the marginal output at any starting point. The evidence of substitutability, complementarity and non-linarites at the margin can be better shown by Figure 3.2 and 3.3 of the marginal effects of the variable analysed. Figure 3.2 and Figure 3.3 show the effect of the linear, the quadratic and the interaction terms of the high-skill and low-skill labor variables and the foreign and domestic intermediate input factors. For both figures, we report the values of the two linear terms, the interaction term and the two quadratic terms on the x-axes (in logarithm), while on the y-axes, it is shown their disentangled marginal effects on output, controlling for all the other effects and the other terms. The marginal effects are shown at specific points within a confidence interval of 95%.

Figure 3.2: Marginal Effects for High-Skill and Low-Skill Labor

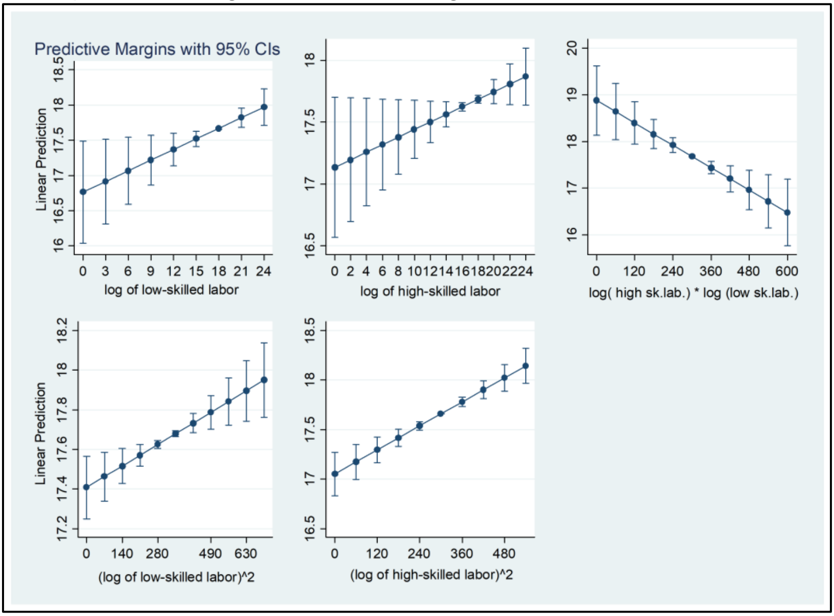
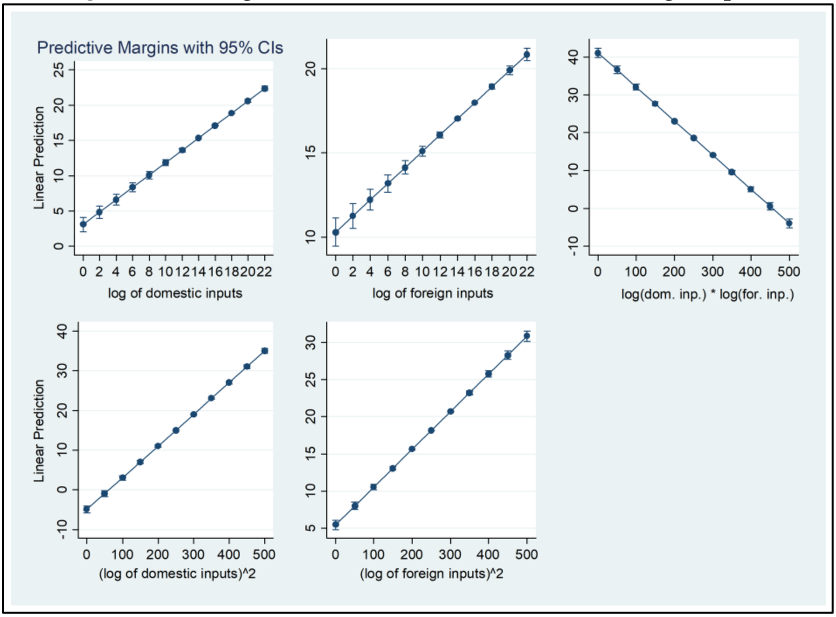


Figure 3.3: Marginal Effects for Domestic and Foreign Inputs



All the single term coefficients show a positive linear prediction for each input level. The marginal effect of the quadratic term of all the variables confirm the presence of increasing marginal returns and the marginal effect of the two interaction terms mentioned before has a negative slope, illustrating, therefore, the existence of a substitution effect between the two variables considered.

A further visual representation of the autonomous and biased effects is given by the examples in Figure 3.4 and Figure 3.5. In particular, Figure 3.4 shows the nonlinear effect of imported intermediate inputs, and hence participation to global value chains, on real gross output at five different levels of domestic intermediate market size, controlling for the average values of the other inputs. We report the values of foreign intermediate inputs on the x-axis (in logarithm) and its marginal effect on output (considering simultaneously linear, quadratic and interaction effects) on the y-axis (in logarithm) The marginal effects are shown for five different levels of domestic intermediate inputs, considering percentile values (namely 10th, 25th, 50th, 75th and 90th) of our sample. Therefore, each upward (or downward) shift of the marginal effect curve corresponds that to an increase (or decrease) of the domestic input endowment. In all cases, the impact of foreign intermediates is non-linear and positive only after a certain point. However, the gap between the effects at different levels of domestic inputs shrinks along with greater sourcing of intermediates from abroad and eventually the impact of intensification in international sourcing overwhelms the impact of combination of both. This corroborates the idea that complementarity channels between intermediates are overcome by substitutability if the level of sourcing from abroad is over a certain threshold. Analogously, in Figure 3.5 we report the values of high-skill labor on the x-axis (in logarithm) and its combined (linear, quadratic and interaction) marginal effect on output on the y-axis (in logarithm), for five percentile values of low-skill labor of our sample. The relative impact of increasing highly skilled workforce with respect to low-skilled labor is diminishing. However, substitutability shows up only for high levels of endowment of both labor groups. This implies that country-sector size may have a role in skill distribution and their complementarity.

Figure 3.4: - Marginal Effect of Foreign Inputs

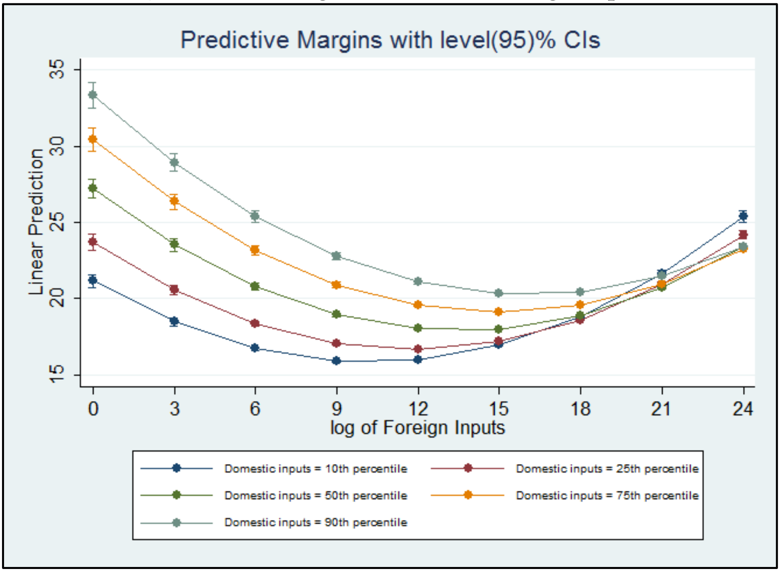
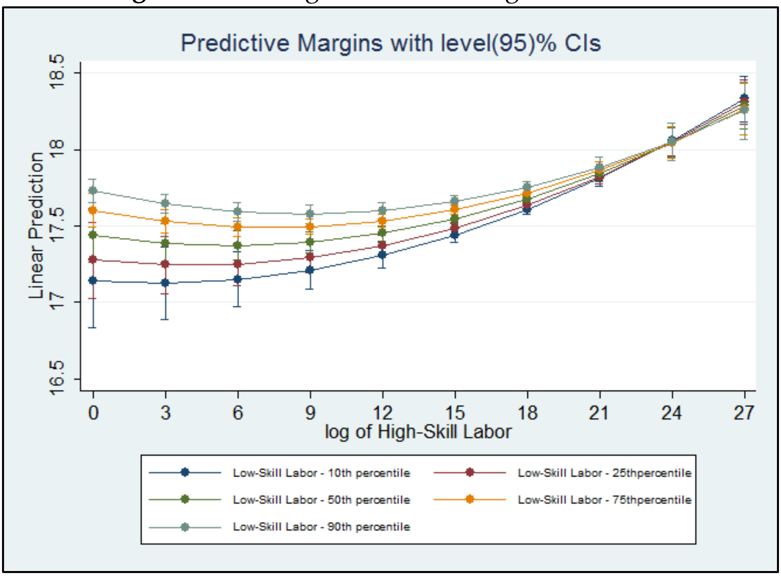


Figure 3.5: - Marginal Effect of High-Skill Labor



3.4.2 Endogenous Treatment with New Revealed Comparative Advantage

In this section, we exploit the richness of the WIOD to analyse the effect of various input factors on global production processes, taking into account also the actual trade specialization pattern of the observed country-sector units We do this by including a dummy variable for the New Revealed Comparative Advantage in our first baseline equation.

It is important to highlight that the NRCA, similarly to the RCA, presents a major shortcoming regarding its asymmetry. With both measures we cannot infer on their magnitudes because of their asymmetry or, in other words, the lack of an upper bound. Therefore we make use of a dummy variable which takes the value 1 if the observed unit shows a NRCA (or, in other words, if NRCA is larger than or equals 1) and 0 otherwise[12]. While alternative specifications of the RCA index deal with some of the drawbacks of the original Balassa index, all of them yield the same result when the matter is whether or not a given country has a comparative advantage in a given sector (Sanidas and Shin, 2010).

Since our additional variables has the objective to capture trade specialization à la Heckscher-Ohlin, based on Ricardo's theory of comparative advantage, we cannot exclude endogeneity due to the fact that factor endowments represent the main drivers of revealed comparative advantages. In fact, for the moment, in our model, we imply that the only source of trade specialization heterogeneity is related to differences in relative resource endowments and the comparative advantage is affected by the relative abundance of factors of production while technology of production is the same at a global level.

We propose a system of simultaneous equations to tackle the endogeneity issue, keeping as a reference the approach offered by Angrist (2001). In our system, the first regression is our baseline equation with the inclusion of the NRCA dummy variable, and the second equation has the above mentioned dummy variable as

[12] The comparative advantage or disadvantage refers to a specific country-sector in a specific year.

dependent variable and a set of covariates corresponding to relative factor endowments.

$$NRCA_{ckt} = \beta_0 + \beta_1 KL_{ckt-1} + \beta_2 HM_{ckt-1} + \beta_3 HL_{ckt-1} + \beta_4 FD_{ckt-1} + \beta_5 ER_{ckt-1} + \varepsilon_{ckt-1} \quad (3.2)$$

The covariates are: KL, capital-labor ratio; HM, high-medium-skill labor ratio; HL, high-low-skill labor ratio; FD, foreign-domestic intermediate input ratio. We add the exchange rate (ER) with US dollar as a further control. The FD ratio can be interpreted as the degree of global value chain participation relative to domestic market size of intermediates.

It is meaningful from an economic point of view to assume that the relative factor endowments have an impact on the specialization in value-added terms after one year. Therefore, all the covariates of the second equation are lagged.

The results of the simultaneous equations are shown in Table 3.4, Column 3. Most coefficients are highly statistically significant and the results do not differ qualitatively from our baseline estimation. The Wald test of independent equations is rejected which means that there is actually a level of dependence between production choices and specialization patterns. In the next section, we consider further determinants of value-added comparative advantage.

3.4.3 System of Simultaneous Equations and Institutions

Recent researches suggest that institutions and their quality may be key drivers and long term determinants of specialization patterns. We introduce institution indicators in the second equation of the simultaneous system as part of the set of covariates that affects trade specialization in terms of existence of value-added revealed comparative advantage.

We make use of two different indicators capturing the quality of economic and financial institutions. The first indicator is the economic institution index representing the rule of law developed by Kaufmann et al. (2009; 2011). The index covers all the countries under and the years 1996, 1998, 2000 and from 2002 up to 2014[13]. Limited data

[13] We will use the index up to year 2009 because this is last available year for the Socio-Economic Accounts of the WIOD.

availability over time of the Rule of Law index reduces our sample size but it this does not render our analysis ineffective as the size is still large.

Our second indicator for institutions is a recently developed measure of financial development by International Monetary Fund (Sahay et al., 2015). The financial institution index captures the financial institutions quality.

Consistently with the controls of relative factor endowments, the institution indexes are included with a one-year lag.

To render our analysis more robust, we provide five different specifications. The results of the different specifications are shown in Table 3.4, from column 3 to column 7.

The first and third specifications (columns 3 and 5) include the economic and financial institution indicators respectively in absolute terms (EI_{ckt-1} and FI_{ckt-1}); the second and the fourth specifications (columns 4 and 6) consider them as distance from their mean value (EID_{ckt-1} and FID_{ckt-1}); finally, the last specification (column 7) includes both the economic and the financial institution indicators.

Interestingly, in most cases we obtain the same signs for the coefficients of the production function and the NRCA function. All the coefficients for institutions are positive and statistically significant, with financial institution coefficients displaying a relatively higher magnitude compared to the economic ones. This means that long-term characteristics of a country such as institutions matter in the trade specialization pattern. However, in the last estimation, when considering both economic and financial indicators, only the first coefficient remains statistically significant. This may imply that the quality of economic institutions such as contract enforcement is a more significant predictor for trade specialization trajectories. Alternatively, it could suggest that the level of development of the financial environment may be already encompassed in the indicator for economic institutions. Considering the impact of international trade involvement on specialization, the FD ratio is negative and statistically significant in three specifications. We may argue that participation to global value chains (relative to domestic intermediate market) affects negatively trade specialization in value-added.

Finally, in all the specifications the Wald tests reject again the hypothesis of independent equations. The Wald test is particularly relevant in our structural equation modelling because it points out that the estimation of alternative models overlooking the endogeneity between production and trade in value-added specialization would provide biased estimates and misleading results.

All these results confirm previous empirical findings that institutions are a further source of revealed comparative advantage; however, neither financial nor economic institutions are variables that break down the relationship of endogeneity between the specialization pattern and the output performance. Since, even after considering long-term determinants such as institutional quality, we cannot exclude the hypothesis of independence between value-added-based specialization trajectories and production choices, we might argue that policymakers should not overlook the numerous sources of specialization, which also impact on the production outcomes. Recent literature strands are giving more weight not only to formal institutions, which we have considered, but also to informal institutions[14] as one of those drivers able to either facilitate or hinder trade and therefore specialization. Nunn and Trefler (2014) explore the recent literature on how alternative institutions and enforcement systems emerge when formal contracting institutions are absent or weak. Interaction dynamics, firm boundaries, networks as well as beliefs and culture all impact on production choices and specialization to an extent that still need a great amount of further investigation.

3.5 Robustness Checks

In order to better support our initial analysis on global-scale production, we provide some robustness checks aggregated in Table 3.5.

