UNIVERSIDADE FEDERAL DO RIO DE JANEIRO
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RICARDO REZENDE RAMOS

AN APPLICATION OF INPUT-OUTPUT DECOMPOSITION TECHNIQUES TO THE STUDY OF THE IMPACTS OF THE FINAL DEMAND COMPONENTS IN BRAZIL

RIO DE JANEIRO
2018

Ricardo Rezende Ramos

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Tese de Doutorado apresentada ao Programa de Pós-Graduação em Políticas Públicas, Estratégias e Desenvolvimento, Instituto de Economia, Universidade Federal do Rio de Janeiro, como requisito parcial à obtenção do título de Doutor em Ciências, em Políticas Públicas, Estratégias e Desenvolvimento.

Orientador: Prof. Dr. Victor Prochnik

Rio de Janeiro
2018

FICHA CATALOGRÁFICA

R175 Ramos, Ricardo Rezende

An Application of Input-Output Decomposition Techniques to the Study of the Impacts of the Final Demand Components in Brazil / Ricardo Rezende Ramos. – 2018.

124 p.; 31 cm.

Orientador: Victor Prochnik

Tese (doutorado) – Universidade Federal do Rio de Janeiro, Instituto de Economia, Programa de Pós-Graduação em Políticas Públicas, Estratégias e Desenvolvimento, 2018.

Bibliografia: f. 111 – 118.

1. Cadeias globais de valor. 2. Intensidade tecnológica. 3. Análise insumo-produto. I. Prochnik, Victor, orient. II. Universidade Federal do Rio de Janeiro. Instituto de Economia. III. Título.

CDD 338.47

Ficha catalográfica elaborada pelo bibliotecário: Lucas Augusto Alves Figueiredo CRB 7 – 6851 Biblioteca Eugênio Gudin/CCJE/UFRJ

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Aprovada em 24 de maio de 2018 pela Banca Examinadora:

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Rio de Janeiro
2018

ACKNOWLEDGEMENTS

To my family, Jorge and Marilda, the genesis, Ricardo and Filipe, the future.
To my beloved girlfriend, Gabriella, my reason to keep smiling.
To my PhD supervisor, Victor, a mentor and a true friend.
To my undergraduate and Masters supervisor, Seixas, a friend for life.
And to all the real (and few) friends I have made throughout my life.
Every past achievement and those yet to come, all of you are behind them all.

RESUMO

RAMOS, Ricardo Rezende. Uma aplicação de técnicas de decomposição insumo-produto ao estudo dos impactos dos componentes da demanda final no Brasil. Tese de Doutorado (D.Sc. em Políticas Públicas, Estratégias e Desenvolvimento) - Instituto de Economia, Universidade Federal do Rio de Janeiro, Rio de Janeiro, 2018.

A fragmentação das atividades econômicas está remodelando o comércio global em uma rede de cadeias transfronteiriças. Esta tendência e o rápido crescimento econômico de diversos países em desenvolvimento, principalmente os do leste asiático, tornam essencial o estudo da evolução da inserção de qualquer país na economia mundial. Com este objetivo, esta tese aplica os métodos recém-aprimorados com base na tradicional análise de insumo-produto de Leontief, através da sua adaptação para o estudo dos impactos dos componentes da demanda final no comércio em valor agregado e a fragmentação da produção através das cadeias globais de valor. Esta abordagem enfatiza que diferenças estão sendo observadas nas mudanças estruturais entre as indústrias dependendo do seu nível de intensidade tecnológica. Além disso, na economia brasileira, os resultados são divergentes quando os produtos e serviços finais são comercializados para os componentes da demanda agregada: consumo das famílias e formação bruta de capital fixo. A metodologia é aplicada a outras duas economias ricas em recursos naturais de dimensões similares ao Brasil: Austrália e Canadá. Os resultados mostram diferenças significativas sobre os impactos causados pelos dois componentes da demanda agregada quando a intensidade tecnológica dos setores é considerada, evidenciando as diferenças induzidas nas indústrias que originaram o valor agregado dos produtos e serviços consumidos pela demanda final doméstica, bem como dos exportados para outros países.

Keywords: análise insumo-produto, cadeias globais de valor, mudança estrutural, comércio em valor agregado, intensidade tecnológica.

ABSTRACT

RAMOS, Ricardo Rezende. An application of input-output decomposition techniques to the study of the impacts of the final demand components in Brazil. PhD. Thesis (PhD in Public Policies, Strategies and Development) - Institute of Economics, Federal University of Rio de Janeiro, Rio de Janeiro, 2018.

The fragmentation of economic activities is reshaping global trade into a network of cross-borders chains. These trends and the rapid economic growth of several developing countries, mainly from East Asia, have made it important to study the evolution of any country's insertion in the world economy. Pursuing this objective, this thesis applies recently enhanced decomposition methods based on Leontief's traditional input-output analysis, adapting them to study the impacts of the final demand components on the trade in value-added and the fragmentation of production across global value chains. It emphasizes differences are being employed in structural changes between industries depending on their level of technology intensity. Besides, in the Brazilian economy, the results are divergent when the final goods and services are traded for households' consumption and gross fixed capital formation. The methodology is applied to two other sizable natural resource-rich economies: Australia and Canada. The results show significant differences between the impacts caused by the two different components of the aggregate demand when the technological intensity of the sectors is considered, emphasizing differences are being employed in the industries which originated the value-added of the final goods and services consumed by domestic final demand as well as exported to other countries.

Keywords: input-output analysis, global value chains, structural change, trade in value-added, technology intensity.

LIST OF ABBREVIATIONS

DVA – Domestic Value-Added

FVA – Foreign Value-Added

FUNCEX – Fundação Centro de Estudos do Comércio Exterior

GVC – Global Value Chain

IBGE – Instituto Brasileiro de Geografia e Estatística

IO – Input-Output

IPEA – Instituto de Pesquisa Econômica Aplicada

OECD – Organization for Economic Co-operation and Development

SNA – System of National Accounts

SUT – Supply-Use Table

WTO-OECD TiVA – Joint Initiative WTO-OECD Trade in Value-Added

WIOD – World Input-Output Database

WIOT – World Input-Output Table

WTO – World Trade Organization

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]INTRODUCTION

Baldwin and Lopez-Gonzalez (2015) provide evidences that after reaching a peak of 67% around the 1990s, by 2010 the G7 World GDP share had decreased to the same percentage of 1900. Some large emergent economies, led by China, and an aggregate of smaller economies have experimented strong economic growth, in part benefited from the offshoring movement of the 1980-90s based on low-cost factors to production, among other factors. An upgrade of managerial and manufacturing expertise has also been implemented, many times, after those uprising economies had received production facilities to perform simpler assembling activities. Frequently the expertise augmentation occurred through transferring organizational and technical routines from large transnational corporations from United States, Europe, and Japan (BALDWIN; LOPEZ-GONZALEZ, 2015).

Notwithstanding the existing debate among scholars, policymakers and corporate leaderships on the various dimensions of globalization, it is a fact that, a global network of production units and services has been established. Along that network, each stage is responsible for some value-adding activity that will result in a final product in the country-industry of completion (LOS; TIMMER; DE VRIES, 2015; TIMMER et al., 2014a). That is the way this Thesis sees a global value chain (GVC) and how it builds its conceptual framework.

According to Johnson (2017, p. 1), “researchers have struggled to develop a coherent empirical portrait of global value chains”. In the same line, Amador and Cabral (2016, p. 279) argue that a “comprehensive theoretical framework is still missing.” For Hermida, Xavier and Silva (2016, p. 5), the recent released world IO databases have helped to increase the number of empirical studies on the new configurations of international trade, however the works “which formally treat the relation between fragmentation, GVC and economic growth”, for instance, are still rare.

After the seminal work of Hummels, Ishii and Yi (2001) on vertical specialization, and recently, with the increasing number of new world IO databases, some scholars have been developing enhanced decomposition techniques based on the Leontief tradition (DAUDIN; RIFFLART; SCHWEISGUTH, 2009; JOHNSON; NOGUERA, 2012a; KOOPMAN; WANG; WEI, 2014; TIMMER et al., 2014b). This recent strand of research aims, among many goals, to improve the understanding of the causes and consequences of the international fragmentation of production in a macroeconomic setting.

The GVC framework emerged as a theoretical concept to empirically keep track of the fragmentation of production to explain its political, social and economic factors and impacts by[1]:

- characterizing the (increasing) complexity of the international trade;
- mapping the extension and evolution of the supply chains;
- decomposing the content and flows of trade of goods and services between firms, industries, countries and regions;
- using trade in value-added as an alternative to the often-misleading traditional trade in gross terms;
- following the structural changes in the economies of countries and regions;
- evaluating the impacts of technological change on structural change as a driver of economic growth and labor productivity;
- observing the shifts on patterns of production, including labor and capital;
- tracking the flows of intermediates and their content into final goods and services;
- measuring the relative contribution of services to manufacturing;
- developing alternative measures of comparative advantage;
- linking actors and activities geographically dispersed;
- analyzing economic growth, competitiveness and productivity rates in different levels of aggregation;
- incorporating the results in the effects on the statistics of the System of National Accounts (SNA).

The list of possibilities is far from being complete, as the recent contributions to the literature have been proving by developing new theoretical methods and solid empirical results.

At the micro-level, the formation of GVCs affects the strategies of transnational corporations, for which the decision to outsource or offshoring is now dependent of finding the most competitive region in the supply of intermediate goods or services. At the macro-level, those movements of offshoring and outsourcing of industrial activities directly affects

[1] The list is far from being limited to those topics and the GVC framework brought forth many analytical tracks for scholars and policymakers; for more possibilities, see (AMADOR; CABRAL, 2016; BALDWIN; LOPEZ-GONZALEZ, 2015; CORRÊA, 2016).

the allocation of labor and capital between sectors and regions, which can result, for instance, in the increase of unemployment and the reduction of income.

Structural change is a topic that has been largely discussed in the literature, since the early contributions of Kuznets (1966, 1973) and others. Its connection to the GVC context is inevitable in such a way it would be too hard to propose novel empirical methods to measure the international fragmentation of production and do not take for granted the basics of structural change.

The relation between structural change and technological change and its impacts on economic growth have been widely studied. Recently, Verspagen and Kalterberg (2015, p. 54), using measures of total factor productivity, concluded that "[industries] with higher rates of technological change contribute towards economic growth more than others", and continue by saying that "high values of structural change are mostly achieved by a large contribution of technological change". Based on these arguments, this work's methodological approach is developed to contribute to the GVC research, focusing on the technology intensity of the industries.

The relevance of the manufacturing sector as the engine of economic growth, for both developing and developed countries, has been widely proposed and empirically confirmed by many authors (DOSI; PAVITT; SOETE, 1990; HAUSMANN; RODRIK, 2006; SZIRMAI; VERSPAGEN, 2015; VERSPAGEN; KALTENBERG, 2015). Nonetheless, recent studies have empirically demonstrated an ongoing process of structural change both in the world economy and in many countries, in which the manufacturing sector is losing participation in the economy, measured in terms of employment, gross output, value-added (MORCEIRO, 2016; RODRIK, 2011, 2016; SARTI; HIRATUKA, 2017). However, recent studies have been arguing that the relevance of the services sector should not be set aside, because of the high-skilled activities, such as R&D, engineering, IT, marketing, that have become intrinsic to the manufacturing industries, positively impacting its competitiveness and value creation (FORNARI; GOMES; HIRATUKA, 2016; MIROUDOT; CADESTIN, 2017).

In general, the literature provides evidences that the development of strategies to support the creation of new activities to attract and reallocate the factors and capabilities a country already possesses still remain a complex challenge (HAUSMANN; RODRIK, 2006; RODRIK, 2011). For some, industrial policies still have a role to play in the XXI century (CHANG, 2002; RODRIK, 2004), and factor endowments should be pushed beyond its limits to go further than specialization, but also to promote diversification, which history has proved to be a hard but viable task, when it is driven by high levels of capital investment in the manufacturing sector (RODRIK, 2007; VIOTTI, 2004).

Some authors claim that there is a positive correlation between participation in GVCs and economic growth[2]. It seems that there is a long road ahead to specify and test robust econometric models to establish this causal relation for the new context of the world economy, although some attempts are emerging (FOSTER; STEHRER; TIMMER, 2013; HERMIDA; XAVIER; SILVA, 2016).

In the specific case of the Brazilian economy, the empirical findings reveal that since the 2000s the country has passed through two different economic "waves": a period of rapid growth during 2003-2010, followed by a slowdown since 2011 (MORCEIRO, 2016; SANTOS et al., 2016; SERRANO; SUMMA, 2015; SILVA; LOURENÇO, 2014; TORRACCA; CASTILHO, 2015). Using different approaches, those works, among many others, show evidences that even during the years of continuous increasing demand, the industries that presented relative levels of output and employment growth, also presented an increase in the import content, revealing one side of the fragility of the competiveness of the Brazilian economy. Further, in the literature review, more details on those facts are explored, including the causes and consequences exposed by those studies.

The quantitative approach to study the GVCs has been proposing IO decomposition techniques on the Leontief tradition to understand the effects of international fragmentation of production on structural change in the global and local contexts. Those methods of IO research on GVCs frequently capture increases in the shares of value-added occurring outside the country-industry of completion. That dynamic scenario compels the decision-making process of corporations and governments to be grounded in solid evidences.

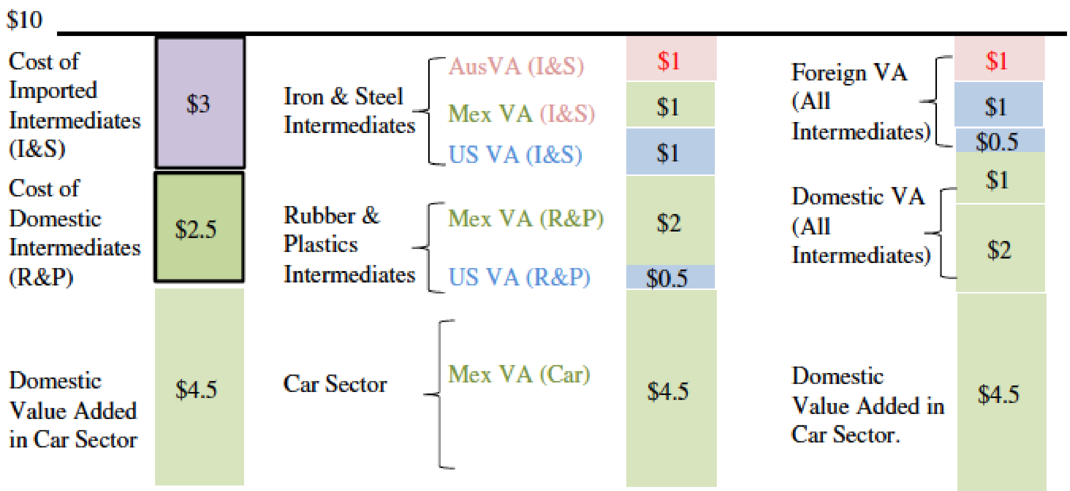
Therefore, the availability of relevant and reliable data and statistics becomes a critical component to empirical studies, going from microdata (product/establishment-level) to multi-

[2] For two solid reviews on this matter, see Amador and di Mauro (2015) and Taglioni and Winkler (2016).

regional input-output databases (MRIO)[3] (INOMATA, 2017). A realistic example of the trade in value-added is given by Baldwin and Lopez-Gonzalez (2015, p. 1687-88).

The accounting scheme in Figure 1 shows how to decompose the value added in each stage of the GVC of a Mexican car exported to the United States. In the first column, the $10 value is due to $4.5 of domestic value-added (productive factors, e.g., wage, interest etc.) paid in the Mexican car industry, $2.5 of domestic intermediates (rubber and plastic) purchased in Mexico and $3 of imported intermediates (iron and steel). A second breakdown (second column) shows that both domestic and imported intermediates carries value added in previous stages of production located in other country-industry (including Mexico). The imported iron and steel intermediates carries Australian (identified in light pink), Mexican and American value-added ($1 each). In the example, the American iron and steel industry uses Mexican intermediates in its exports to Mexico. The domestic purchased rubber and plastics intermediates carries Mexican and American value-added ($2 and $0.5, respectively). It means Mexico imports intermediates from the United States. The remainder $4.5 is due to direct value-added in Mexican car industry.

Figure 1. Trade in value-added example - $10 Mexican car exported to United States.



Note: I&S – Iron and Steel; R&P – Rubber and Plastics. Mexican domestic value added is identified in light green; Mexican intermediates are identified in dark green; Imported intermediates (first column) are identified in purple; American intermediates are identified in blue; and Australian intermediates are identified in pink.
Source: Baldwin and Lopez-Gonzalez (2015, p. 1688).

The IO data used by the authors allowed them to trace the true origin of the value-added, considering the direct value-added in the Mexican car industry and the value-added by

[3] Multi-regional input-output (or multi-countries input-output) databases are constructed as a set of national input-output tables, usually referred to as world input-output tables (WIOT). For a detailed theoretical explanation of the formation of the WIOT tables, see Miller and Blair(2009).

the interregional flows of intermediates. The total cost of intermediates is $5.5 ($2.5 domestic + $3 imported), of which $3 is value-added in Mexico. The cost of imported intermediates of $3 also embodies value-added in Mexico ($1).

According to Frederick (2014, p.13), the GVC studies, in general, make use of three categories of basic data:

- International trade by product/services
- Industrial statistics by economic activity
- Labor and occupation statistics

Those data are usually collected in three levels:

- National (establishment-level, by country) micro data
- National (country-level) aggregate public data sets
- International datasets (compilations of national-level data)

The data used in this work follows the MRIO model of the last version of the World Input-Output Database (WIOD), released in November 2016, hereinafter referred as WIOD 2016. This database provides information on the flows of intermediates between industries and countries and output for the final consumption by households, government, private investment.

The use of these novel types of frameworks for GVCs is justifiable, because traditional trade statistics, usually measured in gross values, have made economists, business managers and policymakers misunderstand the nature of international economic relations. Measuring trade in the traditional way presents shortcomings to precisely tracing the value added by an economy to the production of a specific good or service. It also distorts bilateral trade balance, gives credit for production to wrong countries or regions, double count trade flows of intermediates and misleads governments about how imports and exports are related (ELMS; LOW, 2013; KOOPMAN; WANG; WEI, 2014). An explanation to the problem is well synthesized in a sentence by Koopman, Wang and Wei (2014, p.459-60), "all official trade statistics are measured in gross terms, which include both intermediate inputs and final products, [so] they "double count" the value of intermediate goods that cross international borders more than once."

This work has grounded its motivation and objectives inspired by the recent research on IO based decomposition techniques applied to GVCs (LOS; TIMMER; DE VRIES, 2015;

TIMMER et al., 2016) and the recent empirical evidences of the slowdown of the performance of the Brazilian economy after 2011 (MORCEIRO, 2012; SARTI; HIRATUKA, 2017; SERRANO; SUMMA, 2015). This work's approach provides analyses and measures focusing on the industries responsible for the final production of the goods and services ("country-industry of completion"), including the contributions of all previous stages within the production chain.

By making use of the recent released of the WIOD 2016, this Thesis aims to update the recent empirical research of the Brazilian participation on GVCs in the international context, applying enhanced decomposition methods of the trade in value-added based on the Leontief tradition.

The main point is to show that the decomposition methods devised by Los, Timmer and de Vries (2015) are particularly useful in studies on a more Keynesian tradition, works that emphasize the relevance of the aggregate demand and its components.

Los, Timmer and de Vries (2015) concept of GVC departs from the production activities attend the final demand (production by industries of completion). In their view, the GVC is the integrated sum of all the value-added activities that compound the products and services of the industries of completion. But the products and services purchased by the demand components are by definition the same that are supplied by the industries of completion. Through the application of the value-added matrix, these products and services are broken down in the value-added activities that are necessarily performed in their production. This disaggregation of the products and services of the industries of completion thus shows the ultimate activities on which the demand components impact. The composition of value-added activities, in terms of their value and industry and country of origin is the supply side of the demand components.

Without being a Thesis in Economics, this works intends to show how the decomposition methods devised by Los, Timmer and de Vries (2015) may be the most useful in an array of Economic works that emphasizes the absolute and relative impact of the households' consumption, gross fixed capital formation etc.

Three questions derive from the general objectives:

- How much national economic activities are integrated to GVCs, considering the origin of the value-added (domestic/foreign, industry of completion) and its technology intensity?

- What differences can be observed between the impacts induced by the expenditures for gross fixed capital formation and by the households' consumption?
- The structural changes observed in Brazil regarding the economy integration to GVCs also apply to Australia and Canada?

After this introduction, the Thesis is organized as it follows.

The Chapter 1 presents a literature review on the theoretical methodologies in line with the objectives of this work. It also describes in details the theoretical framework adopted to study the research problem and to develop the methodology.

Then, the Chapter 2 describes the quantitative indicators that are used in the empirical analyses of the Thesis, presents the characteristics, advantages and limitations of the WIOD 2016 and proposes the use of a taxonomy of technology intensity as a way to aggregate the industries within the sectors of the economy.

The Chapter 3 applies the mentioned methods to the WIOD database, showing characteristics of the value-added activities that make the supply side relative to the main demand components. In the conclusion of this chapter, some recent papers on the evolution of the Brazilian economy are reviewed through the use of the same methods.

In the Chapter 4 it is shown that the same point can be extended to the level of an international comparison among different countries. The Brazilian economy, considered to be at a development stage, is analyzed in comparative perspective with Australia and Canada. These countries are classified as developed economies, although they are rich in natural resources as much as Brazil. By doing that, it is expected the results may contribute to the policy debate about the development of strategies to increasing the integration of the national economic activities to the new organization of the global production across GVCs. In addition, based on the evidences, the qualitative conclusions may provide useful insights of how those policies should be designed, evaluated and updated to overcome the challenges of upgrade the industries' and sectors' activities to those with higher economic value (a.k.a. "smile curve" approach)[4].

[4] For details on the "smile curve" scheme, see Baldwin, Bridgman and Venables (2012), Corrêa (2016), Gereffi and Fernandez-Stark (2016) and World Bank (2017).

1. GLOBAL VALUE CHAINS AND TRADE IN VALUE-ADDED

This Chapter aims to present the theoretical background of GVCs and trade in value-added. The first section offers a brief overview of the origins of the GVC concept, which emerged, with the strand of research based on case studies. It continues by providing a more detailed literature review focused on the empirical research related to the Thesis' objectives. Then, the second section explains the concepts of IO analysis, based on the Leontief tradition, and its extension to be applied in the study of the GVCs phenomenon and the trade in value-added. This quantitative approach is the basis of the analytical methodologies and the enhanced decomposition techniques used in this Thesis that attempt to provide a broader macroeconomic view of the international fragmentation of production. It is grounded on the perspective of the origin of the value-added content embodied in the final goods and services to be consumed by foreign countries (exports) and domestic demand and its effects on the evolution of the structural change of the economy. Finally, the third section summarizes the Chapter.

