Dissertation

Master in International Business

Participation of Portuguese Manufacturing Industry in Global Value Chains

Katsiaryna Pechankova

Leiria, *September, 2016*

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Resumo

A indústria de manufatura de Portugal tem uma importância significativa na criação de rendimento nacional e no emprego. Como tem sido indicado por vários investigadores, os métodos tradicionais de análise não conseguem atingir todas as dimensões da competitividade económica. Esta dissertação é então, no fundo, uma análise da indústria de manufatura em Portugal relativa ao valor acrescentado desta à produção e o impacto para o emprego no âmbito das cadeias de valor globais (CVGs). A presente dissertação visa estudar de que forma a indústria de manufatura portuguesa, e os seus respetivos setores, tem um impacto direto e indireto sobre a criação de valor acrescentado e emprego, assim como a forma como esse impacto pode ser medido.

Para o desenvolvimento deste trabalho foi utilizada a abordagem *input-output* para o cálculo de multiplicadores e o novo quadro proposto por Timmer et al. (2013) para o cálculo dos indicadores do rendimento CVG (*GVC income*) e empregos CVG (*GVC jobs*), através do conjunto de dados do projeto *WIOD*. Além disso, para ilustrar a aplicação da metodologia indicada foi utilizada a indústria têxtil portuguesa a titulo de exemplo.

Verificou-se que as mudanças na demanda final de setores como a *Celulose, Papel, Impressão e Publicação*; *Maquinaria, Nec* e *Têxteis e Produtos Têxteis* teria um impacto maior no valor acrescentado criado do que alterações na demanda por outros setores da industria manufatora. Ao mesmo tempo, o emprego criado pelas mudanças na demanda final de setores tais como *Alimentos, bebidas e tabaco; Madeira e Produtos de Madeira e Cortiça* e *Tecidos e Produtos Têxteis* seria mais impactante do que nos remanescentes. Neste respeito, o numero de postos de trabalho ocupados por indivíduos menos qualificados parece ser mais influenciado pelas mudanças na demanda final do setor do que aqueles postos ocupados por indivíduos com qualificações mais elevadas.

Além disso, foi descoberto que a distribuição de rendimento CVG e empregos CVG para indústria de manufatura portuguesa partilham uma disposição semelhante. No entanto, uma observação mais atenta da distribuição de empregos CVG por níveis de qualificação, revelou uma aparente progressão geral em que as necessidades de trabalhadores pouco qualificados pelos setores são colmatadas localmente, enquanto as necessidades de trabalhadores mais qualificados são atendidas com maior recurso ao estrangeiro.

Os resultados obtidos através de cálculos dos multiplicadores apresentados fornecem uma ferramenta poderosa para os decisores políticos realizarem o planeamento estratégico de desenvolvimento da economia nacional. Usando a metodologia designada e os resultados obtidos, um governo e/ou organizações supranacionais podem direcionar as suas políticas para as indústrias com maior impacto de uma unidade adicional de demanda para economia e, assim, definir novos investimentos.

Palavras-chave: Cadeias de valor globais, rendimento CVG, empregos CVG, modelo input-output, multiplicadores, WIOD.

Abstract

Portugal's manufacturing sector has a significant importance both in national income and employment. As has been pointed out by several researchers, the traditional methods of analysis fail to grasp all the dimensions of economic competitiveness. This dissertation is then, at its core, an analysis of Portugal's manufacturing industry in terms of the latter's value added to production and impact to employment under the framework of global value chains. The current dissertation seeks to study in which way the Portuguese manufacturing industry, and its respective sectors, has a direct and indirect impact on the creation of value added and employment and how this impact can be measured.

For development of this work the input-output approach for calculation of multipliers and the new framework proposed by Timmer et al. (2013) for calculation of GVC income and GVC jobs indicators were used, elaborated on the basis of the WIOD project dataset. Moreover, to illustrate the application of the provided methodology the Portuguese textile industry was used as an example.

It was found that the changes in final demand of such sectors as *Pulp, Paper, Printing and Publishing; Machinery, Nec and Textiles and Textile Products* would have a larger impact on generated value added than other manufacturing sectors. At the same time, employment created by the changes in final demand would be more impacted by such sectors as *Food, Beverages and Tobacco; Wood and Products of Wood and Cork* and *Textiles and Textile Products*. In this regard, the number of low-skilled workers in Portugal seems to be more effected by changes in final demand, than those occupied by higher -skilled individuals.

Moreover, it was found that the distribution of GVC income and GVC jobs for the Portuguese manufacturing industry shares a similar outlook. However, upon closer inspection of GVC labour distribution by skill levels there seems to exist a general progression in which low-skilled jobs requirements are met by local resources, while the need for higher skilled jobs require a greater "off-shoring" of work

The results obtained through calculations of presented multipliers provide a powerful tool for policy makers in strategic planning of development of national economy. Using the

provided methodology and obtained results, a government and supranational organizations could define which industry would have the greatest impact for an additional unit of output generated through the economy, and thus define the sectors for further investments.

Keywords: Global value chains, GVC income, GVC jobs, input-output model, multiplicators, WIOD.

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List of acronyms

GVC	Global value chains
EU27	European Union (in 2011)
EU26	European Union (in 2011, minus Portugal)
OECD	The Organization for Economic Co-operation and Development
PMAN	Portuguese manufacturing industry
PREST	Portuguese non-manufacturing industry
PTEXT	Portuguese textile sector
REST	Rest of the countries
WIOD	World Input-Output database
WIOT	World Input-Output table

Abbreviations from WIOD

Variables:

GO	Gross output by industry at current basic prices (in millions of national currency)
LAB	Labour compensation (in millions of national currency)
EMP	Number of persons engaged (thousands)
EMPE	Number of employees (thousands)
LABHS	High-skilled labour compensation (share in total labour compensation)
LABMS	Medium-skilled labour compensation (share in total labour compensation)
LABLS	Low-skilled labour compensation (share in total labour compensation)

Countries:

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

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1. Introduction

Recently, the topics of fragmentation and global value chains are gaining a lot of attention. Generally, a global value chain of a product is defined as the collection of all activities needed to produce a product (Los et al. 2015). This term reflects a strong trend to the dispersion of value chain activities across the world (Powers, 2012). Yet, global value chains are heterogeneous throughout industries, products and services. (OECD, 2013)

Product fragmentation is becoming more profitable, since additional production costs of coordination and transportation are reduced (Bridgman, 2012). In this way, growing fragmentation determines more possibilities for international competition for more parts of production process, which means that more parts of production process become open to international competition. (Timmer et al., 2013) Thus, there is a new stage of globalization when we can see international competition more at the level within industry, rather than at the level of the whole industries. Timmer et al. (2013) define national competitiveness as "a country's ability to realize income and employment growth without running into long-run balance of payment difficulties" (Timmer et al., 2013, p. 615). For them competitiveness is the ability to perform activities that meet the test of international competition and generate increasing income and employment.

Since manufacturing goods are more subjected to international fragmentation because of a high degree of international contestability, it seems reasonable to concentrate attention on this topic. In Portugal, manufacturing sector has a significant importance both in national income and employment. Currently, more than 30% of the final demand for manufactured goods and market services represents value added created abroad (OECD, 2012). The Portuguese participation in GVCs is mainly determined by the use of foreign intermediates in Portugal's export, which means high degree of backward participation. Nowadays, the Portuguese economy is fully integrated in the world trade system. Nevertheless, there is substantial room to increase the intensity of its participation in GVCs. (Amador &Stehrer, 2012).

The current study focuses on Portuguese manufacturing sector. More precisely, the aim of this work is to study which of the manufactures have the most direct and indirect impact on value added and employment in Portugal, following the perspective of global value chains.

In order to achieve this aim, the input-output framework will be used. In generic terms, input-output tables include the consumption of production factors (inputs) which can be, on the other hand, the output of other industries. In this way, the input-output tables show interactions and interdependencies between industries. (Sargento, 2009) An input-output table displays the "the flows of products from each industrial sector, considered as a producer, to each of the sectors, itself and others, considered as consumers" (Miller & Blair, 2009, p. 2).

Therefore, for conducting this research, the World Input-Output Database (WIOD), presented on the site www.wiod.org, will be used. It is a new alternative in study of globalization of production processes. Having been developed by Timmer et al. (2015), the WIOD contains annual time series of world input-output tables from 1995 onwards. A world Input-Output table is understood as "a set of national input-output tables that are connected with each other by bilateral international trade flows" (Timmer et al. 2015).

This work is going to follow a macroeconomic perspective; the obtained results can be used by policy makers in decision making process, when they can estimate the potential impact on income and jobs from changes occurring in the chosen industries and in the whole economy.

The dissertation has the following structure. Chapter 1 presents the theoretical framework regarding globalization, competitiveness and global value chains. Chapter 2 includes different approaches to GVC measurement. Chapter 3 describes the contributions in the literature that relate GVCs and IO models, particularly the recent WIOD database. Chapter 5 reflects the empirical approach to Portuguese manufacturing sector, following by Chapter 6 with Conclusions and Discussion section, where main achievements, implications and limitations are indicated.

2. Globalization, competitiveness and Global Value Chains

The process of increasing globalization has changed the international environment significantly. Generally, globalization is defined as "the increasing interdependence of economies via cross-border transactions of goods, services, natural resources, capital and labor" (Di Mauro & Foster, 2008, p. 7). It is turning out quite difficult to measure globalization because of the growing number of cross-national cultural, political, social and economic interactions as well as the development of a network of direct and indirect relations between individuals that are far away from each other, which entails that distance, as a limiting factor, has a reduced influence. (Arribas et al., 2009)

Baldwin (2006) defines a new paradigm of globalization, taking place at a finer level of disaggregation. Coordination costs as well as those of international communications have fallen and EU firms offshore many tasks. Therefore, if previously international competition took place between firms and economic sectors in different countries, now it appears at the level of individual workers, doing similar tasks in different states.

Moreover, globalization has facilitated and extended the distribution of global production, which requires the organization of ties within global production networks more intensive (Navdi, 2008)

Globalization creates pressure to distribute resources between sectors and firms. Baldwin (2006) defines globalization as an *unbundling* with two stages. The *first unbundling* allowed the geographical separation of factories and consumers. The *second one* has separated the factories and offices themselves. Geographical separation became possible and attractive, because the gap in the North-South relation of productivity-wage grew, and communication and transportation costs became lower.

Gerrefi & Lee (2012) distinguish the consolidation of global value chains and the new geography of value creation and capture. During the past decade, a lot of GVCs shifted production from North to South in the global economy, and nowadays large emerging economies are playing very important roles in these industries as exporters and also new

markets. As the number of intermediate products expands, the geographical gap between the value added to a product, as added in a specific location, and that where a product reaches its final stage in production and is exported widens.

The existing approaches towards the understanding of international trade have been changing too. In the past, it was important to perform tasks in close proximity, because transportation and communication costs were preponderant. In order to communicate, it was necessary to travel physically and transportation was slow and costly. Thus, specialization required geographical concentration. Nowadays, the great reduction of these costs have simplified trade between countries. If before producers divided the production process into several tasks and utilized the gains of productivity from worker specialization, today there are additional gains derived from the cheaper cost of work in different locations (Grossman & Rossi-Hansberg, 2006). Thus, declining additional production costs of coordination and transportation make product fragmentation and vertical specialization become more profitable (Bridgman, 2012).

In this way, the link between specialization and geographical concentration is becoming weaker. Today, the majority of goods are not produced from start to finish in a single country. Countries participate more and more in global supply chains where the manufacture of complex goods requires many tasks, which can be performed in several different locations. (Grossman & Rossi-Hansberg, 2006). Furthermore, there is no need to make the stages of production process near to each other and more parts of production process become open to international competition. Increasingly, there is a new stage of globalization where we can see international competition more at the within industry level, rather than between industries. The increasing integration of world market brings attached an increased disintegration of the production process, where manufacturing or services activities from abroad are compounded by those done at home. (Feenstra, 1998)

It is important to note, that, according to Sturgeon & Memedovic (2010), trade in intermediate goods is more volatile than trade in final goods, which supports the notion that parts and components suppliers suffer from so called “bullwhip” effects during recessions, these entail increased impacts during slowdowns and downturns on the trade of material, parts and components than on that of final goods since, during the periods of economic uncertainty, final goods producers tend to delay orders for parts and components (Escaith et al, 2010).

Since buyers and suppliers gain the ability to communicate and follow quite complex requirements for information exchange in GVCs, international trade needs greater levels of explicit coordination, making more important "customized"[1] intermediate goods. Trade in "customized" intermediates should be increasing in relation to "generic" products and commodities, because of the rise of GVCs, and the increasing competence of local suppliers and transnational corporation in developing countries. (Sturgeon & Memedovic, 2010)

Bridgman (2012) explains, using trade costs, the alteration in international trade. He defines a model that makes it possible to shift production from domestic to foreign sources and allows the decomposition of various trade costs and offshore some of them. Supporting foreign direct investment, financial liberalization has allowed firms to offshore and keep production within the firm at the same time. This kind of trade between affiliates within multinationals determined trade growth.

From what has been exposed before, there is no doubt, that globalization has impacted the international environment and the profound changes in this process require the definition of new and more complex measures of competitiveness. Besides, due to the highly dynamic pace of change, finding how to *stay competitive* has become one of the prime and foremost concerns in many countries.

The notion of competitiveness as a key element of market economy has gained a lot of attention in economic policy and mass media. There are many different and specific definitions of this notion. In general terms, when applied to countries, competitiveness can be defined as "the ability of a country to realize central economic policy goals, especially growth in income and employment, without running into balance-of-payments difficulties" Fagerberg (1988, p.355). Besides, Timmer et al. (2013b) in defining competitiveness emphasize "the ability to perform activities that meet the test of international competition and generate increasing income and employment" (Timmer et al., 2013b, p.616).

Taking into consideration the above mentioned new aspects in globalization and international trade, a new problem in defining competitiveness has surfaced. It is becoming

[1]In their study Sturgeon & Memedovic (2010) distinguish customized and generic goods. By "customized" products they understand items made specifically for one or a few final products. "Generic" products are used in a wide variety of end products

easy to indicate the geographical location of the last stage of production, but this doesn't mean that this place is the where most of the value of the produced article has been added.

At the same time, growing fragmentation brings forth greater possibilities for international competition for more parts of production process, which means that more parts of production process are available and susceptible to international competition. (Timmer et al, 2013)

Global value chains are heterogeneous throughout industries, products and services. (OECD, 2013). According to Sturgeon & Memedovic (2010), global economic integration depends on the characteristics of specific products and the processes and the activities and regulations that prevail in certain industries.

The production systems of manufacturers are more subjected to international fragmentation because of their high degree of cross-borders contestability: they can be produced in any country with little variation in quality. Moreover, it should be noted that the global value chain of manufacturers contains not only activities in the manufacturing sector, but also in such sectors as agriculture, business services and others. (Timmer et al., 2013)

In this situation, insertion and participation in GVCs has become very important for the economic growth of many countries, in particular for nations with a low income, due to the accompanying job creation potential, inflow of foreign currency and contributions to poverty reduction. Globalization has created new opportunities for developing countries to participate in the global economy. At the same time, intense international competition threatens to push many firms out of GVCs. Developing countries can no longer compete on cheap labor alone, they must increase their capabilities or specialize in particular market segments. (Gerrefi & Fernandez-Stark, 2011).

Therefore, the notion of global value chain has been gaining a lot of attention. Gereffi et al. (2005) define a value-added chain as "the process by which technology is combined with material and labor inputs, and then processed inputs are assembled, marketed, and distributed". Generally, a global value chain of a product is defined as the collection of all activities needed to produce a product (Los et al., 2015). This term reflects a strong trend to the dispersion of value chain activities across the world (Powers, 2012).

According to Koopman et al. (2013) at each stage in the process, as goods cross an international border, "the value-added trade flow is equal to the value added paid to the

factors of production in the exporting country" (Koopman, 2013, p. 2). Nevertheless, as all official national trade statistics are still measured in gross terms, which include both intermediate inputs and final products, they "double count" the value of intermediate goods that cross international borders more than once and there is a discrepancy between gross and value-added trade.

Powers (2012) introduces the notion of the "value-added trade balance" as the difference between exports of value added (domestic value added consumed abroad) and imports of value added (foreign value added consumed at home). The countries with the biggest gap between the gross and value-added deficits are integrated more tightly to the major regional supply chains.

Gross exports statistics are unable to capture the value added in internationally fragmentized production. According to Timmer et al. (2013) the strong process of international fragmentations, leads to an increasing disconnection between gross export and GVC income. Timmer et al. (2013) analyze value added and jobs involved in global production chains and, thus, propose a new measure of the competitiveness of a country based on value added and jobs involved in global production chains – these are *GVC income* and *GVC jobs* indicators, which are described in detail below, in Chapter 4.1.