[14] For informal institution we consider all non-State rules or enforcement. See also Anderson (2008).

Table 3.5: Robustness Checks

	(1)	(2)	(3)	(4)
α_K	0.063***	-0.781***	0.222	0.234***
	(0.017)	(0.0882)	(0.1787)	(0.0028)
α_H	0.054	0.367***	-0.124	-0.003
	(0.0331)	(0.0373)	(0.3963)	(0.0022)
α_M	-0.216***	0.367***	-1.812**	0.044***
	(0.0375)	(0.1091)	(0.7709)	(0.0036)
α_L	0.029	-0.358***	1.269***	0.009***
	(0.0284)	(0.1138)	(0.4321)	(0.0021)
α_D	0.600***	1.462***	1.41***	0.558***
	(0.0451)	(0.1056)	(0.343)	(0.0055)
α_F	0.766***	0.214***	0.423	0.177***
	(0.0409)	(0.074)	(0.2925)	(0.0044)
δ_T	-0.034***	-0.058***	-0.002	-0.006***
	(0.0038)	(0.0083)	(0.0498)	(0.0009)
Substitutability and complementarity Effects				
β_{KH}	-0.014***	0.005	-0.04**	
	(0.0035)	(0.0046)	(0.0194)	
β_{KM}	0.037***	-0.019**	-0.022	
	(0.0033)	(0.0081)	(0.0374)	
β_{KL}	0.000	0.034***	0.032	
	(0.0018)	(0.0059)	(0.0204)	
β_{KD}	0.007*	-0.089***	-0.041**	
	(0.0034)	(0.0082)	(0.0171)	
β_{KF}	-0.03***	0.016***	-0.075***	
	(0.0027)	(0.0056)	(0.0143)	
γ_{KT}	0.000	0.000	-0.005**	
	(0.0003)	(0.0006)	(0.0022)	
β_{HM}	-0.006**	0.006**	-0.044	
	(0.0031)	(0.0025)	(0.0322)	
β_{HL}	-0.008***	-0.006*	0.005	
	(0.0022)	(0.0035)	(0.0253)	
β_{HD}	0.026***	-0.002	0.09***	
	(0.005)	(0.0052)	(0.0318)	
β_{HF}	0.005	-0.005	0.014	
	(0.0045)	(0.0035)	(0.0259)	
γ_{HT}	-0.001	0.000	0.003	
	(0.0004)	(0.0003)	(0.0032)	
β_{ML}	0.012***	0.002	-0.373***	
	(0.0028)	(0.0102)	(0.0531)	
β_{MD}	-0.02***	0.028***	-0.123**	

	(0.0052)	(0.0105)	(0.0611)	
β_{MF}	-0.013***	-0.036***	-0.057	
	(0.0044)	(0.0088)	(0.0493)	
γ_{MT}	0.002***	0.004***	0.007	
	(0.0004)	(0.0008)	(0.0063)	
β_{LD}	-0.007**	-0.033***	0.052	
	(0.0035)	(0.0081)	(0.0354)	
β_{LF}	0.003	0.031***	0.015	
	(0.0028)	(0.0069)	(0.0311)	
γ_{LT}	-0.002***	-0.002***	-0.003	
	(0.0002)	(0.0006)	(0.0039)	
β_{DF}	-0.088***	-0.133***	0.111***	
	(0.0036)	(0.0081)	(0.0337)	
γ_{DT}	-0.002***	-0.001	-0.014***	
	(0.0005)	(0.001)	(0.0052)	
γ_{FT}	0.004***	0.003***	0.013***	
	(0.0004)	(0.0008)	(0.0047)	
Return to Scale effects				
β_{KK}	0.002*	0.041***	0.053***	
	(0.0013)	(0.0036)	(0.0051)	
β_{HH}	0.001**	0.002***	0.004	
	(0.0007)	(0.0008)	(0.0036)	
β_{MM}	-0.005*	-0.005	0.334***	
	(0.0027)	(0.0065)	(0.0455)	
β_{LL}	-0.001**	-0.005	0.11***	
	(0.0003)	(0.005)	(0.0169)	
β_{DD}	0.034***	0.097***	-0.05**	
	(0.0025)	(0.0062)	(0.0222)	
β_{FF}	0.053***	0.066***	-0.004	
	(0.0021)	(0.004)	(0.0124)	
δ_{TT}	0.000	-0.001***	0.001*	
	(0.0001)	(0.0002)	(0.0008)	
NRCA	0.110***	0.166***	0.488***	-0.524***
	(0.0073)	(0.0085)	(0.0507)	(0.0097)
constant	-0.967***	4.263***	-2.665	-0.162***
	(0.1776)	(0.9926)	(2.4811)	(0.0372)

Treatment Equation (Dep. Variable: NRCA dummy)				
$\beta_1 KL_{ckt-1}$	0.000	0.000**	0.000	0.000
	(0.0000)	(0.0001)	(0.0009)	(0.0000)
$\beta_2 HM_{ckt-1}$	-0.018***	-0.207***	0.203***	-0.025***
	(0.003)	(0.0362)	(0.0489)	(0.0021)
$\beta_3 HL_{ckt-1}$	-0.003	-0.483***	-1.319***	-0.293***
	(0.022)	(0.0845)	(0.2264)	(0.0188)
$\beta_4 FD_{ckt-1}$	-0.072***	0.055	0.443**	-0.211***
	(0.0175)	(0.0381)	(0.1871)	(0.0139)
$\beta_5 ER_{ckt-1}$	0.078***	0.024**	15.866	-0.023**
	(0.0262)	(0.0117)	(15.0993)	(0.0091)
$\beta_6 EI_{ckt-1}$	0.068**	0.351***	-0.243	0.014
	(0.0269)	(0.0624)	(0.3587)	(0.0157)
$\beta_7 FI_{ckt-1}$	-0.247***	0.936***	1.595	-0.139**
	(0.0934)	(0.1715)	(1.0979)	(0.0635)
Constant	-0.045	-0.360***	-0.981**	0.219***
	(0.0545)	(0.0855)	(0.4781)	(0.0357)
Obs.	9,145	2,310	670	12,715
/athrho	-0.703***	-1.593***	-0.902***	1.183***
	(0.0532)	(0.0605)	(0.1256)	(0.0212)
/lnsigma	-2.429***	-2.129***	-1.214***	-0.851***
	(0.0187)	(0.0214)	(0.0496)	(0.0097)
Wald Test Ind. Eq	0.000	0.000	0.000	0.000

Standard errors in parentheses;
Source: WIOD, WGI, IMF.
**p<.1; **p<.05; ***p<0.1.*

First, our objective is to test whether country heterogeneity of the sample could bias our estimation. Therefore, we group countries in three sets according to their level of development, with the set of the most developed countries being the largest group. We repeat the simultaneous system of estimation and the results are in line with those related to the entire sample. The results for the high, medium and low-income groups are in columns 1, 2 and 3 respectively of Table 3.5. All the three groups confirm the presence of some substitutability between high and low skilled workers and between domestic and foreign intermediate inputs. Economic and financial institutions have a positive and statistically significant effect, especially in high and middle-income countries.

Secondly, we provide the estimations with another functional form, the Cobb-Douglas function, to allow for comparison with the translog one.

The estimated coefficients are shown in Table 3.5, column 4. The Cobb-Douglas production function has the advantage of a quite straightforward to interpretation but it has a significant limitation regarding its simplistic assumptions. In fact, it does not allow for variability of the elasticities of substitution (Cobb and Douglas, 1928). Unlike the Cobb-Douglas production function, the translog function imposes no a priori restrictions on the structure of technology and it is not claimed any restriction regarding elasticities of substitution and returns to scale (Kim, 1992). The limitations of those restrictions highly increase whenever the number of factors of production is more than two, as proved by Uzawa (1962) and McFadden (1963).

The elasticities estimated with the Cobb-Douglas function conform the signs of the statistically significant coefficient of the estimation of the translog (except for the medium-skill labor). Further comparisons concerning output elasticities are complicated by the intrinsic differences in the functional forms: in the case of the translog estimation, output elasticities have a degree of variability which depends on the level of all the variables, and this feature is more appropriate for the purpose of our study.

3.6 Conclusions

In the light of the emergence of global value chains, there is a growing attention on novel measurements of trade, growth and their short and long term determinants. In this chapter, we give a contribution on the empirical studies on the interdependence between production performance and the sources of comparative advantage and by making use of a relatively unexploited panel dataset, the WIOD.

First, we highlight the contribution of intermediate input sourcing from abroad and different education levels of labor force to growth. We find that there is a certain degree of substitutability between foreign and domestic intermediate inputs, such that a crowding-out effect cannot be excluded at different stages of economic integration. The crowding-out effect of domestic industries may be a result of the greater participation to global value chains and increased competition from foreign industries in output and input markets, including the labor market for high- and low-skilled workers.

Therefore, policymakers should be cautious about considerations on the benefits of greater participation to global value chains. Similarly, we find that the interdependence between labor inputs at different skill levels might create an obstacle to job creation in the development process along the value chain.

Secondly, consistently with previous studies, we confirm that both economic and financial institutions represent a relevant determinant of the comparative advantage, also based on value-added, and are long-term sources of the relationship of interdependence between specialization and production performance.

Chapter 4

Tracking Value-Added Efficiency in the Hospitality Sector: Evidence from Tuscany

4.1 Introduction

Over the last decades, tourism industry has grown steadily. The number of international tourist arrivals worldwide reached 1.2 billion in 2016. International tourism generated 1.5 trillion dollar in exports and employed around one tenth of the global workforce. It accounts for 7% of world's exports and 30% of services exports. In particular, tourism is one of the fastest growing economic sectors in developing and emerging countries, with China being the largest international tourism spender in the world in 2016 (UNWTO, 2017). It favours development prospects in places with limited investment opportunities, harnessing natural and cultural resources in alternative manners compared to traditional extractive and manufacturing activities. The main determinants of the long-standing growth of the tourism sectors are related to the advancements and cost reductions in both transportation and IT, which dramatically reduced the physical and informational distance between customers and potential destinations. In spite of the exponential growth in international arrivals in emerging economies, developed countries still represent the main international tourism destinations with three European countries (France, Spain and Italy) among the top five incoming countries. The Italian tourism market is particularly fragmented: accommodation firm size is small and hotels are usually family-run and owned, there are very few large tour operators (Manitiu, 2014). Regional policies aimed at improving tourism sector competitiveness are crucial in such a context, in which single firms lack the necessary organizational and economic resources (Hong, 2009; Lopez-Gamero et al., 2009). Despite the challenging characteristics, such as seasonality and high sensitivity to tourism preferences and other sectors, the impact of tourism activities is growing also in more developed economies and it constitutes a relevant source of employment opportunities in an ample range of other sectors. In fact, tourism is a composite sector, highly internationalized; it has tight linkages with other domestic and foreign industries and it is gaining a particular relevance also under a global value chain (GVC) perspective (Christian et al., 2011).

Given the importance of the competitiveness of the hospitality sector as a major node in the tourism value chains of a country and its relative growth and employment implications, it appears crucial to investigate the relationship between the accommodation sector economic performance and the internal and external determinants of efficiency.

Expanding on previous empirical literature on the link between hotel businesses efficiency and its sources, this chapter studies the firm-level and location-level determinants of hotel efficiency in an Italian Region, using firm-level data over a 9-year span and employing the stochastic frontier production function. The focus of this chapter is the Italian Administrative Region of Tuscany, corresponding to the NUTS 2 Region. The Italian constitutional framework considers regional administrations as the main authorities responsible for enacting policies to improve tourism industry competitiveness. Tuscany is located in the centre of Italy and its population consists of ca. 3.8 million inhabitants and it is a traditionally well-renowned destination in Italy in particular for cultural tourism locations such as cities and towns and seaside tourism.

Our main contribution is the estimation of hotel inefficiency in Tuscany with the stochastic frontier approach (Battese and Coelli, 1995; Bernini and Guizzardi, 2010) using a novel firm-level dataset. We employ an up-to-date micro-level panel dataset of over 1000 hotel businesses located in one of the most relevant tourism destinations in Italy. The whole panel consists of a total of 4884 observations; 50% of the sample is represented by hotels in art cities and 27% in seaside destinations. We find that, consistently with other studies (Bernini and Guizzardi, 2010), individual firm characteristics such as intangible assets and human capital as well as external territorial factors, such as the type of tourism destination (and hence, the degree of participation to a tourism value chain), are considerable sources of technical efficiency. We find that hotels with above-the-median average labor costs per employee and share of intangible assets (both representing 50% of the sample) have higher mean efficiency scores (of respectively 0.64 and 0.63) compared to the whole sample (0.57). Moreover, mean efficiency scores are higher for larger (with more than 7 employees), younger hotels (0.59) and those located in cities of art (0.61) and on the seaside (0.60). The remaining part of this chapter is structured as follows. In section 2, we review the main literature on the tourism value chains and hotel performance determinants. In section 3 we present the datasets employed, we provide descriptive statistics on the Italian hospitality sector with respect to other countries and among Italian regions and present the firm-level dataset used for the empirical application. Section 4 provides the methodology of the study, the results and a discussion on technical efficiency. Finally, section 5 concludes.

4.2 Literature Review

While the notion of GVC and the associated methodologies of governance analysis (Gereffi and Sturgeon, 2005) have been mainly employed in the manufacturing sector, the number of studies that analyse the tourism sector under this novel perspective is limited but increasing (Clancy, 1998; Barham et al., 2007; Guzman et al., 2008). The motives in favour of the need of a value chain analysis applied to the tourism sector are mostly two: first, tourism is a heavily internationalized sector; secondly, a value chain analysis can be helpful in detecting and assessing the backward and forward linkages across economic sectors related to tourism. A tourism GVC is characterized by wide range of individuals, organizations and firms involved in the creation of value, and collaborating with each other. Romero and Tejada (2011) group the main actors along a tourism GVC into four main categories: designers of tourism products, suppliers of intermediate tourism goods and services and tourism intermediaries. Tejada et al. (2011) adapts the GVC framework to the tourism sector in order to better analyse the underlying patterns in terms of interdependence between governance policies and upgrading strategies. Song et al. (2013) find that the efficiency of the tourism value chains is heavily dependent on the quality of its governance that influences coordination as well as integration among the nodes of its members.

It is not possible to address the tourism as a unique industry, as the tourism product is composite and complex by nature and it involves the interaction of heterogeneous agents in different sectors. However, one of the most relevant actors in the emerging tourism GVCs are the firms operating in the hospitality industry, since the sector is closely related to the dynamics of both international and domestic flows and is undergoing a wave of internationalization due to hotel chains. This chapter provides a descriptive evaluation of the role and position occupied by the hospitality sector in the economic system in several countries, relying on a GVC framework and using input-output methodologies. Due to its relevance within a tourism value chain and its interdependence with both location and governance, it is interesting to analyse the hospitality industry and the sources of its productivity.

This chapter adds to the well-established empirical literature which has identified several factors affecting hotel firm productivity (Reynolds, 2003; Barros and Alves, 2004; Chiang et al., 2004; Barros, 2005b; Rodriguez and Gonzales, 2007). Some are strictly related to the individual firm characteristics, others are linked to the location or external conditions.