1.1 BACKGROUND

The globalization is not a new phenomenon[5]. The cost reduction and improvements in technologies of transportation, communication and manufacturing, along with trade liberalization, are often mentioned as relevant factors that have led to the increase of the international outsourcing and offshoring of production stages (AMADOR; CABRAL, 2016; BALDWIN; LOPEZ-GONZALEZ, 2015). Notwithstanding the existing debate among scholars, policymakers and corporate leaderships on the various dimensions of the globalization, it is a fact that, a global network of production units and services has been established for quite a long time.

However, only recently the empirical research on the international fragmentation of production gained momentum by means of the introduction of the concept of GVC. It has focused on the complex international network of flows of goods, services, know-how and

[5] For Gereffi, Humphrey and Sturgeon (2005, p.100), globalization "implies the functional integration and coordination of […] internationally dispersed […] economic activities". They refer to internationalization as "the geographic spread of economic activities across national boundaries" (ibid., p.100). Although it does not reveal the true complexity of the phenomenon, internationalization is more suitable to the Thesis's purpose.

people, the so-called "supply-chain trade" (AMADOR; CABRAL, 2016; BALDWIN; LOPEZ-GONZALEZ, 2015).

The international business literature has been using many different terms to refer to the globalization phenomenon, such as those pointed by Amador and Di Mauro (2015, p.14):

> 'vertical specialization', 'outsourcing', 'offshoring', 'internationalization of production', 'international production sharing', 'disintegration of production', 'multi-stage production', 'intra-product specialization', 'production relocation', 'slicing up the value chain', and 'international segmentation of production'.

Hereinafter, 'fragmentation of production' will refer to all those terms indistinctively, unless where it is otherwise required, and it is theoretically and empirically linked to the globalization.

The primary characteristics of the three "chains" frameworks are summarized in the Table 1, allowing for a systematic comparison between the theoretical approaches.

Table 1. Theoretical background and characteristics of the main chains frameworks.

	World Systems	**Global Commodity Chain**	**Global Value Chain**
Theoretical background	World-systems theory	World-systems theory Organizational sociology	International business Global commodity chains
Object of inquiry	World-capitalist economy	Inter-firm networks in global industries	Sectoral logics of global industries
Main guiding concepts	International division of labor Core-periphery-semi-periphery Unequal exchange Kondratieff cycles	Industry structure Governance (producer-driven/buyer-driven) Organizational learning Industrial upgrading	Value-added chains Governance models (market, modular, relational, captive, hierarchy) Coordination/power asymmetry Transaction costs Industrial upgrading and rents
Intellectual influences (literature)	Dependency theory Structuralist development economics	Multinational Corporation Comparative development	International business Industrial organization Trade economics International production networks

Source: Adapted from Bair (2005, p. 160).

According to Bair (2005), the history of the GVC concept[6] can be traced back to the previous studies on global commodities chains (GCCs) (BAIR; GEREFFI, 2001; GEREFFI, 1994, 1996, 1999b; GEREFFI; HUMPHREY; STURGEON, 2005) and World Systems (ARRIGHI; DRANGEL, 1986; HOPKINS; WALLERSTEIN, 1977, 1986). It has focused on

[6]Similar concepts are found in the literature, referring to the globalization and international fragmentation of production, for instance, GPN – Global Production Network (COE; DICKEN; HESS, 2008; HENDERSON et al., 2002) and GSC – Global Supply Chain (BALDWIN, 2012; BLANCHARD, 2015; KELLY; CAVA, 2014). In this Thesis, the similarities or differences between those frameworks and GVC are not discussed, as it is not part of the objective. For a brief overview and comparison, see Coe, Dicken and Hess (2008) and Henderson et al. (2002).

the interaction of firms along the flows of production from raw materials to goods and services sold to final demand. The main methodologies have been the study of individual cases and the analysis of inter-sectoral flows of goods, technology etc., emphasizing the interaction among sectors and the patterns of behavior of the firms operating in these sectors.

In this context, it is worth mentioning that despite the similarities between GCC and GVC, Gary Gereffi and colleagues replaced the word "commodity" by "value" because the latter "focuses on value creation and value capture across the full range of possible chain activities and products (goods and services), and because it avoids the limiting connotations of the word 'commodity'" (BAIR, 2005, p. 174). In line with that view, Henderson et al. (2002) criticize the use of the term "commodity", as it "has long been captured by orthodox economics of whatever paradigm. As a consequence, it has transmuted into a reified language shorn of its social content" (p. 444)[7].

1.1.1 "Case Studies" Research on GVCs

The GVC framework introduced and developed by Gereffi and his followers has provided an undeniable contribution to the field of international trade and to understand the importance of GVCs for economic and social welfare (AMADOR; CABRAL, 2016). In terms of industrial upgrading, Gereffi (1999a, p. 39) argues that participation in GVCs "is a necessary step", and "involves organizational learning to improve the position of firms or nations in international trade networks" [8]. That perspective started to give importance to aspects related to the activities within a GVC, rather than the sectoral dimension (CATTANEO et al., 2013; HERMIDA; XAVIER; SILVA, 2016). Some activities along a value chain with the same industry are prone to more or less economic value-added, depending on the stage of production to which it is harnessed. The so-called "smile curve" represents a different way to analyze the industrial organization, as shown in Figure 2.

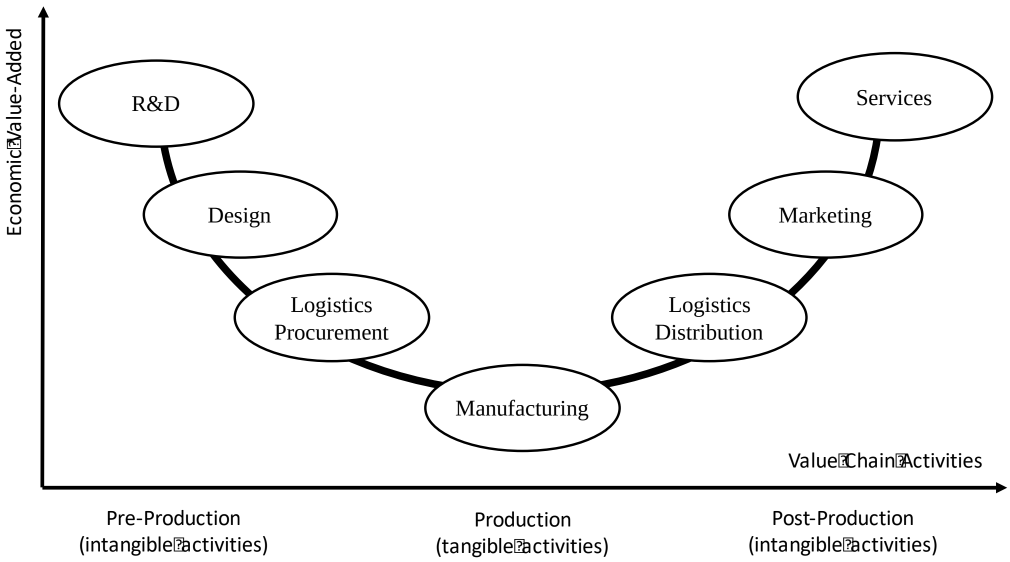
A firm or country can specialize in the upstream (pre-production) activities, such as R&D and design, which are more skill-intensive and value-adding, or in the primary goods production and pre-assembly, which are less skill-intensive and add low economic value. On

[7] The term value draws on the research on competitive advantage, introduced by Porter (1985).

[8] In the original text, Gereffi (1999a) still used the expression "global commodity chains". However, the argument applies to the GVC context that emerged later.

the other hand, there are downstream (post-production) activities, such as marketing and customer-support, which add more economic value than, for instance, assembly activities. Different strategies and policies are required by governments and firms to promote the so-called industrial upgrading within the GVC framework (WORLD BANK, 2017)[9].

Figure 2. “Smile Curve” of value-adding activities in GVCs.



Source: Author’s elaboration based on Baldwin, Ito and Sato (2014) and Gereffi and Fernandez-Stark (2016).

Within this context, Gereffi (1999a, p. 39) argue that industrial upgrading

> involves organizational learning to improve the position of firms or nations in international trade networks […]. Participation in global [value] chains is a necessary step for industrial upgrading because it puts firms and economies on potentially dynamic learning curves.

Looking back at Gereffi (1999a)’s arguments and questions regarding the successful Asian countries catch-up process, they still seem to be part of the current agenda for scholars and policymakers concerned with international trade challenges, such as (p. 38)

> [u]nder what conditions can trade-based growth become a vehicle for genuine industrial upgrading, given the frequent criticisms made of low-wage, low-skill, assembly-oriented export activities?

Besides those institutional matters of industrial upgrading trajectories, Gereffi’s research focused on dimensions such as the governance and coordination of supply chains by leading firms (buyer-supplier linkages) (GEREFFI; FERNANDEZ-STARK, 2016; PIETROBELLI; SALIOLA, 2008; STURGEON; GEREFFI, 2009). In their well-known study on the iPod and notebooks production chains, Dedrick, Kraemer and Linden (2010) show evidences of the increasingly worldwide dispersion of the supply chain of the high-end

[9] The theoretical framework on industrial upgrading is out of the scope of this Thesis. For a recent study on that topic applied to developing countries, see Corrêa (2016).

electronics. The evidences show that China captured a much smaller amount of the value added by the production chain of the iPod, with most of the inputs being imported from Korea, Japan and United States.

Sturgeon, van Biesebroeck and Gereffi (2008) apply the GVC approach based on elements such as inter-firm governance, institutions and lead-firm power decision to analyze the case of the North American automotive industry. The authors present the distinctive characteristics of the automotive chain compared to other industries (e.g. electronics and apparel). According to them, the manufacturers of the automotive industry usually must comply with strict government requirements, especially when it comes to decisions of where to install the assembly, which in the end, stays near the end consumers. However, the standardized parts and components are far more dispersed globally.

Although quite instructive on the causes and characteristics of the fragmentation of production at the product- or firm-level, and for specific industries, the empirical research derived from that Gereffi's approach presents shortcomings. It can neither provide a representative knowledge-base about the fragmentation of production phenomenon (INOMATA, 2017; LOS; TIMMER; DE VRIES, 2015), nor build a solid theoretical framework to account for the flows of international trade and evaluate the structural change of the world economy (KOOPMAN et al., 2010).

Inomata (2017, p. 23) argues that "these approaches have limited applicability when considering macroeconomic issues such as trade policies […] This is far from sufficient to capture the entire value flows in the national context." For instance (p. 23),

> the product-level approach considers only the value-added structure of direct input suppliers (the first tier), leaving the rest of the value-added stream untracked. […] [A] hard-disk drive in an iPhone contains subparts produced in different countries and thereby requires further decomposition of the value-added sources.

In order to overcome those shortcomings and to provide a broader comprehension of the dynamics value-added flows across GVCs, novel accounting frameworks derived from the IO tradition pioneered by Leontief (1936, 1949) started to receive increasing attention of policymakers and scholars.

This Thesis focuses on the aforementioned strand of research on the GVC concept which is concerned with the measurement of the fragmentation of production in a macroeconomic setting. The works on this methodological approach make use of international trade statistics, world IO tables (WIOTs) and a variety of quantitative indicators based on enhanced decomposition techniques of the trade in value-added. The next section provides a review of the recent literature of IO research on GVCs and trade in value-added.

1.1.2 IO Research on GVCs and Trade in Value-Added

Seminal Contributions

Feenstra (1998) and Feenstra and Hanson (1999) are among the first contributions to analyze the interconnectedness of production processes across vertical chains. Feenstra (1998), based on aggregate quantitative evidences for a small sample of countries and industries, highlights the implications of the “disintegration of production” (or “outsourcing”, as he uses throughout his work) on employment, wages, labor standards and regulatory policy. In his theoretical work’s conclusions, Feenstra (1998) reminds that a broader conceptual framework still should be worked out.

The empirical work of Feenstra and Hanson (1999), hereinafter FH, is often cited as the first systematic approach to measure the fragmentation of production in a macroeconomic setting[10]. FH propose to measure the foreign outsourcing of intermediate inputs, considering the share of imported inputs related to all intermediate inputs for a specific industry, which they call in a broad sense approach. In the narrow sense approach, their measure considers intermediate inputs produced by the same industry as the purchasing industry. Their conceptual framework presents shortcomings which are listed by Los, Timmer andde Vries (2015, p. 69), that is: FH measures (i) do not reveal the origin (country or region) of the imports, (ii) are “insensitive to substitution of the use of domestic production factors for intermediates”, (iii) assume that the domestic value-added embodied in imported intermediates and the foreign value-added embodied in domestic intermediates are both zero[11]. Although FH develop simple techniques to measure the fragmentation of production, recent works confirmed that the aforementioned shortcomings can lead to considerable

[10] In their work, Feenstra and Hanson (1999) use data from the NBER Productivity Database, data on U.S. total imports and exports (provided by previous studies) and the Census of Manufactures, covering the period 1979-1990. According to FH, the Census of Manufactures contains raw data used to construct IO tables.

[11] Later, Johnson and Noguera (2012a) and Koopman, Wang and Wei (2014) provided theoretical and empirical evidences that a share of domestic and/or foreign value-added embodied in intermediates production is increasingly present as a result from an internationally fragmented economy.

accounting miscalculations of international trade[12] (JOHNSON; NOGUERA, 2012a; KOOPMAN; WANG; WEI, 2014).

Following FH, a strand of quantitative research emerged with the availability of global IO tables[13]. The seminal contribution to that body of research is given by Hummels, Ishii and Yi (2001), hereinafter HIY. HIY propose a multi-country setting technique to measure the imported content embodied in a country's exported goods – the concept known as Vertical Specialization (VS). According to the VS approach, the country is considered to be vertically specialized in one product if it gives a relatively low contribution to the export value of this product. The contribution is measured as a ratio of domestic value added in exports. The authors' empirical analyses reveal that the VS exports of the countries in their database represented at least 21% of total exports and had grown 30% in the period 1970-1990[14].

According to Amador and Cabral (2016), the VS concept has been receiving several generalizations and producing new metrics for the fragmentation of production across GVCs. The authors mention that among the pioneering works applying WIOTs and the trade in value-added concept are Daudin, Rifflart and Schweigsguth (2009), Johnson and Noguera (2012a) and Koopman, Wang and Wei (2014), using the Global Trade Analysis Project (GTAP) database, and Foster-McGregor and Stehrer (2013) and Timmer et al.(2014), using the World Input-Output Database (WIOD)[15]. Other widely used WIOT database was made public by the joint OECD-WTO Trade in Value Added (TiVA) initiative (OECD, 2013; OECD; WTO, 2012). Amador and Cabral (2016) argue that the OECD-WTO TiVA initiative have been mostly used in policy-oriented studies, which include the development of

[12] For instance, the multiple border crossings of intermediates, that eventually generate value-added in intermediary stages of production in foreign and local industries, are not captured by the FH measures.
[13] The IO analysis advanced by Leontief (1936) and its extension to the GVC research are further presented in the remainder of this Chapter.
[14] The database used by HIY included the OECD IO database (10countries), plus IO tables from Ireland, Korea, Taiwan, and data from Mexico's maquiladoras. The whole database accounted for more than 60% of world trade.
[15]For a summary of the main global MRIO databases, see Amador and Cabral (2016) and Tukker and Dietzenbacher (2013). Among the institutions working on those databases are the Institute of Development Economies-Japan External Trade Organization (IDE-JETRO), the World Trade Organization (WTO), the Organization for Economic Co-operation and Development (OECD), the United States International Trade Commission (USITC), the World Bank, the International Monetary Fund (IMF), the United Nations Conference on Trade and Development (UNCTAD). There are also the integrated projects, such as the Global Trade Analysis Project (GTAP), the OECD Trade in Value-Added (OECD-TiVA), the Eora MRIO project and the World Input-Output Database (WIOD). Dietzenbacher et al.(2013) presents the methodology and the concepts of the construction of the WIOD.

indicators of trade in value-added, comparable country notes and investment policies targeting at GVCs.

The enhanced decomposition techniques proposed by those recent works based on the GTAP and WIOD database and their main findings are summarized in the sequence, as they form the background of the recent IO research on GVCs and inspired the analytical framework of this Thesis.

Enhanced Decomposition Techniques of GVCs and Trade in Value-Added

Daudin, Rifflart and Schweigsguth (2009) recognizes and follows the VS concept, but extends it to study the trade patterns using a database that covers the entire world economy. They use three releases of the GTAP covering 66 regions and 55 industries for years 1997, 2001 and 2004, also including 113 regions for 2004. Their framework computes not only the VS (share of imported intermediates in exports), but also the so-called VS1 (share of exports used as intermediates to other parties' exports), previously advanced by HIY, the VS1* (domestic content of imports, that is, the exports that are further re-imported as embedded intermediates for final consumption) and the "value-added trade". According to Daudin, Rifflart and Schweigsguth (2009), their work went further than HIY, since the latter had used a much smaller database, had presented the VS1 formula but with narrow empirical results restricted to particular cases and had not computed VS1* and trade in value-added. Although Daudin, Rifflart and Schweigsguth (2009) recognize shortcomings in their estimations, they gave a relevant contribution to the IO research on GVCs by tracing with more precision "who produces for whom in the world economy" (p. 23).

Among other findings, Daudin, Rifflart and Schweigsguth (2009) show that manufacturing exports accounted for 67% of the total value added in manufacturing in 2004, although a large amount of the manufacturing value-added exports embodies contributions of primary and services sectors. As a consequence, in the case of VA exports as a share of total VA, only around 32% of world manufacturing value-added and 11% of the world services value-added is consumed by foreign demand. The latter share is higher than the estimated services gross exports of 7% share of total value-added. Those results confirmed that the services sector presented a higher dependence of foreign demand than the trade in gross terms suggested.

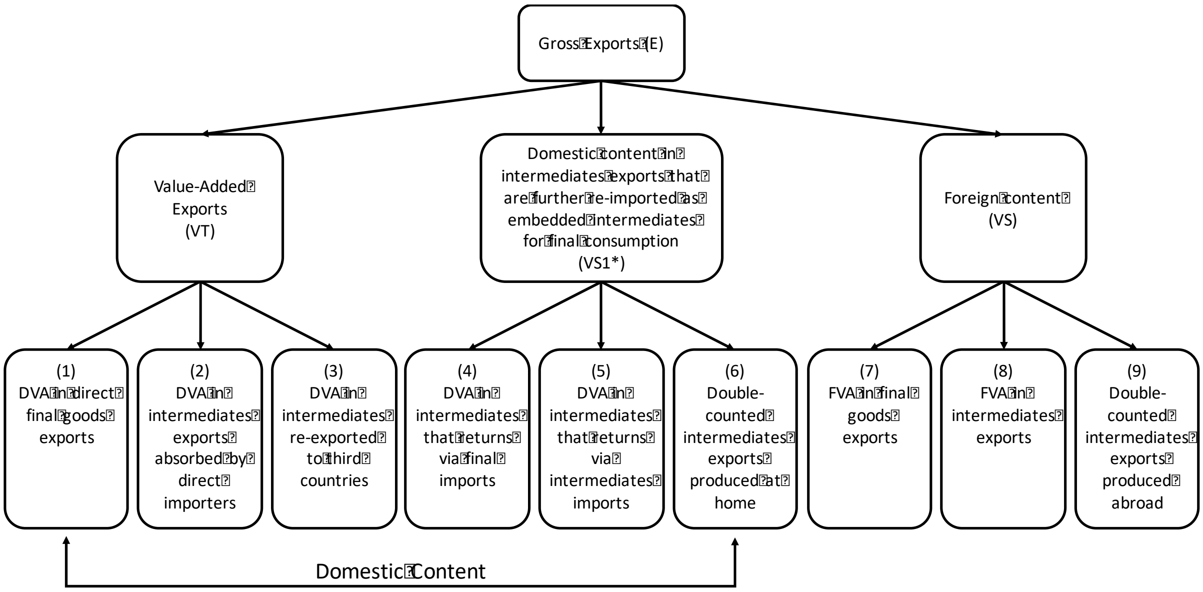
Johnson and Noguera (2012a), JN hereinafter, introduce and demonstrate the applicability of the value added to gross exports (VAX) ratio, which accounts for the intensity of production sharing by computing the value-added content of bilateral trade at country- and sectoral-levels. JN uses the GTAP 7.1 database for the year 2004, which includes IO tables for 94 countries and 19 composite regions covering 55 industries. Among their findings, JN show that across industries VAX ratios are higher in the primary and services sectors than in manufacturing due to the fact that the latter purchases intermediates from the former sectors, which contains value-added originating in the primary and services sectors. In the country-level, they find that developed countries mostly exports manufactured goods, resulting in a lower aggregate VAX ratio, but within manufacturing sector they export at higher VAX ratios.

In the bilateral trade perspective, JN reveal that VAX ratios vary significantly across partners when measured in gross terms and value-added terms. Taking the US exports, for instance, they find that in value-added terms the exports to Canada are 40% lower than in gross terms and to France they are equal. Those results are explained in terms of the production sharing, which includes variations in the degree of absorption, reflection and redirection of intermediates trade across partners.

Finally, Koopman, Wang and Wei (2014), KWW hereinafter, introduce an integrated accounting framework that provides a full decomposition of the gross exports into nine value-added components. KWW incorporate previous measures of vertical specialization and trade in value-added found in the literature, including VS, VS1, VS1* and VAX[16]. The value-added components are divided by KWW according to the origin, domestic (DVA) or foreign (FVA), including separate double-counted categories, as show in Figure 3.

[16] For the detailed derivation of the mathematical formulas and conciliations between KWW framework and other VS and trade in value-added measures of previous literature, see Koopman, Wang and Wei (2014).

Figure 3. KWW decomposition of gross exports into value-added components.



Source: Koopman, Wang and Wei (2014).