3. Different approaches to GVCs

3.1. Datasets used to measure GVCs

Normally, international trade data reflects the gross value of products. Since they cross borders, it becomes challenging for researchers to calculate the real value added for products within a certain country. Goods cross borders many times passing through global supply chains and, in this way, some elements are double-counted, which overestimates the amount of domestic value-added in exports. The data of bilateral gross exports do not tell us where the value added embodied in those exports is finally consumed. Thus, gross trade is becoming a misleading measurement of value added and its exchange between countries. (Johnson, 2014)

This is why, nowadays, global value chains are always considered while speaking about the global economy. This notion normally includes a rising share of international trade, global GDP and employment. GVCs also connect firms, workers and consumers all over the world and insertion in this process is the first step for firms and workers that want to be a part of the global economy. (Gerrefi & Fernandez-Stark, 2011).

For measuring trade in value added, it is necessary to see the way that goods pass through the global supply chain from input producers to final consumers, distributing the value added in final goods to producers at each stage. (Johnson, 2014). In this way, for the analysis of GVCs, the input-output structure is generally used.

Besides Input-output tables, there are two more main approaches for GVC measurement, that are possible to distinguish in the existing literature: international trade statistics on parts and components and customs statistics on processing trade. (Amador & Cabral, 2014)

The simplest methodological approach is to classify goods as **parts and components** and measure fragmentation by comparing trade in these classified goods with the trade in final products. The data for this approach is generally obtained from the UN trade database the Standard International Trade Classification, that contains information about imports, which includes intermediate goods used to make goods for exports and those that are used for domestic consumption, and about export - using imported parts and components and final assembled goods for transactions.

The determinants of trade in parts and components of bilateral trade relations at the global level were analyzed by Athukorala et al. (2005 and 2006). They found that trade in fragmentated goods is expanding more quickly than final-good trade. Moreover, different regions (North America and Europe compared to East Asia) depend more on this new form of international specialization. The explanation for this fact can be relatively more favorable policy for international production, as well as benefits from the early entry into this new form of specialization, and considerable wage difference.

Sturgeon and Memedovic (2011) follow a similar approach. They found evidence of deepening economic integration and significant differences between industries, which means that global economic integration depends on the characteristics of specific products and processes. Using the United Nations COMTRADE database, they examined characteristics of final and intermediate goods trade and find a growing participation of developing countries in GVCs. For Sturgeon and Memedovic (2011), it is important to investigate trends in intermediate goods trade in order to understand better GVC formation.

It is important to note that parts and component trade measured with the help of reported trade data provides only a representative measure of fragmentation trade, it has the low accuracy of the measure and relies a lot on the product classification of trade statistics. On the other hand, the main advantage of this approach is the high coverage and low complexity of the data and its comparability across countries. (Amador & Cabral, 2014)

The methodological approach of **customs statistics on processing trade** analyzes customs statistics. These statistics contain information on trade that is associated with customs arrangements, where tariff exemptions or reductions are granted in accordance to the domestic input content of imported goods. (Amador & Cabral, 2014)

A lot of studies use the US Offshore Assembly Programme and the EU Processing Trade datasets in order to obtain a measure of international fragmentation.

For instance, Clark (2006) investigates country and industry-level determinants of vertical specialization-based trade. He identifies industries based on use of offshore assembly provisions in the US tariff code. Investigating the factors for vertical specialization, he found that firms tend to shift the simple assembly operations to countries of unskilled employees and vertical specialization-based trade continues to grow in relation to total trade.

However, this approach has some limitations. The main disadvantage is that it captures only the cases where components are exported (imported) for processing abroad (internally) and then reimported (reexported). (Amador & Cabral, 2014)

An important view in the GVCs research is occupied by firm-level approach. It has appeared recently and is expanding rapidly. The data for this approach generally obtained both from international trade data and surveys.

Mion&Zhu (2013) analyze the impact of imports from different origins on firm employment growth, exit, and skill upgrading, using Belgian manufacturing firm-level data and distinguishing between firm-level offshoring of final versus intermediate goods. They found that China differs from both other low-wage and OECD countries, as industry-level import competition from China reduces firm employment growth and induce skill upgrading in low-tech manufacturing industries and offshoring of final goods to China actually increases firms' probability of survival.

Using Japanese firm-level data, Hijzen et al. (2010) explore the impact of offshoring on firm productivity and found that offshoring has a positive effect on productivity growth.

Another source for firm-level data for GVCs research is survey data - the International Study Group on Exports and Productivity, the Competitiveness Research Network, the Research Institute of Economy, Trade and Industry survey of corporate offshore activities by manufacturing firms are an attempt to provide survey information on offshoring of production activities a service. Survey data generally do not cover a wide range of countries, but provide detailed information for one or several countries.

3.2. Different indicators of GVCs

There are different indicators of GVCs such as the participation index (importance), depth, length of global value chains and the specific position of countries in GVCs that can be considered.

In order to define to what extent countries are involved (GVC participation index) in a vertically fragmented production, the vertical specialization (VS) share is used, which corresponds to the value of imported inputs in the overall exports of a country. (Hummels et al., 2001; Koopman et al. 2013) The VS share reflects the importance of foreign suppliers in the value chains. On the other side, a country also participates in GVCs as a supplier of inputs used in third countries for further exports. In this case Hummels et al. (2001) introduce "VS1' share, which reflects "the percentage of exported goods and services used as imported inputs to produce other countries' exports" (Hummels *et al.*, 2001 p.). The VS and VS1 shares together (Koopman et al, 2013) allow to make a comprehensive assessment of the participation of a country in GVCs as a user of foreign inputs and supplier of intermediate goods and services used in exports of other countries.

Foreign inputs and domestic intermediates used in third countries for exports show the importance of vertical specialization. However, they don´t measure the value chains *length*, i.e. number of production stages involved.

In their study, Dietzenbacher et al. (2005) introduced the measure of *average propagation length*, that was later developed in their other study Dietzenbacher et al. (2007) as "the average number of steps it takes a stimulus in one industry to propagate throughout the production structure and affect another industry (or itself)" (Dietzenbacher & Romero, 2007, p. 364).

Dietzenbacher & Romero (2007) investigated linkages between industries in production chains, paying a special attention to sequencing. In this regard, the important aspects are both the strength of the linkages and the distance between industries. They see production as a stepwise procedure. Not investigating separate product chains, they tried to find chains in the national and intercountry production structures. In this production chain, there are two important aspects — strength of the various links and the number of steps. Thus, they studied linkages between industries from the perspective of production chains, where sequencing

plays an important role. And the distance between two industries is a relevant aspect, next to the strength of the linkage.

Fally (2011) used a simpler index. This index takes the value of 1 if there is one stage in production in the final industry and this value increases when inputs from the same industry or other industries are used, with a weighted average of the length of the production involved in these sectors. Using this index, Fally (2011) found that the US industries have become less vertically fragmented over the past 50 years, with a smaller average number of production stages. The same approach used Antràs et al. (2012) in their study, however it was used as an intermediate stage to measure uppstremness.

Speaking of the *specific position* of a country in the GVC, there is a distinction based on specialization between upstream and downstream country: upstream countries produce products and services at the beginning of production process (ex. activities related to innovation, design, etc.), while downstream countries assemble products and are closer to final consumer or provide final consumption related services (such as marketing, branding, logistics, etc).

The measure of *upstreamness* was introduced by Fally (2011) and Antràs *et al.* (2012) and it refers to *the distance to final demand*. If *upstreamness* increases, the economy is becoming more specialized in the production of inputs at the beginning of the value chain. If the distance to final demand has decreased, there is a trend to specialize in goods and services more downstream.

The GVC approach analyzes the global economy from two opposite directions: top down and bottom up. In regards to the top down view, normally it refers to the governance of global value chains. By governance of GVCs, we mean understanding the coordination of a GVC when certain actors in the chain (lead firms) have more influence than others. Because this subject is beyond the scope of application of the present work, it will not be developed here (for useful references in GVCs governance, please refer, for instance, to Gereffi et al. (2005) and (Sturgeon et al., 2008)). Concerning the bottom up direction, it refers to upgrading. This notion is generally used for the strategies used by countries or regions to maintain or improve their positions in the global value chains. (Gereffi. & Fernandez-Stark, 2011). In other words, *upgrading* in GVCs, generally means adding value to production or shifting to higher value activities in global production operations (Gereffi et al., 2005).

Gereffi (2005, p. 171) defines industrial upgrading as "the process by which economic actors – nations, firms and workers – move from low-value to relatively high-value activities in global production networks". Ponte & Ewert (2009) define the GVC upgrading as an ability to make better products through improving processes of producing these products, and/or acquiring new functions

There are 4 categories of upgrading (Schmitz, 2006):

(1) *product* upgrading: shifting to more sophisticated products with increased unit value;(2) *process* upgrading: by the reorganization of productive activities, achieving a more efficient transformation of inputs into outputs;

(3) *functional* upgrading: acquiring new functions (or abandoning old ones) that increase the skill content of activities;

(4) *inter-sectoral* (or inter-chain) upgrading: applying competences acquired in one function of a chain and using them in a different sector/chain.

Upgrading of product and practices effects product quality and includes better practices, however, it doesn´t mean higher value added nor more efficient processes. Nevertheless, in this way, GVC participants, especially from developing countries, can improve their position in GVCs. (Ponte & Ewert, 2009)

Fernandez-Stark et al. (2012) present a typology for policy recommendations to increase the capabilities of the labor force to develop GVC upgrading. They distinguish three core groups: E*arly reactive interventions*, *ongoing proactive intervention*s and f*uture-oriented interventions*. *Early reactive interventions* respond to instant needs of industry and help to secure current participation in the GVC. *Ongoing proactive interventions* develop a qualified labor force for the emerging needs of the industry, *which s*upports upgrading within the chain. *Future-oriented interventions* create a solid base for the workforce to respond to new demands that are likely in the future. Each of these initiatives can be implemented to respond to imperfections of the existing education and training systems in different countries. These interventions support GVC upgrading and creates competitive industries with flexible workers able to adapt to international trends. (Fernandez-Stark et al., 2012)

Besides upgrading seen as a shifting to higher value activities in global production operations, another important positive effect can be associated, in some cases, to countries'

involvement in GVCs: the increase of sustainable management practices. According to Jorgensen & Knudsen (2006), multinational buyers define social and environmental requirements for small and medium-sized enterprises, that are integrated into global value chains. In recent years, large firms have increasingly adopted sustainable supply chain management practices in global value chains. At the same time SMEs have become increasingly integrated into global value chains and hence SMEs have also become exposed to such practices.

Johnson and Noguera (2012a) compute and analyze the value added content of trade and developed a data set of "value added exports" that describes the destination where the value added produced in each source country is absorbed. This measure of "value-added exports" corresponds to "the amount of domestic value added embodied in final expenditure in each destination" (Johnson & Noguera, 2012a, p.227). Thus, they introduced the appropriate measure of exports in international models that are written in value-added terms. Basing on the ratio of value added to gross exports, they measure the extent of double counting in trade statistics, which is an important metric of product fragmentation in the context of multi-stage production.

Using an IO table approach, Timmer et al. (2013) introduced new measures of competitiveness: GVC income and GVC jobs.

All value added in all the stages of production are considered as a *GVC income*. GVC income indicates competitive strength in a particular set of activities (directly or indirectly related to the production of final manufactures). GVC income is obtained from decomposition of the value added of a final product into the value added by each country involved in its production process. It is important that GVC income measure consists of value added in the production for both domestic and foreign final demand, which is very important in analysis of competitiveness of countries with a large domestic market. It is possible to designate world GVC income as the GVC income summed over all countries in the world. GVC income indicates the extent of a country's competitiveness to other nations in terms of activities (not products) related to global manufacturing. Moreover, it shows how economy can compete in both domestic and global markets.

Another important question in GVC structure is employment and characteristics of workers directly and indirectly involved in production. Using number of workers per unit of output,

it is possible to obtain the number of workers directly and indirectly involved in the production of manufacturing goods and sector of employment, which corresponds to *GVC jobs*. (Timmer et al., 2013).

Table 1, below, summarizes some key contributions made by preeminent researchers in the field of GVC and where they have done so.

In regards IO based indicators, more detailed information will be discussed in the following section of this work, Chapter 4..

Table 1. Contributions to GVC indicators

Reference (s)	Dataset used c	GVC Indicator	Indicator description
Hummels et al., 2001;	OECD Input–Output Database	VS and VS1	VS is the value of imported inputs in the overall exports of a country.. VS1 is the percentage of exported goods and services used as imported inputs to produce other countries' exports"
Koopman et al. 2013	Global Trade Analysis Project (GTAP)		
Dietzenbacher et al. (2005)	Andalusian input-output tables.	average propagation length	Average propagation length is the average number of steps it takes a stimulus in one industry to propagate throughout the production structure and affect another industry (or itself)
Dietzenbacher & Romero, 2007	1985 intercountry input—output table for six European countries		
Fally (2011)	US input-output matrices developed by the Bureau of Economic Analysis	Distance to final demand	Distance to final demand - number of stages before obtaining good i, an alternative measure Di can be constructed to reflect the number of production stages between production of good i and final demand
Gereffi et al. (2005)	Inter-firm data	Upgrading	The process by which economic actors – nations, firms and workers – move from low-value to relatively high-value activities in global production networks
Ponte & Ewert (2009)	South-African input-output table	Upgrading	An ability to make better products through improving processes of producing these products, and/or acquiring new functions
Johnson and Noguera (2012a)	GTAP	Value added exports (VAX)	Amount of domestic value added embodied in final expenditure in each destination"
Timmer et al. (2013)	WIOD	GVC income	Value added of all production factors, including capital and labour, in the country that have been directly and indirectly involved in the production of final demand
		GVC jobs	number of workers per unit of output, it is possible to obtain the number of workers directly and indirectly involved in the production of manufacturing goods and sector of employment

Source: Developed by the author

4. GVCs in the IO framework

4.1. IO approach in international trade analysis

As it was mentioned above, normally, gross exports overestimate the competitiveness of countries that have a big part of imported intermediates (Los, 2015). In order to obtain a complete picture of fragmentated production process the GVC perspective with input-output approach is used.

Input-output analysis is a theoretical framework that was developed by Wassily Leontief in 1930s. Later, it was developed for many countries and in 1960s an input-output framework was integrated into the system of national accounts, published by the United Nations, and nowadays it is widely used in analysis of a country economy.(UN,1999)

An input-output model is constructed for a particular economic area and it includes the transactions of products between sectors (interindustry flows). The monetary values of these transactions (usually designated as z_{ij}) between pairs of sectors (from each sector i to each sector j) constitute an important set of data for the creation and utilization of the input-output model. (Miller & Blair, 2009, p.11)

If we put these transactions in a table reflecting inwards and outwards flows, the input-output table will be obtained, which is a valuable tool in the further input-output analysis. The general view of IO table is represented in *Figure 1*.

The rows in this table show the output of each product ***i***, that is used for intermediate consumption by different industries ***j*** for the various purposes of final demand. The columns of an IO table contain information on the provided input of the total supply of each product ***j***, which include both national production and imported products. The value of production includes intermediate consumption of several inputs ***i*** from different industries and value added.

The essential part of the IO table is the interindustry transactions table, since it contains detailed data on the interrelation of various economic activities. Each column of this intermediate consumption table represents the total amount of each input *i* used in the production of output *j*, regardless of the geographical origin of that input. (Sargento, 2009)

Products	1…n	Total Final Demand	Total Demand
1 … n			
Total intermediate consumption			
Value Added			
Total Supply of domestic products			
Imported products			
Total Supply			

Figure 1. Simplified structure of IO table

(Source: Sargento, 2009)

While using input-output analysis, it is assumed that the amount of goods produced by sector ***j*** during one year influences sector ***j***'s demand for input from other sectors during the same period. Moreover, there are some external (exogenous) purchasers such as households, government and foreign trade. Generally, their demand is not related to the amount being produced, but is determined by other considerations. This demand (*final demand*) is for goods that are not supposed to be used as an input to an industrial production process, but to be used as goods as such.