The internal characteristics affecting hotel efficiency include quality and intensity of input factors (capital, labor productivity, workers satisfaction), management, ownership type and age. In particular, firm efficiency is affected by the degree of intangible investments (Nakamura, 1999; Bond et al., 2000), physical and human capital (Blake et al., 2006). In particular in tourism businesses, qualifications of managerial staff are generally below average, compared to others sectors. There are several studies which find positive correlations between workplace environment or product quality measurements and economic performance (Hoque, 2013; Campos et al., 2005; Reynolds and Biel, 2007). Furthermore, heterogeneity in human resources management and labor market conditions are further factors influencing competitiveness (Baum and Szivas, 2008; Morrison et al., 2001). Hotel management characteristics such as hotel ownership and managerial ability affect productivity as well (McGuckin and Nguyen, 1995; Blake et al., 2006). Finally, accumulation of knowledge over time generates learning-by-doing effects which contribute to increase efficiency and competitiveness (Malerba, 1992; Lundvall and Battese, 2000). Similarly to previous works, in the empirical analysis of this chapter we consider physical and human capital as well as learning-by-doing effects among the determinants of efficiency.

The external determinants of hotel performance are linked to the concept of location advantage. First put to light by Dunning (1998), the notion of location advantage can be defined as the benefits that firms in a specific location reap, arising from a privileged access to scarce resources available in that location. Cuervo-Cazurra et al. (2014) argue that the process of creation of location advantage in the hotel industry is the result of the interaction between two separate processes: the first is generated by firms, which contribute to the creation of tourist firm agglomeration or districts; the second process is induced by policymakers through specific public investment in infrastructure.

The seminal paper by Marshall (1920) puts to light the channels through which territorial concentration contributes to competitiveness advantages. Firm concentration in a specific location leads to agglomeration or network externalities due to the diversification of tourism offer, knowledge and technological spillovers and the development of more upstream industries in the value chain, favouring a facilitated access to intermediate inputs. Knowledge and technological spillovers are present in tourism industry, as tourist firms make abundant use of IT technology and are mainly based on labor-intensive activities (Kahle, 2002; Hallin and Marnburg, 2008). Hotel networks may gain in competitiveness and efficiency from the development of new complementary products and innovative services, from the exploitation of network shared resources and from accession to a more specialized labor and intermediate input markets (Baum and Haveman, 1997; Bernini, 2009; Michael, 2003; Novelli et al., 2006; Hong, 2009). Researchers have traditionally explained tourist firm concentration mostly from a demand perspective (McCann and Folta, 2008; Brown and Rigby, 2013). Location of firms in the tourist industry is mainly driven by the presence of attractions and destination-specific tourist resources or other firms with complementary products (Yang et al., 2014). Destination-specific characteristics have impact on individual firm competitiveness (Capone and Boix, 2008); additionally, businesses belonging to the same tourist cluster are affected by the same stochastic demand pattern, which in turn influences organization and operation management. The empirical analysis in this chapter considers external determinants of efficiency, related to the location advantages of specific tourist destinations.

More recent studies highlight the role of industry clusters in the internationalization processes of firms (Marco-Lajara et al., 2017). On one hand, businesses located in clusters decide to employ their resources and exploit their competitive advantage abroad; on the other hand, industrial districts may attract FDI domestically. The specific benefits from localization in an urban environment bring about the so-called urbanization externalities (Bernini and Guizzardi, 2016), which are correlated with city size (Hoover, 1937), infrastructural endowments (Camagni, 1992) and diversity (Jacobs, 1969). Urbanization externalities in tourist industry consist in a larger offer of services and infrastructures and a diversification of tourist activities. On the contrary, agglomeration externalities in urban environment may bring about diseconomies related to territorial congestion and social sustainability issues arising between local residents and tourists (Concu and Atzeny, 2012). Although the effects of localization and urbanization overlap and their externalities are rapidly dispersed across space, it is possible to identify the impact of potential economies or diseconomies by spatially delimiting the analysis to restricted location and sample of firms.

Looking at the methodological procedures, firm performance analysis can be done using the efficiency model, that is a technique aimed at assessing the ability of the firm to process its inputs for production compared to the maximum potential output level. The efficiency analysis overcomes the limitations of the productivity approach, based on the simple output-input ratio and it is widely used by empirical research to evaluate firm competitiveness, starting from the works by Koopmans (1951) and Farrell (1957) on efficiency and technical efficiency respectively. Aigner et al. (1977) and Meeusen and Van den Broeck (1977) propose a stochastic frontier methodology. The distribution of efficiency scores around the expected values may have different shapes (Battese and Coelli, 1996), which depend on the assumption on market structure. Simar et al (1994) propose a procedure with maximum likelihood estimation of both the technical efficiency and the its firm-specific determinants. While in the empirical literature on tourism industry efficiency there is a prevalence of data envelopment analysis, there is a growing strand of research employing stochastic function frontier with two-stage estimation. De Jorge and Suarez (2014) study territorial effect heterogeneity in Spanish regions and connect hotel efficiency to tourism demand size. Barros (2005) and Honma and Hu (2013) corroborate the relationship between location and efficiency. They find that distance from the airport influences hotel efficiency. In hospitality firm performance studies, the cost function approach prevails compared to the production function approach (Barros, 2004; Weng and Wang, 2006; Chen, 2007; Rodriguez and Gonzalez, 2007). As a matter of fact, most cost function studies are based in a multiproduct framework, in a precise and homogenous empirical environment, either a small geographical location or a chain, under the assumption of standard opportunity costs. Conversely, the production function approach considers the use of inputs such as labour and capital to generate output in a technical efficient manner. The benefits of using the production function approach are greater in a competitive market, with a single-output product, if opportunity costs may be overlooked. With these respects, this chapter adds to the empirical works on hotel efficiency based on the stochastic frontier production model.

Regarding the research on hotel performance in Italy, which is the focus of this chapter, there are only a few and relatively recent studies relying on a large number of observations. Among others, Bernini and Guizzardi (2010) find that Italian cities of art and on the seaside have a greater efficiency because they either have a diversified tourist offer or experience large and seasonal demand spikes. Suzuki et al. (2011) find that destination performance of Italian Provinces can be improved significantly and confirm previous findings by Cracolici et al. (2008). Bernini and Guizzardi (2016) find significant agglomeration effect on performance in the hospitality sector in one Italian Region, Emilia-Romagna. Expanding on previous literature, we provide a rich empirical analysis based on a relatively unexploited micro-level panel dataset and estimate hotel technical efficiencies in Tuscany, their determinants and the distribution along different internal and geographic dimensions.

4.3 Descriptive Statistics and Data

In this section, we present an overview of the accommodation and food services industry in major countries by output produced in the sector, making use of the World Input-Output Database (Timmer et al., 2015). In the light of tourism GVCs, this descriptive analysis allows us to detect the geographic dispersion of value-added and the forward linkages of a crucial sector for tourism in several countries. Then, we restrict our analysis on the dynamics of the Italian sector in the latest years and, in particular, we focus on one of its major tourism destinations, which is the administrative Region of Toscana. We source from Orbis a panel dataset of firms in the accommodation sector of Toscana and use it for our empirical application on technical efficiency in the following section. Although it is not possible to identify specific sectors or products with a full tourist character, as tourist goods and services can be also purchased by locals, a tourism value chain can be defined as the ensemble of economic agents involved in the tourism industry, collaborating to create value for tourists and themselves. The major nodes of a tourism value chains are represented by designers of tourist products, suppliers of goods and services and intermediaries. In this chapter, our focus is on one key supplier sector, that is hotel and restaurant. This sector has several backward and forward linkages with other domestic and foreign sectors in and outside the tourism domain, such as real estate, construction, retail trade.

Firstly, Table 4.1 presents the list of ten countries with largest output in the hotel and restaurant sector. On average, the incidence of the sector on total output is small (2.50%). Among these countries, this sector has the highest relevance on national output in Spain, Japan and

Italy. The sector impact on total GDP is more limited in countries such as Germany and China. Similar considerations can be made by looking at the ranking of countries by value added in the hotel and restaurant sector and its relative impact on aggregate value added in Table 4.2. In particular, value added generated by the Italian hotel and restaurant sector is 3.61% of total value added. Great Britain ranks first with almost 7% of total value added, being a key destination for domestic and business tourism flows. Table 4.3 presents the decomposition of gross output in intermediate input and value added shares for the set of countries with largest sectoral output. The share of intermediate inputs in output is larger for Asian countries and lower for American countries such as the US and Brazil. In Europe, Spain has the largest incidence of value added while Italian value added share (51.44%) is consistent with the group average. In Table 4.4, we provide the allocation of output to internal and external sectors or final use. More than three fourths of sectoral output is destined on average to internal final use. Spain, Italy and Germany allocate over 80% of their sector output to internal final use. Higher shares of output are destined to other national productive sectors in Asian countries such as China, India and Japan.

Table 4.1: H&R sector Total Production in 2014 (output, US$ million)

Countries	Total ouptut of sector H&R	Total Output of country	Output Share of Sector H&R
United States	892,676	30,971,024	2.88
China	532,328	31,745,102	1.68
Japan	303,710	8,668,736	3.50
Great Britain	154,343	5,283,464	2.92
Spain	148,043	2,567,906	5.77
Italy	135,056	4,075,402	3.31
France	127,484	5,020,135	2.54
Germany	111,437	7,066,741	1.58
Brazil	96,114	4,103,502	2.34
India	87,535	3,983,527	2.20

Source: own calculation based on WIOD

Table 4.2: H&R Sector total production, 2014 (value added, US$ million)

Countries	Total Value Added of sector H&R	Total Value Added of country	Value Added Share of Sector H&R
United States	487,987	17,348,070	2.81
China	200,016	10,283,983	1.94
Japan	134,192	4,437,887	3.02
Great Britain	87,057	1,259,829	6.91
Spain	77,534	2,666,096	2.91
Italy	69,466	1,925,310	3.61
France	69,307	2,537,743	2.73
Germany	52,310	3,484,775	1.50
Brazil	48,648	2,071,926	2.35
India	36,235	1,357,151	2.67

Source: own calculation based on WIOD

Table 4.3: Composition of Output of the Sector H&R in 2014

Countries	Total ouptut of sector H&R	% of Total Input in Total Output	% of Value Added in Total Output
United States	892,676	45.25	54.67
China	532,328	62.36	37.57
Japan	303,710	55.64	44.18
Great Britain	154,343	44.26	50.23
Spain	148,043	39.88	58.81
Italy	135,056	47.09	51.44
France	127,484	44.25	54.36
Germany	111,437	51.04	46.94
Brazil	96,114	43.91	50.61
India	87,535	66.55	32.98

Source: own calculation based on WIOD

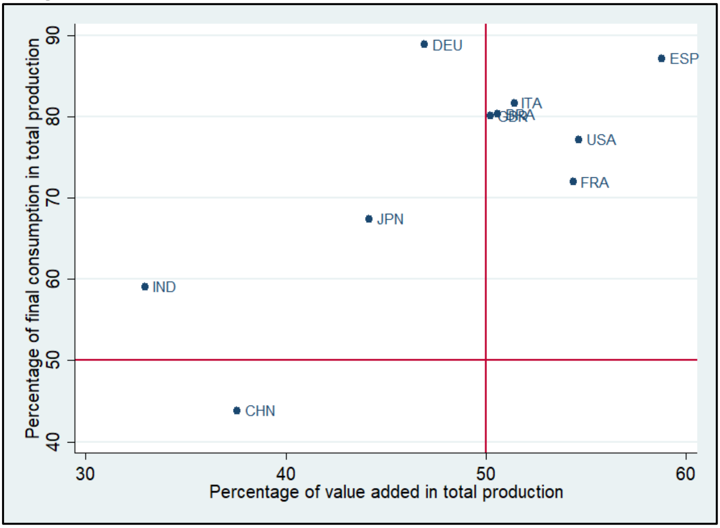
Table 4.4: H&R Sector Total Production Allocation in 2014

Countries	% of output destined to internal productive sectors	% of output destined for internal final use of the country	% of output exported towards productive sectors of ROW	% of ouput exported towards final use of ROW
United States	22.8	77.1	0.1	0.1
China	55.1	43.2	1.2	0.6
Japan	31.7	66.9	0.9	0.5
Great Britain	14.5	77.1	5.4	3.0
Spain	9.8	85.3	3.0	1.9
Italy	18.2	81.7	0.0	0.0
France	28.0	72.0	0.0	0.0
Germany	5.6	85.2	5.4	3.7
Brazil	17.4	79.2	2.3	1.1
India	40.9	59.1	0.0	0.0

Source: own calculation based on WIOD

Following Lamonica and Mattioli (2015), we represent in Figure 4.1 the hotel and restaurant sector structure of production in several countries worldwide in 2014. It is possible to detect three different groups. The first includes the USA, Italy and Spain and consists of countries having a high share of output destined for final consumption and value-added percentage over 50% of total sector output. The second group comprises China. In this group, the hotel and restaurant sector produces most output for other sectors, it is therefore mostly an intermediate sector and generates a lower share of value added. In the third group, where there are countries such as Germany Japan and India, the sector is characterized by a relatively lower share of value added in total output (not exceeding one half) and a higher percentage of output intended for final consumption, domestically or abroad. The numbers seem to suggest that the role of hotel and restaurant sector is related to level of country development. It plays a greater role in Asian emerging economies' domestic industries, such as China and India, as intermediate sector. In European mature economies, such as Spain, Germany and Italy, the hotel and restaurant sector allocates less output to other domestic industries and we may argue that its forward linkages are weaker, compared to other countries[15].

Figure 4.1: Productive structure of the H&R Sector in 2014



Source: own calculation based on WIOD

Despite the long-standing tradition and the good performance, Italian tourism businesses suffer from some major weaknesses which hinder its innovation and competitiveness in the global scenario. In particular, the Italian accommodation industry is characterized by high fragmentation, with a low business size compared to international standards, and still mostly family-run. Moreover, although some areas are known for their cultural and historical resources, most regions are specialized in sea-and-sun product and are therefore strongly dependent on seasonality. The focus of this chapter is the Italian administrative Region of Tuscany and corresponds to one NUTS 2 local administrative unit. The Italian constitutional framework considers regional administrations as the main authorities responsible for enacting policies to improve tourism industry competitiveness (Bernini and Guizzardi, 2016). Tuscany is a traditionally well-renowned

[15] For a broader discussion on forward and backward linkages in the tourism sector, we refer you to Cai et al. (2006)

destination in Italy in particular for cultural destinations such as cities and towns and seaside tourism. As shown in Table 4.5, it ranks third both for tourist arrivals and overnight stays among other Regions on a national level and accounts for more than one tenth of all national arrivals and overnights while tourist average stay in Tuscany is in line with the national mean value.