In their empirical analyses, KWW used the GTAP 7 database and information from UN COMTRADE to construct a global ICIO table for 2004 covering 26 countries and 41 industries. Besides the detailed accounting decomposition of DVA in exports, KWW also provided the equivalent measures previously available in the literature using the results of their framework. Referring to the Figure 3, JN's VAX ratio is given by summing terms (1) to (3); HIY's VS share is given by summing terms (7) to (9); the domestic content (DC) discussed in the VS literature is given by summing terms (1) to (6); and the share of vertical trade is obtained by summing DC and VS1[17]. Among other findings, KWW confirmed that for any country, the share of gross exports in excess of the value-added exports equals the double-counting value. In terms of foreign content, Mexico processing trade (37.1%) and China exporting processing zones (34.1%) present a high share in their final goods exports, which can reflect their position in the GVCs as mere assemblers. Later, Wang, Wei and Zhu (2013) propose an extension to the KWW framework by decomposing the gross exports into the sum of 16 components of value-added and double-counted contributions at the sector, bilateral, or bilateral-sector levels. Although the authors claim to offer a deeper and more detailed decomposition of the gross exports than KWW, that even uses other techniques

[17] For the details of the mathematical derivation of the VS1 measure, see Koopman, Wang and Wei (2014). The VS1* measure proposed by KWW, according to the authors, is a subset of VS1 and has minor adjustments compared to the one proposed by Daudin, Rifflart and Schweigsguth (2009). KWW argue that the latter "include only domestic value added returned home in final goods imports but exclude domestic content returned home by being embodied in the imports of intermediate goods" (KOOPMAN; WANG; WEI, 2014, p. 484).

besides the Leontief IO analysis, the mathematical complexity of their extended framework seems to turn it into an extremely difficult analytical tool to be adopted by policymakers[18].

A different way to define a GVC is proposed by Timmer et al. (2013). For them, the GVC is identified by the country-industry where the last stage of production in fact takes place before final consumption, which later Los, Timmer and de Vries (2015) called “country-of-completion” and Timmer et al. (2014), “country-industry of completion”. Among their empirical findings, Timmer et al. (2013) show that the international fragmentation of production lead to an increase in the number of jobs in the services sector at the expense of a decrease in the manufacturing sector in the European Union during 1995-2008. Based on their results, Timmer et al. (2013) argue that the emphasis of trade and industrial policies should shift their focus from industry-specific actions to the type of activities carried out, considering the integration of the production process within and across countries.

Following Timmer et al. (2013), other works have adopted the same conceptual characterization of the GVC identified by the country-industry of completion (LOS; TIMMER, 2018; LOS; TIMMER; DE VRIES, 2015, 2016; MIROUDOT; YE, 2017; TIMMER et al., 2014b). Those works derive from the datasets constructed by the WIOD project, which is coordinated by the Groningen Growth and Development Center (GGDC) of the University of Groningen (DIETZENBACHER et al., 2013). Since the release of the two versions of the WIOD (2013 and 2016), many works have used those databases to study different aspects of the international fragmentation of production.

In Timmer et al. (2014), a decomposition technique is proposed to trace the value-added by all labor and capital directly and indirectly required in the production of a final good or service. Their accounting framework of GVCs is represented by a matrix that allows for the decomposition of all value-added contributions by each country-industry of origin on the supply side (the rows) for the value of each final product delivered to each country in the WIOD (the columns; which indicates the GVC itself). The mathematical details on the decomposition technique are given by Los, Timmer and de Vries (2015). The technique derives from the IO analysis applied to the WIOT, adopting a specific arrangement of the final demand matrix in the Leontief IO model, in which all levels of final demand are set to zero, except for those containing the output of the country-industry of completion of interest

[18] It is neither in the scope of this review nor of this Thesis objective to describe or apply the extended framework proposed by Wang, Wei and Zhu (2013).

(no matter if the final consumption is domestic or foreign). Further in this chapter, the Section 1.2 presents the details of the accounting framework for GVCs proposed by Timmer et al. (2014) and Los, Timmer and de Vries (2015), which is the accounting framework adopted by this Thesis for the empirical analyses.

The findings of Los, Timmer and de Vries (2015) show that the fragmentation of production has expanded much faster globally than regionally in the period 1995-2011 for all production chains, with only a temporary slowdown caused by the 2008 world financial crisis. Using the same framework and database, the WIOD 2013, Timmer et al. (2015) compared their measures of VAX ratios for 40 countries with the same measures obtained by two other studies (JOHNSON; NOGUERA, 2012a; KOOPMAN; WANG; WEI, 2014) and those available at the OECD-WTO TiVA database 2013 version (OECD; WTO, 2012). Results showed a high pairwise correlation, although some differences were identified in the case of China and Mexico. Other works had explained those special cases which are due to the processing trade that is pervasive in the Chinese and Mexican economies (DE LA CRUZ et al., 2011; KOOPMAN; WANG; WEI, 2012). In line with previous works conclusions, Timmer et al. (2015) argues that when production for exports is more intensive in the use of imported intermediates than production for domestic consumption, the IO table should correctly model the exports, otherwise the measures of domestic value-added in exports might be overestimated.

Other relevant results found in Timmer et al. (2015) are those regarding the empirical analysis of the German automotive production. Adopting the concept of the GVC as the country-industry of completion, they show that during 1995-2008 the German share of factors in the final output of the German automotive industry declined for less-skilled domestic labor (mostly for low- and medium-skilled workers). However, that decline was not a direct reflection of the structural changes in the foreign less-skilled labor. Instead, according to Timmer et al. (2015), it is eventually explained by the lower foreign wages and by the fact that those foreign activities were substituted by automation, as indicated by the significant increase in the share of foreign capital. According to the authors, those results highlight the relevance of the substitution across factors as a driver for the international fragmentation of production.

Recently, Miroudot and Ye (2017) emphasized the need for industry-level decomposition techniques. They propose a framework, similar to Los, Timmer and de Vries (2015), in which the source industry, the exports industry and the final demand industry are clearly identified. The authors argue that “neither the KWW framework nor the hypothetical extraction method can be easily extended to decompose the value-added in gross exports at the industry level” (MIROUDOT; YE, 2017, p. 4). The “hypothetical extraction” method is a recent proposition made by Los, Timmer and de Vries (2016), later complemented by (Los and Timmer (2018) for the bilateral trade, with the intention to simplify the mathematically complex KWW framework. However, according to the authors, the method still needs further development as, so far, it is limited to calculations of aggregate GDP measures and does not offer a decomposition for the foreign value-added yet. Later in Sections 1.2 and 2.1, it is shown that the framework and indicators proposed in this Thesis are an attempt to respond part of the claims of Miroudot and Ye (2017).

Empirical Research on GVCs, Structural Change and Trade in Value-Added in Brazil

In the Brazilian economy, Morceiro (2016) argues that the discussion about the manufacturing competitiveness have been concentrated in an aggregate level of analysis and its macroeconomic effects, while rare sectoral studies are available. Hiratuka and Sarti (2015) argue that this debate is on the agenda about the Brazilian industrial development, but the authors remind that meaningful changes in the global economy, such as global competition and strategies of transnational corporations, were not “adequately” taken into consideration. Other works of Brazilian authors on GVCs and structural change have been analyzing the role of the services for the competitiveness of the manufacturing sector (CARDOSO; PEROBELLI, 2013; FORNARI; GOMES; HIRATUKA, 2016). A common argument among those authors is the recognition of the lack of a solid theoretical and empirical research on the nature of the services and how they integrate the production processes of the manufacturing (and primary) sector[19]. This gap is an opportunity to explore this topic using IO techniques to evaluate how the services sector are contributing to the fragmentation of production across GVCs.

Recent empirical works have proposed and applied decomposition techniques of trade in value-added to study the Brazilian participation in GVCs and its competitiveness in the international market (CORRÊA, 2016; FERRAZ; GUTIERRE; CABRAL, 2015; GUILHOTO; IMORI, 2014; HERMIDA; XAVIER, 2017; PEROBELLI; BASTOS; DE OLIVEIRA, 2017; TORRACCA; CASTILHO, 2015). Some of the difficulties for the

[19] The works on the role of services on the Brazilian economy are in line with the efforts of the empirical studies in the international literature. For a sample of contributions, see Miroudot (2017), Miroudot and Cadestin (2017), Peneder and Streicher (2018) and Verspagen and Kaltenberg (2015).

Brazilian manufacturing sector to improve its competitiveness, in terms of market share of the world exports, have been highlighted by evidences which show that the exports composition has increased towards agriculture and mining during 1995-2012.

The paper of Torracca and Castilho (2015) discusses the national and international performance of the Brazilian industry, revealing important differences between the competitiveness of the manufacturing industry in these two competitive environments. Regarding the international arena, they discuss the growing participation of commodities in the Brazilian exports, due to price and quantum effects. But they do not agree that the increased share of commodities export both in the Brazilian exports and in world exports of commodities is an indicator of deindustrialization. In fact, the Brazilian exports of manufacturing products have grown faster than the world exports of the same product in the period 2000-2013. They also note that exports of commodities were incentivated by the surge of the Chinese market and that the export of manufacturing of more sophisticated goods were not impaired, two other reasons to put aside a possible relation between the growth of commodities exports and the deindustrialization process.

In fact, the competitiveness of the Brazilian industry in the domestic market is related to other factors. Among these, Torracca and Castilhos emphasize the imports side. They provide evidences of the growing exposure of Brazilian manufacturing to imports, since the 2000s. The import penetration indicator showed that each broad economic category (durable consumer goods, intermediate goods, non-durable consumer goods, capital goods) was affected in a different way, but all of them increased during 2000-2014[20]. For durable consumer goods, the cumulative growth was higher than 500%during 2000-2013.

Morceiro (2016) compares the levels of manufacturing production, domestic demand and total demand (production plus imports) during 2000-2013[21]. Along the period of analysis, the manufacturing production increased 33.9 p.p., while the total demand increased 55.3 p.p. This difference, according to the author, indicates a “demand leakage” to foreign industries that was supplied by imports, a result that confirm the decrease of the competitiveness of the manufacturing sector. Morceiro (2016) also shows that, for disaggregate industries, for instance, the total demand for high- and medium-high-technology (HT and MHT)

[20] The import penetration (IP) indicator is measured by the dividing the quantum index of imports by the apparent consumption, which is the sum of domestic production and imports net of exports. The IP was calculated with data at constant prices from IPEA (apparent consumption) and FUNCEX (quantum index).
[21] For that conclusion, Morceiro (2016) uses data at basic and constant prices. See the main text for details.

manufactures grew 2.7 times more than the total demand for medium-low- and low-technology manufactures (MLT and LT), 88.9% and 33.5%, respectively. The production of HT and MHT increased 53.1% and of MLT and LT, 23.6%. Based on those figures, Morceiro (2016) concludes that the Brazilian industries have lost competitiveness in HT and MHT industries much more than in MLT and LT industries. The author's results not only are in line with Torracca and Castilho (2015), but confirms that the loss of competitiveness in Brazilian manufacturing is even more evident in the more dynamic and knowledge-intensive industries. Sarti and Hiratuka (2017) also presents similar arguments regarding the low performance of the manufacturing competitiveness, highlighting that the behavior remained during 2011-2014, not because of the lack of domestic demand, but due to the demand leakage through imports increase and also to subsequent reduction of the productive linkages, as a result of the decrease in the private investment. Those findings and arguments definitely pose complex challenges to Brazilian policymakers[22].

Guilhoto and Imori (2014) applies a decomposition technique of the value-added, similar to the one proposed by Timmer et al. (2014), to analyze the Brazilian integration to GVCs. The difference is that they also are concerned with the contribution from the buyer perspective (products destination). The authors use the WIOD 2013 and the 2005 IDE's BRICS international IO table[23]. Their results are in line with other works that reveal the limited participation of Brazilian economy in GVCs and trade in value-added, but with an increasing trend during 1995-2011. In the sectoral-level, the mining and metallurgical industries generated larger shares of exports of value-added, mainly to China.

Perobelli, Bastos and Oliveira (2017) propose indexes of direct and direct plus indirect intensity to measure the productive integration of the manufacturing sector to other sectors, based on the IO model. The authors' hypothesis is that manufacturing industries are responsible for driving technological change, higher productivity and inter-industrial linkages and, for that reason, the more the manufacturing sector is integrated to the rest of the economy, the higher the economic development will be. The WIOD 2013 matrices for Brazil from 1995 to 2009 are applied in the empirical analyses with an aggregation of the original 35

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[22] As Verspagen and Kaltenberg (2015) argue, the domestic market is the main driver of economic growth in global terms and the specialization in more sophisticated products have a relative potential to increase the competitiveness of manufacturing and to foster the catching up process of developing countries.

[23] The IDE's BRICS database is used to provide a comparison of the bilateral trade.

industries into 20[24]. Among the main findings, Perobelli, Bastos and Oliveira (2017) show that the manufacturing sector in Brazil is more integrated to its own productive process (intra-sectoral integration), which means higher indexes of direct and direct plus indirect intensities than the other sectors. However, there is a decreasing tendency, revealing that the manufacturing is losing "industrial intensity". In the case of the primary and services sectors, both have become more integrated to the productive processes of manufacturing. According to Perobelli, Bastos and Oliveira (2017), if their indexes are used as a measure of deindustrialization, the disaggregate analyses reveal that it is occurring in the industries of lower technology intensity (extractive industries, textiles, wearing apparel and leather products), which presented reduction in both indexes.

Comparative Advantages and International Competitiveness

The literature on GVCs and trade in value-added also stimulated scholars to propose and apply new indicators of international trade specialization based on the original Balassa (1965)'s measure of *Revealed Comparative Advantage* (RCA)[25]. The works on this strand of research highlight the advantages of measuring the RCA in value-added instead of gross terms to provide a more precise measure of international specialization (BRAKMAN; VAN MARREWIJK, 2017; HERMIDA; XAVIER, 2017; KOOPMAN; WANG; WEI, 2014; TIMMER et al., 2013).

KWW compare the results of the RCA calculated in gross and value-added terms, finding significant differences among two industries for all countries in their database in 2004, "finished metal products" and "real state, renting, and business". For instance, in "finished metal products", Brazil presents a comparative disadvantage, with a gross RCA measure of 0.59, 14th in the ranking, although in value-added RCA it presents a comparative advantage, with a measure of 1.18, 6th in the ranking. In "real state, renting, and business", India is the 2nd in the ranking of gross RCA with a measure of 2.4, but with value-added RCA of 0.7, it drops to 13th position. Those variations in the measures of RCA, depending on the way the exports is measured, gross or value-added terms, are in line with other works (BRAKMAN; VAN MARREWIJK, 2017; TIMMER et al., 2013).

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[24] Industry 1 for agriculture, Industry 2 for "extractive industries", Industries 3-18 for "manufacturing industries", Industry 19 for "commerce" and Industry 20 for "other services".

[25] The RCA of an industry is calculated by dividing its exports share in the country's total exports by the world exports share of that same industry in the world's total exports.

Brakman and van Marrewijk (2017) propose a novel approach, by comparing the probability distributions of the RCA in terms of gross exports and value-added, instead of the usual industry-by-industry RCA comparison. They use who use data of the WIOD 2013 release covering 40 countries and 32 industries over a 15 years period (1995-2009). Applying their novel methodology to data of unemployment and RCA after the 2008 World crisis, the authors conclude that, although both measures of RCA (in value-added and gross terms) produce, in general, different results between countries and industries, the RCA calculated in value-added terms represents the real economy better than RCA calculated in gross terms. Among Brakman and van Marrewijk (2017) general conclusions, it's worth highlighting that: (i) different countries specialize differently, both in gross exports or value-added RCA measures; (ii) most industries that are considered strong (or weak) in gross exports RCA, are also considered strong (or weak) in value-added RCA, but this does not always hold, and some industries are classified differently depending on the RCA measure (gross or value-added); and (iii) the most frequent switches from weak to strong and strong to weak happens in wood, construction, wholesale trade, education, electricity, petroleum and health, and the lest frequent switches are in textiles, chemicals, water transport, and air transport.

Timmer et al. (2013, p. 6) define competitiveness as "the ability to perform activities that meet the test of international competition and generate increasing income and employment". They propose novel measures based on value added on manufacturing final goods, called "GVC income" and "GVC jobs". "GVC income" indicates the price paid by final demand for a good that end up as income for all labor and capital involved in the production process. "GVC jobs" is the number of jobs directly and indirectly required in the production process. In terms of RCA[26], their results revealed that fragmentation seems to be related to higher RCA levels, increasing the specialization of European countries in activities that require high-skilled workers[27]. A result that contradicts the RCA measured in gross terms which had suggested a stagnation in the specialization pattern in Europe.

Hermida, Xavier and Silva (2016) tested an econometric model to investigate the relationship between trade and economic growth, using variables related to the formation of GVCs and the international fragmentation of production. Adopting GDP per capita as

[26] Timmer et al.(2013) considers the RCA as a country's share in the world GVC income, considering a group of manufactures divided by the same ratio for all manufactures.

[27] By activities, the authors refer to those directly and indirectly related to the production of final products within manufacturing sector but also in supporting industries (business, transport and communication and finance services).

dependent variable and proxy for economic development, they confirmed that among other factors, the investment presented a positive significant for different specified models using panel data and the Generalized Method of Moments. The authors argue that the investment have been fundamental for economic growth of many countries, for the effects on income generation and the direct impact on the international competitiveness through its production capabilities.

In a recent contribution, Hermida and Xavier (2017) proposes a novel approach to evaluate the international competitiveness of Brazilian exports during 1995-2011. They use indexes of RCA and market share (MS) in comparative analyses with selected economies (China, India, Japan, Mexico, Russia and USA). For both indexes, they use data from the WIOD 2013 on gross exports and value-added exports. Among their relevant conclusions, they find that countries holding a downstream position, characterized mostly as assemblers have overestimated values of RCA and MS, when measured in gross terms. In fact, when measured in value-added terms, both their indexes decreased. In the case of countries holding an upstream position, as Brazil, most industries present underestimated indexes measured in gross terms, when the value-added indexes reveal increases in RCA and MS measures at the industry level.

Hermida and Xavier (2017) show that, in particular for primary industries, Brazilian competitiveness and specialization have increased during 2000-2005 in gross terms. However, the value-added indexes reveal a decrease in the RCA values. Besides, the industries in which Brazil traditionally presents higher comparative advantages, such as primary goods and low-technology manufactures, are those which revealed overestimation in the gross RCA and MS measures (both higher than value-added RCA and MS measures). For the authors, such results indicate a fragile competitiveness in those industries, possibly because of the increase in the import content of intermediates to the final goods production before exports.

The conclusions of Hermida and Xavier (2017) are similar to the previous panel econometric analyzes presented by Holland and Xavier (2005), who evaluated the Brazilian industries competitiveness during 1997-2001, using the Pavitt taxonomy as an aggregation criteria based on the technology intensity. First, they tested and confirmed the hypothesis that the Brazilian exports have a positive relation with the comparative advantages. However, in the second hypothesis, the exports present a negative relation with the contribution to the trade balance. According to Holland and Xavier (2005), the only exception is the "industry intensive in other crop resources" which presented high values of comparative advantages and a proportional contribution to the trade balance, even with a low MS. Some exporting industries changed from a negative to a positive contribution to the trade balance after the year 2000, such as the "R&D intensive industry" and the "industry intensive in energy resources".

1.1.3 Effects of the Aggregate Demand in the Brazilian Economy

Recent works have analyzed the performance of the Brazilian economy after 2000 on the perspective of the aggregate demand and its relation to the value-added, the imports and the exports (BIELSCHOWSKY; SQUEFF; VASCONCELOS, 2015; MIGUEZ, 2016; MORCEIRO, 2012, 2016; SANTOS et al., 2016; SARTI; HIRATUKA, 2017; SERRANO; SUMMA, 2015; SILVA; LOURENÇO, 2014). Those studies seem to agree and provide evidences to confirm that since mid-2000s to 2010 Brazil presented growth rates higher than world average in the same period[28].

Among the reasons to that expansion, the most often cited are the favorable external conditions[29] and a slight change in the domestic macroeconomic policies (MIGUEZ, 2016; SERRANO; SUMMA, 2015), and the increase in the domestic demand (MORCEIRO, 2016; SARTI; HIRATUKA, 2017; SILVA; LOURENÇO, 2014). In the same line, Bielschowsky, Squeff and Vasconcelos (2015) indicate the three main drivers to the expansion in the period 2003-2008, arguing in favor of their potential to promote structural changes in the long-run, such as (i) the public and private infrastructure (GFCF), (ii) the strong domestic and foreign demand for Brazilian natural resources and (iii) the sizable domestic market for households' consumption.

Despite the controversies of causation[30], Silva and Lourenço (2014) argue that, traditionally, the components of the aggregate demand that lead the contribution to the economic growth are the autonomous consumption, governmental expenditures and exports.

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[28] Morceiro (2016) shows that Brazilian and World GDP grew 4.01 and 2.93% per year, respectively, during 2004-2013. In the same line, Serrano and Summa (2015) reveal that during 2004-2010 the average GDP growth was 4.4%, which is twice than the observed growth during 1995-2003.

[29] For Silva and Lourenço (2014), during most part of the Lula governments, the relative favorable external conditions were the world economy growth, the "China-effect" with its increasing demand for Brazilian exports, the improvements in the terms of trade, among others. Morceiro (2016) also reveals the favorable terms of trade during 2003-2013, which contributed to revert the trade deficit in the period, due to the increase in the commodities prices driven mainly by the industrialization process in China.

[30] It's out of the scope of this Thesis the existing discussion between different strands of economic thinking about the causality relation between aggregate demand (or industrial output) and economic growth.

Santos et al. (2016) tests econometric models that confirmed the strong relation between the GFCF and the GDP, including the relevance of the GFCF in machinery and equipment and the positive relation between private investment and public investment. Part of the private investment (except for construction) (AFTALION, 1913; HICKS, 1950; SAMUELSON, 1939; THIRLWALL, 1979), besides the imports and part of the private consumption are usually considered as variables induced by variations in the autonomous components of the aggregate demand (apud SILVA; LOURENÇO, 2014, p. 27). However, several authors indicate an important autonomous component of the private investment, which is linked to financial and technological aspects and to the corporate leaderships expectations under uncertainty context (KALECKI, 1954; KEYNES, 1996; SCHACKLE, 1968 apud SILVA; LOURENÇO, 2014, p. 27).

Silva and Lourenço (2014) highlight that a relative higher growth of a specific component compared to the others does not necessarily mean that its contribution has been higher to economic growth, once it depends on the component's share of the aggregate demand (SILVA; LOURENÇO, 2014). Their conclusions are based on data of the aggregate demand and its components of the Brazilian economy during 1999-2010[31]. During the period of rapid economic growth (2003-2010), the average growth of the households' consumption (4.8 p.p.) was lower than the GFCF (9.3 p.p.), which in this case includes private and public investment. However, the contribution of the households' consumption to the GDP growth was 2.6 p.p. against 1.14 p.p. of the total GFCF.

Serrano and Summa (2015) debate the economic slowdown of 2011-2014, comparing this period with a previous one of faster growth, 2004-2010 (the "rapid growth"). They attribute the economic slowdown mainly to the decline of the investment rate, due to policy measures of the government, in opposition to other interpretations that favor the reduction in exports and changes in the productive structure due to an appreciated exchange rate and the international financing conditions.