Let assume that one economy consists of ***n*** sectors. If the total output (production) of sector ***i*** is x_i and the total final demand for sector *i*'s product is f_i, the equation accounting for the way in which sector ***i*** distributes its product through sales to other sectors and to final demand is the following:

$$x_i = z_{i1} + \cdots + z_{ij} + \cdots + z_{in} + f_i = \sum_{j=1}^{n} z_{ij} + f_i \qquad (1)$$

The z_{ij} represents *interindustry* sales by sector ***i*** (also known as *intermediate* sales) to all sectors ***j*** (including itself, when $j = i$). This equation represents the distribution of sector *i output*. Identifying sales of the output of each of the **n** sectors, we have:

$$\begin{aligned} x_1 &= z_{11} + \cdots + z_{1j} + \cdots + z_{1n} + f_1 \\ &\vdots \\ x_i &= z_{i1} + \cdots + z_{ij} + \cdots + z_{in} + f_i \\ &\vdots \\ x_n &= z_{n1} + \cdots + z_{nj} + \cdots + z_{nn} + f_n \end{aligned} \qquad (2)$$

Let:

$$x = \begin{bmatrix} x1 \\ \vdots \\ xn \end{bmatrix}, \qquad Z = \begin{matrix} z11 & \dots & z1n \\ \vdots & \ddots & \vdots \\ zn1 & \dots & znn \end{matrix} \quad and\ f = \begin{bmatrix} f1 \\ \vdots \\ fn \end{bmatrix} \tag{3}$$

So, this information on the distribution of each sector's sales can be summarized in matrix notation as equation (4).

$$\mathbf{x} = \mathbf{Zi} + \mathbf{f} \tag{4}$$

The **i** is used for a column vector of 1's (summation vector).
Let's put the information in the ***j***th column of ***z***'s on the right side:

$$\begin{bmatrix} z_{1j} \\ \vdots \\ z_{ij} \\ \vdots \\ z_{nj} \end{bmatrix} \tag{5}$$

These elements reflect sales to sector j – j's purchases of the products of the various producing sectors in the country; the column contains the information about the sources and volumes of sector j's *inputs*. It is important to note that during the production process, a sector also pays for other components, such as labor and capital, and uses other inputs as well, for example inventoried items. These are considered as *primary inputs* and designated as *value added* in sector. Moreover, sector j may purchase imported goods as its input. All these inputs (value added and imports) may be united and called payments sector.

As there is a possibility of purchases by a sector of its own output as an input to production, these *inter*industry inputs include *intra*industry transactions as well.

When the values of these interindustry flows are inserted in a table, with sectors of origin (producers) listed on the left and the same sectors, destinations (purchasers), listed across the top, we obtain *input–output table (*Figure 1*)*, where the columns reflect each sector's inputs and the rows represent each sector's outputs.

Technical coefficients. In order to measure a relationship between a sector's output and its input, it is necessary to find technical coefficients; technical coefficients express the amount of intermediate input *i* used per unit output of sector *j* :

$$\mathbf{a_{ij}} = \frac{z_{ij}}{x_j} \tag{6}$$

where

a_{ij} – technical coefficient,

z_{ij} – value of transaction from sector *i* to sector *j*,

x_j – total output of sector *j*.

Assuming that technical coefficient are unchanging and replacing each z_{ij} by a_{ij}, we obtain:

$$\begin{aligned} x_1 &= a_{11}x_1 + \cdots + a_{1i}x_i + \cdots + a_{1n}x_n + f_1 \\ &\vdots \\ x_i &= a_{i1}x_1 + \cdots + a_{ii}x_i + \cdots + a_{in}x_n + f_i \\ &\vdots \\ x_n &= a_{n1}x_1 + \cdots + a_{ni}x_i + \cdots + a_{nn}x_n + f_n \end{aligned} \tag{7}$$

Looking at these equations, it is possible to see the dependence of interindustry flows on the total outputs of each sector. In this way, if it is possible to forecast the demands of exogenous sector for a certain period of time, the estimated amount of the output from each of the sectors can be estimated in order to supply these final demands (Miller & Blair, 2009). In this case, the $f_1, \ldots, f_n$ are known numbers, the a_{ij} are known coefficients, and the $x_1, \ldots, x_n$ are to be found. (Miller, Blair, 2009). So, putting all *x* to the left, we obtain the following matrix:

$$\begin{aligned} x_1 - a_{11}x_1 - \cdots - a_{1i}x_i - \cdots - a_{1n}x_n &= f_1 \\ &\vdots \\ x_i - a_{i1}x_1 - \cdots - a_{ii}x_i - \cdots - a_{in}x_n &= f_i \\ &\vdots \\ x_n - a_{n1}x_1 - \cdots - a_{ni}x_i - \cdots - a_{nn}x_n &= f_n \end{aligned} \tag{8}$$

Then, putting the x_1 together in the first equation, the x_2 in the second, and so on, we obtain the following matrix:

$$\begin{aligned}
&(1-a_{11})x_1 - \cdots - a_{1i}x_i - \cdots - a_{1n}x_n = f_1 \\
&\vdots \\
&-a_{i1}x_1 - \cdots + (1-a_{ii})x_i - \cdots - a_{in}x_n = f_i \\
&\vdots \\
&-a_{n1}x_1 - \cdots - a_{ni}x_i - \cdots - (1-a_{nn})x_n = f_n
\end{aligned} \tag{9}$$

Taking into consideration the basic definition of inverse, we can obtain the general view of matrix of technical coefficients:

$$\mathbf{A} = \mathbf{Z}\hat{\boldsymbol{x}}^{-1} \tag{10}$$

So, the corresponding matrix for (6) is

$$\mathbf{x} = \mathbf{A}\mathbf{x} + \mathbf{f} \tag{11}$$

Let **I** be the $n \times n$ identity matrix – ones on the main diagonal and zeros elsewhere:

$$\mathrm{I} = \begin{bmatrix} 1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & 1 \end{bmatrix} \tag{12}$$

Then:

$$(I-A) = \begin{bmatrix} (1-a_{11}) & -a_{12} & \cdots & a_{1n} \\ -a_{21} & (1-a_{22}) & \cdots & -a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ -a_{n1} & -a_{n2} & \cdots & (1-a_{nn}) \end{bmatrix} \tag{13}$$

Thus, the system shown in (8) can be presented as:

$$(\mathbf{I} - \mathbf{A})\mathbf{x} = \mathbf{f} \tag{14}$$

From the basic definition of an inverse for a square matrix, $(\mathbf{I}-\mathbf{A})^{-1}=(1/|\mathbf{I}-\mathbf{A}|)[\text{adj}(\mathbf{I}-\mathbf{A})]$. If $|\mathbf{I}-\mathbf{A}| =0$, then $(\mathbf{I}-\mathbf{A})^{-1}$ can be found, and using standard matrix algebra results for linear equations the unique solution to is given by

$$\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{f} = \mathbf{L}\mathbf{f} \qquad (15)$$

where $(\mathbf{I}-\mathbf{A})^{-1}= \mathbf{L} = [l_{ij}]$ is known as the *Leontief inverse* or the *total requirements matrix*. Miller & Blair (2009, p.19-20)

An important part of input-output analysis is occupied by **multipliers**. Input-output multipliers are the summary measures obtained from the elements of **L**.

Miller & Blair (2009) define the following mostly used types of multipliers, that estimate the effects of exogenous changes on

(a) outputs of the sectors in the economy;

(b) income earned by households in each sector because of the new outputs;

(c) employment (jobs, in physical terms) that is expected to be generated in each sector because of the new outputs;

(d) the value added that is created by each sector in the economy because of the new outputs. Miller & Blair (2009, p.244)

Multipliers express the impact produced by a given change in one specific sector j, for instance, motivated by a final demand increase. There are two groups of multipliers: the simple and the total ones. The simple multipliers capture direct and indirect effects obtained from an input–output model that is open for households. This means that all households' expenditures are considered to be exogenous. Besides these two effects, the total multipliers include also induced effects – effects which take into account the effects of increasing output on household's income and, consequently, household's consumption. Total multipliers are, thus, obtained from a model that is closed for households.

In this study we will deal with simple multipliers, given the structure of the matrix used as the database.

Multipliers refer to the difference between the initial effect of an exogenous change and the total effects of that change. There are two groups of multipliers: the simple and the total ones. The simple multipliers capture direct and indirect effects (obtained from an input–output model that is open for households). Besides these two effects, the total multipliers include also induced effects (obtained from a model that is closed for households).

In this study we will deal with simple multipliers, given the structure of the matrix used as the database.

Output multipliers. An output multiplier for sector ***j*** corresponds to "the total value of production in all sectors of the economy that is necessary in order to satisfy a dollar's worth of final demand for sector j's output". (Miller&Blair, 2009, p. 245) Output multipliers (column sums of **L**) represent sector-to-economy multipliers, that link final demand in sector ***j*** to economy output.

For the simple output multiplier, this total production is found from a model with households exogenous. The initial output effect on the economy shows just the initial dollar's worth of sector ***j*** output that is necessary to satisfy the additional final demand. Thus, it is possible to say that the output multiplier is the ratio of the direct and indirect effect to the initial effect alone.

In practical terms, we can see that if the government try to define on what sector to spend additional dollar (or other amount), when compare output multipliers it would see the greatest impact for a total dollar value of output generated through the economy.

Value added multipliers. Another kind of multiplier relates the new value added created in each sector in response to the initial exogenous shock to that initial shock. The only new information required is a set of sectoral value-added coefficients – $\mathbf{v}'$

$$\boldsymbol{v} = \boldsymbol{v}'\hat{\boldsymbol{x}}^{-\mathbf{1}} \tag{16}$$

And the value-added multipliers can be denoted, then, as

$$\boldsymbol{m}(\boldsymbol{v}) = \boldsymbol{v}_{\boldsymbol{c}}'\boldsymbol{L} \tag{17}$$

It is often mentioned that value added is a better measure of a sector's contribution to an economy because it represents the value that is added by the sector in engaging in production

– the difference between a sector's total output and the cost of its intermediate inputs. (Miller&Blair, 2009, p. 256)

Income Multipliers and Employment Multipliers. The economic impact of new final demand on created jobs and increased household earnings is more question of concern than simply output by sector. Income and employment multipliers allow to explore the impact on the households in physical (jobs) or monetary (earnings) terms.

Using labor-input monetary (wages received per unit of output, as in [$a_{n+1,1}$, …, $a_{n+1,1}$]) or physical (person-years per unit of output) coefficients, it is possible to convert the elements in **L** into dollars' worth of employment. (Miller & Blair, 2009) Thus, let the row vector of this information be designated as **h'** (for households). For monetary values, it is [$z_{n+1,1}$, …, $z_{n+1,1}$], for calculation in physical terms it should be some measure of number of employees in a certain period. Then the row of respective input coefficients in monetary would be denoted as:

$$\boldsymbol{h_c' = h'\hat{x}^{-1}} \tag{18}$$

Then the income multipliers are denoted as:

$$\boldsymbol{m(h) = h_c'L} \tag{19}$$

It is necessary to note that of the employment multiplier (in physical values), it is more illustrative to consider the jobs created per thousand of dollars of additional output.

Then in physical values the technical coefficients are denoted as :

$$\boldsymbol{e_c' = e'^{\hat{x}^{-1}} * 1000} \tag{20}$$

And multipliers as:

$$\boldsymbol{m(e) = e_c'L} \tag{21}$$

This decomposition method can be used for analysis of value and quantities of specific production factors (labor or capital) in the production of a certain final good. In the current

study this method is used in Chapter 5, for the analysis of Portuguese textile sector and the impact of changes in its final demand.

Therefore, IO framework provides a valuable tool for international and domestic trade analysis and allows to evaluate direct and indirect effects on the economy. The empirical application of IO analysis is provided in Chapter 5.

4.2. GVC jobs and GVC Income variables

Following the approach of Johnson &Noguera (2012) and Timmer et al. (2013) we can measure GVC income and GVC jobs, applying IO approach. Using international input-output model, Timmer et al. (2013) traced the value added at the various stages of production and developed an ex-post accounting of the value of final demand (Timmer et al., 2013). For these calculations, the model developed by Johnson & Noguera (2012) can be used and then generalized to value added analysis by specific production factors.

Following Timmer et al. (2013), ***S, F*** and ***N*** denote sectors, production factors and countries respectively. Each country-sector produces one good, thus, there are SN products. For output production in each country-sector, domestic production factors and intermediate inputs, that can be of domestic or foreign origin, are used. Country-sector output is used to satisfy final demand (domestic or foreign) or used as intermediate input in production (domestic or foreign). Final demand has such components as household and government consumption and investment. To track the shipments of intermediate and final goods within and across countries, it is necessary to define source and destination country-sectors.

For a particular product, the source country is denoted by *i*, the destination country is denoted by *j*, the source sector is denoted by *s* and the destination sector is denoted by *t*. By definition, the quantity of a product produced in a particular country-sector is equal the quantities of this product used domestically and abroad. The product market clearing condition can be written as

$$x_i(s) = \sum_j f_{ij}(s) + \sum_j \sum_t m_{ij}(s,t) \qquad (22)$$

Where $x_i(s)$ denotes the output of sector s of country *i*, $f_{ij}(s)$ is the value of goods shipped from this sector for final use in any country *j*, $m_{ij}(s,t)$ is the value of goods shipped from this sector for intermediate use by sector t in country j.

In this way, the market clearing conditions for each of the *SN* goods can be combined to create a compact global input-output system. If *x* is a vector of production of dimension (SNx1), which is obtained by putting output levels in each country-sector and *f* is the vector of dimension (SNx1) that is constructed by obtaining world final demand for output from

each country-sector $f_i(s)$. World final demand is the summation of demand from every country. Obtaining a matrix of global intermediate input coefficients of dimension *SNxSN*, the elements of which are denoted as $a_{ij}(s,t) = m_{ij}(s,t)/x_i(t)$ denote the sector ***s*** output in country ***i*** used as intermediate input by sector *t* in country *j* as a share of output in the latter sector. With this information, we come again to the equation **x = Ax+ f**, or, after its rearranging to equation (10).

In order to decompose the final demand of a specific product into value added in country-sectors that directly and indirectly participate in the production process of the final good, let $p_i(s)$ represent the value added per unit of gross output produced in sector ***s*** in country ***i***, thus creating the stacked *SN*-vector *p* containing these value added coefficients. The elements in *p* do not account for value added embodied in intermediate inputs used. To take these into account, we derive the *SN*-vector of value added levels *v* as generated to produce the unit final demand column vector z_n , with the *n*th element representing an additional unit of global consumption of goods from country-sector *n*, and pre-multiply the gross outputs needed for production of this final demand by the direct value added coefficients vector ***p***:

$$\mathbf{v} = \hat{\mathbf{p}}(\mathbf{I} - \mathbf{A})^{-1}\mathbf{f} \qquad (23)$$

Where $\hat{p}$ is a diagonal matrix with the elements of a vector (in this case ***p***) on the diagonal. From now, it is possible to multiply $\hat{\boldsymbol{p}}(\boldsymbol{I} - \boldsymbol{A})^{-1}$ with any vector of final demand levels to estimate what value added levels should be attributed to this particular set of final demand levels.

This decomposition method can be used for analysis of value and quantities of specific production factors (labor or capital) in the production of a certain final good.

In the current study this method is used in Chapter 5.4 and 5.5, in the analysis of the whole Portuguese manufacturing industry, as well as in the illustrative example where it is shown how the increase in final demand of the Portuguese textile sector will influence the number of jobs and income generated in Portugal.

Therefore, IO framework provides a valuable tool for international and domestic trade analysis and allows to evaluate direct and indirect effects on the economy. The empirical application of IO analysis is provided in Chapter 5.

4.2. International IO databases

It is difficult to analyze international fragmentation because of some limitations regarding the bilateral data that encapsules only the domestic or foreign origin of the final product and doesn't provide information about intermediaries and international fragmentation (Los et al., 2015). In the analysis of the international fragmentation, the total inputs, imported input shares of gross output or exports are taken into consideration. For this purpose, the information is normally obtained from input-output databases. (Amador&Cabral, 2014)

Since final goods and services that we buy include inputs from different countries around the world and it often isn't easy to reflect the global production chains of their goods and services within custom measures of international trade, input-output tables that contain countries worldwide have been created. In this section, a short description of the most popular input-output databases is provided.

As GVCs expand all over the world, the concept of "country of origin" becomes increasingly complicated to apply. (Amador&Cabral, 2014)

The accuracy of this fragmentation measurement is defined by the product's available classification. The more it is detailed, the more appropriately the production chain is identified and the more correctly intermediate products used are specified. Input-Output databases try to provide most possible sectorial information available in order to make it possible to perform a cross industry and time analysis. Generally, the input-output tables contain information for a range of countries, for some set of industries and for some years on a comparable basis. (Amador&Cabral, 2014)

As we see, an industry's integration in a GVC and its role in trade in intermediate products is an important part in the analysis of the industry's export potential and competitiveness. In this way, the analysis of trade in value added allows us to find the original source country and becomes a useful tool in the study of net trade flows. Exports are produced and used as inputs in other products or consumed as final goods and services; this is possible because of combination of domestic and foreign value added. Thus, imported intermediate products to be included in exports are a significant part of the production process, which makes the gross value of exports bigger than their domestic value-added component.

Normally, in order to measure trade in value added, input-output tables are used in conjunction with the data about all bilateral exchanges of intermediate and final goods, which allows an idea of the value-added along the GVC to each producer to be add.

Recently, some different global input-output matrices have become available, these contribute a lot to the measurement of GVCs and help in investigating the different dimensions of international bilateral flows of value-added. Most commonly used databases for IO analysis are presented in *Table 2*.