Table 4.5: Top 10 Italian Regions in terms of Arrivals (2014)

Nuts 2 Region	Arrivals	Overnight stays	Arrivals (share on total)	Overnight stays (share on total)
Veneto	16,262,831	61,863,257	15.3	16.4
Lombardia	14,091,530	34,293,526	13.2	9.1
Toscana	12,385,052	43,150,721	11.6	11.4
Lazio	10,367,031	30,808,575	9.7	8.2
Trentino Alto Adige	9,637,795	43,798,842	9.0	11.6
Emilia-Romagna	9,196,421	35,384,389	8.6	9.4
Campania	4,632,876	18,060,075	4.3	4.8
Sicilia	4,621,370	14,866,938	4.3	3.9
Piemonte	4,442,253	13,061,306	4.2	3.5
Liguria	4,066,978	13,474,247	3.8	3.6
Others	16,848,215	69,008,930	15.8	18.3

Source: ISTAT

Table 4.6 provides insights about the Italian accommodation sector. It ranks fifth among Italian Regions for value-added generated by the accommodation sector and accounts for 9.7 % of sector national value-added. It has the second highest number of accommodation businesses, which employ almost one tenth of the entire labor workforce in the national sector. For the purpose of our analysis, we employ a panel dataset from Orbis, consisting of 1073 companies in the accommodation sector operating in the Italian NUTS 2 administrative region of Tuscany. All firms of the sample belong to the NACE sectors 55.1 and 55.2. The data refers to the period 2008-2016 (last available year).

Table 4.6: Top 10 Italian Regions in terms of Value Added in the Accommodation sector in 2014

Nuts 2 Region	Value added		Firms		Employees	
	total	share	total	share	total	share
Trentino Alto Adige	1,376,645	14.8	6,870	14.8	31,629	12.6
Veneto	1,149,899	12.4	3,533	7.6	27,213	10.8
Lombardia	1,122,585	12.1	3,697	8.0	27,345	10.9
Lazio	966,249	10.4	3,726	8.0	24,601	9.8
Toscana	898,009	9.7	5,623	12.1	24,789	9.9
Emilia-Romagna	696,962	7.5	4,275	9.2	23,619	9.4
Campania	656,919	7.1	2,955	6.4	17,397	6.9
Sicilia	409,169	4.4	2,455	5.3	12,044	4.8
Sardegna	339,486	3.7	1,310	2.8	8,288	3.3
Puglia	312,292	3.4	1,991	4.3	9,747	3.9
Others	1,347,449	12.7	9,987	17.7	44,805	15.1

Source: ISTAT

The sample under investigation accounts for 28% of all the firms in the hotel sector in Tuscany existent on Orbis. Missing data relative to value added are treated in two ways: first, they are linearly interpolated with previous and subsequent data according to year or, alternatively, extrapolated, taking the two closest scores[16]. In this way, linear interpolation corresponds to the average of the previous and the following observations. Then, values still missing are replaced with the difference between revenues and outside purchases. Finally, we exclude negative observations. Treated missing values represent 1127 observations, which correspond to 23% of the sample. In Table 4.7, we provide descriptive statistics for the main variables employed in the empirical application. All the nominal data are deflated by national consumer price index and expressed at constant 2008 prices. We limit our analysis to firms with non-negative value added; hence all the variables are positive and show a high degree of variability due to the

[16] For further methodological explanation, we refer you to Stata Data-Management Reference Manual (command *ipolate*, option *epolate)*.

presence of a few very large businesses. Variability tends to decrease if values in the first and last deciles are excluded. According to the ISTAT tourism municipality classification, 23% of municipalities in Tuscany are cities of the arts, 12% are seaside municipalities while over 47% of municipalities are hill or mountain localities. However, in our sample, businesses in art localities and seaside destination are over-represented with 50% and 27% of the total sample observations, respectively. Furthermore, we provide the disaggregation of our sample by Province, the Italian administrative unit corresponding to NUTS 3, in Table 4.8. In all the Provinces, the share of art cities in the sample range between 11% and 94%, except the case of Livorno which nonetheless has a majority of hotels in seaside localities. Almost one third of the observations over the period are hotels located in the Province of Florence. The hotels in the Province of Grosseto are the oldest ones (average of 22 years of operation) and have the largest average size, in terms of output and input variables.

Table 4.7: Descriptive statistics of variables (output, input and inefficiency determinants)

	Variable	Mean	Std. Dev.	Min	Max
Output					
VA	Value Added	612989.50	1546238.00	1.98	23197309.00
Inputs					
K	Total assets	4629611.00	11518510.00	2563.83	144243470.00
L	Number of Employees	13.67	25.75	1.00	353.00
Time	Time trend	5.74	2.37	1.00	9.00
Inefficiency determinants					
AGE	Years of operation of firms	17.89	15.25	0.00	96.00
HUMCAP	Costs of employees/ Number of employees ratio	28873.54	41487.19	2.13	914608.60
KIMM	Total assets/fixed assets ratio	6.87	84.46	1.00	3835.67
D_ART	City-art municipality (dummy)	0.50	0.50	0.00	1.00
D_SEA	Seaside municipality (dummy)	0.27	0.44	0.00	1.00

Nominal data are deflated by national consumer price index and expressed at constant 2008 prices

Source: Orbis Dataset, ISTAT Municipality Classification

Table 4.8: Descriptive statistics of variables according to Italian Administrative Province (Mean values)

Province	N. OBS.	VA	K	L	AGE	HUMCAP	KIMM	D_ART	D_SEA
Arezzo	178	269,332	1,513,280	10	16	17,425	2.4	0.75	0
Firenze	1,584	903,246	6,032,678	17	18	26,804	4.7	0.82	0
Grosseto	363	938,261	7,764,320	24	22	25,637	3.1	0.11	0.77
Livorno	684	548,316	4,926,313	10	21	45,947	3.1	0	0.95
Lucca	491	414,755	2,177,327	11	15	26,893	20.9	0.36	0.60
Massa-Carrara	131	267,862	2,606,482	8	16	23,646	2.8	0.25	0.69
Pisa	288	359,953	3,566,083	10	14	21,814	19.5	0.82	0
Pistoia	339	307,793	3,386,384	12	19	25,708	5.8	0.19	0
Prato	93	640,646	3,825,020	16	18	24,599	6.6	0.94	0
Siena	733	399,999	3,624,266	10	17	28,839	5.0	0.53	0

Nominal data are deflated by national consumer price index and expressed at constant 2008 prices

Source: Orbis Dataset, ISTAT Municipality Classification

4.4 Methodology and Results

In this section, we consider a single stochastic production function for hotel businesses in Tuscany and explore the impact of internal features affecting firm performance in terms of efficiency.

The choice of the production function approach is motivated by three main reasons: first, Italian hotel firms are still family-run and relatively small in size, so it is possible to overlook opportunity costs since in several cases, hotels represent also the family's home. Secondly, we assume a competitive market environment in which inputs are exogenous with respect to the production function. Finally, we avoid a multiproduct setting since our focus is on a single output production.

For these reasons and for the purpose of our analysis, the advantages of using a cost function are reduced compared to the use of a production parametric framework.

We estimate both a stochastic frontier production function and a technical inefficiency model, following Battese and Coelli (1995). More specifically, we make use of a Cobb-Douglas production function.

$$\ln y_{it} = \beta_0 + \beta_1 \ln K_{it} + \beta_2 \ln L_{it} + \beta_3 t + (V_{it} - U_{it}) \qquad (4.1)$$

Where *ln* stands for natural logarithm, y_{it} indicates value added of hotel *i* at time *t*[17], the two inputs, capital and labor, are represented by total assets and number of employees respectively. The variable *t* indicates the year of the observation involved, it accounts for the time-trend and captures the Hicksian neutral technological change.

The V's are random variables and it is assumed that they are independent and identically distributed, $N(0;\sigma^2)$. The non-negative random variables U_{it} account for production technical inefficiency and are assumed to be independently distributed. U is the truncation at zero of the $N(\mu; \sigma^2_U)$ distribution where the mean μ is specified as a function of both observable firm and territorial characteristics and unobservable determinants. We opt for the truncated normal form since, under the hypothesis of competitive market environment, most

[17] Missing values are either interpolated or replaced with the difference between output and outside purchases.

hotel firms are expected to operate near their maximum efficiency level. In particular, our specification of mean technical inefficiencies of a hotel business is defined as in Bernini and Guizzardi (2010):

$$\mu_{it} = \delta_0 + \delta_1 \ln AGE_{it} + \delta_2 \ln HUMCAP_{it} + \delta_3 \ln KIMM_{it} + \delta_4 D_{ARTi} + \delta_5 D_{SEAi} + \delta_6 t \quad (4.2)$$

where AGE is the number of years of operation of the hotel business and is a proxy for efficiency gains due to learning-by doing; HUMCAP is calculated as the ratio between costs of employees and number of employees and serves as a proxy for the average skill level of firm labor force under the assumption of homogenous real wages across different Provinces of the Region. KIMM is the inverse of the share of fixed assets on total assets. It can be interpreted also as a measurement of the investments in intangible assets such as employees' skills and it is expected to be negatively correlated with efficiency. We introduce two dummy variables controlling for the tourist specificity of the hotel location according to ISTAT tourism municipality classification. The use of these variables has the objective of capturing firm external characteristics affecting efficiency, common to all the hotel businesses located in the same tourist area. *D_ART* is a dichotomic variable assuming value 1 if the hotel i is located in a city of art, while *D_SEA* controls for hotels located in major sea tourism destinations. The idea behind the use of these binary variables is that different locations are specialized in different types of tourism products and present different tourist demands, seasonalities as well as heterogeneous infrastructure and accommodation endowments. The two dummy variables have the objective to capture location externalities such as technology and knowledge spillovers in tourism districts or urbanization effects that impact efficiency. A positive coefficient δ indicates that an increase in the corresponding variable increase the mean level of technical inefficiency.

All the parameters (β, δ, σ^2_U, σ^2_V) of both the stochastic frontier production function in equation 4.1 and the inefficiency model in equation 4.2 are estimated simultaneously using maximum likelihood estimation. Following Battese and Coelli (1992), the technical efficiency of hotel *i* is derived as $TE_i = e^{-U_i}$ where U is the term specified in equation 4.1 plus an error term. In this way, the technical efficiency levels of the firms range from 0 to 1 and are inversely related to technical inefficiency effects. Table 4.9 provides the results of the simultaneous estimation of the stochastic frontier production function and the technical inefficiency model. The estimates of the coefficients β and δ are consistent with our expectations.

Table 4.9: Maximum likelihood estimates for parameters of the stochastic frontier with inefficiency effects model

Coefficient	**Estimate**	**Standard error**	**t-Ratio**
Stochastic frontier			
Capital	0.280***	0.010	29.120
Labor	0.676***	0.015	43.670
Time	0.002	0.007	0.340
Constant	7.656***	0.135	56.780
Inefficiency model			
AGE	0.206	0.197	1.050
HUMCAP	-1.483***	0.364	-4.070
KIMM	-3.576***	1.318	-2.710
Time	-0.372***	0.135	-2.750
D_Art	-2.789***	0.865	-3.220
D_Sea	-2.153***	0.734	-2.940
Constant	13.818***	2.915	4.740
Variance parameters			
$\sigma^2 u$	6.402***	1.957	3.270
$\sigma^2 v$	0.426***	0.018	23.700
Log-likelihood function			
LL	-6451		
Number of iterations	21		
Number of cross sections	1073		
Number of time periods	9		
Total number of observation	4884		

**** significant at 1% level; ** significant at 5% level; * significant at 10% level*

The nature of technical inefficiency can be investigated by testing several hypotheses with the generalized likelihood ratio statistic, λ, which equals:

$$\lambda = -2[ln(L(H_0)) - ln(L(H_1))] \qquad (4.3)$$

where L indicates the value of the likelihood function under two hypotheses: the null hypothesis H_0 and the alternative hypothesis H_1, which corresponds to the general stochastic frontier model. We test two main hypotheses: first, we test whether there is no technical inefficiency, so that the model can be brought back to a simple production function with neither deterministic nor stochastic inefficiency effects; secondly, we test whether the inefficiency determinants are not stochastic, so that they can be included in the production function with the other input factors and their effect is purely deterministic; The parameter λ has a chi-square (or mixed chi-square) distribution, if the null hypotheses involves σ^2_U and it is not rejected (Coelli, 1995). Generalized LR (likelihood-ratio) tests of the null hypotheses are shown in Table 4.10. The first null hypothesis, that specifies that the inefficiency effects are absent, is strongly rejected. In fact, the LR test equals 987, which exceeds the 5% threshold for the mixed chi-square distribution with 8 degrees of freedom (Kodde and Palm, 1986). The second null hypothesis specifies that the inefficiency effects are deterministic (and therefore included in the production function) and is also rejected. A third specification tests whether the determinants in equation 4.2, except the constant term, do not affect the mean technical inefficiency. However, this cannot be tested, since the maximum likelihood estimation of the null hypothesis model does not converge. The large number of missing values and the limited sample size does not allow the estimation of the model, due to the presence of a discontinuous region. We may argue that the inefficiency effects are present and are stochastic but we are not able to draw conclusion on the significance of the joint stochastic effects of the inefficiency determinants, although the individual effect of most variables is statistically significant.

Table 4.10: Hypotheses testing for the functional form of the stochastic production function

H_0	Hypothesis tested	LL	λ	Nr. of restrictions	χ2 (0.95)
$\sigma^2_u = \delta_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = 0$	No technical inefficiency	-6945	987	8	14.85
$\sigma^2_u = \delta_0 = \delta_6 = 0$	Inefficiency factors are not stochastic	-6594	286	3	7.05

The sum of the elasticities estimated relative to the input factors in Table 4.9 is close to one (0.94) which indicates that the Cobb-Douglas production function is a good approximation for the hotel sector in Tuscany and that it has slightly decreasing returns to scale. Labor elasticity is high and this confirms that the accommodation sector is a labor-intensive industry.

A one-percent increase in labor input generates almost a 0.7 percent increase in value added. The coefficient for the time trend suggests that the value of output has tended to increase by a very small but not statistically different from zero over the nine-year period. Our results on estimates of labor elasticity and decreasing returns to scale are consistent with extant empirical research on the average structure of the tourism industry (Bernini and Guizzardi, 2010).

However, our empirical estimation allows us not only to analyse the production structure of the accommodation sector in Tuscany but also to detect the sources of technical inefficiency, that is the relative distance from potential output.

There are various internal determinants that affect the individual firm level of technical efficiency.

In our estimation, we find that the most important and significant factors are the ratio between labor costs and number of employees and the ratio between total and fixed assets. The first ratio is considered as a proxy for the average quality of human capital or, more generally, the potential for improvement of the workers' skill level.

The second ratio approximates the amount of intangible investments, such as professional training, patents and trademarks, marketing and R&D activities. Intangible investments have a direct impact on the effectiveness of the work environment, employers' motivation as well as on the organization of operations and its flexibility with respect to seasonal demand. All the dimensions linked to these two variables influence the overall hotel performance and competitiveness.

The findings suggest that, since both variables have negative coefficients, hotels with a higher quality of human capital or with a larger share of investments in intangible assets have on average higher degree of efficiency.

Considering another internal characteristic, we find that the age of the business (that is the years of operation) does not have a statistically significant impact on efficiency. This implies that, according to our results and contrary to previous works (Wang et al., 2006), learning by doing effects over time do not influence significantly the firm efficiency.