In terms of exports, Serrano and Summa (2015) show that during 2011-2014 the average growth was 1.6 p.p., much lower than the previous period, 2004-2010, when it achieved 5.2 p.p., including a strong slowdown of 11.6 p.p., in 2010, to 5.1 and 0.1 p.p., in 2011 and 2012, respectively. Although the exports had a significant average growth during 2004-2010, its share of the GDP is around 10-12%, that is why the authors argue that the

[31] The data source is IPEA – www.ipeadata.gov.br.

exports behavior cannot be the main responsible component to the economic growth as a whole. They also attribute the exports slowdown mainly to the world demand slowdown, not to the appreciation of the exchange rate.

Regarding the imports, they debate the proposition that the increase of the import coefficient was a leakage of domestic demand that has favored the foreign production. They have estimated the import coefficient in 11.6%, 10.9% and 12.5% respectively in 2004, 2011 and 2014. They reach the conclusion that the increase in the import coefficient in the last period is not enough to produce the economic slowdown that occurred.

In terms of the households' consumption, they show the same growth tendency than Silva and Lourenço (2014), that is, during 2004-2010, the average growth of the households was 5.3 p.p., including 6.4 only in 2010. After the rapid growth period, a slowdown of the households' consumption started, when the average growth decreased to 3.1 p.p., during 2011-2014. The Table 2 summarizes the figures of the aggregate demand given by Serrano and Summa (2015).

Table 2. Sample of Brazilian macroeconomic indicators during 2004-2010 and 2011-2014.

	2004-2010	2011-2014	2014
GDP	**4.4**	**2.1**	**0.1**
Industrial output	**3.6**	**-0.9**	**-4.2**
Aggregate demand components			
Households' consumption	5.3	3.1	1.3
Public administration consumption	3.2	2.2	1.2
Investment	8.0	1.8	-4.4
Machinery and equipment	12.3	-0.7	-8.7
Construction	5.8	2.8	-3.7
Exports	5.2	1.6	-1.0
Imports	13.4	4.1	-1.1

Note: All figures are in percentage points.
Source: Adapted with data provided by Serrano and Summa (2015).

The authors conclude their study emphasizing that the main cause of the economic slowdown in the recent period 2011-2014 was due to changes in the orientation of the macroeconomic policies, when incentives to the private sector (reduced interest rates, large tax breaks, exchange rate devaluation) were given hoping it would lead the economic growth through autonomous investments and exports. According to Serrano and Summa (2015), their analysis also sustains the argument that a supposed deindustrialization process is much more related to the decrease of the investment growth rates, rather than to the appreciation of real exchange rate, a thesis supported by other scholars. A conclusion that is in line with other studies on the Brazilian economy and the causes of the reduction of the manufacturing participation in the GDP (MORCEIRO, 2012; SANTOS et al., 2016; SILVA; LOURENÇO, 2014). In addition, based on the empirical analyses of Sarti and Hiratuka (2017), the scenario during 2014-2016 was even worse.

After this literature review, the next section details the analytical framework adopted by this Thesis. Although the basic concept of IO analysis is extensively available in the literature, a brief description of the theory in a single-country case to contextualize its application to the world economy. Then, it extends the basic model to the conceptual framework of the IO analysis applied on the research of the international fragmentation of production across GVCs and trade in value-added.

1.2 ANALYTICAL FRAMEWORK: IO ANALYSIS, GVCs, TRADE IN VALUE-ADDED

1.2.1 Basic Concepts of IO Analysis

The basic model of the IO analysis advanced by Wassily Leontief uses information of the flows of output produced by one industry as inputs (intermediates) for other industry or as final goods and services for the final demand for households' consumption. government purchases. investment and exports. Those inter-industrial transactions are represented in the well-known IO tables. The development of that type of table derives from the expanded IO table of transactions for national economies. The basic concepts are presented in the remainder of this section[32].

Assume that a country's economy is formed by K industries. Consider $\boldsymbol{x}$ a column vector containing the values x_i of the total output of each industry. If $\boldsymbol{f}$ is a vector representing the final demand levels f_i for the output of each industry in $\boldsymbol{x}$, and $\boldsymbol{Z}$, a $K \times K$ matrix with intermediates sales values z_{ij} to all industries. the following equation accounts for the transactions between industries inputs and final demand:

[32] The brief explanation of the IO analysis in this section draws on the detailed presentation of the concept found in Miller and Blair (2009) with minor changes in notations.

$$\boldsymbol{x} = \boldsymbol{Z}\boldsymbol{i} + \boldsymbol{f}$$

Where $\boldsymbol{i}$ is a $K \times 1$ column vector of 1's. As $\boldsymbol{Z}$ is post-multiplied by $\boldsymbol{i}$. the result is a column vector with the row sums of the matrix $\boldsymbol{Z}$. The contents of the vectors $\boldsymbol{x}$ and $\boldsymbol{f}$ and the matrix $\boldsymbol{Z}$ are shown below:

$$\boldsymbol{x} = \begin{bmatrix} x_1 \\ \vdots \\ x_K \end{bmatrix}. \quad \boldsymbol{Z} = \begin{bmatrix} z_{11} & \cdots & z_{1K} \\ \vdots & \ddots & \vdots \\ z_{K1} & \cdots & z_{KK} \end{bmatrix} \quad \text{and} \quad \boldsymbol{f} = \begin{bmatrix} f_1 \\ \vdots \\ f_K \end{bmatrix}$$

Each industry j purchases intermediates from other industries. including its own output (intra-industry transactions). The total primary intermediates represent the value added in industry j. which includes labor and capital used in production and inventoried items. Naturally. imported inputs may also be used by industry j. All IO transactions of primary intermediates represented by $\boldsymbol{Z}$, including imports and output purchased by the final demand $\boldsymbol{f}$, are used to construct the complete set of income and product accounts for a national economy. This scheme also includes imports for final demand.

An example of an expanded IO table of transactions for a given economy with K industries is shown in the Table 3. The industries that demand intermediates also pay for employee compensation (L) and a whole set of other value-added (N), such as taxes, interests, rentals, profits etc.[33]. The total value-added (V), or total factor payments in the economy, is represented by $\mathrm{V} = L + N$. The total gross output throughout the economy (X) can be found by summing the contents of the last column in Table 3, the total output ($\boldsymbol{x}$), the total value-added (V) and the total imports of inputs and final products (M), which gives

$$X = x_1 + \cdots + x_K + V + M$$

As mentioned in the beginning of this section, part of the gross output of an economy is sold for the final demand components, on the domestic side: households' consumption (C). government procurement (G). private investment (I); and, on the foreign side: exports (E). By summing the total outlays of an economy, the result is the same value

$$X = x_1 + \cdots + x_K + C + I + G + E$$

33 The "circular flow of income and expenditures" is more complex than explained here and is beyond the scope of the Thesis. For details, see Miller and Blair (2009, pp. 122-132).

Table 3. Example of an expanded IO table of transactions in a generic national economy with K industries.

		Intermediates Demand			Final Demand				
		Industry 1	**...**	**Industry K**	**C**	**I**	**G**	**E**	**Total Output**
Supply	**Industry 1**	z_{11}	...	z_{1K}	c_1	i_1	g_1	e_1	x_1
	⋮	⋮	⋱	⋮	⋮	⋮	⋮	⋮	⋮
	Industry K	z_{K1}	⋮	z_{KK}	c_K	i_K	g_K	e_K	x_K
Value-Added (V)	**L**	l_1	...	l_K	l_C	l_I	l_G	l_E	L
	N	n_1	...	n_K	n_C	n_I	n_G	n_E	N
Imports	**M**	m_1	...	m_K	m_C	m_I	m_G	m_E	M
	Total Outlays	x_1	...	x_K	C	I	G	E	X

Source: Adapted from Miller and Blair (2009).

The two ways of calculating the total gross output can be equated, and after subtracting $\boldsymbol{x}$ on both sides, the result is

$$V + M = C + I + G + E$$

or

$$V = C + I + G + (E - M)$$

In the second expression, the left-hand side represents the gross national income and the right-hand side. the gross national product. including the total value of net exports. All these data are part of the System of National Accounts (SNA)[34] of a country's economy. Those two ways of calculating the total gross output represent an important accounting convention that is further explored in the World IO tables, which is presented in the next section.

An essential information in the IO analysis of an economic model. is the technical coefficient (a_{ij}). The traditional Leontief IO analysis works under some assumptions. In the case of the technical coefficients, they are assumed as constant. which means it measures fixed relationships between an industry's output and inputs. ignoring economies of scale in production. Another assumption is that the Leontief production functions require fixed proportions of inputs to be used by the industries to produce one unit of output.

[34] The formation of SNAs is beyond the scope of this Thesis. For a detailed explanation, see Miller and Blair (2009).

Through the technical coefficients, it is possible to trace the impact of the changes in one sector on the rest of the economy. It contains the intermediates quantity needed to produce one unity of output. Given that $\boldsymbol{A}$ is the matrix of technical coefficients, each value a_{ij} can be obtained by dividing each cell (z_{ij}) in a column of the intermediates matrix ($\boldsymbol{Z}$) by the gross output of the correspondent industry, that is

$$a_{ij} = \frac{z_{ij}}{x_j}$$

As all gross output of each industry must be used as intermediates or final products by other industries, the gross output can be expressed by the following equation:

$$x_i = \sum\nolimits_j (x_{ij}) + f_i$$

Re-arranging the technical coefficients equation, the result is

$$x_{ij} = a_{ij}.x_j$$

Then, applying a simple substitution, the total output of an industry is also given by

$$x_i = \sum\nolimits_j (a_{ij}.x_j) + f_i$$

By taking all rows (suppliers industries) in the economy and using the matrix notation. the gross output can be expressed as

$$\boldsymbol{x} = \boldsymbol{Ax} + \boldsymbol{f}$$

A simple manipulation of the previous equation using standard algebra results in the fundamental IO identity introduced by Leontief, given by

$$\boldsymbol{x} = (\boldsymbol{I} - \boldsymbol{A})^{-1}\boldsymbol{f}$$

The matrix resulting from $(\boldsymbol{I} - \boldsymbol{A})^{-1}$is the famous Leontief inverse, usually represented by $\boldsymbol{L}$. The matrix $\boldsymbol{I}$ is a $K \times K$ identity matrix. The matrix of technical coefficients represented by $\boldsymbol{A} = [a_{ij}]$ can be calculated as $\boldsymbol{A} = \boldsymbol{Z}\hat{\boldsymbol{x}}^{-\mathbf{1}}$. where $\hat{\boldsymbol{x}}^{-\mathbf{1}}$is a $K \times K$ diagonal matrix with the elements $1/x_j$ in the diagonal cells.

The Leontief inverse ($\boldsymbol{L}$) contains “the gross output values that are generated in all stages of the production process of one unit of consumption” (TIMMER et al., 2015, p. 580). The fundamental characteristic of the Leontief inverse is that it ensures that all contributions in all tiers of suppliers are taken into account. in order to produce all goods needed by the final demand (LOS; TIMMER; DE VRIES, 2015; MILLER; BLAIR, 2009). That property means that the product $(\boldsymbol{I}-\boldsymbol{A})^{-1}\boldsymbol{f}$ captures the effects in the economy of changes in final demand (household's consumption. government purchases etc.). in terms of output necessary to supply those changes.

In some empirical applications, instead of gross outputs, the impacts of exogenous final demands are required to be measured in terms of effects on employments, energy consumption, value-added etc.[35]. The transformation required to capture those effects, for instance, on the value-added, may be done by creating a vector of the total value-added per industry, or total payments factor $\boldsymbol{p}' = [p_1 = l_1 + n_1 \quad \dots \quad p_j = l_j + n_j]$[36] converting the gross outputs which generates the value-added into the desired measures (the reference is the basic model with K industries shown in Table 3).

To obtain those effects on the value-added, first, let's form the transpose vector $\boldsymbol{v}' = \boldsymbol{p}'(\widehat{\boldsymbol{x}})^{-1} = \left[{}^{p_1}/_{x_1} \quad \cdots \quad {}^{p_K}/_{x_K}\right]$ containing the value-added per unity of gross output in each industry. Then, the Leontief identity $\boldsymbol{x} = (\boldsymbol{I}-\boldsymbol{A})^{-1}\boldsymbol{f}$ is used to postmultiply $\widehat{\boldsymbol{v}}$, the diagonalized vector $\boldsymbol{v}$, which results in

$$\boldsymbol{va} = \widehat{\boldsymbol{v}}\boldsymbol{x} = \widehat{\boldsymbol{v}}(\boldsymbol{I}-\boldsymbol{A})^{-1}\boldsymbol{f} = \widehat{\boldsymbol{v}}\boldsymbol{L}\boldsymbol{f}$$

$$\boldsymbol{va} = \begin{bmatrix} v_1 & & \cdots & & 0 \\ & \ddots & & & \\ \vdots & & v_j & & \vdots \\ & & & \ddots & \\ 0 & & \cdots & & v_K \end{bmatrix} \begin{bmatrix} 1-a_{11} & \cdots & -a_{1j} & \cdots & -a_{1K} \\ \vdots & \ddots & \vdots & & \vdots \\ -a_{i1} & \cdots & 1-a_{ij} & \cdots & -a_{iK} \\ \vdots & & \vdots & \ddots & \vdots \\ -a_{K1} & \cdots & -a_{Kj} & \cdots & 1-a_{KK} \end{bmatrix}^{-1} \begin{bmatrix} f_1 \\ \vdots \\ f_i \\ \vdots \\ f_K \end{bmatrix}$$

$$\boldsymbol{va} = \begin{bmatrix} v_1 & & \cdots & & 0 \\ & \ddots & & & \\ \vdots & & v_j & & \vdots \\ & & & \ddots & \\ 0 & & \cdots & & v_K \end{bmatrix} \begin{bmatrix} l_{11} & \cdots & l_{1j} & \cdots & l_{1K} \\ \vdots & \ddots & \vdots & & \vdots \\ l_{i1} & \cdots & l_{ij} & \dots & l_{iK} \\ \vdots & & \vdots & \ddots & \vdots \\ l_{K1} & \cdots & l_{Kj} & \cdots & l_{KK} \end{bmatrix} \begin{bmatrix} f_1 \\ \vdots \\ f_i \\ \vdots \\ f_K \end{bmatrix}$$

The elements of the $K \times 1$ vector $\boldsymbol{va}$ are the total valueadded in each industry derived from gross output required by the exogenous final demand $\boldsymbol{f}$ (MILLER; BLAIR, 2009, p. 24).

Early in IO analysis applications. the restrictions in computer capacity needed to matrix inversions stimulated the adoption of alternative methods to obtain approximations to

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[35] This Thesis is concerned with the impacts of the final demand for goods and services on the trade in value-added.

[36] A prime denotes a transpose vector or matrix.

$\boldsymbol{L} = (\boldsymbol{I} - \boldsymbol{A})^{-1}$. One of those procedures. known as power series approximation. presents a useful economic interpretation to understand the flows of intermediates through the chain of suppliers until the final good production (LOS; TIMMER; DE VRIES. 2015; MILLER; BLAIR, 2009). The power series procedure requires some assumptions regarding the matrix $\boldsymbol{A}$. According to Miller and Blair (2009, p. 32). "[f]or input–output coefficients matrices with these two characteristics – $a_{ij} \geq 0$ and $\sum_{i=1}^{[K]} a_{ij} < 1$ for all j – it is possible to approximate the gross output vector $\boldsymbol{x}$ associated with any final demand vector $\boldsymbol{f}$ without finding $(\boldsymbol{I} - \boldsymbol{A})^{-1}$."

First, given that $\boldsymbol{A}$ is a square matrix. one may write $\boldsymbol{A}^2 = \boldsymbol{AA}$ and $\boldsymbol{A}^3 = \boldsymbol{AAA} = \boldsymbol{AA}^2$. Based on that, the following matrices product identity stands out

$$(\boldsymbol{I} - \boldsymbol{A})(\boldsymbol{I} + \boldsymbol{A} + \boldsymbol{A}^2 + \boldsymbol{A}^3 + \cdots + \boldsymbol{A}^K) = (\boldsymbol{I} - \boldsymbol{A}^{K+1})$$

Then, assume that when $K \to \infty$, $\boldsymbol{A}^{K+1} \to \boldsymbol{0}$ (or, all $a_{ij} \to 0$). That leads to

$$(\boldsymbol{I} - \boldsymbol{A})(\boldsymbol{I} + \boldsymbol{A} + \boldsymbol{A}^2 + \boldsymbol{A}^3 + \cdots + \boldsymbol{A}^K) = \boldsymbol{I}$$

Accordingly, from the definition of an inverse matrix

$$(\boldsymbol{I} - \boldsymbol{A})(\boldsymbol{I} + \boldsymbol{A} + \boldsymbol{A}^2 + \boldsymbol{A}^3 + \cdots + \boldsymbol{A}^K) = (\boldsymbol{I} - \boldsymbol{A})(\boldsymbol{I} - \boldsymbol{A})^{-\boldsymbol{1}}$$

$$(\boldsymbol{I} + \boldsymbol{A} + \boldsymbol{A}^2 + \boldsymbol{A}^3 + \cdots + \boldsymbol{A}^K) = (\boldsymbol{I} - \boldsymbol{A})^{-\boldsymbol{1}} = \boldsymbol{L}$$

By definition, $\boldsymbol{A}$ is a non-negative matrix and as all elements in $\boldsymbol{A}^K$ must approach zero under certain convergence conditions[37]. the Leontief inverse can also be approximated by

$$\boldsymbol{L} = (\boldsymbol{I} - \boldsymbol{A})^{-\boldsymbol{1}} = (\boldsymbol{I} + \boldsymbol{A} + \boldsymbol{A}^2 + \boldsymbol{A}^3 + \cdots)$$

Finally, the gross output $\boldsymbol{x}$ can be found as

$$\boldsymbol{x} = \boldsymbol{Lf} = (\boldsymbol{I} - \boldsymbol{A})^{-\boldsymbol{1}}\boldsymbol{f} = (\boldsymbol{I} + \boldsymbol{A} + \boldsymbol{A}^2 + \boldsymbol{A}^3 + \cdots)\boldsymbol{f} = \boldsymbol{f} + \boldsymbol{Af} + \boldsymbol{cf} + \boldsymbol{A}^3\boldsymbol{f} + \cdots$$

$$\boldsymbol{x} = \boldsymbol{f} + \boldsymbol{Af} + \boldsymbol{A}(\boldsymbol{Af}) + \boldsymbol{A}(\boldsymbol{A}^2\boldsymbol{f}) + \cdots$$

This result shows that each term after the first is obtained by postmultiplying $\boldsymbol{A}$ by the previous term. According to Miller and Blair (2009, p. 35), most of the effects induced by a

[37] For details on the series convergence, see Miller and Blair (2009).

certain final demand may be captured considering the first few terms in the power series procedure[38], usually until $\boldsymbol{A}^7\boldsymbol{f}$ or $\boldsymbol{A}^8\boldsymbol{f}$.

To obtain the total value-added measure ($\boldsymbol{va}$) with the power series procedure by postmultiplying $\hat{\boldsymbol{v}}$ by the $\boldsymbol{Lf}$ approximation, the result is expressed as

$$\boldsymbol{va} = \hat{\boldsymbol{v}}(\boldsymbol{I} - \boldsymbol{A})^{-1}\boldsymbol{f} = \hat{\boldsymbol{v}}\boldsymbol{f} + \hat{\boldsymbol{v}}\boldsymbol{A}\boldsymbol{f} + \hat{\boldsymbol{v}}\boldsymbol{A}(\boldsymbol{A}\boldsymbol{f}) + \hat{\boldsymbol{v}}\boldsymbol{A}(\boldsymbol{A}^2\boldsymbol{f}) + \cdots$$

As it was previously highlighted in this section, such result has an important economic interpretation, especially when one is interested in tracing the origin of the value-added contributions of the different stages of a production chain.

The conceptual method applied by this Thesis is built upon the two accounting concepts previously presented for the single-country economy. The next section describes how the power series procedure and the effects of the final demand in the value-added can provide a useful economic interpretation and application for the multi-region input-output (MRIO) model, also known as inter-country input-output (ICIO) model when the regions represent countries. In addition, it presents how those concepts are applied to build the accounting framework and the IO decomposition techniques adopted in this Thesis to analyze the fragmentation of production across GVCs and trade in value-added.

1.2.2 World IO Tables and Trade in Value-Added

The strand of research on GVCs which applies IO analysis and decomposition methods of the trade in value-added requires the construction of harmonized datasets, using data available on national IO tables, national supply and use tables (SUTs), national accounts and international trade statistics. Those datasets accounts for the interregional flows of intermediates and final products between countries. To understand how such databases are constructed. one should be familiarized with the concept of World Input-Output Table (WIOT).

A simplified schematic of a WIOT for N counties and K industries is outlined in Table 4. In the following explanation, it is assumed as an extension of the single-country case

[38] In a simple example of a two-sectors economy, Miller and Blair (2009, p. 34) show that more than 98% of the effects in both sectors associated with a given final demand are captured in three rounds.

(presented in the previous section) aiming to represent the trade flows on a global scale[39]. For simplification reasons, the same notation used in the previous section is adopted here.

Table 4. An example of a World Input-Output Table (WIOT).

			Intermediate consumption (demand)									Final consumption (demand)			Total
			Country 1				…	Country N				Country 1	…	Country N	consumption
			Industry 1	Industry 2	…	Industry K	…	Industry 1	Industry 2	…	Industry K		…		
Supply	Country 1	Industry 1	Domestic consumption of intermediates					Intermediates exports by country 1 to country N				Domestic final demand		Foreign final demand (N from 1)	
		Industry 2													
		…													
		Industry K													
	…	…													
	Country N	Industry 1	Intermediates exports by country N to country 1					Domestic consumption of intermediates				Foreign final demand (1 from N)		Domestic final demand	
		Industry 2													
		…													
		Industry K													
Value added by labor and capital															
Gross output															

Source: Ramos and Prochnik (2017).

The WIOT provides a summary of the trade flows in the global economy. Although it is a useful resource to empirical analyses of international trade, according to Timmer et al. (2015, p. 594), there is a limitation in any IO table, which is

> the assumption of homogeneity within industries. A column in a WIOT only provides the average production structure across all firms in a particular industry. These structures might be rather different for various types of firms.

Previous works found evidences of the impacts of the technology heterogeneity between industries and firms. especially when processing trade is pervasive in the economy[40].