The initial studies, that used input-output databases, were taken by the **Global Trade Analysis Project (GTAP) database realized by** the Center for Global Trade Analysis in Purdue University. The GTAP database represents a harmonized set of input-output tables (domestic and import) for 109 individual countries and 20 regions, and contains data for 57 sectors,

In applying this database, Johnson & Noguera (2012a) combined input–output and bilateral trade data to compute the value added content of bilateral trade. They introduce a ratio of value added to gross exports (VAX ratio) as a measure of the intensity of production sharing. Using this measure, they determine that bilateral production linkages define variation in bilateral VAX ratios. Applying input-output approach and trade data they compute bilateral trade in value added and make a conclusion about significant differences between value added and gross trade flows.

Then later, Jonhson & Noguera (2012c) took that data and tried to find the dependency between fragmentation are geographical proximity and came to the conclusion that geographically close partners have lower value added to export ratios, and these ratios falling more rapidly over time among geographically close partners than among partners that are far away from each other. In this way, they found out that the factors associated to distance (ex. communication and transportation costs, language similarities etc.) have their influence on the process of fragmentation

Based on the same database, Daudin et al. (2011) developed a measure of international trade: "value-added trade" as a measure of double-counted vertical trade. They investigate the effect of vertical trade on trade patterns, calculating the share of imported inputs in exports, the share of exports used as inputs to further exports, the domestic content of imports and

value-added trade. They found that services are much more dependent on external demand that the standard trade statistics suggest.

Koopman et al. (2014) suggests a framework for gross exports accounting that decomposes a country's gross exports into various value-added components by source and additional double counted terms, integrating all previous measures of vertical specialization and value-added trade in the literature into a unified framework.

With the joint support of the WTO and OECD the **OECD-WTO Trade in Value Added database** was launched in 2013**.** This database is processed by the OECD and WTO approximately once every 5 years and contains harmonized input-output tables. The latest 2015 edition includes 61 country economies that cover OECD, EU, G20, most East and South-east Asian economies and some South American countries. This database includes 34 sectors (16 manufacturing and 14 services sectors) and covers 1995, 2000, 2005 and 2008 to 2011 years.

Based on this data, the OECD-WTO TiVA database provides information about some indicators, which are designed for better understanding of trade relations between countries. The guidelines for the use and policy implication of this database are provided in OECD Syntethis report (2013).

This database is mainly used in policy-oriented studies. Thus, applying the OECD-WTO TiVA, De Backer & Miroudot (2013) look for better evidence for the examination of a country's position within international production network providing a more comprehensive picture of GVCs.

A lot of different concepts and investigation in value added are associated with the W**orld Input-Output Database (WIOD) database**. This database includes the 27 EU countries, 13 major other economies and a "Rest of World" aggregate geographical unit. It provides annual data for the period 1995 to 2011, and contains 35 industries and 59 products. An important point of departure is that WIOD uses only data that is publicly available. This database was used to define new measures of competitiveness (Timmer et al., 2013), based on the value added in trade, to investigate the connection between international outsourcing and the skill-structure of labour demand (Foster-McGregor et al., 2013), to find basic trends in offshoring in Europe (Schworer, 2013), etc. The WIOD was used by Foster-McGregor &

Stehrer (2013) and Dietzenbacher et al. (2014) in their GVCs studying. Since this database is also used in the current dissertation, it will be described in more detail in the next section.

Besides these three databases, mostly used for global trade, there are some that are devoted to the Asian region, and have more detailed information for Asian countries. One is the **IDE Jetro, Asian International Input-Output Tables (AIIOTs),** that covers an important part of the global economy. This database was designed to depict the industrial network extended over the ten Asian countries (China, Indonesia, Korea, Malaysia, Taiwan, the Philippines, Singapore, Thailand, Japan and the United States of America). It provides information about input composition and output distribution of each domestic and foreign industry. The Asian International Input-Output Table is available for the years of 1985, 1990, 1995 and 2000, 2005 and partly for 1975 (except China and Taiwan). The construction and application of this database are discussed by Meng et al. (2013).

Another Asian database is the **Asian Development Bank, multi-regional input-output tables (ADB-MRIO).** It is the initiative of The Asian Development Bank to extend the WIOTs for analysis work related to the Asia and the Pacific Region. For this purpose, 5 additional Asian countries (Bangladesh, Malaysia, Philippines, Thailand and Vietnam) for 6 years 2000, 2005-2008 and 2011.

Table 2. Databases for Input-Output Analysis of International Trade

Name of database	Nº of countries	Years	Sectors	Research using this data
GTAP	129	1990, 1992, 1995, 1997, 2001, 2004, 2007	57	Johnson&Noguera (2012, 2014), Daudin et al. (2011), Koopman et al. (2014)
WIOD	40 + RoW	1995-2011	35	Baldwin&Lopez-Gonzales (2013); Timmer, Los, Stehner&de Vries (2013)
WTO-OECD	57 - 61	1995, 2000, 2005, 2008, 2009	34	OECD and WTO (2012), Backer & Miroudot
ADB-MRIO	WIOD + 5 countries	2000, 2005-2008 and 2011	35	Asian Development Bank
AIIOTs	10	1985, 1990, 1995, 2000, 2005	56	Meng et al. (2013)

Source: Developed by the author.

To conclude, despite the research over the last decades, the mapping and measurement of GVCs requires a complex approach and is still incomplete. The computation of global input-output tables is a big difficult progress in comparison to the use of national matrices, which explains their time, sectorial and country coverage limitations.

4.3. Use of the WIOD

International fragmentation of production processes makes it necessary to take into consideration an interdependent structure. The description of this interdependent structure is provided in supply and use tables and/or input–output tables.

Following the methodology of Dietzenbacher et al. (2013) and Wiedmann et al. (2011), it is possible to distinguish the characteristics of the database that are useful for analyzing economic, social and environmental issues and policies. This database must "(i) be global, (ii) cover changes over time in order to evaluate past developments, and (iii) include a variety of socio-economic and environmental indicators" Dietzenbacher et al. (2013, p. 72). Besides, all data should be presented in a coherent framework with the same product and industry classifications and consistent definitions.

In order to have this kind of information, The World Input–Output Database (WIOD) project has been developed. This database has information concerning fragmentation, socio-economic and environmental issues and contains detailed information about national production and international trade.

Timmer et al. (2015) describes in detail the WIOD project, indicating that present statistical frameworks are incapable of providing the necessary data to analyze international trade.

Compared to other databases, the WIOD has some distinguishing characteristics. WIOTs from the WIOD are benchmarked with the National Accounts and can be reconciled over time. Moreover, WIOD is based on official and publicly available statistics, which ensures a high level of data quality. Furthermore, the WIOD is still the only database that is publicly available for free, providing full transparency by exposing all the data sources and methodologies.

Making the unit of observation a product group, Timmer et al. (2014) analyze GVCs from the product perspective from the conception stages to its delivery. They decompose ("slice up") the global value chains, using Leontief's technique and determine the value added by all labor and capital directly and indirectly involved into the production of final goods. Analyzing the distribution of value across production factors, Timmer et al. (2014) were able to identify the following trends: i) more value is being added by capital and high-skilled labor, and less by low-skilled labor; there has been a change in production location – overall,

value added increased in emerging countries, and didn't in advanced countries within the period of 1995-2008.

Costinot & Rodriguez-Clare (2014). assessed the magnitude of the gains from trade liberalization. They provide an alternative approach for quantifying the consequences of globalization. The authors consider various economic variables —market structure, firm-level heterogeneity, multiple sectors, intermediate goods, and multiple factors of production, and then their effect on the magnitude of the gains from trade liberalization.

Applying the WIOD, Ottaviano et al. (2014) study the benefits of trade openness within EU countries and analyze the possible effects related to an eventual leaving in the EU. Using the Costinot & Rodriguez-Clare (2014) methodology, they calculate some changes in welfare, measured by real consumption, caused by an exit the UK from the EU. They came to the conclusion, that in the case of bilateral increases of tariffs and non-tariff barriers between the UK and EU, there is a decrease in UK welfare.

In his turn, Johnson (2014) pays a special attention to such a measure as *value added exports* that corresponds to the amount of value added in domestic country an embodied in final output of each destination (Johnson&Noguera 2012a). Applying the WIOD, Johnson (2014) highlights the differences between gross and value-added exports and indicates that these are growing over time.

Los et al. (2015) investigate the trend in the international fragmentation of value chains and the distribution of value-added between countries in the production chain. They separate the foreign value added in the region where the product belongs and the outside and analyze if global value chain is global or regional.

In order to describe the international fragmentation of specific value chains, Los et al. (2015) suggest a metric based on the information from world input–output tables. Their measure considers final output values and all rounds of production, and takes into account the geographical origin of value added. They decomposed the value of a final product and obtained the value-added shares generated in all countries that contribute to its value chain. In this way, Los et al. (2015) found that value chains have become more internationally fragmented (in comparison to 1995, in 2011 the shares of foreign value added have considerably increased). The global fragmentation has been developing much faster than regional fragmentation. Geographical proximity of countries or their belonging to a trade

bloc is still important for the country's distribution of value added in product value chains, but it matters less so than in 1995.

Wang et al. (2013) provide a general framework that decomposes gross trade flows (for both exports and imports) at the sector, bilateral, or bilateral sector level, allocating bilateral intermediate trade flows into their final destination of absorption. In this way, they distinguish a measure of domestic value added exports based on forward linkage from a measure of value added exports based on backward-linkage and, thus, develop a new approach for calculation of domestic and international production sharing.

Koopman et al. (2014) suggest a framework for gross exports accounting that decomposes a country's gross exports into various value-added components by source and additional double counted terms. Identifying which parts of the official trade data are double counted and the sources of the double counting, it connects official trade (in gross value terms) and national accounts statistics (in value added terms). They provide a unified framework uniting all previous measures of vertical specialization and value-added trade in the literature.

Foster-McGregor & Stehrer (2013) provide a new approach for decomposing the value added into foreign and domestic components, considering both exports and imports simultaneously (before only export component was usually considered). Their framework allows to calculate such indicators as multilateral foreign value added in imports for evaluating the increasing roundaboutness in the world economy.

Schworer (2013) uses the WIOD to analyze offshoring and domestic outsourcing in nine European countries. He estimates the productivity effects of service and material offshoring, combining the offshoring data with a manufacturing firm panel. In this way, he came to the conclusion that offshoring has increased in all countries and industries in Western Europe and it has increased with respect to different types of supplier countries, though strongest for low-wage supplier countries. Offshoring of services and non-core manufacturing activities determined an increase in productivity, and offshoring of core activities and domestic outsourcing have had no such effects. Thus, offshoring raises productivity by allowing firms to specialize on their core activities.

Indicating new challenges in the analysis of international trade and countries' competitiveness, Timmer et al. (2013) emphasize the rise of global value chains (GVCs). They argue that traditional measures of international trade with the increasing fragmentation

of production across borders and the increasing use of foreign inputs should be reviewed. Accordingly, Timmer et al. (2013) introduce new concepts of competitiveness: GVC income and GVC jobs. All value added in all the stages of production are considered as a GVC income. GVC income indicates competitive strength in a particular set of activities (directly or indirectly related to the production of final manufactures). GVC income is obtained from the decomposition of the value added of a final product into the value added by each country involved in its production process. It is important that GVC income measure consists of value added in the production for both domestic and foreign final demand, which is very important in analysis of competitiveness of countries with a large domestic market. It is possible to designate world GVC income as the GVC income summed over all countries in the world. GVC income indicates the extent of a country's competitiveness to other nations in terms of activities (not products) related to global manufacturing. Moreover, it shows how an economy can compete in both domestic and global markets. In their study, Timmer et al. (2013) found that exports are not equivalent to domestic incomes. Strong export performance of some EU countries does not mean income growth. The competitiveness of countries that rely heavily on imported intermediates is overestimated by gross export measures.

Another important question in GVC structure is employment and the characteristics of workers directly and indirectly involved in production. Using the number of workers per unit of output, it is possible to obtain the number of workers directly and indirectly involved in the production of manufacturing goods and sector of employment, which corresponds to GVC jobs. (Timmer et al., 2013). Their research indicates a Europe specialization on high skilled GVC jobs. They registered a significant increase of high skilled jobs in Europe, which is, from the perspective of competitiveness, evidence of Europe's ability to achieve employment growth in activities that are productive and relatively well paid in a highly competitive international environment. Later, Timmer et al. (2014) also show the importance of GVCs manufactures for employment – advanced countries specialize in high-skilled jobs.

With a similar aim, Foster-McGregor et al. (2013) investigate the connection between international outsourcing and the skill structure of labor demand. Using the WIOD and estimating a system of variable factor demand equations, they examine both a cross-country and cross-industry dimension and split employment into three skill categories. In this way, the found that all skill levels are negatively influenced by offshoring, especially medium-skilled workers. The question of the influence of offshoring on labor markets is becoming

more and more relevant, because countries start to be a part of an international production network. (Foster-McGregor et al., 2013)

As we can see, WIOD is widely used for analysis, being an important data source in many fields of economics. The application of the WIOD for the current dissertation will be described in the next chapter.

5. GVCs in the Portuguese manufacturing industry: an empirical application

5.1. Source of Data and Data Manipulation

Following the Input-Output framework in the analysis of Portuguese participation in GVCs in the current study, the World Input-Output Database (WIOD) was chosen as a source of data for the further investigation. This database is presented in free access on the website www.wiod.org and is widely used in GVC studies (see Chapter 4).

The WIOD as a new alternative in study of globalization of production processes was developed by Timmer et al. (2015) and contains annual time series of world input-output tables (WIOTs) from 1995 to 2011. A WIOT represents "a set of national input-output tables that are connected with each other by bilateral international trade flows" (Timmer et al, 2015, p. 577).

This database was chosen among others because of the range of its distinctive characteristics. First of all, it reflects development over the time and contains information of value added, trade and consumption from national accounts (i.e. IDE-JETRO and GTAP databases were made only for particular years and can hardly be used in analysis over time). Moreover, the data is of a high level of quality, as it is based on official and publicly available data from SUTs from statistical institutions. One more advantage of this database among others is the presents of RoW part that covers countries from trade database with no developed SUTs. Besides, the WIOD project contains a wide range of socio-economic data, which allows to analyze economy from different sides. Finally, by now this is the only publicly available and free database that contains World Input-Output Tables (WIOTs) for such a long period (for a comparison with other IO databases, see Table 2 in Chapter 4.2).

Each WIOT contains information about all transactions of all presented countries between industries and final users. Its rows indicate how the output of industries is distributed between user categories. The WIOT has industry-by-industry format, where each of 40 presented countries is divided by 35 industries, that cover agriculture, mining, construction, utilities, services and 14 manufacturing sectors (Timmer et al., 2015). In this study only

Portuguese manufacturing sector is considered, thus, the industries considered are *Food, Beverages and Tobacco; Textiles and Textile Products; Leather, Leather and Footwear; Wood and Products of Wood and Cork; Pulp, Paper, Printing and Publishing; Coke, Refined Petroleum and Nuclear Fuel; Chemicals and Chemical Products; Rubber and Plastics; Other Non-Metallic Mineral; Basic Metals and Fabricated Metal; Machinery, Nec; Electrical and Optical Equipment; Transport Equipment; Manufacturing, Nec; Recycling*.

The schematic outline of the WIOT is presented on the Figure 2. There is *m*-number of countries that are divided by *n*-number of sectors and in the rows and columns it is possible to see the transactions between them.

			Use by country-industries							Final use by countries			Total use
			Country 1			…	Country M			Country 1	…	Country M	
			Industry 1	…	Industry N	…	Industry 1	…	Industry N				
Supply from country-industries	Country 1	Industry 1											
		…											
		Industry N											
	…												
	Country 2	Industry 1											
		…											
		Industry N											
Value added by labor and capital													
Gross output													

Figure 2. WIOT Schematic view

Source: Timmer et al., 2015

Currently, the WIOD project contains developed 17 WIOTs from 1995 by 2011. In this study, the input-output table of 2011 was considered, since it is the most recent (at the moment of writing) in WIOD project.

5.2. Descriptive analysis

The WIOT for 2011 contains information about all transactions between a large number of countries' economies expressed in millions of dollars. These values represent either final consumption or intermediate input for other countries. Before proceeding with the Input-Output model, Leontief inverse and indirect effects generated by output, the descriptive part of the available data and analysis of direct requirements will be presented in the current chapter.

As it was mentioned above, the WIOT provides valuable data regarding the inward and outward transaction to and from different countries. In this study the country of interest is Portugal, so a particular attention will be paid to transactions from, to and within this nation. On Figure 3 we can see a grouping of countries to which Portugal exports, from which imports and how much (in millions $) it does so, either to intermediate of final consumption. On Figure 3, below, we can observe that among foreign countries, Portugal exported (in 2011) more to countries such as Spain ($7.845 millions), Rest of the World countries ($ 6.907 millions), Germany ($3,737 millions), France ($3.216 millions), the USA ($2.713 millions) and Brazil ($1.516 millions).