We introduce two dummy variables to capture external location effects for the main types of tourism destinations in Tuscany, art cities and seaside destinations. We find that both coefficients are highly significant and negative.

Similarly to other works (Wang et al., 2006; Bernini and Guizzardi, 2010), we find that the type of destination, which is strongly related to the tourism product offered and seasonality pattern, affects the hotel efficiency level. The dichotomic variables may also control for urbanization effects, in terms of amount of tourist attractions and infrastructure endowments.

The strongest positive effect on efficiency concerns art destinations. This may be due to the fact that art cities are usually characterized by relatively higher tourist flows with respect to their hotel capacity and less subject to seasonal demand patterns, as they are more prone to host several tourism demand segments (i.e. business tourism).

Moreover, tourism resources in cultural destinations are diversified and integrated among different agents in the tourist network, favouring the emergence of tourism clusters. Tourism clusters generate positive externalities on the performance of businesses.

We find also positive external location effects on efficiency in seaside destinations. The effect is lower than in art cities, but still statistically significant. Despite municipalities on the seaside usually have a less diversified tourism offer compared to other destinations, they face a large upsurge in tourist arrivals and overnights during summer, due to a strong seasonal demand. The spikes in demand may facilitate the access to labor and capital market as well as other intermediate input factors and therefore improve efficiency and counterbalance potential negative externalities linked to congestion and social sustainability.

Finally, the coefficient relative to the time trend T is negative and statistically significant. This means that average Tuscan hotel efficiency tends to increase over the time period considered. The technical change variable captures the impact of all the dynamic factors impacting the mean efficiency level such as economic, financial and technological environment, governmental policies.

4.4.1 Discussion on technical efficiencies

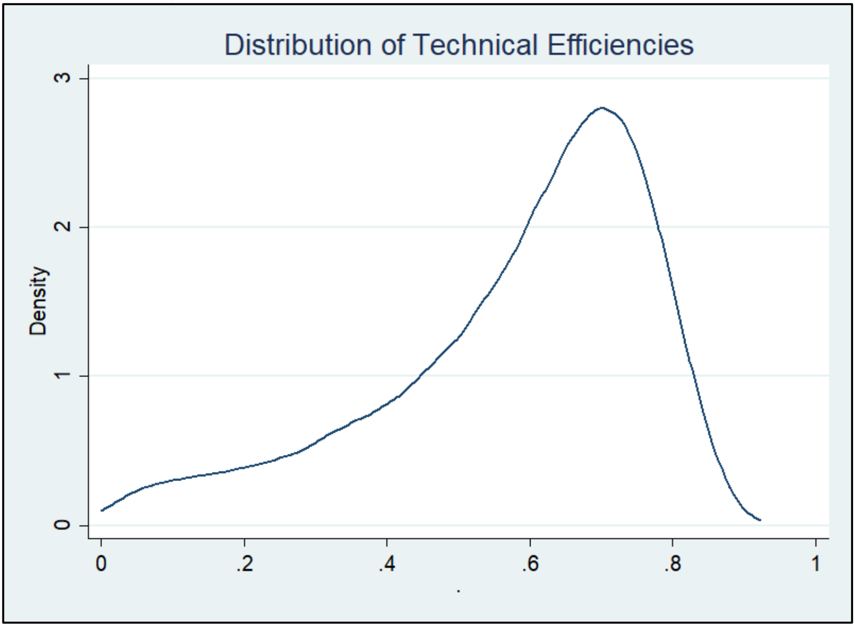
We use the stochastic production function with the inefficiency model estimated with equations 4.1 and 4.2 and compute the technical efficiencies for our sample panel.

This allows us to analyse the performance of hotel businesses according to the internal, external and time dimensions considered in the empirical model.

The distribution of technical efficiencies shown in Figure 4.2 is asymmetric around the mean value (0.58), with a thinning left tail. The use of the truncated distribution for U_i in the empirical mode is supported by the fact that the mode is not in the final tail of the distribution (Battese and Coelli, 1996).

There is only a small part of hotel companies with very low technical efficiency scores, since the tenth percentile threshold is 0.29.

Figure 4.2: Distribution of Technical Efficiencies



In order to better depict the distribution of technical efficiencies controlling for internal and external characteristics, we split our sample of 4884 observations according to the median values of the internal characteristics and to the external characteristics, used in the empirical analysis. We present the distributions in Figure 4.3.

First of all, we consider firm size. Almost 53% of our sample (2610 observations) consists of firms with 7 or more employees, which is the median number. The first graph shows that firm size has a mean positive effect on efficiency. If the firm is small (number of employees below 7), the efficiency distribution is dispersed around lower efficiency scores (0.57), compared to larger firms (0.59).

Secondly, the effect of firm age is negative. In other words, the number of operating years decreases the mean level of efficiency. In particular, firms younger than 14 years (representing almost 49% of our panel sample) exhibit a higher mean efficiency score (0.59) compared to older firms (0.57) but, as shown in the regression results, the age effect is not statistically significant. Combining both dimensions, hotels with both more than 7 employees and less than 14 years (22% of the total) report a higher mean efficiency level (0.61)[18].

Thirdly, the quality of human capital computed as the average labor costs per employee is the key internal determinant impacting technical efficiency. Hotels with average labor costs smaller than 22,532 euros per employee and possibly with less qualified workforce show lower technical efficiency scores (0.52), while companies with above the median labor costs per employee have higher levels of efficiency (0.64). Similarly, technical efficiency is also correlated with the intensity of intangible investments. Companies with intangible assets above the median value exhibit a larger mean efficiency value (0.63) compared to others (0.53). The discrimination according to median values of average labor costs and intensity of intangible investments splits our sample exactly in two halves (2442 units for each group).

Considering external characteristics, the type of tourism destination is determinant for the degree of efficiency of the hotel businesses. Firms in cities of art and municipalities on the seaside (respectively 50% and 27% of our sample) have a higher mean efficiency (0.61 and 0.60 respectively) compared to firms operating in other locations (0.51). On one hand, cultural tourism in art cities generate positive agglomeration externalities on hotel sector performance due to either diversification of tourist activities or the quality of infrastructure endowments. On the other hand, seaside municipalities, which are usually single-product tourism destinations and suffer from seasonality, have a larger mean efficiency value compared to other locations due to high productive scale. In Figure 4.4, we show the distributions of technical efficiency scores over time. The average efficiency per year increases from 0.56 in 2008 to 0.64 in 2016.[19]

[18] Figure C.1 in Appendix C shows the distribution of technical efficiencies according to both variables.

[19] As further robustness check, Figure C.2 and C.3 in Appendix C show the distribution of technical efficiencies according to the Wang and Ho (2010) estimation which takes into account time-invariant unobserved heterogeneity.

Figure 4.3: Distribution of Technical Efficiencies by Variable

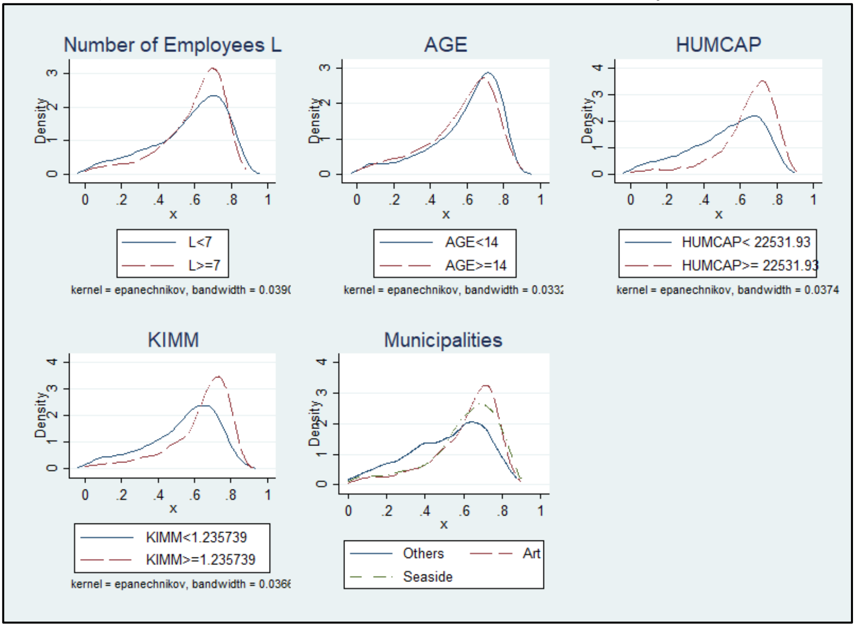


Figure 4.4: Distribution of Technical Efficiencies by Year

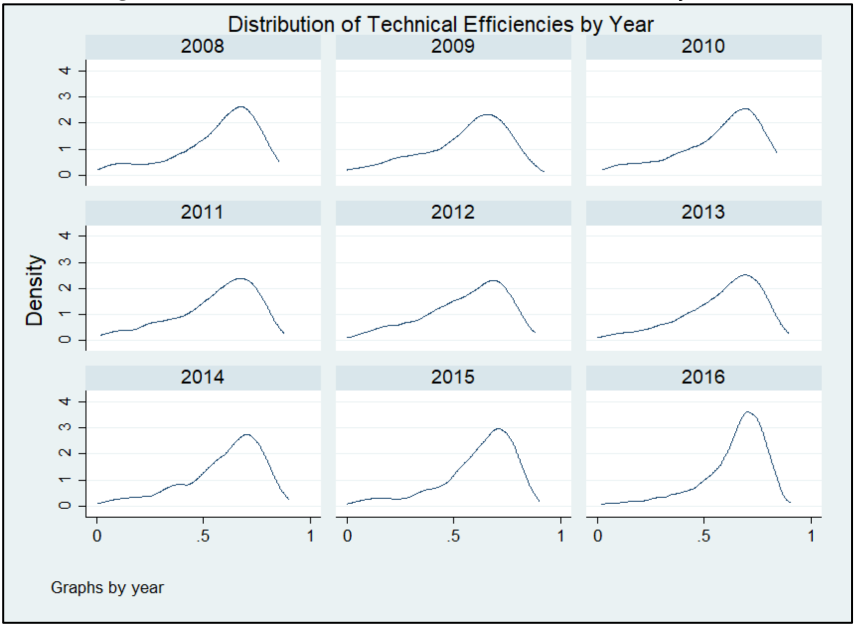
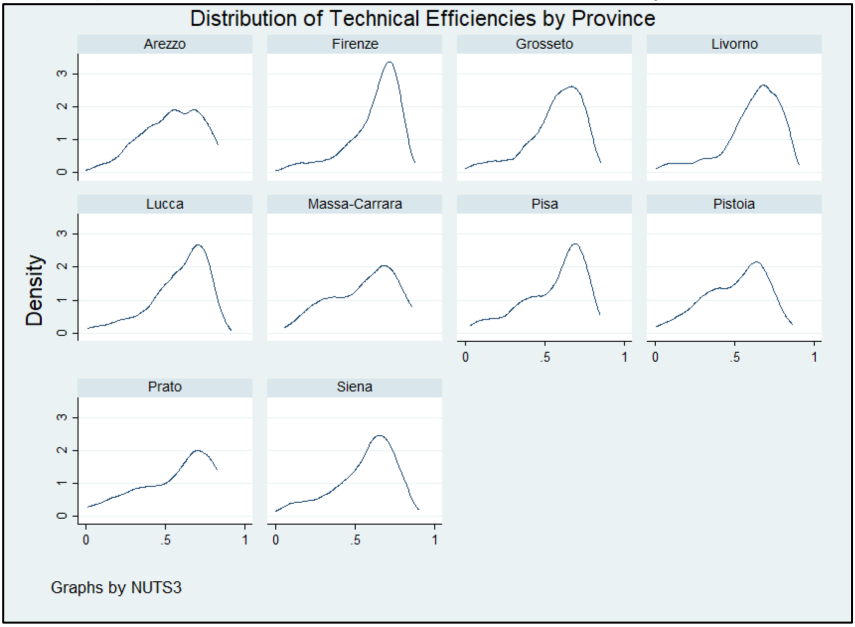


Figure 4.5: Distribution of Technical Efficiencies by Province



In Figure 4.5, we show the technical efficiency distributions of hotels according to the administrative Italian Provinces, corresponding to NUTS 3.

The Provinces which report higher mean efficiency scores are Firenze, Livorno and Lucca (0.61, 0.61 and 0.59 respectively). The Province of Florence is the administrative centre of the Region, with the largest and best-renowned cultural heritage as well as considerable tourist infrastructural endowments. Concerning the other two main Provinces in terms of technical efficiency, the firms in the Province of Livorno display the largest human capital indicator while the hotels in the Province of Lucca have the largest average intangible investment index. Firm heterogeneity in terms of composition of investments and labor skills across different territories is one of the drivers of average technical efficiency in the hotel sector locally.

Conversely, the Provinces of Pistoia, Arezzo and Massa-Carrara have the lowest mean efficiency values, ranging between 0.50 and 0.54. The administrative area of Pistoia has the lowest tourism share of art and seaside destinations combined, with respect to our sample. The hotels considered in the Provinces of Arezzo and Massa-Carrara have the average lowest output (value-added) and low scores of relative intangible investments. Tourism destination offer as well as average hotel industry features are simultaneous determinants of the territorial-level efficiency of the accommodation sector.

4.5 Conclusions

In the light of sudden changes in global production structures of both manufacturing and services, it is crucial to assess the performance of tourism and its related industries and the role it may play in supporting a destination competitiveness, growth and job creation. Mature destinations such as Italy have experienced a recent decline in traditional tourism destination products which require a transformation with respect to public governance and private organizational structure of the sector itself.

Our aim in this chapter is to explore the internal and external determinants of hotel performance in Tuscany, an Italian Region well-renowned for its cities of art and seaside locations. For this purpose, we use an up-to-date firm-level panel dataset of hotel businesses in Tuscany over a nine-year time period and estimate a dynamic stochastic frontier production function and the technical efficiency values.

The analysis shows that the main internal drivers of efficiency are related to the share intangible assets and the quality of human capital. Introducing innovations and technologies as well as increasing workers skills and their motivation are good strategies to improve the hotel business efficiency and competitiveness. The role of an effective management and strategic investments are crucial for the accommodation sector performance in Italy.

Additionally, the empirical analysis puts to light the relationship between external location factors and single-firm efficiency. We find that hotels located in cities of art and seaside destinations reap efficiency gains with respect to hotels located in other locations. In detail, cities of art are usually multi-product destinations, favouring a diversification of tourism offer and a reduction of the seasonality. They are characterized by greater tourism opportunities and services, a higher quality of infrastructural and cultural endowments as well as a better connection with other sectors, and a greater involvement in supply chains. Conversely, in seaside destinations the most important positive factor influencing efficiency is the large productive scale during seasonal spikes that allows an easier access to productive factors and a better input provision in intermediate markets.

Considering the above results, we may draw some policy implications to improve the performance of the accommodation sector in Tuscany and which can be extended to the whole national sector in Italy. From a policy perspective, it is reasonable to favour investments, technological and labor skill improvements in the poorest areas and those outside the traditional tourism circuits and less connected to local value chains. Intangible investments and in human resources in Italy may be actually hindered by the firm size, small and fragmented, and by the managerial and ownership structure of most businesses, still mostly family-run and little internationalized.