The structure of the WIOT is analogous to the single-country case. Each row contains the values of the output per country-industry of origin. This production is to be consumed as intermediates by other industries or final products by households, governments or firms (gross fixed capital formation and stocks), which can be either domestic or foreign consumption. The cells of the diagonal submatrices of intermediate and final demand contain the values of the domestic demand. The other submatrices (outside the diagonal) contain the foreign demand, the inter-country trade.

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[39] The WIOT derives from the multi-regional input-output (MRIO) model (MILLER; BLAIR, 2009).The database used in this Thesis is formed by a set of WIOTs and will be further detailed in the Chapter 2.

[40] In the processing trade, there is no charge for foreign exchange but a processing fee. It means "the business activity of importing all or part of the raw and auxiliary materials, parts and components […] and re-exporting the finished products after processing or assembly by enterprises within the mainland" (HKTDC, 2015). Koopman, Wang and Wei (2012) provide a method to correct for the bias introduced by processing trade in the measures of import content. They found significant variations in the domestic value-added between exporting and non-exporting firms in China. In the case of Mexico, De la Cruz et al. (2011) apply the KWW method to measure the significant differences in the import content between maquiladoras and non-processing firms.

The development of the IO analysis indicators for the ICIO model is straightforward. A stylized WIOT is outlined in Table 5, illustrating its content represented by scalars, vectors and matrices notations for N countries and K industries. A four-dimension notation is required to represent trade flows in the WIOT.

Table 5. A stylized World Input-Output Table.

			Intermediate demand									**Final demand**			**Total demand**
			Country 1				⋯	Country N				Country 1	⋯	Country N	
			Industry 1	Industry 2	⋯	Industry K	⋯	Industry 1	Industry 2	⋯	Industry K	*FD Comp.*	⋯	*FD Comp.*	
Supply	Country 1	Industry 1	$\boldsymbol{Z}^{11}$				⋯	$\boldsymbol{Z}^{1N}$				$\boldsymbol{F}^{11}$	⋯	$\boldsymbol{F}^{1N}$	x_1^1
		Industry 2													x_2^1
		⋯													⋯
		Industry K													x_K^1
	⋯	⋯	⋯				⋱	⋯				⋯	⋱	⋯	⋯
	Country N	Industry 1	$\boldsymbol{Z}^{N1}$				⋯	$\boldsymbol{Z}^{NN}$				$\boldsymbol{F}^{N1}$	⋯	$\boldsymbol{F}^{NN}$	x_1^N
		Industry 2													x_2^N
		⋯													
		Industry K													x_K^N
Value added $(\boldsymbol{p}_j^s)^T$			p_1^1	p_2^1	⋯	p_K^1	⋯	p_1^N	p_2^N	⋯	p_K^N				
Gross output $(\boldsymbol{x}_j^s)^T$			x_1^1	x_2^1	⋯	x_K^1	⋯	x_1^N	x_2^N	⋯	x_K^N				

Source: Adapted from Los, Timmer and de Vries (2015).

In the supply side (rows), each industry i in a country s produces goods and services to be consumed elsewhere by industries j in any country r, that is, the demand/buying side (columns). In the case of the intermediates trade, transactions can be intra-industry, $i = j$, or inter-industry, $i \neq j$. Likewise, they can be domestic, $s = r$, or foreign, $s \neq r$. In the case of the final demand, final goods and services are sold by industries in the supply-side for domestic ($s = r$) or foreign ($s \neq r$) final demand.

Each column in the intermediates matrix $\boldsymbol{Z}$ contain the information on production processes and when they are expressed as ratios to gross output, the columns' cells inform the shares of intermediates in total costs (TIMMER et al.. 2015).Those shares are given by the technical coefficients matrix $\boldsymbol{A}$, similar to the single-country case. The inter-country technical coefficients can be obtained as

$$a_{ij}^{sr} = \frac{z_{ij}^{sr}}{x_j^r}$$

where, $i, j = 1 \ldots K$ and $s, r = 1 \ldots N$. In matrix notation, $\boldsymbol{A}$ is now a $KN \times KN$ square matrix that is obtained as

$$\boldsymbol{A}^{sr} = \boldsymbol{Z}^{sr}\boldsymbol{\hat{x}}^{-1}$$

where $\widehat{\boldsymbol{x}}$ is the $KN \times KN$ diagonalized output vector $\boldsymbol{x}$ with the elements $1/x_j^r$ in the diagonal cells.

Assuming the final demand $\boldsymbol{f}^r$ a $KN \times 1$ column vector with the aggregate final demand levels for each country r, the $KN \times N$ matrix $\boldsymbol{F} = [\boldsymbol{f}^1 \quad \cdots \quad \boldsymbol{f}^N]$ can be formed to represent the world final demand.

Usually the WIOT provides separate final demand components (e.g. households' consumption. governmental procurement. gross fixed capital formation etc.). Let C be the number of final demand components for each country r. Then, the final demand matrix can be represented by a $KN \times CN$ matrix $\boldsymbol{F} = [\boldsymbol{F}^1 \quad \cdots \quad \boldsymbol{F}^N]$, where $\boldsymbol{F}^r$expresses the $KN \times C$ final demand of country r with C components. As $\boldsymbol{F}^r$ contains the consumption of a country own final output and the final output imported from other countries, $\boldsymbol{F}$ can be easily expressed in $K \times C$ final demand submatrices $\boldsymbol{F}^{sr}$,

$$\boldsymbol{F} = \begin{bmatrix} \boldsymbol{F}^{11} & \cdots & \boldsymbol{F}^{1N} \\ \vdots & \ddots & \vdots \\ \boldsymbol{F}^{N1} & \cdots & \boldsymbol{F}^{NN} \end{bmatrix}$$

reminding that the final consumption can be either foreign ($s \neq r$) or domestic ($s = r$)

Let $\widehat{\boldsymbol{v}}$ be the diagonalized vector of value-added to gross output ratios in all K industries of each one of the N countries, calculated and expressed as

$$\widehat{\boldsymbol{v}} = \begin{bmatrix} v_1^1 = {p_1^1}/{x_1^1} & & \cdots & & 0 \\ & v_2^1 = {p_2^1}/{x_2^1} & & & \\ \vdots & & \ddots & & \vdots \\ & & & v_{K-1}^N = {p_{K-1}^N}/{p_{K-1}^N} & \\ 0 & & \cdots & & v_K^N = {p_K^N}/{p_K^N} \end{bmatrix} = \begin{bmatrix} \widehat{\boldsymbol{v}}^1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & \widehat{\boldsymbol{v}}^N \end{bmatrix}$$

where each $\widehat{\boldsymbol{v}}^s$ is the resulting diagonalization of the vector of value added in the K industries of each country s.

Adapting the fundamental Leontief identity for the ICIO model, the effects on the value added by the final demand for goods and services (considering C final demand components per country), reclassified by country-industry of origin, can be expressed by the $KN \times CN$ matrix $\boldsymbol{VA}$ as

$$\boldsymbol{VA} = \widehat{\boldsymbol{v}}(\boldsymbol{I} - \boldsymbol{A})^{-1}\boldsymbol{F} = \widehat{\boldsymbol{v}}\boldsymbol{LF}$$

or

$$\boldsymbol{VA} = [\boldsymbol{VA}^1 \quad \boldsymbol{VA}^2 \quad \cdots \quad \boldsymbol{VA}^N]_{KN\times CN}$$
$$= \begin{bmatrix} \widehat{\boldsymbol{v}}^1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & \widehat{\boldsymbol{v}}^N \end{bmatrix}_{KN\times KN} \begin{bmatrix} \boldsymbol{L}^{11} & \cdots & \boldsymbol{L}^{1N} \\ \vdots & \ddots & \vdots \\ \boldsymbol{L}^{N1} & \cdots & \boldsymbol{L}^{NN} \end{bmatrix}_{KN\times KN} \begin{bmatrix} \boldsymbol{F}^{11} & \cdots & \boldsymbol{F}^{1N} \\ \vdots & \ddots & \vdots \\ \boldsymbol{F}^{N1} & \cdots & \boldsymbol{F}^{NN} \end{bmatrix}_{KN\times CN}$$

where each $\boldsymbol{L}^{sr}$ is a $K \times K$ Leontief inverse submatrix[41].

In the above result for $\boldsymbol{VA}$, each $KN \times C$ matrix $\boldsymbol{VA}^r$ contains the value added in each KN country-industry resulting from exogenous changes in the final demand components $\boldsymbol{F}^r$ of each country r. For instance, the row cells of $\boldsymbol{VA}^1$ represents the value-added contribution of the KN country-industries to the total value-added consumed by $\boldsymbol{F}^1$, the row cells of $\boldsymbol{VA}^2$ represents the value-added contribution of the KN country-industries to the total value-added consumed by $\boldsymbol{F}^2$, and so on.

The proper choice of a specific final demand matrix allows for several different ways to analyze the GVCs and the value-added contribution of regions. countries and industries (LOS; TIMMER; DE VRIES, 2015; TIMMER et al., 2014, 2015). The next section describes some of those possibilities, especially those related to the Thesis objectives.

1.2.3 Accounting Framework for the GVC as the Country-Industry of Completion

This Thesis sees the GVC not as a set of interacting firms from subsequent sectors on the production chains, but as a set of value-adding activities, which is identified by the country-industry of the last stage of production, referred to as the “country-industry-of-completion”. This conceptual method was advanced by Los, Timmer and de Vries (2015) and Timmer et al. (2014, 2015). The particular interpretation of a GVC in the accounting framework is illustrated by the stylized example of an international fragmented value chain. shown in Figure 4.

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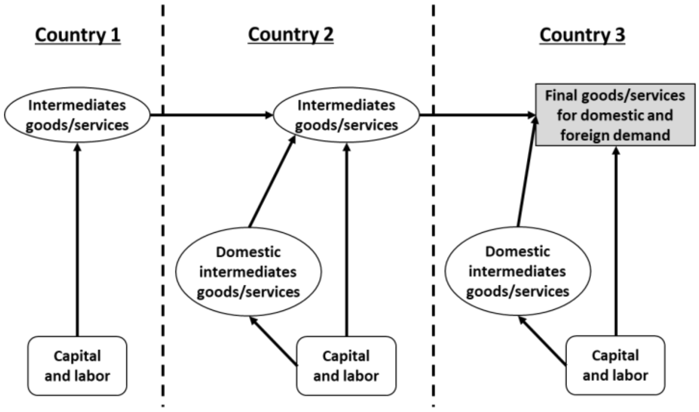
[41] For $s = r$, $\boldsymbol{L}^{sr}$ represents the intra-country effects, and for $s \neq r$, $\boldsymbol{L}^{sr}$ represents the inter-countries effects (spillover effects). When $\boldsymbol{v}$ is postmultiplied by $\boldsymbol{L}$, the resulting product $\boldsymbol{vL}$ allows for the analysis of the intra- and inter-country interdependence in terms of value-added due to exogenous changes in final demand $\boldsymbol{F}$ (GUILHOTO; IMORI, 2014).

Figure 4. Stylized example of an internationally fragmented value chain.



Source: Adapted from Los, Timmer and de Vries (2015).

The value added in the last stage of production (country 3) is also considered as a contribution to the value of the final good or service, or, the country-industry of interest. Therefore, the production of the final product (good or service) requires not only labor and capital in the country-of-completion, but also intermediates and labor and capital from all previous tiers of suppliers.

The first tier of value-adding activities in the country-industry-of-completion (country 3) can be calculated by

$$\boldsymbol{VA}^{Tier_0} = \hat{\boldsymbol{v}}\boldsymbol{F}^{Industry}$$

where $\boldsymbol{F}^{Industry}$ is the final demand (domestic and foreign) for the country-industry of interest, which means all rows of $\boldsymbol{F}$ are set to zero, except for the row whose cells represent the final demand values for the country-industry of interest. The production of the final product also requires intermediates, domestic and foreign, that come from the output produced by the first tier of suppliers ($\boldsymbol{AF}^{Industry}$), which generates value-added that can be calculated by

$$\boldsymbol{VA}^{Tier_1} = \hat{\boldsymbol{v}}\boldsymbol{AF}^{Industry}$$

To produce its output, the first tier of suppliers also requires domestic and foreign intermediates from a second tier of suppliers ($\boldsymbol{AAF}^{Industry}$), which also generates value-added that can be calculated by

$$\boldsymbol{VA}^{Tier_2} = \hat{\boldsymbol{v}}\boldsymbol{A}(\boldsymbol{AF}^{Industry}) = \hat{\boldsymbol{v}}\boldsymbol{A}^2\boldsymbol{F}^{Industry}$$

That derivation continues for higher tiers indefinitely. The summation of all tiers is then expressed as

$$\begin{aligned} \boldsymbol{VA}^{Industry} &= \boldsymbol{VA}^{Tier_0} + \boldsymbol{VA}^{Tier_1} + \boldsymbol{VA}^{Tier_2} + \cdots \\ &= \widehat{\boldsymbol{v}}\boldsymbol{F}^{Industry} + \widehat{\boldsymbol{v}}\boldsymbol{A}\boldsymbol{F}^{Industry} + \widehat{\boldsymbol{v}}\boldsymbol{A}^2\boldsymbol{F}^{Industry} + \cdots \\ &= \widehat{\boldsymbol{v}}(\boldsymbol{I} + \boldsymbol{A} + \boldsymbol{A}^2 + \cdots)\boldsymbol{F}^{Industry} \end{aligned}$$

This expression for $\boldsymbol{VA}^{Industry}$ can be rewritten using the power series approximation for $(\boldsymbol{I} - \boldsymbol{A})^{-1}$, as explained in the previous section.

Therefore, the value-added contributions for the GVC of the country-industry of interest can expressed as

$$\boldsymbol{VA}^{Industry} = \widehat{\boldsymbol{v}}(\boldsymbol{I} - \boldsymbol{A})^{-1}\boldsymbol{F}^{Industry}$$

For some applications, it is convenient to rearrange the final demand $\boldsymbol{F}$ to become a square matrix $KN \times KN$, so that the value-added contribution of each country-industry of origin to the final product of each GVC in the world can be accounted[42] (LOS; TIMMER; DE VRIES, 2015; TIMMER et al., 2014, 2015). The accounting framework for GVCs resulting from this arrangement of the final demand $\boldsymbol{F}$ as a square matrix can be seen in the Figure 5.

Figure 5. An accounting framework for GVCs.

			Final products of a global value chain, identified by country-industry of completion							**Value added**
			Country 1			…	Country M			
			Industry 1	…	Industry N		Industry 1	…	Industry N	
Value added from country-industries participating in global value chains	Country 1	Industry 1								
		…								
		Industry N								
	…	…								
	Country M	Industry 1								
		…								
		Industry N								
Total final output value										**World GDP**

Note: This accounting framework was designed for the conceptual method developed by the research group of the Groningen Growth and Development Center (GGDC).
Source: Los, Timmer and de Vries (2015) and Timmer et al. (2014, 2015).

It results from the conceptual approach previously explained, which is concerned with the value added by each country-industry of origin (rows) to the value-added structure of the GVC (columns), given a final demand. The methodology and indicators presented in the

[42] When $\boldsymbol{F}$ represents the total consumption outside a given country (exports), the calculation provided by $\boldsymbol{VA}$ is usually referred as VAX, introduced by Johnson and Noguera (2012a), and measures the domestic value-added embodied in final expenditures abroad (TIMMER et al., 2015).

Chapter 2 that are applied in the empirical analyses of this Thesis derives from the accounting framework aforementioned.

More recently, Miroudot and Ye (2017) compare the relevance of the approach derived from the framework and highlight its (necessary) flexibility to analyze the international fragmentation of production based on three important dimensions[43], such as

> the source industry (i.e. the industry of origin of primary inputs used to generate the value-added in exports), the gross exports industry (i.e. the industry that has produced the gross exports which are decomposed into different value-added terms) and the final demand industry (i.e. the last industry using the value-added identified in exports before final consumption).

What Miroudot and Ye (2017, p. 4) call “the source industry” (first dimension) and “the final demand industry” is directly obtained by the accounting framework which is proposed in this section.

1.3 CONCLUDING REMARKS

After a review of the recent literature on the strands of research aligned with the Thesis objectives, this chapter presented the theoretical background based on the Leontief tradition for a single-country, and extended its basic concepts to the global scale in order to apply provide the analytical framework on the GVC concept. The proposed enhanced decomposition technique follows the conceptual method advanced by Los, Timmer and de Vries (2015).

Among several accounting measures, the accounting framework at the core of this Thesis’ objectives allow for two important decompositions. For instance, when one focus on the value added in exports, in which

> the sum of the […] matrix across columns along a row traces the forward linkages across all downstream sectors from a supply-side perspective and provides the source industry decomposition. And the sum of the […] matrix across rows along a column traces backward linkages across upstream sectors from a users’ perspective and provides the gross exports industry decomposition. Miroudot and Ye (2017, p. 26)

The analytical method proposed is also applied in the empirical analyses to evaluate the domestic market perspective.

[43] For Miroudot and Ye (2017, p. 26), “neither the KWW framework nor the hypothetical extraction method can be easily extended to decompose the value-added in gross exports at the industry level”. The “hypothetical extraction” method is a new decomposition approach that still needs further development, because so far it applies to the calculation of the country’s aggregate GDP. For details on the hypothetical extraction method, see Los and Timmer (2018) and Los, Timmer and de Vries (2016).

2. METHODOLOGY

This Chapter is dedicated to present the method, the database and the indicators applied in the empirical analyses of this Thesis. In the first section, the method adopted by this work is introduced, providing a detailed presentation of the development of the quantitative indicators. They take into consideration (i) the origin of the value added by the country-industry-of-completion and (ii) the intra- and inter-industry (country) linkages of the GVCs. The second section describes the WIOD, highlighting its advantages and limitations to study the GVCs and the trade in value-added. In the third and last section, it is presented the taxonomy of technology intensity adopted to classify the industries of the database and how this classification is useful for the empirical analyses. The final section summarizes the Chapter.

2.1 INDICATORS FOR IO ANALYSIS AND TRADE IN VALUE-ADDED

In the Section 1.2, the theoretical background of the frameworks adopted in this Thesis were detailed. As it was explained, the quantitative techniques and indicators presented here are part of a recent body of research that have been proposing enhanced IO decomposition techniques[44] (JOHNSON; NOGUERA, 2012a; KOOPMAN; WANG; WEI, 2014; LOS; TIMMER; DE VRIES, 2016; TIMMER et al., 2014, 2015). These works, and many others, result from extensions of the VS measure pioneered by Hummels, Ishii and Yi (2001). The increasing quality of the new MRIO databases stimulates the emergence of such empirical methods.

In this Thesis, the proposed indicators for the trade in value-added decomposition are applied to provide an *ex post* analysis of the structural changes in the value-added shares of the primary, manufacturing and services sectors, induced by the final demand for goods and services, considering the country-industry of origin of the value-added. In that sense, the accounting framework advanced by Los, Timmer and de Vries (2015) and Timmer et al. (2014). as shown in Figure 5, is the reference to the proposed indicators.

[44] All the recent enhancements found in the literature are based on the decomposition techniques first introduced and developed by Leontief (1936).

Recurring to the formula derived in the Section 1.2.3, the value-added contributions for the GVC of the country/industry of interest can expressed as

$$\boldsymbol{VA}^{Country/Industry} = \hat{\boldsymbol{v}}(\boldsymbol{I}-\boldsymbol{A})^{-1}\boldsymbol{F}^{Country/Industry}$$

The rearrangement of the final demand $\boldsymbol{F}$ to become a square matrix $KN \times KN$ requires a diagonalization of the $K \times C$ submatrices $\boldsymbol{F}^{sr}$ in such a way that the output value of the final product delivered by each country-industry is represented in the diagonal cells.

Let $d = 1 \dots C$ be the index of the number C of final demand components. Now, consider $\sum_d (f_i^{sr})^d = (f_i^{sr})^1 + \cdots + (f_i^{sr})^C$ the sum of the columns cells along the row i of the C final demand levels of the buying country r supplied by the industry i of the country s. The $K \times 1$ vector $\boldsymbol{f}^{sr}$ is expressed as

$$\boldsymbol{f}^{sr} = \begin{bmatrix} (f_1^{sr})^1 + \cdots + (f_1^{sr})^C \\ \vdots \\ (f_K^{sr})^1 + \cdots + (f_K^{sr})^C \end{bmatrix} = \begin{bmatrix} \sum_{\boldsymbol{d}} (f_1^{sr})^d \\ \vdots \\ \sum_{\boldsymbol{d}} (f_K^{sr})^d \end{bmatrix}$$

Then, the $KN \times KN$ final demand $\boldsymbol{F}$ is formed by an adequate arrangement of $\hat{\boldsymbol{f}}^{sr}$ (the $K \times 1$ vector f^{sr} after diagonalization) can be expressed as[45]

$$\boldsymbol{F} = \begin{bmatrix} \hat{\boldsymbol{f}}_j^{11} & \cdots & \hat{\boldsymbol{f}}_j^{1N} \\ \vdots & \ddots & \vdots \\ \hat{\boldsymbol{f}}_j^{N1} & \cdots & \hat{\boldsymbol{f}}_j^{NN} \end{bmatrix} = \begin{bmatrix} f_1^{11} & & & & \cdots & f_1^{1N} & & & \\ & f_2^{11} & & & \cdots & & f_2^{1N} & & \\ & & \ddots & & \cdots & & & \ddots & \\ & & & f_K^{11} & \cdots & & & & f_K^{1N} \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \vdots \\ f_1^{N1} & & & & \cdots & f_1^{NN} & & & \\ & f_2^{N1} & & & \cdots & & f_2^{NN} & & \\ & & \ddots & & \cdots & & & \ddots & \\ & & & f_K^{N1} & \cdots & & & & f_K^{NN} \end{bmatrix}$$

When postmultiplying $\hat{\boldsymbol{v}}(\boldsymbol{I}-\boldsymbol{A})^{-1}$ by the rearranged final demand $\boldsymbol{F}$, the resulting indicator $\boldsymbol{VA} = \hat{\boldsymbol{v}}(\boldsymbol{I}-\boldsymbol{A})^{-1}\boldsymbol{F}$ is the $KN \times KN$ matrix represented in the accounting framework of the Figure 5, in which the value added by each country-industry on the supply side (each row) to the country-industry of completion of the final products, representing the GVCs (each column) can be traced (LOS; TIMMER; DE VRIES, 2015; TIMMER et al., 2014, 2015).

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[45] The summation operator $\sum()$ and the superscript index are further omitted for simplification.