On the other side, the transaction from other countries to Portugal share a similar outlook. The main countries that export to Portugal are Spain ($14.040 millions), Rest of the World countries ($7.970 millions), Germany ($4.439 millions), France ($2.379 millions), Brazil ($2.286 millions), and the USA ($2.180 millions).

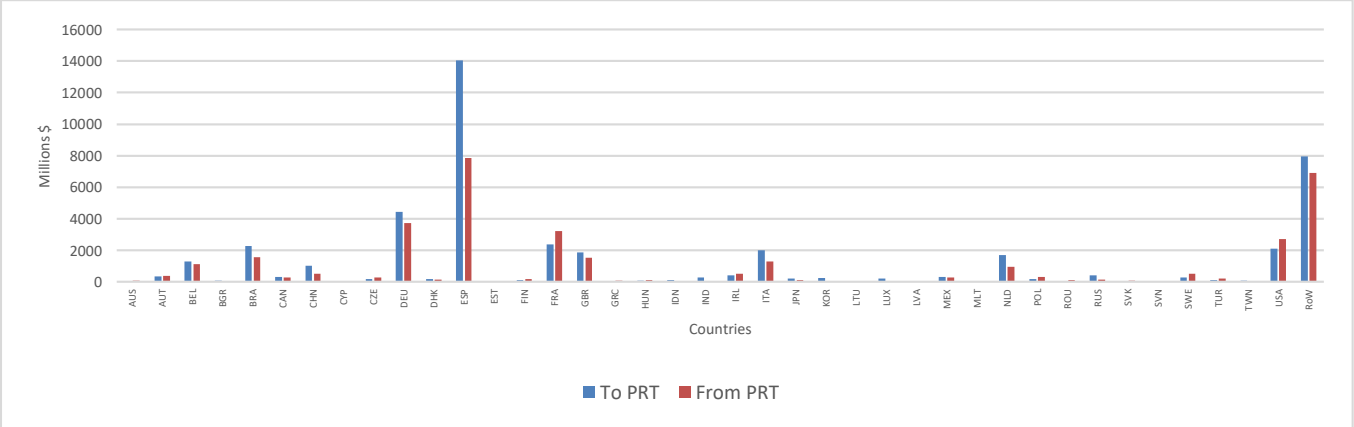

Figure 3. Bilateral transaction between Portugal and other countries

Source: Developed by the author on the WIOD basis

Figure 3 can lead to erroneous conclusions about the bilateral importance of international trade partners as it deals only in gross values, ignoring altogether all information about value added and intermediate consumption or, in other words, neglecting to acknowledge the processes through which countries re-export products or merely consume raw materials. This is a good example of one of the problems (i.e. double-counting) that traditional measures of competitiveness face when analyzing a set of countries.

It is also worth noting, that transactions within Portugal are much bigger than those with other countries by comparison and constitute $171.100 millions. Thus, we can infer that the brunt of the Portuguese economy is geared towards the satisfaction of internal intermediate and final consumption needs.

The WIOT allows the analysis of structure of inward and outward transactions by showing them divided in economic sectors. On Figure 4, we can see that the sectors with the majority of outwards transactions are *Pulp, Paper, Printing and Publishing; Basic Metals and Fabricated Metal*, *Electrical and Optical Equipment*, among others. Spain, which on the graphs previously shown occupied a preeminent position, is widely represented cross all of Portugal's industrial sectors. Germany is an important trading partner for Portugal's *Pulp, Paper, Printing* and *Publishing and Rubber and Plastics* sectors. The countries which constitute the "Rest of the World" category in Figure 4, namely all those not shown in it, also occupy significant positions in these transactions.

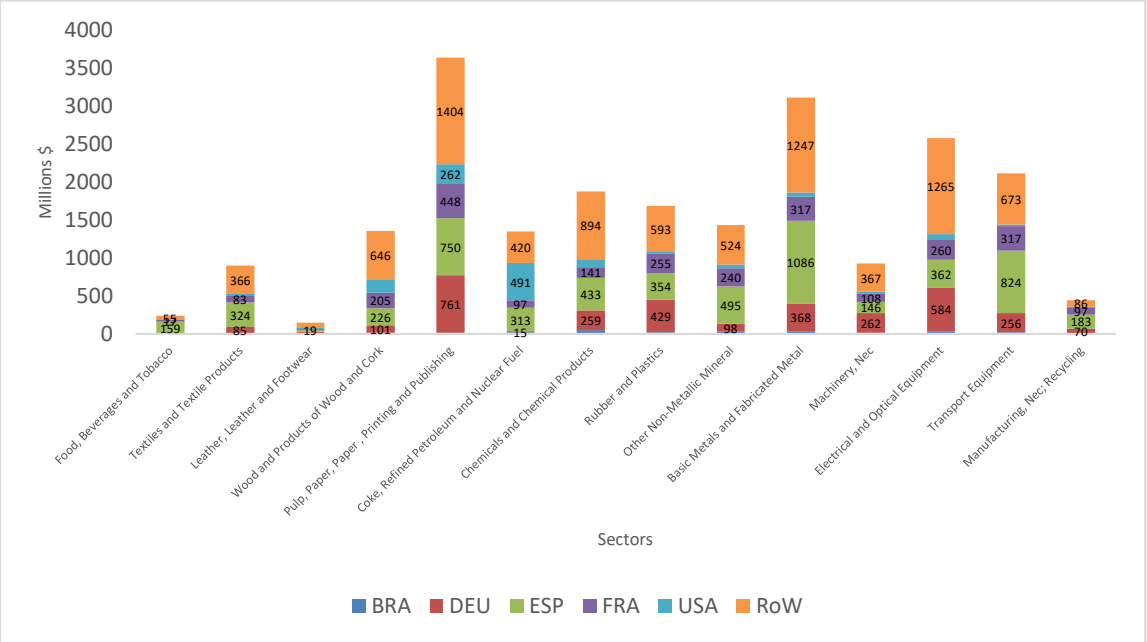

Figure 4. Transactions from each Portuguese manufacturing sector to other countries

Source: Developed by the author on the WIOD basis

Alternatively, we can observe the structure of inward transitions (Figure 5) and their weight relatively to each other. Most transactions are attributable to the *Coke, Refined Petroleum and Nuclear Fuel* sector and the majority of these transactions comes from the "Rest of the World" countries. The sectors *Basic Metals and Fabricated Metal*, and *Transport Equipment* import more products compared to others with Spain, Germany and the "Rest of the World" countries being the main contributors.

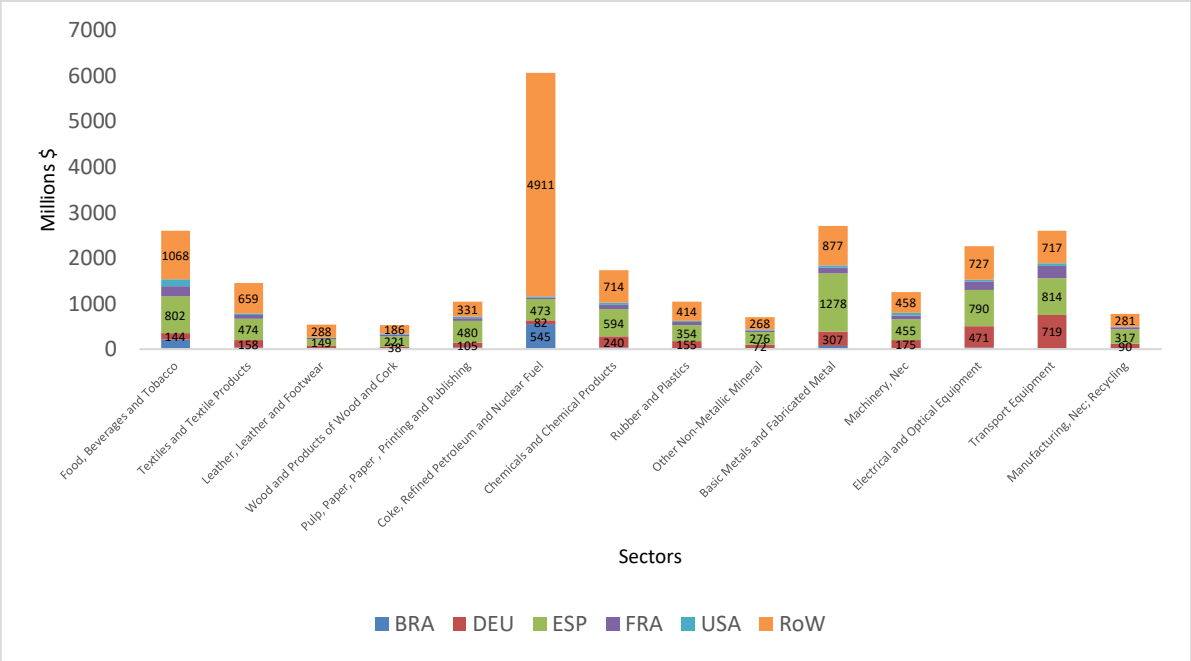

Figure 5. Transactions from other countries to Portuguese industries

Source: Developed by the author on the WIOD basis

Besides bilateral transaction between countries, after a simple calculation, it is possible to observe the percentage of contribution of intermediate consumption of domestic and foreign origin and Portuguese value added in final Portuguese output by sectors (*Figure 6*). On *Figure 6* we can observe the composition of final output in percentage with intermediate consumptions of domestic and foreign origins and value added. It is easy to note that in the majority of the cases the contribution of intermediate consumption of foreign origin is about 15-30%, while intermediate consumption is responsible for about 40%-60% and value added is about 25%-30%. The *Coke, Refined Petroleum and Nuclear fuel* has the biggest share of intermediate consumption of foreign origin (74%) and smallest share of value added (10%). At the same time, Portugal adds more value in such sectors as *Leather, Leather and Footware; Pulp, Paper, Printing and Publishing; Other Non-Metalic Minerals; Machinery, Nec*. (36% of Portuguese value added in final output of respective sectors). The sectors *Food,*

Beverages and Tabaco and *Wood and Products of Wood and Cork* have the biggest percentage of intermediate consumption of Portuguese origin in respective sectors (64% and 62% respectively).

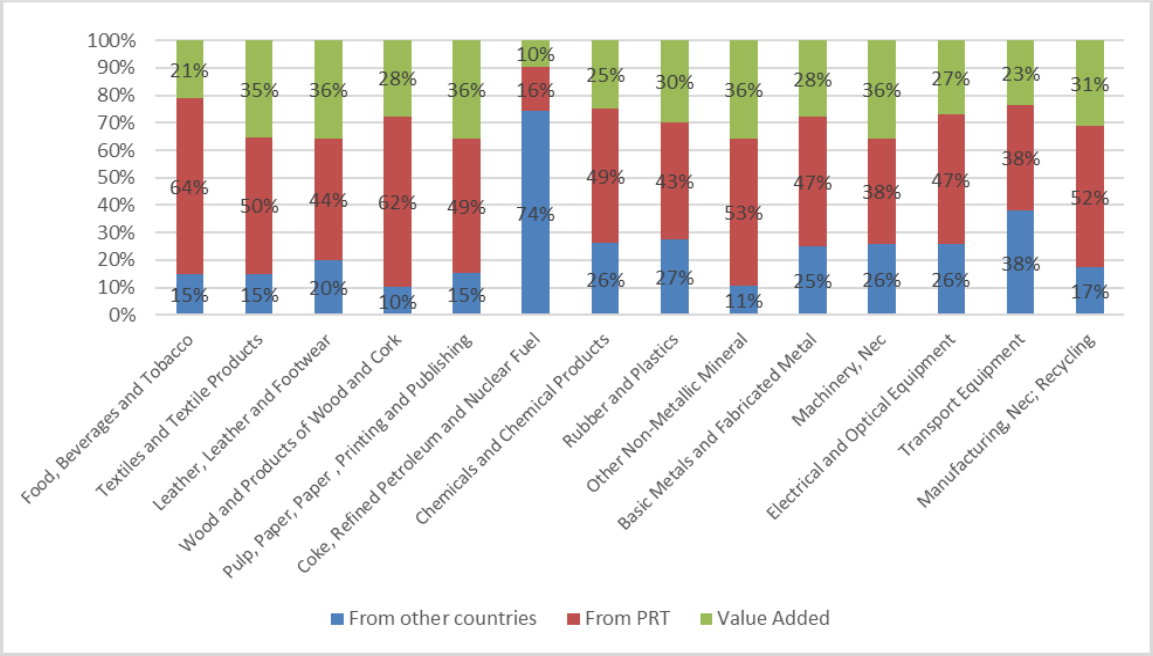

Figure 6. Distributions of domestic intermediate consumption, foreign origin intermediate consumption and Portuguese value added in final output

Source: Author's calculations on the WIOD basis

On Figure 7 it is possible to see the cut of Portuguese economy regarding the composition of final output. In the whole Portuguese economy value added occupies 49%, intermediate consumption of domestic origin is responsible for 40% and of foreign origin for 11%.

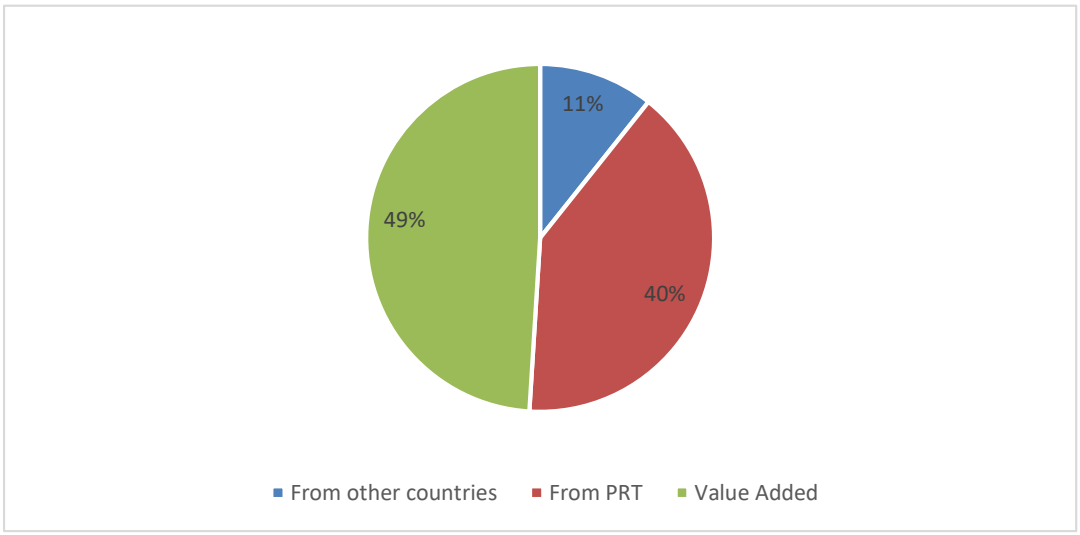

Figure 7. Share of Value Added, Domestic and Foreign Intermediate consumption in the Portuguese Manufacturing Industry

Source: Author's calculations on the WIOD basis

Generally, we can observe (Figure 8), that in Portuguese manufacturing sector the value added is less than in the whole Portuguese economy (average within the manufacturing sector of 29% versus 49% in the economy). On the other hand, the intermediate consumption of domestic origin is similar (average within the manufacturing sector of 47% versus 40% in the economy), while the descrepancy in intemediate consumption of foreign origin is bigger (average within the manufacturing sector of 25% versus 11% in the economy).

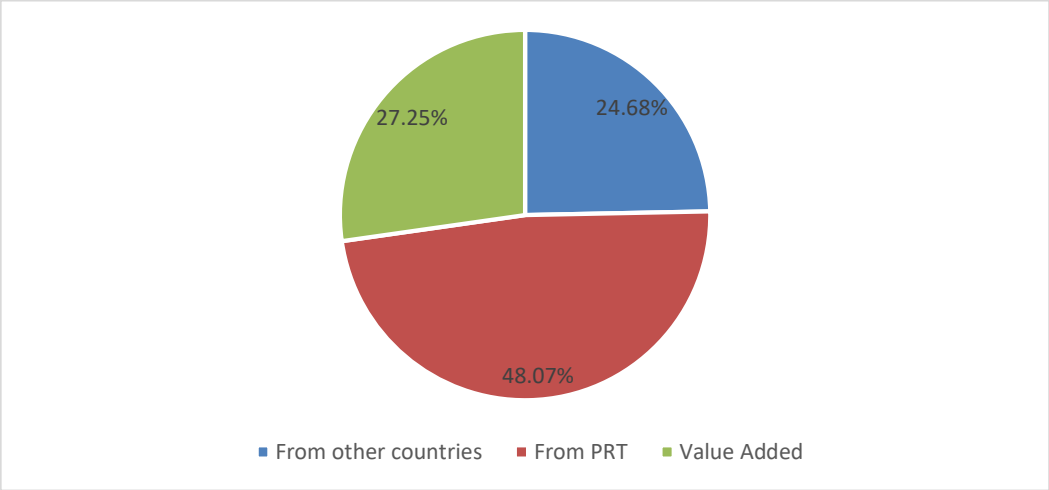

Figure 8. Share of Value Added, Domestic and Foreign Intermediate consumption in the Portuguese Manufacturing Industry

Source: Author's calculations on the WIOD basis

In this way, we can see that Portuguese manufacturing sector has bigger presence of inputs of foreign origin and smaller value added, comparing to the whole Portuguese economy, especially, comparing to services, where we can observe really elevated share of value added (i.e., 80% in *Real Estate Activies* and 87% in *Education* sectors) and small percentage of foreign inputs (2% and 1% in *Real Estate Activies* and *Education* sectors, respectively).