In the context of globalization, higher interdependencies between industries and markets, public investments aimed at the development of tourism hubs, with a diversified offer and appropriate infrastructures, as well as subsidies in R&D, immaterial and human capital may be the key policies which can boost competitiveness of Tuscany hotel firms and more broadly in Italy.

Chapter 5

Conclusions

This thesis empirically investigates sectoral interdependencies with socio-economic results, based on value-added measurements, in the light of the increasing dispersion of production processes and its relevant policy implications regarding welfare gains. The scope of the analysis include both manufacturing and services industries and range from European sector-level in Chapter 2, global macro-level in Chapter 3, to sector-specific micro-level in Chapter 4. All the Chapters exploit the WIOD, a time-series of inter-country input-output tables, covering a total of 39 countries and 15 years, whereas in Chapter 4 we also exploit firm-level metrics of value added content.

In Chapter 2, we review the main literature on global value chain metrics and their link with gross trade statistics. Then, we exploit the decomposition framework of gross exports proposed by Wang et al. (2013) at bilateral-sector level and analyse trade dynamics of European Union countries' transport equipment sector, using global value chain indicators. We estimate the effect of bilateral European Union adhesion on these metrics using gravity models on panel data, with a focus on Germany and Central Eastern European countries. In the transport equipment sector, bilateral joint adhesion to the European Union has a phased-in effect on participation to global value chains of the exporting country but does not contribute to statistically significant changes of its positioning along the value chain. While the role of trade agreements in favouring inter-regional trade flows is well-recognized, there is still uncertainty about its impact on country performance using global value chain measurements.

Our analysis points out that a greater involvement in global value chains, through the adoption of bilateral trade agreements, such as the

European Union, does not necessarily correspond to a movement upstream along the value chain. Peripheral countries of regional trade blocs are usually located in the middle of the so-called smile curve, as they specialize in the lowest value-added tasks of the value chains (such as input provision and assembling). Upgrading strategies should aim at breaking down the relationship of dependence from core countries and at favouring engagement in higher value-added activities such as R&D, customer service and marketing. Countries that wish to pursue development through global value chains need to integrate additional stages of the value chains, by investments in new capabilities and technological advancements.

In Chapter 3, we estimate a global production function at country-sector-level and try to assess the interaction between production choices, trade specialization in value-added and long-term determinants such as institutions. Our results show that there is a certain degree of substitutability between domestic and foreign intermediate inputs and between high- and low-skill labor at a global scale. Moreover, the quality of financial and economic institutions has a positive effect on value-added-based indicators of trade specialization, controlling for traditional Heckscher-Ohlin relative factor endowments.

In the light of the emergence of global value chains, policymakers should be aware that economic and financial institutions are the underlying long-term drivers of the relationship between specialization in value-added and growth. However, a greater involvement in global value chains may entail risks and welfare losses, due to substitution between production factors. A more facilitated access to foreign intermediates and the upsurge in offshoring and outsourcing activities could crowd out the domestic input markets. Similarly, an unbalanced labor skill distribution render the workforce more vulnerable and subject to replacement with higher- or lower-skilled workforces.

In Chapter 4, we estimate a stochastic frontier production function and analyse the internal and external determinants of hotel efficiency in the Italian Region of Tuscany, using a firm-level panel dataset of more than 1000 firms over the period 2008-2016. Our findings suggest that individual characteristics of Tuscan hotels such as size, intangible investments and human capital are positively correlated with hotel efficiency as well as location in cities of art or seaside destinations.

Overall, the hospitality sector represents a key industry in both developed and developing countries to reduce unemployment, also for low-skilled workers, and to favour a sustainable growth. Therefore, it is crucial to pursue policies aimed at improving the sector competitiveness. Since the organization of the Italian accommodation sector is characterized by small firms and is still mostly family-run, initiatives such as the creation of tourism networks and associations as well as incentives for mergers are all possible solutions to increase hotel size. Public intervention should be aimed at favouring innovation and investments in adoption of new technologies (i.e. R&D subsidies) and the improvement of human capital skills, especially in those areas outside the traditional and renowned tourism destinations, for instance through specific training programmes.

Appendix A

Table A.1: Top EU exporters Transport Equipment Sector

	1995			1996			1997	
DEU	107,558	35.8%	DEU	110,790	33.5%	DEU	111,385	33.0%
FRA	52,664	17.5%	FRA	55,333	16.7%	FRA	57,200	16.9%
GBR	33,388	11.1%	GBR	39,995	12.1%	GBR	48,331	14.3%
ESP	25,861	8.6%	ESP	28,450	8.6%	ESP	28,289	8.4%
BEL	23,305	7.7%	ITA	24,316	7.3%	ITA	23,001	6.8%
ITA	22,853	7.6%	BEL	22,219	6.7%	BEL	19,132	5.7%
SWE	14,392	4.8%	SWE	14,262	4.3%	SWE	13,867	4.1%
NLD	11,471	3.8%	NLD	11,107	3.4%	NLD	10,664	3.2%
AUT	6,589	2.2%	AUT	7,330	2.2%	AUT	7,324	2.2%
PRT	2,646	0.9%	PRT	3,988	1.2%	PRT	3,726	1.1%
CEEC	**7,082**	**2.4%**	**CEEC**	**8,006**	**2.4%**	**CEEC**	**9,826**	**2.9%**
UE27	**300,727**	**100.0%**	**UE27**	**331,130**	**100.0%**	**UE27**	**337,948**	**100.0%**
	1998			**1999**			**2000**	
DEU	125,483	33.4%	DEU	130,670	34.2%	DEU	128,215	33.7%
FRA	64,985	17.3%	FRA	65,665	17.2%	FRA	65,422	17.2%
GBR	47,477	12.6%	GBR	47,490	12.4%	GBR	47,487	12.5%
ESP	30,949	8.2%	ESP	31,255	8.2%	ESP	31,511	8.3%
ITA	26,267	7.0%	ITA	25,021	6.5%	ITA	26,147	6.9%
BEL	20,467	5.4%	BEL	19,680	5.2%	BEL	18,250	4.8%
SWE	14,888	4.0%	SWE	14,169	3.7%	SWE	14,060	3.7%
NLD	12,151	3.2%	NLD	12,622	3.3%	NLD	11,636	3.1%
AUT	8,177	2.2%	AUT	9,016	2.4%	AUT	8,698	2.3%
PRT	4,084	1.1%	HUN	4,770	1.2%	POL	6,353	1.7%
CEEC	**15,781**	**4.2%**	**CEEC**	**17,110**	**4.5%**	**CEEC**	**19,449**	**5.1%**
UE27	**376,094**	**100.0%**	**UE27**	**382,077**	**100.0%**	**UE27**	**379,971**	**100.0%**
	2001			**2002**			**2003**	
DEU	139,334	35.5%	DEU	154,513	36.1%	DEU	188,225	36.4%
FRA	68,547	17.5%	FRA	72,500	16.9%	FRA	85,337	16.5%
GBR	44,946	11.5%	GBR	48,389	11.3%	GBR	57,115	11.0%
ESP	30,530	7.8%	ESP	33,339	7.8%	ESP	42,856	8.3%
ITA	24,870	6.3%	ITA	27,778	6.5%	ITA	32,043	6.2%
BEL	19,534	5.0%	BEL	20,034	4.7%	BEL	21,871	4.2%
SWE	13,109	3.3%	SWE	13,985	3.3%	SWE	18,085	3.5%
NLD	10,905	2.8%	NLD	11,484	2.7%	NLD	13,557	2.6%
AUT	9,360	2.4%	AUT	10,847	2.5%	AUT	12,944	2.5%
POL	7,371	1.9%	POL	7,738	1.8%	POL	10,384	2.0%
CEEC	**21,727**	**5.5%**	**CEEC**	**24,666**	**5.8%**	**CEEC**	**33,594**	**6.5%**
UE27	**392,525**	**100.0%**	**UE27**	**427,909**	**100.0%**	**UE27**	**517,199**	**100.0%**

	2004			**2005**			**2006**	
DEU	214,956	35.5%	DEU	229,935	36.4%	DEU	251,870	36.0%
FRA	101,495	16.8%	FRA	100,766	15.9%	FRA	105,909	15.2%
GBR	59,703	9.9%	GBR	62,000	9.8%	GBR	66,300	9.5%
ESP	50,819	8.4%	ESP	51,371	8.1%	ESP	56,358	8.1%
ITA	37,669	6.2%	ITA	37,886	6.0%	ITA	43,975	6.3%
BEL	26,105	4.3%	BEL	25,207	4.0%	BEL	26,943	3.9%
SWE	22,992	3.8%	SWE	24,026	3.8%	SWE	26,572	3.8%
AUT	18,128	3.0%	AUT	19,251	3.0%	POL	22,509	3.2%
NLD	15,661	2.6%	POL	18,304	2.9%	AUT	21,217	3.0%
POL	15,023	2.5%	NLD	15,667	2.5%	CZE	17,830	2.6%
CEEC	**44,791**	**7.4%**	**CEEC**	**52,886**	**8.4%**	**CEEC**	**67,611**	**9.7%**
UE27	**605,054**	**100.0%**	**UE27**	**632,352**	**100.0%**	**UE27**	**698,992**	**100.0%**

	2007			**2008**			**2009**	
DEU	301,699	36.5%	DEU	313,861	36.0%	DEU	214,578	34.3%
FRA	118,554	14.4%	FRA	127,667	14.7%	FRA	100,450	16.1%
GBR	76,122	9.2%	GBR	77,626	8.9%	GBR	58,341	9.3%
ESP	63,404	7.7%	ESP	60,911	7.0%	ESP	47,641	7.6%
ITA	55,401	6.7%	ITA	58,940	6.8%	ITA	40,850	6.5%
SWE	30,521	3.7%	POL	35,328	4.1%	POL	26,950	4.3%
BEL	29,183	3.5%	BEL	29,724	3.4%	BEL	23,262	3.7%
POL	28,178	3.4%	SWE	29,227	3.4%	CZE	20,814	3.3%
AUT	23,458	2.8%	CZE	25,990	3.0%	AUT	16,230	2.6%
CZE	22,751	2.8%	NLD	24,587	2.8%	NLD	16,083	2.6%
CEEC	**89,130**	**10.8%**	**CEEC**	**104,897**	**12.0%**	**CEEC**	**77,719**	**12.4%**
UE27	**825,976**	**100.0%**	**UE27**	**870,737**	**100.0%**	**UE27**	**625,658**	**100.0%**

	2010			**2011**	
DEU	258,619	35.9%	DEU	312,488	36.8%
FRA	118,506	16.4%	FRA	127,659	15.0%
GBR	72,127	10.0%	GBR	84,809	10.0%
ESP	50,960	7.1%	ESP	60,924	7.2%
ITA	45,440	6.3%	ITA	50,462	5.9%
POL	28,561	4.0%	POL	34,410	4.1%
CZE	23,170	3.2%	SWE	29,427	3.5%
BEL	22,517	3.1%	CZE	28,520	3.4%
SWE	21,152	2.9%	BEL	25,594	3.0%
AUT	18,056	2.5%	AUT	23,361	2.8%
CEEC	**83,021**	**11.5%**	**CEEC**	**98,985**	**11.7%**
UE27	**721,067**	**100.0%**	**UE27**	**848,338**	**100.0%**

Table A.2: Decomposition of Germany Transport Equipment Exports

Year	Gross exports	DVA Share	RDV Share	FVA Share	PDC Share
1995	107,558	76.4%	2.0%	18.0%	3.7%
1996	110,790	74.9%	1.9%	19.0%	4.2%
1997	111,385	73.8%	1.7%	20.2%	4.3%
1998	125,483	72.3%	2.0%	20.5%	5.1%
1999	130,670	71.3%	1.9%	21.6%	5.2%
2000	128,215	69.4%	2.0%	22.7%	5.9%
2001	139,334	70.5%	1.9%	21.9%	5.6%
2002	154,513	71.1%	1.8%	21.7%	5.4%
2003	188,225	70.3%	1.9%	22.0%	5.8%
2004	214,956	68.3%	2.0%	23.1%	6.6%
2005	229,935	66.8%	1.9%	24.2%	7.1%
2006	251,870	65.9%	1.8%	25.0%	7.4%
2007	301,699	65.0%	1.7%	25.6%	7.7%
2008	313,861	63.3%	1.6%	26.2%	8.3%
2009	214,578	66.8%	1.8%	24.7%	6.9%
2010	258,619	63.9%	1.7%	26.7%	7.7%
2011	312,488	62.4%	1.7%	27.7%	8.2%

Table A.3: Decomposition of France Transport Equipment Exports

Year	Gross exports	DVA Share	RDV Share	FVA Share	PDC Share
1995	52,664	71.4%	1.2%	23.3%	4.1%
1996	55,333	71.0%	1.0%	24.0%	4.0%
1997	57,200	69.9%	0.9%	24.6%	4.6%
1998	64,985	67.5%	1.0%	26.7%	4.9%
1999	65,665	67.9%	1.1%	25.8%	5.2%
2000	65,422	64.6%	1.3%	27.7%	6.5%
2001	68,547	65.3%	1.2%	27.3%	6.2%
2002	72,500	65.7%	1.2%	26.7%	6.4%
2003	85,337	66.6%	1.2%	26.1%	6.1%
2004	101,495	65.2%	1.2%	27.2%	6.4%
2005	100,766	63.8%	1.2%	28.3%	6.7%
2006	105,909	62.6%	1.1%	29.4%	6.9%
2007	118,554	60.9%	1.1%	30.2%	7.8%
2008	127,667	60.6%	1.0%	30.6%	7.4%
2009	100,450	64.6%	1.0%	28.4%	6.1%
2010	118,506	61.2%	1.0%	30.8%	7.0%
2011	127,659	58.7%	1.0%	32.4%	8.0%

Table A.4: Decomposition of UK Transport Equipment Exports

Year	Gross exports	DVA Share	RDV Share	FVA Share	PDC Share
1996	39,995	69.3%	1.0%	24.4%	5.4%
1997	48,331	70.6%	1.3%	22.7%	5.4%
1998	47,477	71.0%	1.4%	22.2%	5.5%
1999	47,490	71.0%	1.3%	22.2%	5.5%
2000	47,487	69.3%	1.3%	23.3%	6.2%
2001	44,946	68.8%	1.4%	23.0%	6.9%
2002	48,389	68.9%	1.4%	23.4%	6.3%
2003	57,115	68.4%	1.3%	23.9%	6.3%
2004	59,703	67.6%	1.2%	24.8%	6.5%
2005	62,000	67.0%	1.1%	25.8%	6.2%
2006	66,300	66.7%	1.0%	25.6%	6.6%
2007	76,122	65.1%	1.0%	26.9%	7.0%
2008	77,626	63.5%	0.8%	28.0%	6.8%
2009	58,341	66.4%	0.7%	27.2%	5.7%
2010	72,127	62.3%	0.7%	30.9%	6.1%
2011	84,809	61.8%	0.7%	30.8%	6.7%