2.1.1 The General Case

If one is interested in the origin of the value-added by the final demand for goods and services of country 1, for instance, all rows of $\boldsymbol{F}$ should be set to zero, except for those containing the final demand levels related to the output originating in the industries of the country 1 (LOS; TIMMER; DE VRIES, 2015). Then, the value-added decomposition in this situation is given by

$$\boldsymbol{VA}^{C_1} = \widehat{\boldsymbol{v}}\boldsymbol{L}\boldsymbol{F}^{C_1} = \begin{bmatrix} \widehat{\boldsymbol{v}}^1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & \widehat{\boldsymbol{v}}^N \end{bmatrix} \begin{bmatrix} \boldsymbol{L}^{11} & \cdots & \boldsymbol{L}^{1N} \\ \vdots & \ddots & \vdots \\ \boldsymbol{L}^{N1} & \cdots & \boldsymbol{L}^{NN} \end{bmatrix} \begin{bmatrix} \widehat{\boldsymbol{f}}_j^{11} & \cdots & \widehat{\boldsymbol{f}}_j^{1N} \\ \vdots & \ddots & \vdots \\ \boldsymbol{0} & \cdots & \boldsymbol{0} \end{bmatrix}$$

In the previous equation, $\boldsymbol{F}^{C_1}$ includes both foreign and domestic demand for all final goods and services supplied by country 1. The resulting decomposition accounts for the value added by all labor and capital in any stage of the production chain of the final goods and services, measuring the country's contribution to the output value of those goods and service (TIMMER et al., 2015). To apply this procedure to obtain the country's contribution to a particular good or service is straightforward. In that case, all rows of $\boldsymbol{F}$ should be set to zero, except for the row containing the final demand levels related to the output of the particular good or service.

2.1.2 The Indicators for Exports, Domestic Demand and Imports

To calculate the value-added by the exports of final goods and services of country 1, all rows of $\boldsymbol{F}$ should be set to zero, including the partition with the domestic demand $\boldsymbol{F}^{11}$ (or, the equivalent diagonal form $\widehat{\boldsymbol{f}}_j^{11}$). Only the final demand for country 1 exports is considered. In that case, the value-added by the foreign final demand is calculated by

$$\boldsymbol{VA\_FFD}_{exp}^{C_1} = \widehat{\boldsymbol{v}}\boldsymbol{L}\boldsymbol{F}_{exp}^{C_1} = \widehat{\boldsymbol{v}}\boldsymbol{L} \begin{bmatrix} \boldsymbol{0} & \cdots & \widehat{\boldsymbol{f}}_j^{1(N-1)} & \widehat{\boldsymbol{f}}_j^{1N} \\ \vdots & \vdots & \vdots & \vdots \\ \boldsymbol{0} & \cdots & \boldsymbol{0} & \boldsymbol{0} \end{bmatrix}$$

The calculation of the value added by the domestic final demand is straightforward and can take into consideration the effects of the final output of domestic industries (local production) and the final output from foreign industries (imports). In the case of domestic production for local consumption, the value-added by the domestic final demand is calculated by

$$\boldsymbol{VA\_DFD}_{local}^{C_1} = \widehat{\boldsymbol{v}}\boldsymbol{L}\boldsymbol{F}_{local}^{C_1} = \widehat{\boldsymbol{v}}\boldsymbol{L}\begin{bmatrix} \widehat{\boldsymbol{f}}_j^{11} & \cdots & \boldsymbol{0} \\ \vdots & \ddots & \vdots \\ \boldsymbol{0} & \cdots & \boldsymbol{0} \end{bmatrix}$$

where $\boldsymbol{F}_{local}^{C_1}$ corresponds to the total final demand matrix F with all the columns and rows set to zero except for the columns and rows of the country of interest, in this case, the country 1.

In the case of the imports perspective, the value-added by the domestic final demand for imports is calculated by

$$\boldsymbol{VA\_DFD}_{imp}^{C_1} = \widehat{\boldsymbol{v}}\boldsymbol{L}\boldsymbol{F}_{imp}^{C_1} = \widehat{\boldsymbol{v}}\boldsymbol{L}\begin{bmatrix} \boldsymbol{0} & \cdots & \boldsymbol{0} \\ \vdots & \cdots & \vdots \\ \widehat{\boldsymbol{f}}_j^{(N-1)1} & \cdots & \boldsymbol{0} \\ \widehat{\boldsymbol{f}}_j^{N1} & \cdots & \boldsymbol{0} \end{bmatrix}$$

where $\boldsymbol{F}_{imp}^{C_1}$ corresponds to the total final demand matrix $\boldsymbol{F}$ with the columns (instead of rows) set to zero, except for the columns of the country of interest. Notice that now the rows of $\boldsymbol{F}$ (instead of the columns) corresponding to the country of interest are also set to zero, so that once more the domestic final demand for final goods and services domestically produced ($\widehat{\boldsymbol{f}}_j^{11}$ in the case of country 1 as the country of interest) is not included in the total final demand.

In order to obtain the structural change in terms of value-added shares per component of the aggregate demand, the procedure consists in the application of the indicators previously defined, with minor changes in the final demand matrix. Let's recall that the final demand matrix is filled with elements that consist in the sum of the five components in the WIOD 2016[46], so that each element is obtained by $\sum_d (f_i^{sr})^d = (f_i^{sr})^1 + (f_i^{sr})^2 + (f_i^{sr})^3 + (f_i^{sr})^4 + (f_i^{sr})^5$. Each one refers to (1) households' consumption, (2) non-profit organizations serving households, (3) government, (4) GFCF and (5) changes in inventories and valuables. To obtain the impact of a specific component, one should simply keep as elements of the final demand matrix the expenditure value of the final demand component of interest. In order to differentiate the indicators, a simple change in the notation suffices. For instance, when the indicator refers to the value-added induced by the households' consumption, a superscript index is included, such as $\boldsymbol{VA\_DFD}_{\boldsymbol{local}}^{\boldsymbol{households}}$, and for GFCF, $\boldsymbol{VA\_DFD}_{\boldsymbol{local}}^{\boldsymbol{GFCF}}$. The same logic applies to the imports indicator $\boldsymbol{VA\_DFD}_{imp}$.

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[46] The characteristics of the WIOD 2016 are explained the Section 2.2.

In order to evaluate the domestic competitiveness of the Brazilian industries, an adaptation of the Imported Coefficient of the Final Demand (ICFD) found in (MORCEIRO, 2012) is proposed in this Thesis to be used in the empirical analyses[47]. The only difference from the original coefficient is that instead of the gross value of the goods and services, it will be used the value-added. In that case, the indicators for value-added are going to be included in the formulation of the $\boldsymbol{ICFD_{VA}}$, that is expressed as

$$ICFD_{VA} = \frac{\boldsymbol{VA\_DFD_{imp}^{households}} + \boldsymbol{VA\_DFD_{imp}^{GFCF}}}{\boldsymbol{VA\_DFD_{local}^{households}} + \boldsymbol{VA\_DFD_{local}^{GFCF}} + \boldsymbol{VA\_DFD_{imp}^{households}} + \boldsymbol{VA\_DFD_{imp}^{households}} + \boldsymbol{VA\_FFD_{exp}}}$$

The subscript VA is to indicate that value-added is going to be used instead of the gross value. According to Morceiro (2012, p. 181), if the coefficient increases, it is an indication of loss of competitiveness of domestic production.

2.2 THE WORLD INPUT-OUTPUT DATABASE

There are several national and multilateral organizations working on or supporting the collection of useful data to construct multi-regional input-output datasets. Among them, the Institute of Development Economies-Japan External Trade Organization (IDE-JETRO), the World Trade Organization (WTO), the Organization for Economic Co-operation and Development (OECD), the United States International Trade Commission (USITC), the World Bank, the International Monetary Fund (IMF) and the United Nations Conference on Trade and Development (UNCTAD). Those efforts have resulted in integrated projects, such as the Global Trade Analysis Project (GTAP), the Trade in Value-Added (TiVA) initiative, the Eora MRIO project and the World Input-Output Database (WIOD).

The data used in this work comes from the last version of the World Input-Output Database (WIOD), released in November 2016 (TIMMER et al., 2016). This project, coordinated by the University of Groningen, is described in details by Dietzenbacher et al. (2013) and Timmer et al. (2015), who provide the methodology employed to build the model, by drawing on the national input-output tables and international trade statistics[48].

[47] In the original coefficient, Morceiro (2012) also includes the government expenditures, which are left out of the analysis of this Thesis, as it will be further explained in Chapter 3.

[48] Timmer et al. (2015) provide guidelines to scholars to make prudent use of the database for research on international trade. Dietzenbacher et al. (2013), Timmer (2012) and Timmer et al. (2016) also provide useful

The WIOD 2016 is an update of the previous version released in 2013, following the same principles of construction. This new version contains a time-series of WIOTs from 2000 to 2014, which includes 43 countries, as shown in the Table 6 and 56 industries, as shown in the Table 7. It also contains estimated information for the remaining countries of the world economy – called "Rest of the World" (hereinafter, referred to as RoW). The industry/product classification follows the ISIC Rev. 4 (or equivalently NACE Rev. 2).

Table 6. List of economies represented in the WIOD 2016.

Country	Acronym	Country	Acronym
Australia	AUS	Korea	KOR
Austria	AUT	Latvia	LVA
Belgium	BEL	Lithuania	LTU
Brazil	BRA	Luxembourg	LUX
Bulgaria	BGR	Malta	MLT
Canada	CAN	Mexico	MEX
China	CHN	Netherlands	NLD
Croatia	HRV	Norway	NOR
Cyprus	CYP	Poland	POL
Czech Republic	CZE	Portugal	PRT
Denmark	DNK	Romania	ROM
Estonia	EST	Russia	RUS
Finland	FIN	Slovak Republic	SVK
France	FRA	Slovenia	SVN
Germany	DEU	Spain	ESP
Greece	GRC	Sweden	SWE
Hungary	HUN	Switzerland	CHE
India	IND	Taiwan	TWN
Indonesia	IDN	Turkey	TUR
Ireland	IRL	United Kingdom	GBR
Italy	ITA	United States	USA
Japan	JPN	"Rest of the World"	RoW

Source: Timmer et al. (2016).

information on the WIOD releases. The complete information about the WIOD project, including all data, are available online at www.wiod.org.

Table 7. List of sectors and industries represented in the WIOD 2016.

Sector	Industry	
Primary	Mining and quarrying	
	Crop and animal production. hunting and related service activities	
	Forestry and logging	
	Fishing and aquaculture	
Manufacturing	Basic pharmaceutical products and pharmaceutical preparations	Repair and installation of machinery and equipment
	Computer. electronic and optical products	Furniture; other manufacturing
	Chemicals and chemical products	Food products. beverages and tobacco products
	Electrical equipment	Textiles. wearing apparel and leather products
	Machinery and equipment n.e.c.	Wood and of products of wood and cork. except furniture; articles of straw and plaiting materials
	Motor vehicles. trailers and semi-trailers	Paper and paper products
	Other transport equipment	Printing and reproduction of recorded media
	Rubber and plastic products	Coke and refined petroleum products
	Other non-metallic mineral products	Metal products. except machinery and equipment
	Basic metals	
Services	Scientific research and development	Wholesale trade. except of motor vehicles and motorcycles
	Publishing activities	Retail trade. except of motor vehicles and motorcycles
	Computer programming. consultancy and related activities; information service activities	Warehousing and support activities for transportation
	Legal and accounting activities; activities of head offices; management consultancy activities	Postal and courier activities
	Telecommunications	Accommodation and food service activities
	Architectural and engineering activities; technical testing and analysis	Real estate activities
	Advertising and market research	Administrative and support service activities
	Other professional. scientific and technical activities; veterinary activities	Other service activities
	Land transport and transport via pipelines	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use
	Water transport	Activities of extraterritorial organizations and bodies
	Air transport	Electricity. gas. steam and air conditioning supply
	Activities auxiliary to financial services and insurance activities	Water collection. treatment and supply
	Financial service activities. except insurance and pension funding	Sewerage; waste collection. treatment and disposal activities; materials recovery; remediation activities and other waste management services
	Insurance. reinsurance and pension funding. except compulsory social security	Construction
	Motion picture. video and television programme production. sound recording and music publishing activities; programming and broadcasting activities	Public administration and defence; compulsory social security
	Wholesale and retail trade and repair of motor vehicles	Education
		Human health and social work activities

Source: Timmer et al. (2016).

Besides the intermediates transactions between industries and countries, the WIOD 2016 presents the final demand for goods and services of each country disaggregated into five components of final consumption expenditures: households, non-profit organizations, government, gross fixed capital formation (GFCF), changes in inventories.

The advantages of adopting the WIOD to study the international fragmentation of production and trade in value-added have been advanced in previous works[49]. They arise from the construction characteristics of the database, such as:

- A sequential time-series for a period of 15 years (2000-2014 – WIOD 2016), what is not available in the OECD-WTO TiVA, for instance;
- The WIOTs of the WIOD use data originated in the Supply and Use Tables (SUTs), which provide more information than the national input-output tables;
- The use of public official statistics which can be publicly accessed in the national statistical institutes, and international sources such as OECD and UN National Accounts, obeying concepts and accounting identities of the international System of National Accounts, ensuring data quality;
- The tables with data and statistics used to construct the WIOT are provided by the WIOD project, including, for instance, the national and international SUTs.

However, some limitations also arise[50]. Besides the shortcomings of every IO table, as previously discussed[51], the SUTs were derived for two price concepts: current basic prices (all costs borne by the producer) and current purchasers' price (amounts paid by the purchaser). As the supply tables are always in basic prices, the use tables had to be converted to basic prices within the construction procedures[52] (DIETZENBACHER et al., 2013).

In the Section 1.1. the results of previous works on structural change were discussed. Some of those were concerned with the growth rates of Brazilian GDP, including the aggregate demand components, and the share of manufacturing in the total value-added. Morceiro (2012. p. 59) shows when scholars evaluate the countries' deindustrialization by measuring its decreasing share in the total world value-added, the historical series of 1970-2009 measured in current prices reveals a different behavior than the series measured in

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[49] For details, see Hermida, Xavier and Silva (2016) and Timmer et al. (2015).

[50] For all details, see Dietzenbacher et al. (2013) and Timmer et al. (2015, 2016).

[51] The assumptions of the IO Leontief model regarding homogeneity between industries and constant returns to scale were discussed in the Section 1.2.

[52] The procedure refers to the so-called SUT–RAS method, which provides estimates for the supply table, the use table and the final use matrix, all in basic prices. For details on the procedure, see Dietzenbacher et al. (2013) and (Temurshoev and Timmer (2011).

constant prices[53]. In fact, the historical series reveals that the deindustrialization had occurred only using measures based in current prices.

However, later in the same text, when analyzing the potential deindustrialization process of the Brazilian economy during the 2000s, Morceiro (2012. p. 175) notice that

> the "natural phenomenon" is the manufacturing diminishes its share of the GDP when measured in current prices, rather than constant prices […] In that sense, the reduction of 2 p.p. in the share of manufacturing in the economy, measured in constant prices, exhibits a dissonant case of the world tendency, different from the "natural" and from the one found [in previous research].

Morceiro (2012)'s conclusion is based on the comparison between the declines in the shares of the Brazilian manufacturing in the total value-added during 2004-2011, measured in constant and current prices, 2 p.p. and 4 p.p., respectively. Although slightly different, he considers that both measures reveal a deindustrialization process in Brazil (considering this specific concept of deindustrialization).

Among the Thesis main goals, it is the analysis of how the structural change of the Brazilian economy evolves during 2000-2014, by focusing on the shares of value-added of sectors/industries in the GDP. Based on the findings of Morceiro (2012) for the Brazilian economy, the methodological difficulties required to convert the current prices of the WIOD 2016 by using specific deflators in the sectoral level and that the Thesis' main goal is to observe the contribution of sectors/industries in the value-added in a given year, the empirical analyses of the Thesis will relax in the assumption of current prices.

2.3 TECHNOLOGY INTENSITY OF INDUSTRIES

> In the context of economic globalization, technology is a key factor in enhancing growth and competitiveness in business […] High technology industries are those expanding most strongly in international trade and their dynamism helps to improve performance in other sectors (spillover). (HATZICHRONOGLOU, 1997, p.4)

This discussion around GVCs cannot avoid the central role of technology as a factor of economic growth, which includes the direct effects on the costs reduction arising from innovations in information and communication technologies and transportation. As well

[53] The explanation of that specific cause of the deindustrialization is due to the relative prices between manufactures, services and primary goods, based on different gains in productivity. The other explanation is the so-called "cost disease". According to Morceiro (2012, p. 59-60), those issues had been advanced by Baumol (1965) and Rowthorn and Wells (1987), respectively.

stated by Amador and Cabral (2016, p. 280), "[t]echnology is a key driver of GVCs". There are other important factors as well, but this Thesis focuses several aspects related to the role of technology.

Capturing gains from participation in GVCs varies according to many factors such as the level of development. specialization structure in high-, medium- or low-technology industries, sophistication level of the tradable intermediates (on the exports or imports side), size of the market and geography (KOWALSKI et al., 2015). Developing countries keep struggling with many obstacles to increase labor productivity and diversification into higher value-added activities, while they remain specialized in low-technology manufacturing, less-knowledge intensive services and in natural resources (OECD, 2014). Successful cases of economic growth as a result of upgrading or integration into GVCs remain scarce (VERSPAGEN; KALTENBERG, 2015).

Several attempts have been made to create taxonomies of technology intensity for industries (ABRAMOVSKY et al., 2004; CAVALCANTE, 2014; EUROSTAT, 2009; GALINDO-RUEDA; VERGER, 2016; HATZICHRONOGLOU, 1997; PAVITT, 1984). The construction of harmonized taxonomies at the industry-level presents benefits not only to differentiate industrial activities within sectors, but also to allow country- or regional-level analytical comparisons of competitiveness, productivity, comparative advantages and so on (CAVALCANTE, 2014). Besides, the classification of economic activities according to their technological patterns leads to less complex requirements and specifications for empirical analyses and also data volume reduction (HATZICHRONOGLOU, 1997).

However, there are many challenges behind the efforts to create a robust and representative taxonomy such as the lack of disaggregated sectoral data, the choosing of the criteria to define the technology content of an industry (or a product), the setting of cut-off points between classes, and so forth (GALINDO-RUEDA; VERGER, 2016; HATZICHRONOGLOU, 1997). One might ask: how an industry will be classified? According to its use (input) or its production (output) of technology? The answer to that question raises concerns regarding the direct or indirect R&D intensity.

For instance, the automobile industry requires many electronics components as intermediates, but the R&D expenditures of automobiles concentrates on other different activities as well. Some of those activities use lower R&D intensive intermediates, capital goods or services. Depending on the criteria to identify the technology content adopted by the corresponding taxonomy, the motor vehicles and electronics industries may be included in different classes, for example, high-technology (electronics) and medium-high-technology (motor vehicles)[54].

Besides the direct and indirect R&D intensity, other intriguing questions remain. What is in the origin of the intermediate, capital good or service embodied in the output of the final industry? Are they supplied by a domestic or a foreign industry? Do the R&D intensities of their corresponding industries (or firms) vary over time or with the production location?

Those concerns must necessarily be considered when adopting a taxonomy for empirical analysis of industrial organization. Therefore, the harmonized taxonomies need to be constantly revised and updated, for instance, as OECD has been doing (GALINDO-RUEDA; VERGER, 2016; HATZICHRONOGLOU, 1997).

Usually, the technology intensity classes have been defined by the business R&D expenditure to output or value-added ratios. Besides, the first taxonomies were exclusively applied to manufacturing industries. Only recently, the OECD taxonomy of economic activities included classifications to the services activities (GALINDO-RUEDA; VERGER. 2016). According to the authors, the R&D intensity is normalized by gross value-added instead of gross output, mainly because value-added measures are less sensitive to double-counting of reintegrated intermediates within the same industry and to sector reliance on inputs like raw goods. It is a clear evidence that the findings of the research on GVCs and trade in value-added are starting to change the policy thinking[55].

In his seminal work on the sectoral patterns of technical change, Pavitt (1984) proposes a taxonomy based on the analyses of around 2000 product and process innovations. Taking the firm as the basic unit of analysis, he concludes that "different principal activities generate different technological trajectories" (p. 353). To formulate his taxonomy, Pavitt takes into consideration three basic factors to differentiate the sectoral patterns of technical change: sources, nature and impact of innovations. In that sense, this approach provides a more realistic classification of the industrial activities and how technology is produced and

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[54] For details on the methodologies to create and adopt taxonomies of technology (or R&D) intensity, see Galindo-Rueda and Verger (2016) and Hatzichronoglou (1997). Other works propose alternative taxonomies. For example, Abramovsky et al. (2004), who adopt two categories of technology intensity for manufacturing, high or low, classifies motor vehicles as a high-technology industry. In Galindo-Rueda and Verger (2016) and Hatzichronoglou (1997), the motor vehicles industry is classified as medium-high-technology (R&D-intensive) industry.

[55] In this special case, the shortcomings of double-counting arising from gross trade flows.

diffused, in contrast to the neo-classical approaches that assume as exogenous the production of technology and innovations. In a recent work, Cavalcante(2014) extends the original Pavitt's taxonomy to present a correspondence with the OECD's taxonomy of technology intensity (HATZICHRONOGLOU, 1997), restricted to the manufacturing industries.

An adaptation of the OECD taxonomy (HATZICHRONOGLOU, 1997) was proposed by Eurostat (2009), and as far as it could be investigated, it is known to be the first one to propose a classification of technology intensity for the services sector.

In her work on structural changes in developing countries and GVCs, Corrêa (2016, pp. 53-69) proposes an upgrading measure of domestic value-added to exports for manufactures of high- and medium-technology intensity. It derives from the classification of exports of manufactures in developing world into four classes of products (resource-based, low-, medium- and high-technology), first developed by (LALL, 2000). Later, Sturgeon and Gereffi (2009) updated the classification and included primary products. Although suitable to her research objectives, one of the limitations of the classification adopted in Corrêa (2016) is that it lacks a deeper definition of categories of the services industries. To overcome this limitation, Corrêa (2016) adopts a classification for services based on the Eurostat (2009) proposal, adapting it to define three categories: (i) transports, storage, postal services and telecommunications, (ii) financial and (iii) business services.

The OECD's taxonomy of R&D-intensity developed by Galindo-Rueda and Verger (2016) is the most recent proposition. It derives from an update of the traditional OECD version advanced by Hatzichronoglou (1997). The new OECD's taxonomy is a similar one to the Eurostat's, although enhanced, representing a stronger effort to propose different levels of technology intensity to non-manufacturing industries. In this case, not only to services, but also to the primary sector (crop and animal production, hunting and related service activities; forestry and logging; fishing and aquaculture; mining and quarrying). The latter has two categories: medium-low- and low-technology.