Next step in the current analysis is to compute the technical coefficients matrix, in order to capture the direct effect of changes in final output. The matrix of technical coefficients shows the proportion of inputs that have to be used by each sector for producing one unit of outputs. This tool allows to see how much it is needed in dollars purchased units of one industry (country) to produce one unit of output of another industry (country). Due to a big dimension of the technical coefficients matrix, its full version is available by request to the author of this dissertation.

In order to obtain technical coefficients, each cell of the table (input from country/industry) was divided by total output of a respective industry and country. In this way each cell of this matrix of technical coefficients corresponds to the amount of input *i* per unit of output *j*, for example, if the value of transaction from the Portuguese textile sector to Spain ($324 millions) is divided by the total Spanish output $2.905.034 millions, we obtain the technical coefficient of 0,000111409, which means that 1 dollar of output of Spain requires 0,000111409 dollars from the Portuguese textile sector.

Using the technical coefficients matrix, it is possible to see the share of intermediate products that go from Portugal and take part in the final output of other countries. Portuguese intermediate products are shown to represent a small percentage in the final outputs of other countries, the majority of transactions occurring within Portugal. Looking at the Matrix of technical coefficients, it is also possible to distinguish the share of intermediate products from other countries that are consumed in the production of Portugal's output. The sector where foreign countries are most felt is understandably *Coke, Refined Petroleum and Nuclear Fuel* (55% of the imported intermediate products in the Portuguese sector) where Portugal imports significantly from *RoW*-category countries. As shown previously, Spain presents itself as Portugal's foremost trading partner, its intermediate products forming a very sizable portion of Portuguese intermediate consumption.

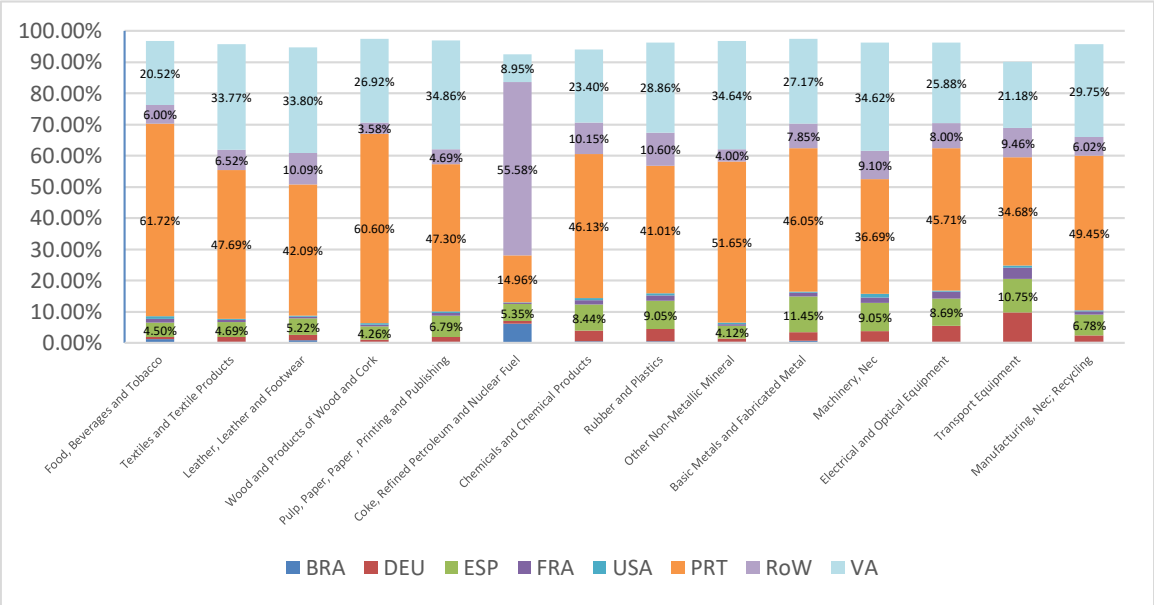

Figure 9. Share of Intermediate Consumption (by origin) and Value Added in Portugal, by sectors

Source: Author's calculations on the WIOD basis

Basically, before proceeding with IO analysis, it is possible to say that Portuguese main trading partners in gross values are Spain, Germany, France, the USA and Brazil, exporting more to such sectors as *Pulp, Paper, Printing and Publishing; Basic Metals and Fabricated Metal, Electrical and Optical Equipment (*where Portugal has a highest share of value added*),* and importing more in the sector *of Coke, Refined Petroleum and Nuclear Fuel,* with smallest share of value added among Portuguese manufacturing sectors.

The next step in the analysis of the Portuguese manufacturing industry is to measure the impact of changes in the final demand of Portugal's manufacturing industry on the national economy and the whole global value chains participating in the production of the products in terms of value added and employment.

5.3. Multipliers within WIOD: calculation and interpretation

The application of input-output analyses requires the calculation of the respective multipliers, which are presented below, each estimating a sector ability to generate output, value added and employment.

The level of work related to this step is affected by the dimension of the source WIOD tables. The data from the WIOT used in this dissertation is presented in a grid 1435 by 1435, 2059225 cells in total, with a corresponding density of required calculations and manipulation with the data.

After dividing each cell representing the input of each sector of each country by the corresponding total output of this industry and country, a matrix of technical coefficients (matrix A) was obtained, which was subsequently subtracted from the diagonal matrix of the same dimension (1435 x 1435), following the input-output methodology (see Chapter 4). The resulting matrix was then inverted using excel's function MINVERSE: In this way, the inverse matrix is obtained for the given year.

As it was mentioned in Chapter 4.1., the inverse matrix, also referred as Leontief Matrix (L), shows which industry and country will be more affected if final demand of a certain industry of a certain country increases one unit. The inverse matrix shows how a change in final demand of one sector creates a chain reaction of interactions throughout other sectors by direct and indirect effects. So, not only primary, but also secondary effects are considered.

A given cell in this matrix reflects the change in gross output of sector ***i*** directly and indirectly required to satisfy one unit change in final demand for the production of sector ***j***. In other words, the numbers in each column indicate the production needed directly or indirectly at each row industry when final demand for column industry increases one unit.

Whenever using a multi-national input-output table, such as WIOD, the elements of the Leontief inverse are coefficients that indicate the amount of output from each source country and sector needed to satisfy a unit change in the exogenous final demand on the output of the industry. In this way, for instance, if the final demand of Portuguese *Coke and Refined Petroleum and Nuclear Fuel* sector increases $1, the estimated increased input from *Mining*

and Quarrying from *Rest of the World* would increase respectively \$0,668319*f and from *Mining and Quarrying* of Brazil \$0,07148*f. Using the same logic, it is possible to say that if Portuguese *Basic Metals and Fabricated Metal* final demand increases by \$1, it is necessary \$0,165085 of Spanish and \$0,0443427 of German inputs from *Basic Metals and Fabricated Metal* sectors, 0,03786 of RoW's *Mining and Quarrying*, 0,03558 of Italian *Basic Metals and Fabricated Metal* etc. In the same way, we can consider the *Transport Equipment* sector, where an increase of1\$ of this sector's final demand, produces an impact on German *Transport Equipment* sector of \$0,10753, of Spanish *Transport Equipment* sector \$0,06573 and from Spanish *Basic Metals and Fabricated Metals* it would be \$0,05856. Due to a big dimension of the inverse matrix, only its part regarding Portuguese economy is provided in *Appendix 1*, the whole version is available by request to the author of the current dissertation.

Thus, a given column sum, corresponding to sector *j* in a given country, estimates the total impact (direct and indirect requirements felt in all countries and all sectors) resulting from a unitary increase in final demand for products of sector *j*, and in this way output multipliers, described below, for a certain industry of a certain country are obtained.

Output multipliers. As it was described in Chapter 4.1., the total value of production necessary for satisfaction of additional 1\$ of final demand for output of sector *j* is represented by an output multiplier for a sector *j*, which allows to measure the direct and indirect input requirements from all sectors needed to supply 1\$ worth of output of sector *j*. Analyzing the Leontief inverse matrix computed on the basis of WIOD available for 2011, we can see which are the sectors with the largest worldwide impact produced by a unitary final demand increase. Focusing attention on Portuguese case, we can see which of the Portuguese sectors have the highest impact on the world economy, in terms of direct and indirect requirements from all the remaining countries and sectors. The results obtained for Portugal from WIOD are presented in *Appendix 2* in decreasing order.

Analyzing the table in *Appendix 2*, we can see that, for example, for each additional \$1 of output generated by Portuguese *Electrical and Optical Equipment*, \$2,741085 worth of direct and indirect input will be generated.

Output multipliers allow to see help how much each sector buys from others for production of a unit of its output, and in this way, it is possible to analyze the backward linkages between sectors and countries.

It is interesting to note that Portuguese manufacturing sector, in general, has stronger backward linkages within the economy comparing to other sectors as agriculture, services etc. In corresponding table in *Appendix 2*, it is possible to see, that the biggest values for output multipliers belong to manufacturing industries. *Electrical and Optical Equipment*; *Transport Equipment*; *Basic Metals and Fabricated Metal; Coke, Refined Petroleum and Nuclear Fuel* industries have respectively the multipliers of 2,741085; 2,734862; 2,731255; 2,676033. The average of manufacturing sector is 2,557271, while in the whole Portuguese economy it corresponds to 2,170423.

Value Added Multipliers. Value added multipliers show how the increase in output of a certain industry (stimulated by an increase in final demand) influences the increase in value added of this industry. Following the assumption that value added depends on final output, value added-output ratios are obtained and can be used to compute value added multipliers.

Value added multipliers resulting from formula (17), express total value added generated by the effect of an additional dollar of final demand for the output of sector $\boldsymbol{j}$.

The value added multipliers for the Portuguese manufacturing sector are presented in *Appendix 3*. They reflect the impact over value added of the whole worldwide economy produced by 1 dollar increase in final demand of that sector. Obtained values represent the following picture: *Pulp, Paper, Printing and Publishing* (0,89737); *Machinery, Nec* (0,89252); *Textiles and Textile Products* (0,88703) and *Wood and Products of Wood and Cork* (0,88648) have the highest ranked value added multipliers, among others. At the same time, *Coke, Refined Petroleum and Nuclear Fuel* with the multiplier of 0,39901 has the smallest multiplier not only among manufacturing sectors, but also among the whole Portuguese economy.

Employment multipliers. Employment multipliers reflect physical effect of changes in final demand on quantity of jobs created. In order to calculate this effect, it is necessary to assume that number of employees is related to the amount of generated output.

As it was mentioned in Chapter 5.1., the WIOD project provides socio-economic data and there are two indicators that can be considered for the current calculations –Number of persons engaged (EMP), a more embracing notion of jobs (including for instance self-employed, individual entrepreneurs) and number of employees (EMPE), expressed in thousands. Due to the fact that the EMPE doesn't have data for 2011 in WIOD, for this study the category EMP was considered. Following the assumption that employment level depends on final output, it is possible to obtain employment-output ratio that represents the average number of jobs per thousand of euros of final output of a given sector. These coefficients are obtained by dividing the number of persons engaged in a certain industry by the level of production (output at basic prices) generated by that industry.

The values in row, e-coefficients, show direct effects of the increase in production of output of one thousand worth on the number of jobs created. And then making calculation indicated in formula (21), the employment multipliers are obtained.

A given cell in the resulting row (representing a given pair Country / Sector), expresses the worldwide effect on employment (as the sum of the effects felt in all sectors of all countries), produced by an increase of 1000$ in final demand of that sector in that country. This is influenced not only by the international and inter-industry existing linkages, but also by the labor intensity of the sector in analysis. Looking at results depicting the Portuguese sectors (*Appendix 4*) we can see that the largest employment multiplier belongs to *Agriculture, Hunting, Forestry and Fishing* sector. However, the manufacturing industry has quite a good positions among others. The manufacturing sectors with the largest value for employment multiplier are *Textiles and Textile Products* (33,37664); *Food, Beverages and Tobacco* (31,75462); *Wood and Products of Wood and Cork* (31,21764) and *Leather, Leather and Footwear* (27,57685).

The calculations provided in this chapter reflect the effect of a possible change in final demand of a certain sector on the world economy within all the sectors. However, using this approach, it is difficult to observe, to what extent, this change will influence each sector in each country, both in terms of value added and jobs created. In order to obtain this data, the approach provided in Chapter 4.2. will be used and presented in the next chapter.

5.4. GVC jobs and GVC income in Portuguese manufacturing industry

In this chapter, the concepts of *GVC jobs* and *GVC income* are used. As was previously mentioned, these two indicators were introduced by Timmer et al. (2013) as a new measure of competitiveness.

The concept of GVC income encompasses all the income received by the production forces of one country during the process related, both directly and indirectly, to the creation of products in their final, usable, shape. GVC jobs encapsules those individuals, or rather, jobs related, again both directly and indirectly, to the creation of products in their last stage of production.

Using the WIOD and methodology proposed by Timmer et al. (2013) and explained in detail in Chapter 4.2 of the current dissertation as the framework of this study, the analysis of the GVC income and GVC jobs applied to the Portuguese manufacturing industry is thus demonstrated below.

As the value of the final output that comes from Portugal's manufacturing industry includes the value added in the last stage of production, which takes place in Portugal, but also the value added created by all other sectors in the chain that take place anywhere in the world, it is necessary to make a decomposition of the output of Portugal's manufacturing industry in order to obtain the corresponding *GVC income*.

Figure 10 shows the distribution of the value added of Portugal's manufacturing industry by origin. The main part of value is added within the Portuguese manufacturing industry (40,75%), however the share of non-manufacturing industries in Portugal is also quite significant (30,87%). The important part in the creation of value added is occupied by the European Union (20,15%).

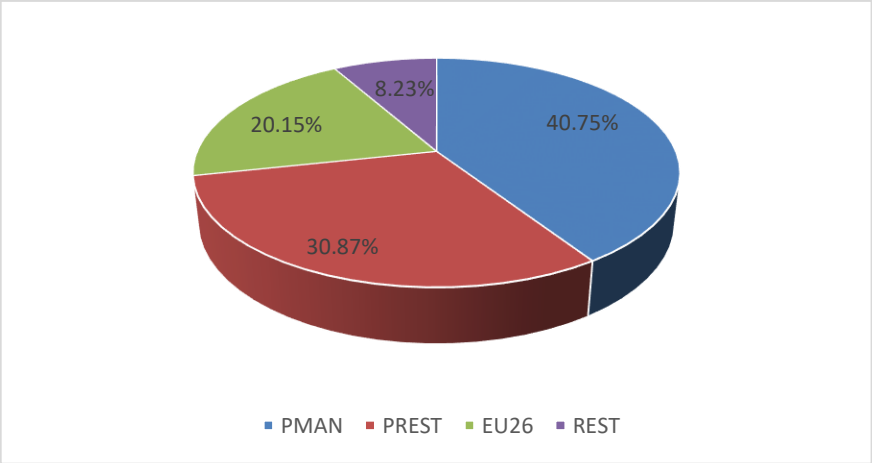

Figure 10. GVC income distribution for the Portuguese manufacturing industry

Source: Author's calculations on the WIOD basis

Figure 11 shows the distribution of GVC workers directly and indirectly related to Portuguese manufacturing sector. The repartition of GVC income and GVC jobs for the Portuguese manufacturing industry resemble each other. The shares of GVC jobs located in Portugal and attributed to the manufacturing and non-manufacturing industries are respectively 39,06% and 36,86%, which are not too dissimilar to those represented in Figure 1. A noticeable difference can be observed in GVC income share representative of the EU27 and that of GVC jobs share of the same origin, these are specifically 20,15% and 10,6%. This difference gains particular relevance when we observe how high-, medium- and low-skilled jobs are distributed, which will be demonstrated below.