Table A.5: Decomposition of Italy Transport Equipment Exports

Year	Gross exports	DVA Share	RDV Share	FVA Share	PDC Share
1995	22,853	76.5%	0.8%	19.0%	3.7%
1996	24,316	78.6%	0.9%	16.7%	3.8%
1997	23,001	78.3%	0.9%	17.0%	3.8%
1998	26,267	77.3%	1.0%	17.5%	4.1%
1999	25,021	77.2%	1.0%	17.5%	4.3%
2000	26,147	73.4%	1.1%	20.0%	5.6%
2001	24,870	72.5%	1.2%	20.4%	6.0%
2002	27,778	73.3%	1.2%	19.7%	5.8%
2003	32,043	71.8%	1.1%	20.9%	6.1%
2004	37,669	72.0%	1.1%	20.6%	6.3%
2005	37,886	71.2%	1.2%	20.7%	6.9%
2006	43,975	68.7%	1.1%	22.8%	7.4%
2007	55,401	68.0%	1.1%	23.3%	7.7%
2008	58,940	67.0%	1.0%	23.8%	7.6%
2009	40,850	73.8%	1.0%	19.9%	5.6%
2010	45,440	69.3%	0.8%	22.9%	7.0%
2011	50,462	68.3%	0.8%	23.5%	7.4%

Table A.6: Decomposition of CEE Countries Transport Equipment Exports

Year	Gross exports	DVA Share	RDV Share	FVA Share	PDC Share
1995	7,082	64.0%	0.2%	29.0%	6.8%
1996	8,006	62.4%	0.2%	30.0%	7.4%
1997	9,826	55.7%	0.1%	34.8%	9.4%
1998	15,781	51.8%	0.1%	36.5%	11.6%
1999	17,110	52.7%	0.1%	35.4%	11.8%
2000	19,449	49.4%	0.1%	37.5%	13.0%
2001	21,727	49.3%	0.1%	36.8%	13.8%
2002	24,666	50.6%	0.2%	34.9%	14.3%
2003	33,594	48.9%	0.2%	35.1%	15.8%
2004	44,791	48.8%	0.2%	35.1%	15.9%
2005	52,886	49.7%	0.2%	33.9%	16.2%
2006	67,611	46.9%	0.2%	36.4%	16.5%
2007	89,130	47.2%	0.2%	36.9%	15.8%
2008	104,897	47.8%	0.2%	36.5%	15.2%
2009	77,719	53.6%	0.2%	34.3%	12.2%
2010	83,021	50.4%	0.2%	35.7%	13.7%
2011	98,985	49.4%	0.2%	35.9%	14.6%

Table A.7: VS Structure of Germany Transport Equipment Industry

Year	Gross exports	VS Share in gross exports	% of VS		
			FVA_FIN Share	FVA_INT Share	FDC Share
1995	107,558	21.0%	60.9%	24.7%	14.4%
1996	110,790	22.4%	58.5%	26.2%	15.3%
1997	111,385	23.6%	58.2%	27.1%	14.7%
1998	125,483	24.6%	59.6%	23.9%	16.4%
1999	130,670	25.8%	61.8%	21.9%	16.3%
2000	128,215	27.5%	60.4%	22.3%	17.4%
2001	139,334	26.5%	61.5%	21.4%	17.1%
2002	154,513	25.9%	61.9%	21.6%	16.5%
2003	188,225	26.5%	61.2%	21.8%	17.0%
2004	214,956	28.3%	59.5%	22.1%	18.4%
2005	229,935	29.8%	59.7%	21.5%	18.8%
2006	251,870	30.9%	60.2%	20.6%	19.2%
2007	301,699	31.8%	58.9%	21.6%	19.5%
2008	313,861	33.0%	58.1%	21.3%	20.6%
2009	214,578	30.4%	59.6%	21.7%	18.8%
2010	258,619	33.1%	59.8%	20.8%	19.4%
2011	312,488	34.4%	59.5%	20.9%	19.6%

Table A.8: VS Structure of France Transport Equipment Industry

Year	Gross exports	VS Share in gross exports	% of VS		
			FVA_FIN Share	FVA_INT Share	FDC Share
1995	52,664	27.0%	66.7%	19.5%	13.7%
1996	55,333	27.7%	68.2%	18.6%	13.2%
1997	57,200	28.8%	66.3%	19.3%	14.4%
1998	64,985	31.1%	66.1%	19.6%	14.3%
1999	65,665	30.5%	63.5%	21.0%	15.5%
2000	65,422	33.6%	59.0%	23.5%	17.6%
2001	68,547	33.0%	62.0%	20.7%	17.3%
2002	72,500	32.6%	57.9%	24.1%	18.1%
2003	85,337	31.7%	60.4%	22.1%	17.5%
2004	101,495	33.1%	59.4%	22.9%	17.7%
2005	100,766	34.5%	60.4%	21.6%	18.1%
2006	105,909	35.9%	62.6%	19.5%	17.9%
2007	118,554	37.5%	58.9%	21.6%	19.5%
2008	127,667	37.5%	61.3%	20.3%	18.4%
2009	100,450	34.1%	56.6%	26.7%	16.7%
2010	118,506	37.4%	57.9%	24.6%	17.4%
2011	127,659	39.8%	56.1%	25.1%	18.7%

Table A.9: VS Structure of UK Transport Equipment Industry

Year	Gross exports	VS Share in gross exports	% of VS		
			FVA_FIN Share	FVA_INT Share	FDC Share
1995	33,388	28.1%	53.3%	30.8%	15.9%
1996	39,995	29.3%	47.7%	35.4%	17.0%
1997	48,331	27.7%	45.0%	37.2%	17.8%
1998	47,477	27.2%	48.9%	32.5%	18.6%
1999	47,490	27.3%	46.0%	35.2%	18.7%
2000	47,487	29.0%	47.6%	32.6%	19.8%
2001	44,946	29.4%	42.8%	35.4%	21.9%
2002	48,389	29.3%	48.0%	32.0%	20.1%
2003	57,115	29.8%	50.3%	29.8%	19.9%
2004	59,703	30.9%	52.5%	27.8%	19.7%
2005	62,000	31.6%	54.9%	26.7%	18.4%
2006	66,300	31.8%	53.4%	27.1%	19.5%
2007	76,122	33.5%	54.1%	26.2%	19.7%
2008	77,626	34.5%	56.3%	25.0%	18.8%
2009	58,341	32.6%	54.8%	28.4%	16.7%
2010	72,127	36.7%	60.2%	23.9%	15.9%
2011	84,809	37.2%	56.8%	25.9%	17.3%

Table A.10: VS Structure of Italy Transport Equipment Industry

Year	Gross exports	VS Share in gross exports	% of VS FVA_FIN Share	FVA_INT Share	FDC Share
1995	22,853	22.5%	59.0%	25.2%	15.7%
1996	24,316	20.3%	47.5%	34.8%	17.8%
1997	23,001	20.6%	48.4%	34.2%	17.4%
1998	26,267	21.5%	51.9%	29.8%	18.3%
1999	25,021	21.6%	53.7%	27.2%	19.1%
2000	26,147	25.3%	51.3%	27.6%	21.0%
2001	24,870	26.1%	49.9%	28.1%	22.0%
2002	27,778	25.2%	49.7%	28.1%	22.1%
2003	32,043	26.7%	51.9%	26.3%	21.8%
2004	37,669	26.6%	51.2%	26.2%	22.6%
2005	37,886	27.3%	50.3%	25.6%	24.1%
2006	43,975	29.9%	52.7%	23.8%	23.6%
2007	55,401	30.6%	51.7%	24.4%	23.9%
2008	58,940	31.0%	53.4%	23.2%	23.4%
2009	40,850	25.2%	51.4%	27.5%	21.1%
2010	45,440	29.6%	50.5%	26.8%	22.7%
2011	50,462	30.6%	52.1%	24.7%	23.2%

Table A.11: VS Structure of CEE Countries Transport Equipment Industry

Year	Gross exports	VS Share in gross exports	% of VS FVA_FIN Share	FVA_INT Share	FDC Share
1995	7,082	35.7%	57.2%	24.0%	18.8%
1996	8,006	37.3%	55.2%	25.1%	19.6%
1997	9,826	44.1%	56.6%	22.4%	21.0%
1998	15,781	48.0%	53.9%	22.1%	24.0%
1999	17,110	47.1%	55.6%	19.5%	24.9%
2000	19,449	50.4%	55.3%	19.2%	25.5%
2001	21,727	50.4%	53.5%	19.4%	27.0%
2002	24,666	49.1%	52.1%	19.0%	28.9%
2003	33,594	50.7%	50.3%	18.9%	30.8%
2004	44,791	50.9%	49.0%	20.0%	31.0%
2005	52,886	49.9%	46.8%	21.1%	32.1%
2006	67,611	52.6%	48.7%	20.4%	30.9%
2007	89,130	52.4%	50.1%	20.2%	29.7%
2008	104,897	51.5%	49.1%	21.8%	29.0%
2009	77,719	46.2%	51.7%	22.4%	25.9%
2010	83,021	49.2%	49.9%	22.7%	27.5%
2011	98,985	50.2%	48.7%	22.8%	28.5%

Table A.12: List of EU countries in 2011 and Date of Accession EU

Country Name	**Accession**
Austria	1995
Belgium	Founder
Bulgaria	2007
Cyprus	2004
Czech Republic	2004
Denmark	1973
Estonia	2004
Finland	1995
France	Founder
Germany	Founder
Greece	1981
Hungary	2004
Ireland	1973
Italy	Founder
Latvia	2004
Lithuania	2004
Luxembourg	Founder
Malta	2004
Netherlands	Founder
Poland	2004
Portugal	1986
Romania	2007
Slovakia	2004
Slovenia	2004
Spain	1986
Sweden	1995
United Kingdom	1973

Table A.13: Descriptive Statistics of the Variables

Variable	Obs	Mean	Std. Dev.	Std. Dev. Within	Min	Max
GDP (current US$, in billions)	11,934	475.00	763.00	231.00	3.60	3,750.00
DIST	11,934	1,442.52	731.88	0.00	160.93	3,779.73
CONTIG	11,934	0.10	0.30	0.00	0.00	1.00
COMLANG	11,934	0.04	0.20	0.00	0.00	1.00
EU	11,934	0.60	0.49	0.41	0.00	1.00
DVA	11,934	300.09	1,224.59	368.71	0.00	24,835.40
FVA	11,934	133.16	501.04	198.19	0.00	9,607.45
RDV	11,934	7.68	47.06	18.43	0.00	1,301.81
PDC	11,934	46.58	194.78	97.95	0.00	5,282.05
MVA	11,934	13.73	79.06	29.02	0.00	1,921.39
OVA	11,934	119.43	438.68	177.69	0.00	8,828.94
Tot. Exports	11,934	487.40	1,914.75	658.64	0.00	41,026.71

Table A.14: Panel gravity equations with country-time and bilateral fixed effects using PPML estimation

Variable	(1)	(2)	(3)	(4)	(5)
EU_{ijt}	0.005	-0.006	-0.061	-0.071	-0.074*
	(0.043)	(0.047)	(0.047))	(0.049)	(0.040)
$EU_{ij,t-1}$			0.053	-0.011	-0.011
			(0.043)	(0.038)	(0.038)
$EU_{ij,t-2}$				0.075**	0.068*
				(0.038)	(0.038)
$EU_{it,t+1}$					0.006
					(0.043)
Observations	11,674	11,674	11,050	10,400	9,698
R-squared	0.964	0.966	0.967	0.968	0.968

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix B

Table B.1: List of Countries in the WIOD

European Union		North America	Latin America	Asia and Pacific
Austria	Latvia	Canada	Brazil	China
Belgium	Lithuania	United States	Mexico	India
Bulgaria	Luxembourg			Japan
Cyprus	Malta			South Korea
Czech Republic	Netherlands			Australia
Denmark	Poland			Turkey
Estonia	Portugal			Indonesia
Finland	Romania			Russia
France	Slovak Republic			
Germany	Slovenia			
Greece	Spain			
Hungary	Sweden			
Ireland	United Kingdom			
Italy				

Table B.2: List of educational skill in the WIOD Socio Economic Accounts

WIOD type	1997 ISCED level	1997 ISCED level description
Low	1	Primary education or first stage of basic education
Low	2	Lower secondary or second stage of basic education
Medium	3	(Upper) secondary education
Medium	4	Post-secondary non-tertiary education
High	5	First stage of tertiary education
High	6	Second stage of tertiary education

Table B.3: List of sectors in the WIOD

Code	NACE	Description
1	AtB	Agriculture, Hunting, Forestry and Fishing
2	C	Mining and Quarrying
3	15t16	Food, Beverages and Tobacco
4	17t18	Textiles and Textile Products
5	19	Leather, Leather and Footwear
6	20	Wood and Products of Wood and Cork
7	21t22	Pulp, Paper, Paper, Printing and Publishing
8	23	Coke, Refined Petroleum and Nuclear Fuel
9	24	Chemicals and Chemical Products
10	25	Rubber and Plastics
11	26	Other Non-Metallic Mineral
12	27t28	Basic Metals and Fabricated Metal
13	29	Machinery, Nec
14	30t33	Electrical and Optical Equipment
15	34t35	Transport Equipment
16	36t37	Manufacturing, Nec; Recycling
17	E	Electricity, Gas and Water Supply
18	F	Construction
19	50	Sale, Maintenance and Repair of Motor Vehicles Retail Sale of Fuel
20	51	Wholesale Trade and Commission Trade, Except of Motor Vehicles
21	52	Retail Trade, Except of Motor Vehicles; Repair of Household Goods
22	H	Hotels and Restaurants
23	60	Inland Transport
24	61	Water Transport
25	62	Air Transport
26	63	Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies
27	64	Post and Telecommunications
28	J	Financial Intermediation
29	70	Real Estate Activities
30	71t74	Renting of M&Eq and Other Business Activities
31	L	Public Admin and Defence; Compulsory Social Security
32	M	Education
33	N	Health and Social Work
34	O	Other Community, Social and Personal Services
35	P	Private Household with Employed Persons

Table B.4: Pairwise Correlation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1) Real Gross Output	1.000										
(2) Capital	0.498	1.000									
(3) High-Skill Labor	0.469	0.151	1.000								
(4) Medium-Skill Labor	0.261	0.062	0.709	1.000							
(5) Low-Skill Labor	0.084	0.012	0.221	0.607	1.000						
(6) Domestic Inputs	0.923	0.342	0.412	0.260	0.086	1.000					
(7) Foreign Inputs	0.446	0.087	0.145	0.105	0.028	0.558	1.000				
(8) Economic Institutions	0.117	0.079	-0.101	-0.168	-0.100	0.077	0.083	1.000			
(9) Economic Institutions (distance from the mean)	0.115	0.078	-0.103	-0.169	-0.100	0.074	0.081	0.999	1.000		
(10) Financial Institutions	0.167	0.090	-0.001	-0.042	-0.034	0.154	0.148	0.705	0.692	1.000	
(11) Financial Institutions (distance from the mean)	0.156	0.088	-0.024	-0.056	-0.039	0.140	0.127	0.763	0.764	0.917	1.000

Construction of the RCA and NRCA indexes.