An important notice to be highlighted is that the OECD itself reminds users that its classification cannot be considered a taxonomy of technology intensity. Instead, it should be taken as a taxonomy of R&D intensity. The following explanation is given by Galindo-Rueda and Verger (2016, pp. 5-6):

> In the seminal study by Hatzichronoglou (1997), the technology classification was created by clustering industries based on a measure of internal R&D intensity combined with estimates of R&D indirectly acquired through purchases of both domestic and imported intermediate inputs and capital goods. […] Recent work on a

> methodological framework for statistics on the development, application and impact of technologies cautions about the inappropriate use of the term “technology” and its confinement to R&D performance. For this reason, the focus of the proposed taxonomy is solely and explicitly on a measure of R&D intensity. While our aim is not to develop a broader taxonomy, this provides a first step towards that objective, which could be attained once relevant measures of skilled labour force, patents, innovation expenditures, knowledge-based capital are developed at the industry level for a sufficiently wide number of countries. Consequently. the proposed clustering should not be interpreted or referred to as a knowledge- or technology-intensity taxonomy, especially in service [sic] industries where R&D expenditure is a less appropriate predictor of technology use, knowledge generation or innovation in general.

Despite that advice, hereinafter in this work, unless when it is advised, the OECD classification is referred to as a taxonomy of technology intensity. It is adopted for:

- being the most recent development;
- including a larger number of countries in the methodology to define the different levels of technology (R&D) intensity; and
- providing a suitable differentiation of technology intensity levels between the primary and services industries, even with the exposed limitations to apply the taxonomy to the services sector.

It is expected that this Thesis’ results inspire further efforts to develop enhancements to the existing or to propose new taxonomies to be applied to the GVC research.

In the Table 8, three taxonomies are presented: Eurostat, OECD and Pavitt. Some industries have different classifications depending on the taxonomy. Their correspondence to the 56 industries comply with the International Standard Industrial Classification revision 4 (ISIC Rev. 4) adopted by the WIOD 2016.

Table 8. Taxonomies of technology/R&D intensity and Pavitt´s pattern of technical change of the 56 industries included in the WIOD 2016.

Sector	**Industry**	**OECD**[(1)]	**Eurostat**[(2)]	**Pavitt**[(3)]
Primary	Mining and quarrying	Medium-low-R&D	Primary	Primary
	Crop and animal production. hunting and related service activities	Low-R&D	Primary	Primary
	Forestry and logging	Low-R&D	Primary	Primary
	Fishing and aquaculture	Low-R&D	Primary	Primary
Manufacturing	Basic pharmaceutical products and pharmaceutical preparations	High-R&D	High-tech	SB
	Computer. electronic and optical products	High-R&D	High-tech	SB
	Chemicals and chemical products	Medium-high-R&D	Medium-high-tech	SI
	Electrical equipment	Medium-high-R&D	Medium-high-tech	SS
	Machinery and equipment n.e.c.	Medium-high-R&D	Medium-high-tech	SS
	Motor vehicles. trailers and semi-trailers	Medium-high-R&D	Medium-high-tech	SI
	Other transport equipment	Medium-high-R&D	Medium-high-tech	SI
	Rubber and plastic products	Medium-R&D	Medium-low-tech	SD
	Other non-metallic mineral products	Medium-R&D	Medium-low-tech	SI
	Basic metals	Medium-R&D	Medium-low-tech	SI
	Repair and installation of machinery and equipment	Medium-R&D	Medium-low-tech	SS
	Furniture; other manufacturing	Medium-R&D	Low-tech	SD
	Food products. beverages and tobacco products	Medium-low-R&D	Low-tech	SI
	Textiles. wearing apparel and leather products	Medium-low-R&D	Low-tech	SD
	Wood and of products of wood and cork. except furniture; articles of straw and plaiting materials	Medium-low-R&D	Low-tech	SD
	Paper and paper products	Medium-low-R&D	Low-tech	SD
	Printing and reproduction of recorded media	Medium-low-R&D	Low-tech	SD
	Coke and refined petroleum products	Medium-low-R&D	Medium-low-tech	SI
	Metal products. except machinery and equipment	Medium-low-R&D	Medium-low-tech	SI
Services	Scientific research and development	High-R&D	Intensive	Services
	Publishing activities	Medium-high-R&D	Intensive	Services
	Computer programming. consultancy and related activities; information service activities	Medium-high-R&D	Intensive	Services
	Legal and accounting activities; activities of head offices; management consultancy activities	Medium-low-R&D	Intensive	Services
	Telecommunications	Medium-low-R&D	Intensive	Services
	Architectural and engineering activities; technical testing and analysis	Medium-low-R&D	Intensive	Services
	Advertising and market research	Medium-low-R&D	Intensive	Services
	Other professional. scientific and technical activities; veterinary activities	Medium-low-R&D	Intensive	Services
	Land transport and transport via pipelines	Low-R&D	Intensive	Services
	Water transport	Low-R&D	Intensive	Services
	Air transport	Low-R&D	Intensive	Services
	Activities auxiliary to financial services and insurance activities	Low-R&D	Intensive	Services
	Financial service activities. except insurance and pension funding	Low-R&D	Intensive	Services

Sector	Industry	OECD[1]	Eurostat[2]	Pavitt[3]
	Insurance. reinsurance and pension funding. except compulsory social security	Low-R&D	Intensive	Services
	Motion picture. video and television programme production. sound recording and music publishing activities; programming and broadcasting activities	Low-R&D	Intensive	Services
	Wholesale and retail trade and repair of motor vehicles and motorcycles	Low-R&D	Less intensive	Services
	Wholesale trade. except of motor vehicles and motorcycles	Low-R&D	Less intensive	Services
	Retail trade. except of motor vehicles and motorcycles	Low-R&D	Less intensive	Services
	Warehousing and support activities for transportation	Low-R&D	Less intensive	Services
	Postal and courier activities	Low-R&D	Less intensive	Services
	Accommodation and food service activities	Low-R&D	Less intensive	Services
	Real estate activities	Low-R&D	Less intensive	Services
	Administrative and support service activities	Low-R&D	Less intensive	Services
	Other service activities	Low-R&D	Less intensive	Services
	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	Low-R&D	Less intensive	Services
	Activities of extraterritorial organizations and bodies	Low-R&D	Less intensive	Services
	Electricity. gas. steam and air conditioning supply	Low-R&D	Others	Services
	Water collection. treatment and supply	Low-R&D	Others	Services
	Sewerage; waste collection. treatment and disposal activities; materials recovery; remediation activities and other waste management services	Low-R&D	Others	Services
	Construction	Low-R&D	Others	Services
	Public administration and defence; compulsory social security	Others	Intensive	Services
	Education	Others	Intensive	Services
	Human health and social work activities	Others	Intensive	Services

Note (1): “Others” corresponds to services activities with no technology intensity classification by OECD, such as ISIC Rev.4 code O84 (Public administration and defence; compulsory social security), P85 (Education) and Q86 (Human health and social work activities).
Note (2): The Eurostat classifies the activities of the services sector according to the knowledge intensity of the correspondent industry. “Others” corresponds to services activities with no technology intensity classification by Eurostat, such as NACE Rev. 2 codes D35 (Electricity. gas. steam and air conditioning supply), E36 (Water collection. treatment and supply) and E37-39 (Sewerage; Waste collection. treatment and disposal activities; materials recovery; Remediation activities and other waste management services). For simplifying the comparison, the industries of the primary sector were considered here as “primary”.
Note (3): Pavitt’s taxonomy is applied to the manufacturing sector as: SB – Science-based; SI – Scale-intensive; SD – Supplier-dominated; SS – Specialized-supplier. For simplifying the comparison, the industries of the primary and services sectors were classified as “primary” and “services”, respectively.
Source: Adapted from Cavalcante (2014), Galindo-Rueda and Verger (2016), Hatzichronoglou (1997) and Pavitt (1984).

The role of the technology intensity at the sector/industry level is extremely important for the GVCs research (AMADOR; CABRAL. 2016). Structural change in the economy have a strong correlation with the dynamics of fragmentation of production across GVCs and the shifts on labor productivity (OECD, 2013; TIMMER et al., 2015; VERSPAGEN; KALTENBERG. 2015). For a long time, the technological change is recognized as a key determinant of structural change and economic growth (DOSI, 1982; DOSI et al., 1988; FAGERBERG, 1994, 1996; NELSON; WINTER. 1982; ROMER, 1986, 1990; SCHUMPETER, 1934, 1942; SOLOW, 1957). For such reasons, this work proposes to analyze the evolution of the interregional flows of value-added embodied in goods and services across GVCs by emphasizing the aggregation of industries, according to their technology intensity.

3. IMPACTS OF THE FINAL DEMAND IN THE BRAZILIAN ECONOMY

This chapter presents the empirical analysis developed to achieve the Thesis' goals, which are divided in the monitoring of two aspects of structural change in the Brazilian economy during 2000-2014: the performance of the country's GVCs in the international context and the effects of the aggregate demand in the domestic context.

The first section starts with an overview of the structural changes in the world economy during 2000-2014. Then, it presents an analysis of the Brazilian GVCs, encompassing the interaction between industries and countries which contribute to the production of the final goods and services for exports and domestic consumption. This is achieved through the application of the indicators of decomposition of the trade in value-added, based on the Thesis' methodological approach. In the sequence, it is introduced a novel approach to analyze the aggregate demand for final goods and services, focusing on two traditionally relevant components for the Brazilian GDP growth: the households' consumption and the gross fixed capital formation. Applying the methodological approach to evaluate the GVCs and the fragmentation of production, this effort represents as an attempt to contribute to this strand of research. In the last section, the main findings are discussed, highlighting the updates and new alternatives explored in this empirical chapter that provide contributions to the same questions found in the literature.

3.1 GENERAL CONTEXT: STRUCTURAL CHANGE IN THE WORLD ECONOMY

In this section, an overview of the general context of the structural change in the world economy is presented. First, the shares of the world total value-added of the 15 largest economies among the 43 countries, including the "Rest of the World" (RoW), are presented in the Table 9, for selected years in the period 2000-2014.

The figures reveal a sharp decrease of the USA and Japan participation in the world total value-added, 9.0 p.p. and 8.6 p.p., respectively. The same decreasing phenomenon is observed, although at lower variations, for traditional developed economies in Europe, such as Italy (0.6 p.p.), Great Britain (0.8 p.p.), Germany (0.9 p.p.) and France (0.5 p.p.). It also reflects the rapid growth of China (10.2 p.p.), and, although a bit slower, the growth of Russia (1.5 p.p.), India (1.3 p.p.), RoW (5.0 p.p.) and Brazil (1.0 p.p.) in the same period.

Table 9. Value-added shares of the world total value-added for the 15 largest economies (+ROW).

Countries	2000	2008	2011	2014	2000-2014	Rank change
USA	32.5	24.6	22.6	23.5	-9.0	0
ROW	9.4	12.6	13.8	14.5	5.0	1
CHN	**3.8**	**7.5**	**10.7**	**13.9**	**10.2**	**4**
JPN	14.7	8.0	8.5	6.0	-8.6	-2
DEU	5.6	5.7	4.9	4.7	-0.9	-1
GBR	4.4	4.2	3.4	3.6	-0.8	-1
FRA	3.9	4.4	3.7	3.4	-0.5	-1
BRA	**1.8**	**2.4**	**3.2**	2.8	**1.0**	**3**
IND	**1.4**	**2.1**	**2.7**	2.7	**1.3**	**5**
ITA	3.2	3.6	3.0	2.6	-0.6	-2
CAN	2.2	2.4	2.4	2.3	0.1	-2
RUS	**0.7**	**2.4**	2.3	2.2	**1.5**	**4**
AUS	1.2	1.7	2.1	1.8	0.7	2
KOR	1.6	1.5	1.6	1.7	0.1	-1
ESP	**1.7**	**2.5**	2.0	1.7	0.0	-3
MEX	1.9	1.8	1.6	1.7	-0.3	-6

Note: All figures are in percentage points and rounded. Major increases are in bold and the respective cells are shaded in gray color. Countries ranked for 2014. ROW stands for "Rest of the World". The column "2000-2014" represents the variation in the respective period for each country. The column "Rank change" reflects the change in the country's ranking position between 2000 and 2014.
Source: Ramos and Prochnik (2017b) based on the WIOD (2016).

In 2014, Brazil was the 8th largest economy, according to its share of the world total value-added. In the whole period, 2000-2014, the country has gained three positions in the ranking of the largest world's GDP countries. Only China, India, Russia and "Rest of the World" had higher increases in shares of the world value-added. The ascendant phase is restricted to the period 2000-2011, when there was a conjugate contribution of strong internal and external facts, mainly during 2004-2011, as it was highlighted in the literature review (SANTOS et al., 2016; SERRANO; SUMMA, 2015). Internal social and economic policies and the growing external demands for our main export products speeded up economic growth. But the structural change towards high competitiveness levels derived from this development cycle seems to have been quite small. The structure of the exports is increasingly based on commodities and the competitiveness of the economy has grown mainly due to an increase in imports of intermediate goods[56].

In the Table 10, the disaggregation of the origin of the value-added per sectors and countries helps to clarify a bit more who is capturing the changes in value production of the world economy[57]. It is analyzed together with the Table 11, which includes a regionalization of the world economy (including China and Japan).

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[56] See Section 1.1.3 for detailed figures presented by the empirical works of Morceiro (2012, 2016), Serrano and Summa (2015), Silva and Lourenço (2014) and Torracca and Castilho (2015).

[57] The Table 40 in the Appendix 1 presents the variations during 2000-2014 of the value-added shares of the world total value-added for each country disaggregated by sector.

Table 10. Value-added shares of the world total value-added per sector and country during 2000-2014.

Sector	Country	2000	2008	2011	2014	2000-2008	2008-2011	2011-2014	2000-2014
Primary	**USA**	**0.7**	**0.9**	0.9	0.9	**0.3**	-0.1	0.0	**0.2**
	ROW	**1.8**	**3.0**	**3.3**	3.2	**1.3**	**0.3**	-0.1	**1.4**
	CHN	**0.8**	**1.3**	**1.7**	**2.1**	**0.5**	**0.4**	**0.4**	**1.3**
	JPN	0.3	0.1	0.1	0.1	-0.2	0.0	0.0	-0.2
	DEU	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
	GBR	0.2	0.1	0.1	0.1	0.0	0.0	0.0	-0.1
	FRA	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
	BRA	0.1	0.3	0.3	0.3	0.1	0.1	-0.1	0.1
	IND	0.4	0.4	0.5	0.5	0.1	0.1	-0.1	0.1
	ITA	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
	CAN	0.1	0.2	0.3	0.2	0.0	0.1	0.0	0.1
	RUS	**0.1**	**0.3**	**0.4**	0.3	**0.2**	0.0	-0.1	**0.2**
	AUS	0.1	0.2	0.3	0.2	0.1	0.0	-0.1	0.1
	KOR	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	ESP	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
	MEX	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0
	"Others"	0.7	0.9	0.9	0.8	0.2	0.0	-0.1	0.1
Manufacturing	USA	5.0	3.1	2.8	2.9	-1.9	-0.3	0.1	-2.1
	ROW	**1.6**	**1.8**	**1.9**	**2.0**	**0.2**	**0.1**	**0.1**	**0.4**
	CHN	**1.2**	**2.5**	**3.4**	**4.1**	**1.2**	**1.0**	**0.7**	**2.9**
	JPN	3.1	1.6	1.6	1.1	-1.5	0.0	-0.4	-2.0
	DEU	1.3	1.3	1.1	1.1	0.0	-0.1	-0.1	-0.2
	GBR	0.7	0.5	0.3	0.4	-0.2	-0.1	0.0	-0.3
	FRA	0.6	0.5	0.4	0.4	-0.1	-0.1	0.0	-0.2
	BRA	0.3	0.3	0.4	0.3	0.1	0.1	-0.1	0.0
	IND	0.2	0.3	0.4	0.4	0.1	0.1	0.0	0.2
	ITA	0.6	0.6	0.5	0.4	0.0	-0.1	-0.1	-0.2
	CAN	0.4	0.3	0.3	0.3	-0.1	0.0	0.0	-0.1
	RUS	**0.2**	**0.4**	0.4	0.3	**0.3**	0.0	-0.1	**0.2**
	AUS	0.1	0.2	0.2	0.1	0.0	0.0	0.0	0.0
	KOR	0.5	0.4	0.5	0.5	0.0	0.1	0.0	0.1
	ESP	0.3	0.4	0.3	0.2	0.1	-0.1	0.0	-0.1
	MEX	0.4	0.3	0.3	0.3	-0.1	0.0	0.0	-0.1
	"Others"	2.0	2.3	2.0	1.9	0.3	-0.2	-0.1	-0.1
Services	USA	26.9	20.6	18.9	19.7	-6.3	-1.7	0.8	-7.2
	ROW	**6.1**	**7.8**	**8.6**	**9.3**	**1.7**	**0.8**	**0.8**	**3.2**
	CHN	**1.8**	**3.8**	**5.6**	**7.7**	**2.0**	**1.8**	**2.1**	**5.9**
	JPN	11.3	6.3	6.8	4.8	-5.0	0.5	-2.0	-6.5
	DEU	4.2	4.3	3.7	3.6	0.1	-0.6	-0.1	-0.6
	GBR	3.5	3.6	2.9	3.1	0.1	-0.7	0.2	-0.4
	FRA	3.2	3.8	3.2	3.0	0.6	-0.6	-0.3	-0.2
	BRA	**1.4**	**1.8**	**2.5**	2.2	**0.4**	**0.7**	-0.2	**0.8**
	IND	**0.9**	**1.4**	**1.8**	**1.8**	**0.5**	**0.4**	**0.1**	**1.0**
	ITA	2.5	2.9	2.4	2.1	0.4	-0.5	-0.3	-0.4
	CAN	1.7	2.0	1.9	1.8	0.3	0.0	-0.1	0.1
	RUS	0.5	1.6	1.6	1.6	1.2	-0.1	0.0	1.1
	AUS	**0.9**	**1.3**	**1.7**	1.5	**0.4**	**0.4**	-0.1	**0.6**
	KOR	1.1	1.1	1.0	1.2	0.0	0.0	0.1	0.1
	ESP	1.3	2.1	1.7	1.4	0.8	-0.4	-0.2	0.1
	MEX	1.3	1.3	1.2	1.2	-0.1	-0.1	0.0	-0.2
	"Others"	**7.2**	**9.4**	8.5	8.1	**2.1**	-0.8	-0.4	0.9
	Total	100.0	100.0	100.0	100.0				

Note: All figures are in percentage points and rounded. Major increases are in bold and the respective cells are shaded in gray color. "Others" represent the rest of the countries in the WIOD 2016. The last four columns to the right represent the variation in percentage points during the respective period.
Source: Author's elaboration based on the WIOD (2016).

It's no surprise to see China increasing its share of the world value-added in the three sectors, more than any other region or country, mainly in manufacturing. The highest increase in the Chinese share of manufacturing value-added was during 2000-2008, at the expense of huge decreases in the NAFTA and Japanese shares, 2.0 p.p. and 1.5 p.p., respectively, in the same period. While Japan continued to lose its share in manufacturing during 2008-2014, NAFTA presented a slowdown in the decreasing tendency, including a very small recovery of 0.1 p.p. during 2011-2014.

Table 11. Value-added shares of the world total value-added per sector and region/country during 2000-2014.

Sector	Region/Country	2000	2008	2011	2014	2000-2008	2008-2011	2011-2014	2000-2014
Primary	**BRIIAT**	**0.9**	**1.5**	**1.9**	1.6	**0.6**	**0.4**	-0.3	**0.6**
	CHN	**0.8**	**1.3**	**1.7**	**2.1**	**0.5**	**0.4**	**0.4**	**1.3**
	East Asia	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
	EU28	0.8	0.8	0.6	0.5	0.0	-0.2	-0.1	-0.3
	JPN	0.3	0.1	0.1	0.1	-0.2	0.0	0.0	-0.2
	NAFTA	1.0	1.3	1.3	1.3	0.3	0.0	0.0	0.3
	Non-EU	0.1	0.2	0.2	0.2	0.1	0.0	0.0	0.0
	ROW	**1.7**	**3.0**	3.3	3.1	1.2	0.3	-0.1	**1.4**
Manufacturing	**BRIIAT**	**1.3**	**1.9**	**2.1**	1.8	**0.7**	**0.2**	-0.3	**0.6**
	CHN	**1.2**	**2.5**	**3.5**	**4.1**	**1.3**	**1.0**	**0.7**	**2.9**
	East Asia	0.8	0.7	0.8	0.8	-0.1	0.1	0.0	0.0
	EU28	5.2	5.2	4.2	3.9	0.0	-1.0	-0.3	-1.3
	JPN	3.1	1.6	1.6	1.2	-1.5	-0.1	-0.4	-1.9
	NAFTA	5.7	3.7	3.4	3.4	-2.0	-0.3	0.1	-2.3
	Non-EU	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
	ROW	1.5	1.7	1.9	1.9	0.2	0.1	0.1	0.4
Services	**BRIIAT**	**4.6**	**7.4**	**9.0**	8.6	**2.9**	**1.5**	-0.3	**4.1**
	CHN	**1.8**	**3.7**	**5.5**	**7.6**	**1.9**	**1.7**	**2.1**	**5.8**
	East Asia	1.8	1.5	1.5	1.7	-0.3	0.0	0.1	-0.1
	EU28	20.5	24.2	20.5	19.4	3.7	-3.7	-1.0	-1.1
	JPN	11.1	6.1	6.7	4.7	-4.9	0.5	-2.0	-6.4
	NAFTA	29.4	23.2	21.5	22.2	-6.2	-1.7	0.8	-7.1
	Non-EU	0.4	0.5	0.5	0.5	0.2	0.0	0.0	0.1
	ROW	**6.0**	**7.5**	**8.4**	**9.1**	**1.6**	**0.8**	**0.8**	**3.1**
	Total	100	100	100	100				

Note: All figures are in percentage points and rounded. Major increases are in bold and the respective cells are shaded in gray color. BRIIAT includes Brazil, Russia, India, Indonesia, Australia and Turkey. East Asia includes Korea and Taiwan. EU28 includes all European countries that have joined the EU until the WIOD 2016 release. NAFTA includes Canada, Mexico and the USA. Non-EU includes Switzerland and Norway. The last four columns to the right represent the variation in percentage points during the respective period.
Source: Author's elaboration based on the WIOD (2016).

Other observation is the increases in the participation of the "Rest of the World" (ROW), which is an economic estimative that represents the economies that are not explicitly and individually available in the WIOD. During 2000-2014, the ROW has increased 3.1 p.p. its share of the services sector and 1.4 p.p. in the primary sector. Nonetheless, besides the BRIIAT (0.6 p.p.) and China (2.9 p.p.), the ROW is the only region with a positive variation in the share of manufacturing value-added, with an increase of 0.4 p.p..