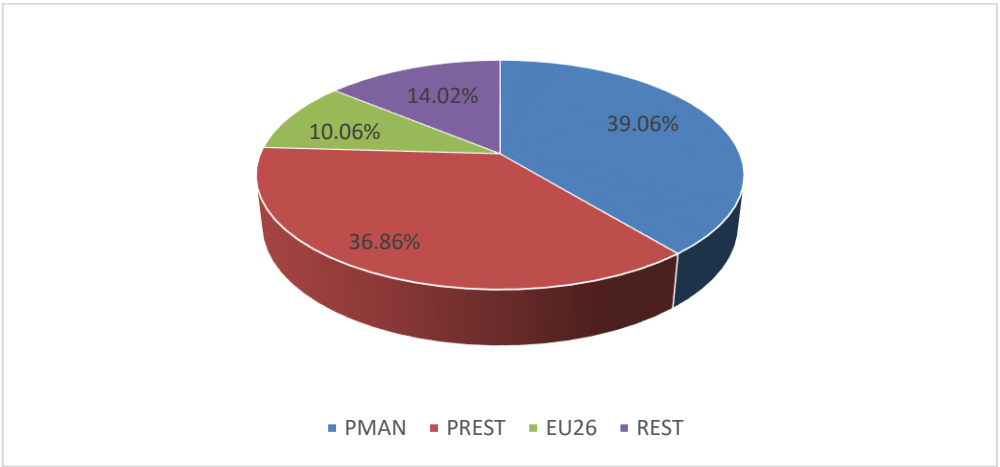

Figure 11. Distribution of GVC workers (in%)

Source: Author's calculations on the WIOD basis

On Figure 12 we can observe the distribution of workers directly and indirectly involved in the production of goods in the Portuguese manufacturing industry by skill-types and geographical regions. The greater part of low-skilled workers, directly and indirectly involved in production of the Portuguese manufacturing industry, belongs to the domestic manufacturing (46%) and non-manufacturing activities (36%).

In regards the labour distribution by skill level it is readily apparent that high-, medium- and low- skilled workers show a distinguishable pattern of attribution by skill. Low-skilled labour seems to be disproportionally concentrated in Portugal (45,41% of manufacturing sector and 39,10% of non-manufacturing sector), and at the same time the EU27 share of labour of this category doesn't go above 5%. Regarding the medium-skilled workers, the share of those coming from Portugal is less than that of low-skilled workers (26% and 25%) while it is observed the significant increase in the share with its origin outside of the EU27. Speaking of high-skilled workers, more than a half are still situated in Portugal, the remaining shares coming from those in the EU26 and outside the EU.

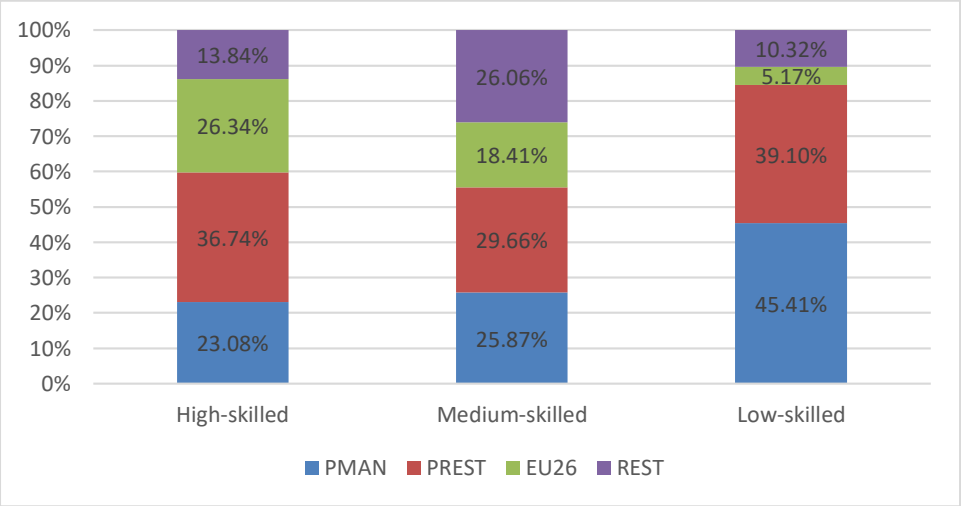

Figure 12. GVC labour distribution by skill level

Source: Author's calculations on the WIOD basis

As it can be observed, the distribution of GVC income and GVC jobs for the Portuguese manufacturing industry shares a similar outlook. However, upon closer inspection of GVC labour distribution by skill levels there seems to exist a general progression in which low-skilled jobs requirements are met by local resources, while the need for higher skilled jobs require a greater "off-shoring" of work.

5.5. Illustrative example: GVC income and GVC jobs in Portuguese Textile Sector

Using the framework developed by Timmer at al. (2013), it is possible to decompose the output of Portugal's sector of *Textiles and Textile Products* sector. In order to track the whole chain of the production directly or indirectly involved in this industry, the technique provided above is used.

The degree of detail involved in the WIOD allows for a more disaggregated analysis, rather than looking at the whole effect of a given final demand increase. In fact, what is most interesting in this database is precisely the chance to track how such increase in a given sector produces an impact throughout the GVC – the series of courtiers / sectors involved in some stage of that final product's production.

As an example, if we assume a broad increase of 10% in the final demand in Portugal's textile sector for any given reason, it is possible to estimate the effect of this change in respect to the changes in value added and jobs generated, in quantity and origin.

The vector of final demand f is represented with zeros in all cells, except for final demand of Portuguese textile sector, which cell is represented by Δf, i.e. 10% or \$1.010 millions.

Using the formula for the impact on value added:

$$\mathbf{v} = \hat{\mathbf{p}}(\mathbf{I} - \mathbf{A})^{-1}\Delta\mathbf{f} \qquad (24)$$

we obtain the vector with the whole impact of this increase on the world economy in terms of value added.

In Table 3, the impact of the indicated increase in the Portuguese textile sector is represented. The major amount of GVC income would be generated within the Portuguese textile sector (\$ 426 millions) and in Portuguese non-manufacturing industries (\$ 258 millions). The shares in all GVC income provided by the 10% increase in Portuguese textile industry remain the same as for the whole textile industry discussed above.

Table 3. GVC income received from 10% increase in Portuguese textile sector

Origin	GVC income ($millions)	GVC income (%)
PTEXT	426	47,56%
PMAN	21	2,36%
PREST	258	28,79%
EU26	133	14,88%
REST	57	6,40%
Total	**896**	**100%**

Figure 13 presents the distribution of the value added of Portugal's textiles industry. As it can be observed, the main part of value is added within the Portuguese textile sector (47,56%), however the Portuguese non-manufacturing industries are also significantly important in this distribution, being responsible for 28,79% of GVC income for the Portuguese textile sector. At the same time, the participation in GVC income of other Portuguese manufacturing industries for Portugal's Textile sector is quite small, being at the level of 2,36%.

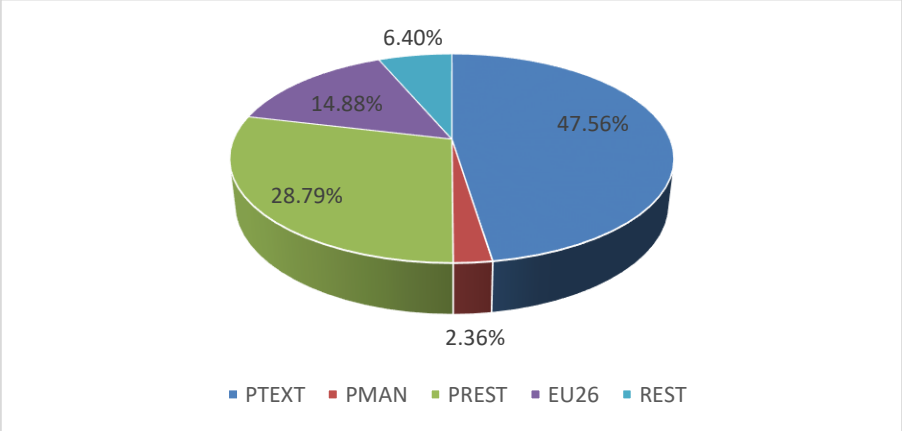

Figure 13. GVC income distribution for the Portuguese sector of Textile and Textiles products

Source: Author's calculations on the WIOD basis

The distribution of GVC workers directly and indirectly involved into production of Portuguese textile sector is presented on Figure 14. The majority of *GVC workers* for the Portuguese textile industry belong to this industry (58,31%). At the same time, we can observe the significant share occupied by the Portuguese non-manufacturing sector (18,62%) and other non-European countries (15,98%).

Using the formula indicated above, but with employment coefficient on the diagonal:

$$\mathbf{e} = \widehat{\boldsymbol{p}_e}(\mathbf{I} - \mathbf{A})^{-1}\Delta\mathbf{f} \qquad (25)$$

we obtain the vector with the whole impact of the given increase on the world economy in terms of jobs generated. Moreover, if we put instead of $\widehat{\boldsymbol{p}_e}$ the coefficients regarding each level of educational attainment, we will obtain the impact on jobs generated by skill levels.

Table 4. GVC jobs generated by 10% increase in Portuguese textile sector

Origin	GVC jobs	GVC jobs, %
PTEXT	19,7	58,31%
PMAN	0,5	1,35%
PREST	6,3	18,62%
EU26	1,9	5,73%
REST	5,4	15,98%
Total	**33,7**	**100%**

As it is observed from Table 4, a 10% increase in the Portuguese textile sector would generate 33,7 jobs, where 19,7 are generated in Portuguese textile sector, followed by Portuguese non-manufacturing sectors with 6,3 jobs and non-European countries with 5,4 jobs.

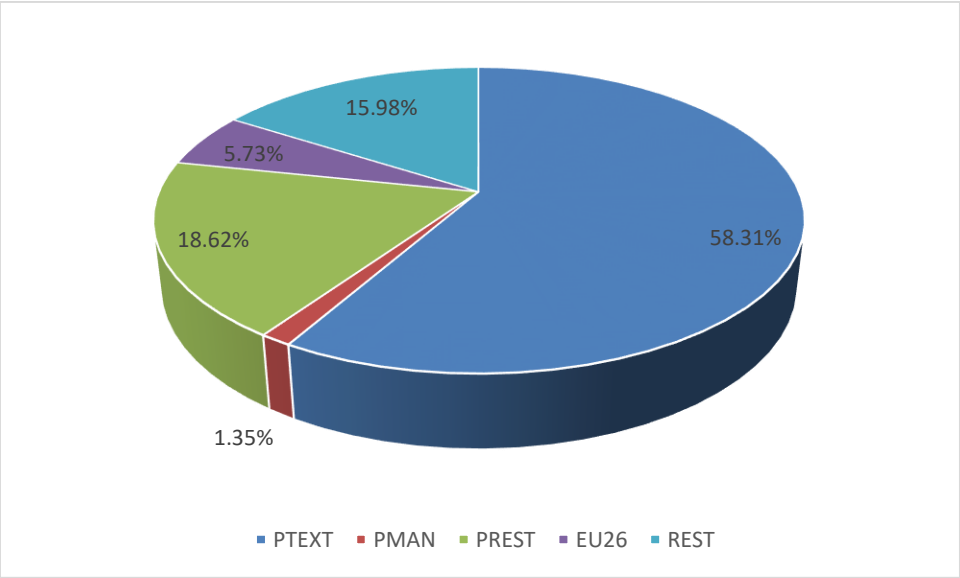

Figure 14. Distribution of GVC workers for the Portuguese Textile sector (in %)

Source: Author's calculations on the WIOD basis

Comparing this figure with the previous one, we can observe that for less value added in textile sector (47,56%) more GVC workers (58,31%) in Portuguese textile sector are involved, which is then compensated by the increased shares of the Portuguese non-manufacturing sectors, where 18,62% of GVC workers are corresponding to 28,79% of GVC income. Moreover, the difference in the shares of GVC income and GVC jobs for Portuguese textile sector that come from non-European Union countries, being respectively of 6,40% and 15,98%, which can be assumed as existing offshoring of jobs to the countries outside the EU.

Table 5. GVC jobs by levels generated by 10% increase in Portuguese textile sector

	High-skilled		**Medium-skilled**		**Low-skilled**	
	nº	**%**	**nº**	**%**	**nº**	**%**
PTEXT	1,14	5,79%	2,77	14,11%	15,75	80,10%
PMAN	0,03	5,79%	0,06	14,11%	0,37	80,10%
PREST	0,82	13,00%	1,48	23,58%	3,98	63,43%
EU26	0,49	25,36%	0,77	39,94%	0,67	34,70%
REST	0,35	6,45%	1,80	33,41%	3,24	60,13%

Source: Author's calculations on the WIOD basis

On Table 5 the labour distribution by skill level generated by a 10% increase in the Portuguese Textile sector is presented. The majority of low-, medium and high-skilled jobs would be created roughly in alignment with the pre-existing shares of jobs by origin and by skill-level. In other words, an increase in the demand for the Portuguese textile sector would make available primarily low-skilled jobs in Portugal, and a proportionally larger share of higher-skilled jobs abroad.

Regarding the labour distribution by skill level for the Portuguese Textile sector shown on Figure 15, it is noticeable the share predominantly of low-skilled workers in Portugal, both in the textile sector and the whole manufacturing industry. A dissimilar dispersal of jobs can be observed in the Portuguese non-manufacturing industries where the share of low-skilled GVC workers is lower and the shares of high- and medium-skilled GVC workers are higher, when compared to the Portuguese manufacturing industry. At the same time, analyzing the

distribution of GVC workers generated by the Portuguese textile sector with their origin in the EU26, it can be observed that the share of low-skilled workers is not so big (35,38%), and the shares of medium- and high-skilled GVC workers are significantly larger compared to the Portuguese manufacturing and non-manufacturing industries.

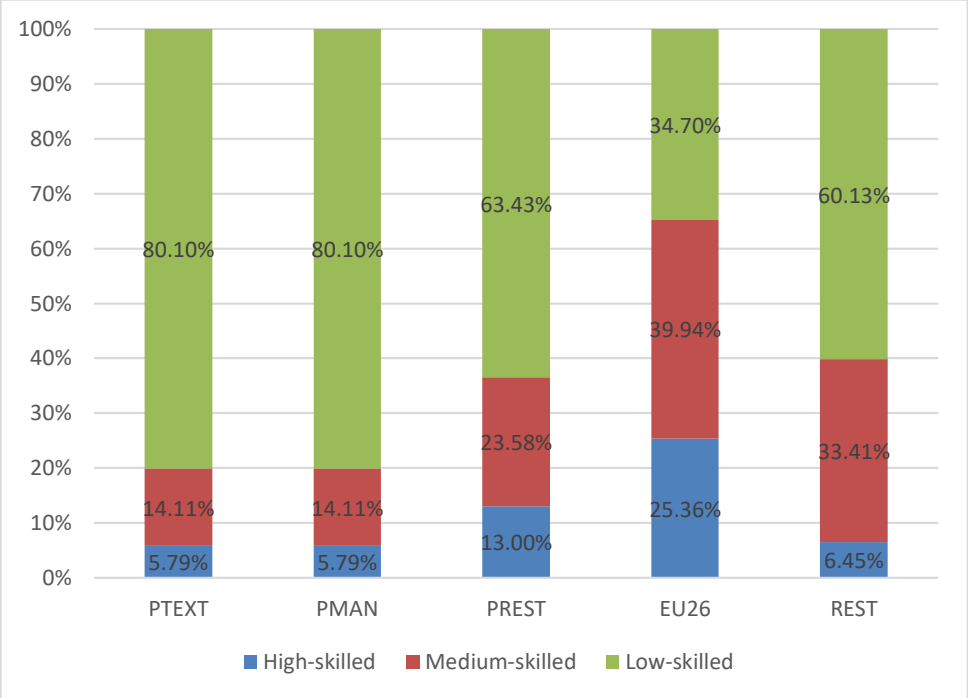

Figure 15. Distribution of GVC workers for Portuguese Textile Sector (in %)

Source: Author's calculations on the WIOD basis

Summing up, it is possible to note that even still having the same general similar outlook, the shares of GVC income and GVC jobs for the Portuguese textile sector have differences – in the Portuguese textile sector a smaller share of GVC income corresponds to a bigger share of workers directly and indirectly involved in this production; and a quite significant difference can be observed in the shares of GVC income and GVC jobs for Portuguese textile sector that come from non-European Union countries. Regarding the labour distribution by skill-levels, from all generated jobs by the Portuguese textile sector within Portugal the absolute and relative majority are characterized as low-skilled jobs, while in the EU the jobs generated by this sector are more equally distributed by levels with a noticeable increased importance of medium- and high-skilled GVC jobs.

It worth noting that the framework used in this chapter is in accordance with the input-output multipliers approach. If we take into consideration this increase of $1010 million in Portuguese textile sector, we can obtain the total values multiplying the value of this increase by value added (0,887) and employment multipliers (0, 0337), we would then obtain the same values describing the impact of this increase, but not distributed by countries sectors.