Balassa (1965) defines an economy *i*'s measure of "revealed comparative advantage" (RCA_{ij}) in sector *j* as follows:

$$RCA_{ij} = \frac{z_{ij}/\sum_i z_{ij}}{\sum_j z_{ij}/\sum_i \sum_j z_{ij}} \tag{B.1}$$

where Z_{ij} is total gross exports of country *i* and sector *j*. If the index exceeds 1, the country-sector has a revealed comparative advantage. The "new revealed comparative advantage" (NRCA) is constructed in a similar way and has a similar interpretation, but it replaces Z_{ij} with a forward-looking measure of domestic value added, according to the disaggregation framework proposed by Wang et al. (2013).

Rate of Technical Change

A noteworthy variable is the time trend, T, for the identification of the technical change. The rate of technical change is calculated as the elasticity of output with respect to time. The formula is the following:

$$\partial \ln \frac{Y_{ckt}}{\partial T} = \delta_T + \delta_{TT} T + \sum_x \gamma_{xT} \ln X_{ckt} \qquad \text{(B.2)}$$

It is dependent on the level of input used and is both time and country-sector specific. Technological progress as well as regulation changes may affect the sign of the rate of technical change. The rate of technical change can be split into two effects (Wylie, 1990): the first two terms of the above equation represent the pure or autonomous effect of technology per se, which is a neutral shift on the production independent on input factors; the last term represent the biased technical change which shows its effects through the use of various inputs.

Along with the technical change rate, we have computed the logarithmic marginal products (the output elasticities of the inputs). Each elasticity and technical change rate is computed at the mean, median and 75th percentile values of each variable. Table B.5 reports all the input elasticities and the rate of technical change. For each, we isolate the autonomous effect and the biased effects.

Apart from the medium-skill labor input which shows a divergent pattern, all the input autonomous effects are positive while the interacted effects are negative at the average, median and 75th percentile values of the population considered for the estimation.

Similarly to the medium skill workforce variable, the rate of technical change computed shows a negative autonomous effect and a positive biased technical change, mainly driven by the effect of the interaction with intermediate imports.

Table B.5: Output Elasticities at Different Values

Output Elasticities at Mean Values

	Direct Effect	Quadratic Effect	Autonomous effect	Biased Effect	Total
Capital	-0.0125	0.2878	0.2753	-0.3085	-0.0331
High-Skill Labor	0.0305	0.0345	0.0650	-0.0536	0.0114
Medium-Skill Labor	-0.1377	-0.1754	-0.3131	0.4397	0.1267
Low-Skill Labor	0.0503	0.0137	0.0640	-0.0505	0.0136
Domestic Inputs	0.8774	1.3286	2.2059	-3.0278	-0.8219
Foreign Inputs	0.4803	0.7768	1.2571	-1.8280	-0.5708
Technical Change Rate	-0.0183	0.0017	-0.0166	0.0093	-0.0073

Output Elasticities at Median Values

	Direct Effect	Quadratic Effect	Autonomous effect	Biased Effect	Total
Capital	-0.0125	0.2905	0.2780	-0.3242	-0.0462
High-Skill Labor	0.0305	0.0345	0.0650	-0.0542	0.0109
Medium-Skill Labor	-0.1377	-0.1759	-0.3136	0.4384	0.1248
Low-Skill Labor	0.0503	0.0137	0.0641	-0.0512	0.0128
Domestic Inputs	0.8774	1.3519	2.2293	-3.0628	-0.8335
Foreign Inputs	0.4803	0.7901	1.2705	-1.8561	-0.5857
Technical Change Rate	-0.0183	0.0018	-0.0165	0.0097	-0.0068

Output Elasticities at 75-th Percentile Values

	Direct Effect	Quadratic Effect	Autonomous effect	Biased Effect	Total
Capital	-0.0125	0.3113	0.2988	-0.3631	-0.0643
High-Skill Labor	0.0305	0.0381	0.0687	-0.0598	0.0088
Medium-Skill Labor	-0.1377	-0.1908	-0.3285	0.4644	0.1359
Low-Skill Labor	0.0503	0.0150	0.0654	-0.0579	0.0074
Domestic Inputs	0.8774	1.4774	2.3547	-3.3039	-0.9492
Foreign Inputs	0.4803	0.8564	1.3368	-2.0195	-0.6828
Technical Change Rate	-0.0183	0.0024	-0.0159	0.0108	-0.0050

Construction of the Variables for the Baseline Model

All the dependent and independent variables can be found in the WIOD in two different sections: World Input-Output Tables (WIOTs) and Socio-Economic Accounts (SEA). All the variables taken in consideration are in log, with the exception of time trend. The WIOTs show all the values in current prices and in millions of US dollars while the values in the SEA are at current basic prices in millions of national currencies. In particular, the WIOTs contain data on real value of gross output, domestic and foreign intermediate inputs while the SEA contains data on capital and labor.

The WIOD contains also data on exchange rates and price levels. We convert all the values in US dollars and use data at constant value with 1995 as base year. Therefore, data availability in the SEA of price levels reduces the sample size of some variables, in particular intermediate inputs. With the exception of the time trend, all the variables are multiplied by one million before applying the logarithm.

Output = Real Value Of Gross Output (base year = 1995)

Capital = Real Fixed Capital Stock (base year = 1995) × Exchange Rate;

High-Skill Labor = Share of High-Skill Labor × Total Hours Worked By Persons Engaged (in Millions)

Medium-Skill Labor = Share of Medium-Skill Labor × Total Hours Worked By Persons Engaged (in Millions)

Low-Skill Labor = Share of Low-Skill Labor × Total Hours Worked By Persons Engaged (in Millions)

Domestic Inputs (country *c*, sector *k*) = Real Value of Intermediate Inputs (base year = 1995) of country *c*, sector *k* sourced from any sector of country *c* (in millions of US dollars).

Foreign Inputs (country *c*, sector *k*) = Real Value of Intermediate Inputs (base year = 1995) of country *c*, sector *k* sourced from any sector of any country except country *c* (in millions of US dollars).

Figure B.1: RCA and NRCA in Chinese and Indian sectors, 1995 and 2009

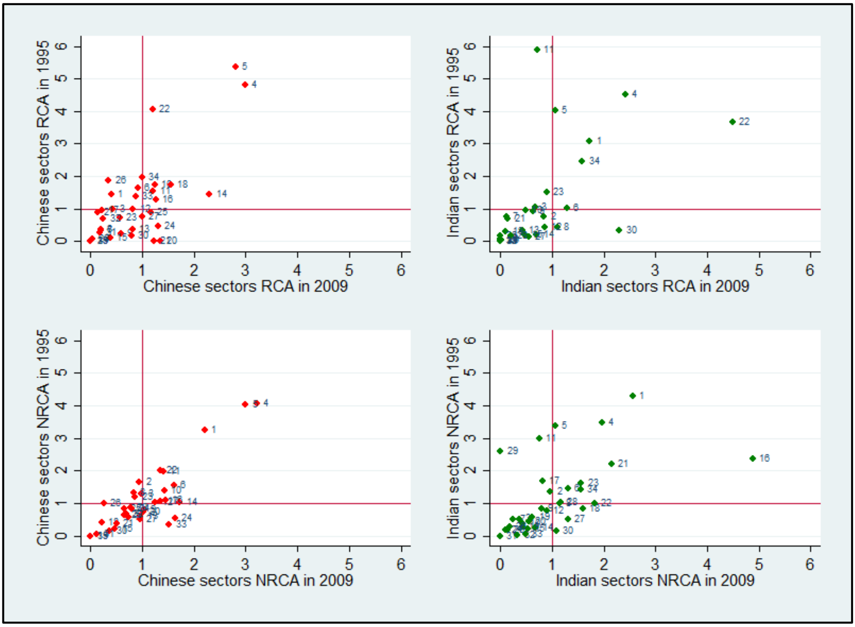
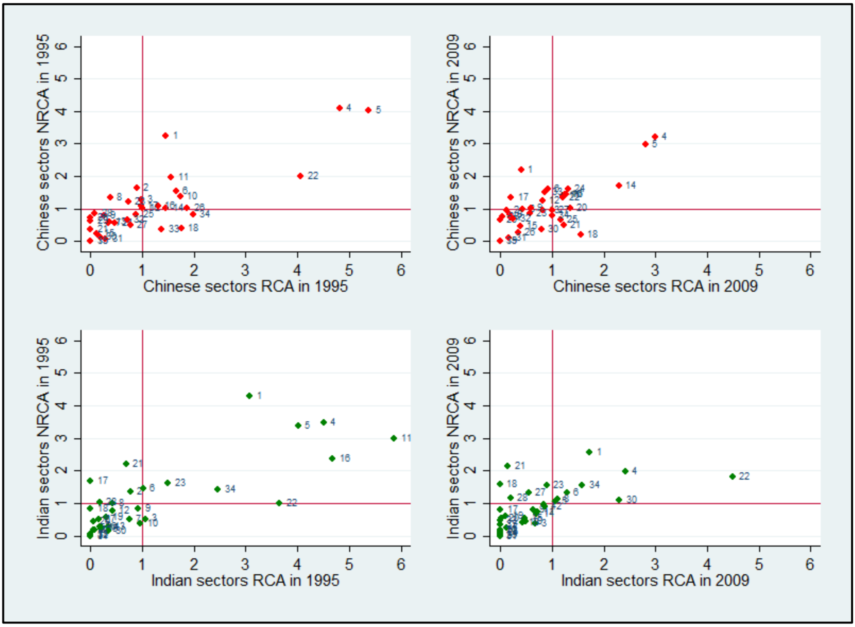


Figure B.2: Comparison between RCA and NRCA in Chinese and Indian sectors, 1995 and 2009



Appendix C

Figure C.1: Distribution of Technical Efficiencies by Number of Employees and Age

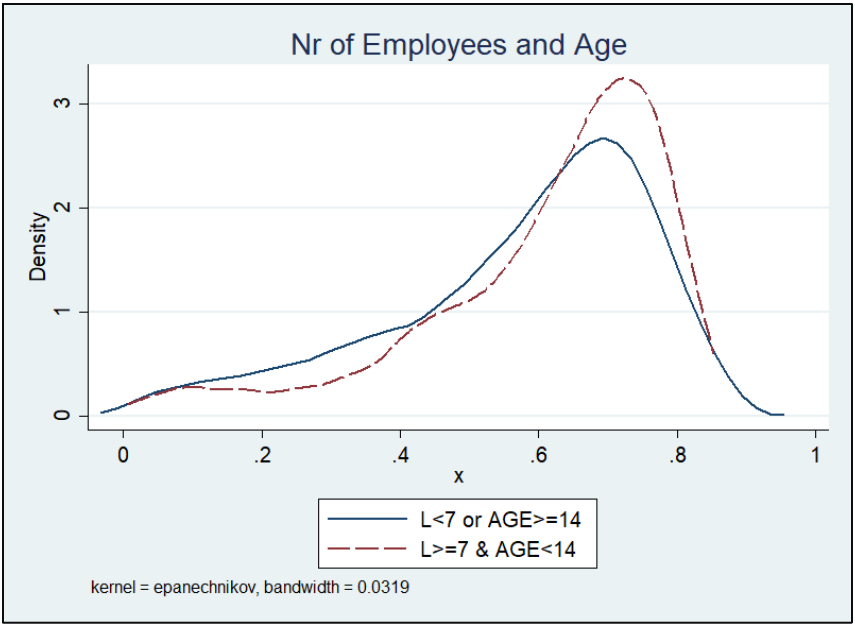


Figure C.2: Distribution of Technical Efficiencies
(Wang and Ho, 2010 estimation)

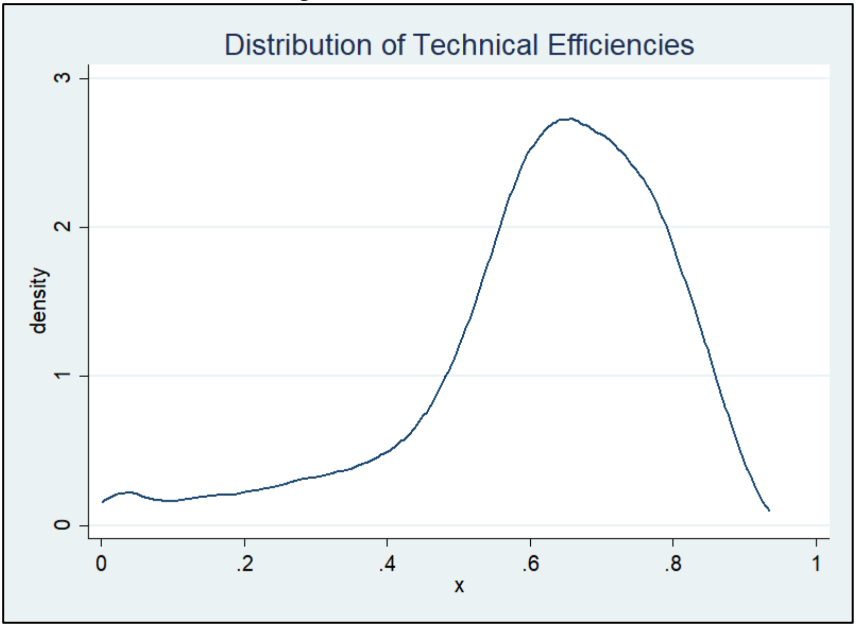
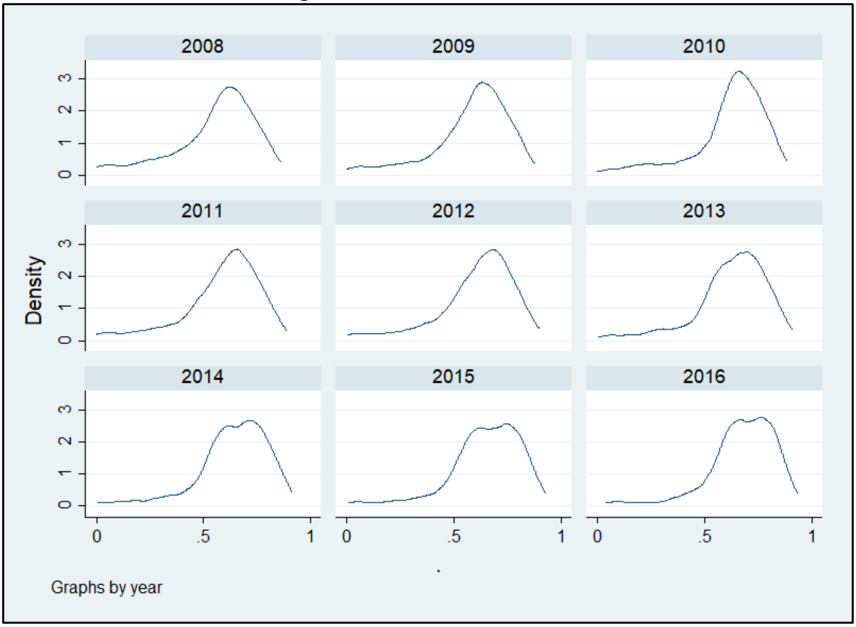


Figure C.3: Distribution of Technical Efficiencies by Year (Wang and Ho, 2010 estimation)



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