5.6. Results Analysis

In this study, it was found that Portuguese manufacturing sector, in general, has stronger backward linkages within the world economy comparing to other Portuguese sectors as agriculture, services etc, which is seen in the analysis of output multipliers that give general view of this kind of linkages - the average in output multipliers is 2,557271, while in the whole Portuguese economy it corresponds to 2,170423. Based on output multiplies, it is possible to see that Portuguese manufacturing sectors that produce a higher direct and indirect impact on others, for production of a unit of its output are *Electrical and Optical Equipment*; *Transport Equipment*; *Basic Metals and Fabricated Metal;Coke, Refined Petroleum and Nuclear Fuel* that have respectively the multipliers of 2,741085; 2,734862; 2,731255; 2,676033.

How the increase in output of a certain industry stimulated by an increase in final demand influences the increase in value added of this industry can be analyzed by value added multipliers. Obtained results show that *Pulp, Paper, Printing and Publishing* (0,89737); *Machinery, Nec* (0,89252); *Textiles and Textile Products* (0,88703) and *Wood and Products of Wood and Cork* (0,88648) have the highest ranked value added multipliers, among others and thus these reflect the impact on value added over the whole worldwide economy produced by an additional unit of final demand of these sector. Using the decomposition technique it was found that the main part of value is added within the Portuguese manufacturing industry (40,75%), however the share of non-manufacturing industries in Portugal is also quite significant (30,87%). An important part in the creation of value added is occupied by the European Union (20,15%).

In order to evaluate the physical effect of changes in final demand on quantity of jobs created, the employment multipliers are used. The Portuguese manufacturing industry has quite high employment multipliers with the largest values in the sectors such as *Textiles and Textile Products* (33,37664); *Food, Beverages and Tobacco* (31,75462); *Wood and Products of Wood and Cork* (31,21764) and *Leather, Leather and Footwear* (27,57685), which means that changes in final demand would influence these industries in the first place. However, this kind of multipliers reflects the impact on employment over the whole worldwide economy produced by an additional unit of final demand of these sector. In order to decompose this impact another technique was used. Thus, it was found that workers directly

and indirectly related to Portuguese manufacturing sector the shares of GVC jobs located in Portugal and attributed to the manufacturing and non-manufacturing industries are respectively 39,06% and 36,86, while the main part of these workers are low-skilled.

Regarding the analyzed Portuguese textile sector, it was found that, proportionally, less value added was created in the Portuguese textile sector (47,56%) by its workers (58,31%) than from workers belonging to the Portuguese non-manufacturing sectors, where 18,62% of workers are corresponding to 28,79% of GVC income. The distribution of the workers' skill-levels hints that higher qualified individuals produce, comparatively, more value added.

6. Conclusions and discussions

The current dissertation is an initial step in the analysis of the competitiveness of Portugal's manufacturing industry in terms of its value added to production and impact to employment, instead of the more traditional gross flows approach. Using the input-output approach and the new framework proposed by Timmer et al. (2013), not only were some input-output multipliers calculated, but also GVC income and GVC jobs indicators. These have been sought in order to provide some insights into the fragmentation and competitiveness of Portuguese manufacturing industry in GVC. As an example of the kind of questions that can be answered, it brought to light sectors which, while impressive in their capability to export, created little value added to the Portuguese economy on the grounds that the greater part of these flows corresponded to intermediate consumption.

With this dissertation an analysis of Portugal's manufacturing industry in general, and the Portugal's textile sector in particular, was provided following the input-output approach and GVC income and GVC jobs framework.

It was possible to conclude that the changes in final demand of such sectors as *Pulp, Paper, Printing and Publishing; Machinery, Nec and Textiles and Textile Products* would have a larger impact on generated value added than other manufacturing sectors. At the same time sectors such as *Food, Beverages and Tobacco; Wood and Products of Wood and Cork* and *Textiles and Textile Products* would have a bigger impact on jobs created, especially for low-skilled workers. At the same time, analyzing the GVC jobs indicator decomposed by skill-level it was found that low skilled jobs are the most subjected to the influence of changes in final demand in the Portuguese manufacturing industry.

Implications for the current state of knowledge of the topic. This dissertation is an attempt to provide an analysis of Portuguese participation in GVC using the World Input-Output Database. Specifically, this dissertation is the first attempt to estimate such indicators as GVC income and GVC jobs for the Portuguese manufacturing industry. Moreover, the impact of possible increase in the Portuguese textile sector was estimated, as an example of what can be done with the framework used in this dissertation.

Implications for policymakers. Since it was recognized that the traditional measures of economic development are not reflective and can hardly be used in the evaluation of a

country's competitiveness, studies using global value chains approach, have been gaining more attention. That is why the results obtained using the indicated input-output framework provide a powerful tool for policymakers in strategic planning for the development of a nation's economy. Thus, comparing output, value added, income and employment multipliers, as well as taking into consideration GVC income and GVC jobs indicators, a government or supranational organizations could define which industry would be most impacted, in terms of value added and employment, per additional unit of output generated through the economy, thus providing insights as to where public investment, reforms, liberalizations or other measures should be applied. Moreover, using the proposed methodology for decomposition, it is possible to estimate the distribution of this impact throughout countries and sectors.

Implications for future research. The current dissertation is intended as an initial step for future research of Portugal's competitiveness and subsequent evolution according the global value chains framework. As the suggestion for further developments within this topic, the revealed competitive advantage in terms of value added for Portugal's manufacturing industry could be calculated and the existence of correlation between the revealed competitive advantage in gross and value added terms could be evaluated. Moreover, the evaluation of GVC income and jobs indicators throughout the years could also be studied. Besides, the provided methodology can be applied to Portuguese economy in general, or to other industries in particular. The estimation of GVC indicators not only for manufacturing sector, but also for final services would also be a question of interest in the future.

As to the ***limitations*** of the current study, the lack of socio-economic data for 2011 was preeminent, being resolved by using the data for 2009. Another limitation was the predefined industry categories as established by the WIOD, not reflecting within these groupings possibly important information in regards the details of each subsector. The lack of standardized information available from a significant number of countries also poses some challenges; in WIOD the solution was to create an aggregate category named "Rest of the World" countries. Lastly, the field of research around GVC indicators is still relatively recent when compared to more traditional forms of competitiveness analysis which results in some difficulties in research, but, on the other hand, provides room for future investigations.

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Appendices

Appendix 1. Some of Leontief Inverse indicators for Portuguese economy

		Food, Beverages and Tobacco	Textiles and Textile Products	Leather, Leather and Footwear	Wood and Products of Wood and Cork	Pulp, Paper, Paper , Printing and Publishing	Coke, Refined Petroleum and Nuclear Fuel	Chemicals and Chemical Products	Rubber and Plastics	Other Non-Metallic Mineral	Basic Metals and Fabricated Metal	Machinery, Nec	Electrical and Optical Equipment	Transport Equipment	Manufacturing, Nec; Recycling
		PRT	PRT	PRT	PRT	PRT	PRT	PRT	PRT	PRT	PRT	PRT	PRT	PRT	PRT
Mining and Quarrying	BRA	0,0020563	0,0013206	0,0012757	0,0016931	0,0015937	0,0714827	0,0040744	0,0023536	0,0030797	0,0034946	0,0020613	0,0017905	0,0017244	0,0021268
Electrical and Optical Equipment	CHN	0,0020356	0,0024213	0,0021826	0,0018021	0,0021106	0,0035216	0,0031909	0,0040518	0,0025787	0,0044084	0,0094489	0,0334118	0,0145376	0,0028539
Chemicals and Chemical Products	DEU	0,0041266	0,0079428	0,0073614	0,0062014	0,0088680	0,0124897	0,0391851	0,0361562	0,0062681	0,0059763	0,0038523	0,0058252	0,0048997	0,0076173
Rubber and Plastics	DEU	0,0025807	0,0018832	0,0042936	0,0015523	0,0019489	0,0007021	0,0024100	0,0059546	0,0015526	0,0024408	0,0032489	0,0069729	0,0058922	0,0047459
Other Non-Metallic Mineral	DEU	0,0004108	0,0002804	0,0002568	0,0003109	0,0002629	0,0002174	0,0005008	0,0005462	0,0013134	0,0006517	0,0006052	0,0008160	0,0011704	0,0005202
Basic Metals and Fabricated Metal	DEU	0,0040846	0,0029172	0,0040312	0,0037870	0,0032963	0,0025505	0,0052962	0,0095871	0,0060571	0,0443427	0,0257423	0,0212725	0,0292388	0,0125307
Machinery, Nec	DEU	0,0016468	0,0013624	0,0013148	0,0015402	0,0015347	0,0015818	0,0022730	0,0054500	0,0047854	0,0039951	0,0229319	0,0044473	0,0097855	0,0024230
Electrical and Optical Equipment	DEU	0,0016471	0,0015915	0,0016321	0,0014131	0,0017931	0,0015234	0,0024338	0,0033745	0,0022957	0,0038124	0,0101844	0,0571342	0,0171057	0,0022056
Transport Equipment	DEU	0,0012334	0,0014468	0,0013783	0,0010711	0,0011429	0,0012700	0,0017098	0,0041875	0,0011470	0,0028591	0,0034233	0,0030133	0,1075281	0,0030231
Textiles and Textile Products	ESP	0,0003891	0,0398252	0,0055428	0,0004549	0,0003877	0,0000883	0,0006576	0,0016315	0,0004472	0,0005612	0,0002793	0,0010659	0,0012109	0,0079703
Leather, Leather and Footwear	ESP	0,0000259	0,0002086	0,0316889	0,0000336	0,0000734	0,0000098	0,0000232	0,0001181	0,0000163	0,0000554	0,0000252	0,0000873	0,0000596	0,0011057
Wood and Products of Wood and Cork	ESP	0,0012625	0,0006844	0,0008781	0,0384718	0,0039266	0,0004063	0,0007250	0,0011636	0,0018015	0,0028614	0,0014167	0,0014924	0,0016078	0,0168377
Pulp, Paper, Paper , Printing and Publishing	ESP	0,0087539	0,0030098	0,0053509	0,0043656	0,0546369	0,0011379	0,0051375	0,0050198	0,0051472	0,0041338	0,0031606	0,0039204	0,0028912	0,0052424
Chemicals and Chemical Products	ESP	0,0077148	0,0153215	0,0137553	0,0125872	0,0180992	0,0248607	0,0803837	0,0738244	0,0127048	0,0122406	0,0075851	0,0107447	0,0081716	0,0149663
Basic Metals and Fabricated Metal	ESP	0,0109992	0,0061174	0,0089435	0,0102317	0,0087449	0,0033900	0,0097854	0,0231856	0,0178776	0,1650854	0,0814458	0,0636390	0,0585620	0,0420725
Machinery, Nec	ESP	0,0022442	0,0016704	0,0015147	0,0024807	0,0023282	0,0012881	0,0027924	0,0076626	0,0075519	0,0060365	0,0362415	0,0051160	0,0076641	0,0033595
Electrical and Optical Equipment	ESP	0,0014772	0,0012953	0,0012409	0,0012624	0,0015746	0,0005983	0,0016722	0,0026056	0,0020751	0,0033905	0,0103274	0,0560647	0,0158978	0,0018496
Transport Equipment	ESP	0,0006783	0,0006040	0,0005943	0,0005949	0,0006061	0,0004258	0,0007138	0,0020745	0,0005557	0,0018075	0,0015366	0,0009977	0,0657276	0,0016824
Leather, Leather and Footwear	ITA	0,0000635	0,0005421	0,0544302	0,0000732	0,0001549	0,0000314	0,0000768	0,0002617	0,0000527	0,0001700	0,0001212	0,0002163	0,0002407	0,0019959
Basic Metals and Fabricated Metal	ITA	0,0027053	0,0020368	0,0036909	0,0025818	0,0021396	0,0012854	0,0028894	0,0064300	0,0047438	0,0355806	0,0218213	0,0147226	0,0168672	0,0095685
Agriculture, Hunting, Forestry and Fishing	RoW	0,0321396	0,0026249	0,0043102	0,0111052	0,0034786	0,0027798	0,0019127	0,0026578	0,0008864	0,0010549	0,0008191	0,0010089	0,0009309	0,0030247
Mining and Quarrying	RoW	0,0262388	0,0212197	0,0196201	0,0256432	0,0246060	0,6688319	0,0645480	0,0409496	0,0454874	0,0378607	0,0252043	0,0240954	0,0234771	0,0296561

Note: The cells filled in green are those that have bigger values.

Source: Author's calculations on the WIOD basis

Appendix 2. Output multipliers for Portuguese Economy[2]

Industry	Multiplier
Electrical and Optical Equipment	2,741085
Transport Equipment	2,734862
Basic Metals and Fabricated Metal	2,731255
Coke, Refined Petroleum and Nuclear Fuel	2,676033
Wood and Products of Wood and Cork	2,654754
Food, Beverages and Tobacco	2,649417
Electricity, Gas and Water Supply	2,623624
Chemicals and Chemical Products	2,597650
Rubber and Plastics	2,564543
Manufacturing, Nec; Recycling	2,557265
Construction	2,522605
Air Transport	2,489994
Machinery, Nec	2,454096
Water Transport	2,428048
Other Non-Metallic Mineral	2,379861
Textiles and Textile Products	2,374811
Leather, Leather and Footwear	2,351640
Pulp, Paper, Printing and Publishing	2,334528
Agriculture, Hunting, Forestry and Fishing	2,126676
Other Community, Social and Personal Services	2,124753
Inland Transport	2,100223
Post and Telecommunications	2,019613
Hotels and Restaurants	2,004993
Renting of M&Eq and Other Business Activities	1,994300
Mining and Quarrying	1,954757
Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies	1,931496
Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	1,884529
Health and Social Work	1,817334
Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods	1,720528
Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel	1,695219
Financial Intermediation	1,553399
Public Admin and Defence; Compulsory Social Security	1,531804
Real Estate Activities	1,376469
Education	1,262647
Private Households with Employed Persons	1,000000

[2] Here and further in the Tables with the provided multipliers, light-blue filling indicates the manufacturing sectors.

Appendix 3. Value Added Multipliers

Private Households with Employed Persons	1
Education	0,977212355
Real Estate Activities	0,975524625
Financial Intermediation	0,958073103
Public Admin and Defence; Compulsory Social Security	0,947728097
Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods	0,942607323
Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel	0,936915214
Post and Telecommunications	0,921073413
Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies	0,919545479
Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	0,918848114
Hotels and Restaurants	0,912064618
Health and Social Work	0,911291293
Renting of M&Eq and Other Business Activities	0,910683429
Pulp, Paper , Printing and Publishing	0,897375161
Machinery, Nec	0,892522068
Other Community, Social and Personal Services	0,891611167
Agriculture, Hunting, Forestry and Fishing	0,887615277
Textiles and Textile Products	0,887035561
Wood and Products of Wood and Cork	0,886486908
Basic Metals and Fabricated Metal	0,885468173
Construction	0,881502241
Electrical and Optical Equipment	0,88135652
Other Non-Metallic Mineral	0,877960748
Manufacturing, Nec; Recycling	0,874438292
Leather, Leather and Footwear	0,867742253
Food, Beverages and Tobacco	0,864344357
Rubber and Plastics	0,862783844
Water Transport	0,85148649
Electricity, Gas and Water Supply	0,833096366
Mining and Quarrying	0,832037935
Air Transport	0,820771248
Chemicals and Chemical Products	0,820109667
Transport Equipment	0,815454963
Inland Transport	0,781003132
Coke, Refined Petroleum and Nuclear Fuel	0,399013744

Appendix 4. Employment multipliers

Agriculture, Hunting, Forestry and Fishing	66,56887
Private Households with Employed Persons	65,27655
Textiles and Textile Products	33,37664
Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods	32,24284
Food, Beverages and Tobacco	31,75462
Wood and Products of Wood and Cork	31,21764
Leather, Leather and Footwear	27,57685
Construction	26,73051
Manufacturing, Nec; Recycling	26,35238
Hotels and Restaurants	25,36256
Health and Social Work	25,07259
Education	23,1817
Renting of M&Eq and Other Business Activities	22,6344
Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	21,67932
Other Community, Social and Personal Services	21,66602
Basic Metals and Fabricated Metal	20,05575
Pulp, Paper, Paper , Printing and Publishing	18,94727
Public Admin and Defence; Compulsory Social Security	18,34196
Machinery, Nec	18,33603
Inland Transport	18,07228
Rubber and Plastics	17,65554
Other Non-Metallic Mineral	17,23747
Electrical and Optical Equipment	16,95182
Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel	16,83214
Transport Equipment	16,2138
Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies	14,60433
Chemicals and Chemical Products	14,47886
Mining and Quarrying	14,4201
Air Transport	14,00366
Water Transport	12,93532
Post and Telecommunications	10,31736
Financial Intermediation	10,00589
Electricity, Gas and Water Supply	7,976975
Coke, Refined Petroleum and Nuclear Fuel	6,45517
Real Estate Activities	4,00442

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