The BRIIAT is an interesting case, because it has presented increases in the three sectors during 2000-2014. A large increase in services value-added (4.1 p.p.) and the same increase in the shares of primary and manufacturing value-added. Coincidently, those last two were due to increases registered during 2000-2011. According to the literature, the Brazilian economy, which is part of the BRIIAT in this analysis, has steadily grown during 2004-2011, and then entered in a period of slowdown during 2011-2014. Some authors give credit for that slowdown to the exchange rate appreciation, while others indicate that the reduction on investment and bad decisions for the macroeconomic policies are the main cause of the lower Brazilian economic growth (SERRANO; SUMMA, 2015).

To move further in the investigation of the international fragmentation of production, the indicator proposed in the Section 2.1.1 for the decomposition of the value-added for the general case, is adapted to trace the origin of the value-added induced by the world final demand ($\boldsymbol{VA}^{World}$). Originally, the indicator was presented to calculate the value-added induced by the final demand for the final goods and services of a single-country ($\boldsymbol{VA}^{C_1} = \hat{\boldsymbol{v}}\boldsymbol{LF}^{C_1}$).

In the extension to the world final demand, the final demand matrix remains the same (rearranged as a square $KN \times KN$ matrix), containing all final demand levels of all $N = 44$ countries supplied by the $K = 56$ industries of each WIOT. Then, the desired indicator can be expressed as

$$\boldsymbol{VA}^{World} = \hat{\boldsymbol{v}}\boldsymbol{LF}^{World} = \begin{bmatrix} \hat{\boldsymbol{v}}_j^1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & \hat{\boldsymbol{v}}_j^{44} \end{bmatrix} \begin{bmatrix} \boldsymbol{L}^{1,1} & \cdots & \boldsymbol{L}^{1,44} \\ \vdots & \ddots & \vdots \\ \boldsymbol{L}^{44,1} & \cdots & \boldsymbol{L}^{44,44} \end{bmatrix} \begin{bmatrix} \hat{\boldsymbol{f}}_j^{1,1} & \cdots & \hat{\boldsymbol{f}}_j^{1,44} \\ \vdots & \ddots & \vdots \\ \hat{\boldsymbol{f}}_j^{44,1} & \cdots & \hat{\boldsymbol{f}}_j^{44,44} \end{bmatrix}$$

Reminding that $j = 1 \ldots K = 56$, the value-added induced by the world final demand ($\boldsymbol{VA}^{World}$) results in a 2464×2464 matrix, as $\hat{\boldsymbol{v}}$ is the diagonal 2464×2464 matrix of value-added per unity of output of each country-industry and $\boldsymbol{L}$ is the 2464×2464 Leontief inverse. The value-added induced by the world final demand ($\boldsymbol{VA}^{World}$) has the same structure of the accounting framework shown in Figure 5.

The Table 12 presents the results of the application of this indicator to the world final demand for selected years during 2000-2014, aggregated per sector and per technology intensity of the industries[58]. This indicator measures the sum of the value-added generated in the sectors of all 44 countries[59].

The figures in the Table 12 reveal that the primary sector contributed with 5.8% of the total value-added induced by the world final demand in 2000 and 9.0% in 2014. Accordingly,

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[58] Hereinafter, the aggregation of the industries per technology intensity follows the OECD 2016 taxonomy.

[59] The Table 40 in the Appendix 1 shows the participation of the 56 supplying industries in the total value-added.

the same table also shows the decrease of the shares of the manufacturing and services sectors, during 2000-2014, of 1.7 p.p. and 1.5 p.p., respectively. In terms of value-added, it seems the world economy remains in a process of "primarization", although the rapid growth occurred in a first phase, during 2000-2011. The so-called deindustrialization[60] seems to have occurred during 2000-2008, with a decrease of the relative participation of the manufacturing industry of 1.7 p.p., and stabilizing in the remaining period. Regarding the services sector, its relative reduction in the period 2000-2014 was around 1.5 p.p., most part of it happening in the 2008 World Crisis.

In fact, in the last sub-period, 2011-2014, all the shares remained remarkably stable.

Table 12. Sum of the value-added shares generated in the supplying industries (per technology intensity) for the production of the final goods and services delivered to the world final demand during 2000-2014.

Sector / Industries per tech. intensity	2000	2008	2011	2014	2000-2014
Primary	**5.8**	**8.3**	**9.2**	**9.0**	**3.2**
Medium-low-tech	2.3	4.5	4.9	4.5	2.3
Low-tech	3.5	3.8	4.3	4.5	1.0
Manufacturing	**18.4**	**16.7**	**16.8**	**16.7**	**-1.7**
High-tech	2.6	2.1	2.1	2.1	-0.4
Medium-high-tech	5.5	5.2	5.4	5.3	-0.2
Medium-tech	3.6	3.5	3.4	3.3	-0.3
Medium-low-tech	6.7	6.0	5.9	5.9	-0.8
Services	**75.8**	**75.0**	**74.0**	**74.3**	**-1.5**
High-tech	0.6	0.6	0.6	0.6	0.0
Medium-high-tech	2.0	2.1	2.1	2.1	0.1
Medium-low-tech	4.3	4.2	3.8	3.8	-0.5
Low-tech	52.4	51.5	50.8	51.4	-1.0
Others[61]	16.6	16.6	16.7	16.4	-0.2
Total	**100.0**	**100.0**	**100.0**	**100.0**	
Total (US$ millions. current prices)	**31,644,539**	**59,891,528**	**68,812,301**	**73,806,913**	

Note: All figures are in percentage points and rounded. The aggregation of the industries per technology intensity follows the OECD 2016 taxonomy. The column "2000-2014" represents the variation in the respective period for each sector/industry.
Source: Author's elaboration based on the WIOD 2016.

The results shown in the Table 12 does not allow to observe, for instance, the region of the industries which generated the value-added. As the indicator value-added induced by the world final demand ($\boldsymbol{VA}^{World}$) contains in the rows the value-added contribution of each country-industry to supply the world final demand, it is simple to sum the contributions per region-industry of origin, in a similar way it was done to produce the results of the Table 11. To simplify the visualization, the regions are arranged along the columns and the sectors and industries remain along the rows. The figures represented in the Table 13 show the

[60] Here, assumed as the decrease in the participation in the total value-added.
[61] In this case of the OECD's taxonomy, and from now on along the remaining sections of the work, "others" is adopted to refer to services activities with no technology intensity classification, such as ISIC Rev.4 code O84 (Public administration and defence; compulsory social security), P85 (Education) and Q86 (Human health and social work activities).

productive structure relative to the total value added by the region along the columns. For instance, the world final demand in 2000 induced in the Chinese manufacturing industries of high-technology (HT) and in the primary industries of low-technology (LT), 3.4 p.p. and 15.1 p.p. of the total value-added in China, respectively.

Once again, the new results reveal that China, the BRIIAT and the ROW are increasing their share of participation, especially the Chinese economy. In this case, for every level of technology intensity those regions' industries are increasing their share of the value-added absorbed by the world final demand. It is worth mentioning the growth observed in the participation of the high-technology industries of the manufacturing and services sectors of East Asia and the ROW. The latter, in 2014, already had the second highest share of the world total value-added. It means that even a small increase in p.p. becomes significant in absolute terms.

Table 13. Structural changes of selected regions induced by the world final demand during 2000-2014, disaggregated per sectors and industries according to the technology intensity.

	BRIIAT		**CHN**		**East Asia**		**EU28**		**JPN**		**NAFTA**		**Non-EU**		**ROW**	
Sectors/Industries per tech. int.	**2000**	**2014**	**2000**	**2014**	**2000**	**2014**	**2000**	**2014**	**2000**	**2014**	**2000**	**2014**	**2000**	**2014**	**2000**	**2014**
Primary	13.9	13.1	20.1	14.9	3.7	2.3	3.0	2.3	1.9	1.6	2.7	4.8	24.0	21.5	18.8	22.0
MLT	3.9	5.5	5.0	5.5	0.3	0.2	0.9	0.7	0.3	0.2	1.5	3.4	21.3	19.5	9.1	12.9
LT	10.0	7.7	15.1	9.4	3.4	2.1	2.2	1.6	1.6	1.4	1.2	1.4	2.6	2.1	9.7	9.1
Manufacturing	18.6	15.2	32.5	30.1	29.0	31.6	19.6	16.2	21.4	19.4	15.9	12.7	11.7	9.3	16.6	13.6
HT	1.0	0.8	3.4	3.5	7.6	9.7	2.3	1.9	3.4	2.9	2.7	2.0	1.0	0.6	1.6	1.4
MHT	4.6	3.8	8.8	9.4	9.0	10.8	6.3	5.7	6.2	5.8	5.0	4.3	2.8	2.6	4.4	4.2
MT	4.3	3.5	8.1	6.7	4.3	4.0	4.0	3.2	3.6	3.2	2.7	2.0	2.6	2.0	3.8	3.0
MLT	8.7	7.1	12.3	10.5	8.0	7.0	7.1	5.4	8.2	7.4	5.4	4.4	5.4	4.1	6.8	5.1
Services	67.5	71.6	47.4	55.0	67.4	66.1	77.4	81.5	76.7	79.0	81.4	82.5	64.3	69.2	64.6	64.4
HT	0.2	0.1	0.2	0.4	0.9	1.7	0.7	0.8	0.3	0.3	0.7	0.8	0.4	0.4	0.3	0.3
MHT	1.4	1.7	0.2	0.6	1.6	1.4	2.4	2.8	2.1	2.2	2.3	2.9	2.2	2.4	0.7	1.1
MLT	2.3	2.4	2.2	3.3	2.8	2.7	4.2	3.7	6.2	7.1	4.7	4.3	3.2	4.0	2.4	3.3
LT	50.1	53.0	36.7	41.6	48.2	44.5	52.8	54.9	52.9	51.1	54.7	54.0	40.6	42.5	49.1	48.8
Others	13.6	14.5	8.0	9.1	13.8	15.8	17.3	19.3	15.2	18.4	19.0	20.6	18.0	19.9	12.1	11.0
Total	100	100	100	100	100	100	100.0	100	100	100	100	100	100	100	100	100

Note: All figures are in percentage points and rounded. The aggregation of the industries per technology intensity follows the OECD 2016 taxonomy. HT: high-technology; MHT: medium-high-technology; MT: medium-technology; MLT: medium-low-technology; LT: Low-technology; Others: non-classified.
Source: Author's elaboration based on the WIOD 2016.

The growth of the Chinese and ROW's economies in the HT, MT and MLT services (specialized activities and highly driven by manufacturing production processes), along with the growth in their manufacturing industries, are strong evidences that some lesser developing economies are becoming apt areas of scientific R&D and other technical services that are essential to increase the competitiveness of the more dynamic industries of the manufacturing sector. Those evidences are in line with the arguments of Verspagen and Kaltenberg (2015), that upgrading to activities of higher value-added and more technology-intensive stages across GVCs have a positive impact in the competitiveness. The BRIIAT block presents similar tendencies in manufacturing and services, although at lower increases.

As the figures of Brazil are aggregated into the BRIIAT, a separate and deeper evaluation of the Brazilian productive structure is required. This is what the next section will present.

3.2 STRUCTURAL CHANGE INDUCED BY THE FINAL DEMAND IN BRAZIL

In this section, the main objective is to evaluate the recent evolution of the Brazilian economic production in terms of value-added, by updating the previous studies that indicated its declining performance and provide new insights of the structural change affecting the composition of the Brazilian GVCs during 2000-2014. The empirical analyses focus on the perspective of the final demand for goods and services and the origin of the value-added induced by this demand, either foreign or domestic.

The Table 14 shows that the Brazilian manufacturing sector has been losing its share in the world value-added. During 2000-2014, the Brazilian manufacturing sector lost 4.0 p.p. of its share of the country's total value-added. The world manufacturing sector presented a smaller decrease in its share of the world value-added (1.7 p.p.). In its turn, the Brazilian services sector has grown its share of the total value-added by 2.7 p.p., a different behavior compared to the world services sector, which presented a decrease of 1.5 p.p. in its share in the same period.

Table 14. Percentage participation of the primary, manufacturing and services sectors in the world and in Brazilian economy in terms of value-added.

	World					**Brazil**				
Sector	**2000**	**2008**	**2011**	**2014**	**2000-2014**	**2000**	**2008**	**2011**	**2014**	**2000-2014**
Primary	5.8	8.3	9.2	9.0	3.2	7.7	10.5	9.5	9.0	1.3
Manufacturing	18.4	16.7	16.8	16.7	-1.7	15.7	14.2	13.9	11.7	-4.0
Services	75.8	75.0	74.0	74.3	-1.5	76.6	75.3	76.7	79.3	2.7

Note: All figures are in percentage points and rounded. The column "2000-2014" represents the variation in the respective period for each sector.
Source: Ramos and Prochnik (2017b) based on the WIOD (2016).

While the world and Brazilian economies have grown their "primarization", in the Table 15, different patterns of structural change are observed. Both the BRIIAT and East Asia presented declining shares in the primary sector. The BRIIAT followed the Brazilian tendency of growth in services, with an increase of 4.5 p.p., at the expense of a reduction of 3.7 p.p. in the share of the manufacturing sector. The only exception among the four regions in manufacturing is the East Asia, which presents an increase of 2.4 p.p.

Table 15. Percentage participation of the primary, manufacturing and services sectors in the BRIIAT and East Asia in terms of value added.

	BRIIAT					East Asia				
Sector	**2000**	**2008**	**2011**	**2014**	**2000-2014**	**2000**	**2008**	**2011**	**2014**	**2000-2014**
Primary	14.5	14.5	15.0	13.6	-0.9	3.8	2.4	2.5	2.4	-1.4
Manufacturing	17.1	15.7	14.6	13.4	-3.7	28.0	28.5	30.8	30.4	2.4
Services	68.4	69.8	70.4	73.0	4.5	68.3	69.1	66.7	67.2	-1.0

Note: All figures are in percentage points and rounded. BRIIAT includes Brazil, Russia, India, Indonesia, Australia and Turkey. East Asia includes Korea and Taiwan. The column "2000-2014" represents the variation in the respective period for each sector.
Source: Author's elaboration based on the WIOD (2016).

The Table 16 and the Table 17 show the value-added shares of the manufacturing industries in the world and in Brazil, respectively, highlighting that this sector presents higher shares of value-added in the industries of lower technology intensity, except for the industries of MHT intensity, where traditionally the "automotive" and "machines and equipment" industries have a higher participation[62]. It is part of the objective of this empirical analysis to investigated how much of this share derives from foreign or domestic value-added, which is done in the remainder of this section.

Table 16. Value-added shares of the manufacturing industries relative to the total value-added in the world manufacturing.

World industries per tech. int.	**2000**	**2008**	**2011**	**2014**	**2000-2014**
Manufacturing	100	100	100	100	
High-tech	13.9	12.5	12.6	12.8	-1.1
Medium-high-tech	30.1	30.9	32.0	32.1	2.0
Medium-tech	19.4	20.9	20.0	19.6	0.2
Medium-low-tech	36.7	35.7	35.4	35.6	-1.1

Note: All figures are in percentage points and rounded. The aggregation of the industries per technology intensity follows the OECD 2016 taxonomy.
Source: Adapted from Ramos and Prochnik (2017b) based on the WIOD (2016).

Table 17. Value-added shares of the manufacturing industries relative to the total value-added in Brazilian manufacturing.

Brazilian industries per tech. int.	**2000**	**2008**	**2011**	**2014**	**2000-2014**
Manufacturing	100	100	100	100	
High-tech	7.6	7.6	6.9	7.2	-0.3
Medium-high-tech	30.9	33.1	30.9	31.0	0.1
Medium-tech	21.5	23.5	23.6	25.3	3.9
Medium-low-tech	40.1	35.8	38.5	36.5	-3.6

Note: All figures are in percentage points and rounded. The aggregation of the industries per technology intensity follows the OECD 2016 taxonomy.
Source: Adapted from Ramos and Prochnik (2017b) based on the WIOD (2016).

Traditional analyses of the international trade compare the impact of the structure of (i) imports with that of (ii) the domestic industry's production for the internal market and (iii)

[62] The author's calculations based on the WIOD 2016 data confirms this fact: both industries accounted for a share of the total value-added in Brazilian manufacturing of around 15, 21, 18 and 17%, respectively, in 2000, 2008, 2011 and 2014. Other reference for this evidence is Morceiro (2016).

exports. The decomposition analysis of Brazilian GVCs presented in the next sections respectively refers to (i) the value-added absorbed by the countries to which Brazil exports final goods and services ($\boldsymbol{VA\_FFD}_{exp}^{C}$), (ii) the value-added by the domestic final demand for imports of final goods and services ($\boldsymbol{VA\_DFD}_{imp}^{C}$) and (iii) the value-added by the domestic final demand for final goods and services produced in Brazil ($\boldsymbol{VA\_DFD}_{local}^{C}$). In the first and third cases, exports and sales to the internal market, the industries of completion are in Brazil. Those indicators were presented in the Section 2.1. From this point, as the country of interest is Brazil, the superscript C is omitted hereinafter.

3.2.1 Foreign Final Demand for Goods and Services

The focus of this section is on the exports perspective of the Brazilian economy. The first analysis provides results to trace the sectoral origin of the value-added by the foreign final demand for final goods and services of the Brazilian industries.

Those figures are shown in the Table 18, representing the share of value-added by each Brazilian-industry of completion, which includes the value added in this last industry and the value added in all previous stages of production of the final good or service exported by Brazil, as explained in the conceptual framework. During 2000-2014, the share of value-added by the foreign final demand ($\boldsymbol{VA\_FFD}_{exp}$) embodied in the Brazilian manufactures has substantially decreased by 8.8 p.p., at the expense of increases in the value-added embodied in primary goods and services, respectively, 4.2 p.p. and 4.6 p.p..

Table 18. Origin of the value-added induced by the foreign final demand for the Brazilian final goods and services during 2000-2014 - $\boldsymbol{VA\_FFD}_{exp}$.

Sectors/Industries per technology intensity	2000	2014	2000-2014
Primary	11.1	15.3	4.2
Medium-low-tech	3.4	4.6	1.2
Low-tech	7.6	10.6	3.0
Manufacturing	48.6	39.9	-8.8
High-tech	5.7	2.0	-3.7
Medium-high-tech	16.6	14.8	-1.8
Medium-tech	10.4	7.4	-3.0
Medium-low-tech	15.9	15.7	-0.2
Services	40.3	44.9	4.6
High-tech	0.8	1.0	0.2
Medium-high-tech	0.9	1.1	0.2
Medium-low-tech	2.3	1.6	-0.7
Low-tech	35.4	40.0	4.6
Others	1.0	1.2	0.3
Total	**100**	**100**	
Total (US$ millions, current prices)	**23,249**	**69,699**	

Note: All figures are in percentage points and rounded, except when explicitly noticed. The aggregation of the industries per technology intensity follows the OECD 2016 taxonomy.
Source: Author’s elaboration based on the WIOD 2016.

At this point, it's important to remind that the value-added by the foreign final demand ($\boldsymbol{VA\_FFD}_{exp}$) returns a square 2464×2464 matrix and that each row of this matrix represents the country-industry of origin that adds value to each GVC, which is represented in a column (the country-industry of completion, in this case, Brazil). Those industries along the rows can be either domestic or foreign.

To obtain the foreign value-added contributions, one shall simply sum the cells of all the rows of foreign industries, which naturally do not include the rows of the domestic industries of the country of completion, in this case, Brazil. The remaining contributions are domestic value added by Brazilian industries output.

The accounting framework provides flexibility to aggregate the industries using any given criteria one might choose. Following the same logic of the previous analyses, the figures obtained through the aforementioned procedure are shown in the Table 19, aggregated according to the technology intensity of the industries.

Table 19. Domestic and foreign value-added (DVA and FVA) embodied in the final goods and services induced by the foreign final demand - $\boldsymbol{VA\_FFD}_{exp}$.

	VA_FFD_{exp}		DVA		FVA		Domestic share		Foreign share	
	(A) = (C)+(E)	(B) = (D)+(F)	(C)	(D)	(E)	(F)	(C) / (A)	(D) / (B)	(E) / (A)	(F) / (B)
Sectors/Industries per technology intensity	**2000**	**2014**	**2000**	**2014**	**2000**	**2014**	**2000**	**2014**	**2000**	**2014**
Primary	11.1	15.3	9.5	12.4	1.6	2.8	85.4	81.5	14.6	18.5
Medium-low-tech	3.4	4.6	2.4	2.5	1.1	2.1	68.6	53.8	31.4	46.2
Low-tech	7.6	10.6	7.1	9.9	0.5	0.7	92.9	93.6	7.1	6.4
Manufacturing	48.6	39.9	42.7	34.6	5.9	5.3	87.8	86.7	12.2	13.3
High-tech	5.7	2.0	4.1	1.4	1.7	0.5	71.0	72.3	29.0	27.7
Medium-high-tech	16.6	14.8	14.3	12.1	2.3	2.7	86.2	81.9	13.8	18.1
Medium-tech	10.4	7.4	9.5	6.4	0.9	0.9	91.5	87.4	8.5	12.6
Medium-low-tech	15.9	15.7	14.8	14.6	1.1	1.1	93.2	92.7	6.8	7.3
Services	40.3	44.9	35.0	39.2	5.3	5.7	86.9	87.2	13.1	12.8
High-tech	0.8	1.0	0.7	1.0	0.1	0.0	88.8	95.2	11.2	4.8
Medium-high-tech	0.9	1.1	0.7	0.9	0.2	0.2	82.5	82.2	17.5	17.8
Medium-low-tech	2.3	1.6	1.9	1.2	0.4	0.4	81.8	74.4	18.2	25.6
Low-tech	35.4	40.0	30.9	35.0	4.5	4.9	87.3	87.7	12.7	12.3
Others	1.0	1.2	0.8	1.1	0.1	0.2	85.6	87.7	14.4	12.3
Total	**100.0**	**100.0**	**87.2**	**86.2**	**12.8**	**13.8**	87.2	86.2	12.8	13.8
Total (US$ millions, current prices)	**23,249**	**69,699**	**20,265**	**60,049**	**2,984**	**9,651**				

Note: All figures are in percentage points and rounded, except when explicitly mentioned. The aggregation of the industries per technology intensity follows the OECD 2016 taxonomy. DVA and FVA stand for domestic value-added and foreign value-added, respectively. The column $\boldsymbol{VA\_FFD_{exp}}$ results from the summation of the columns DVA and FVA for the respective years 2000 and 2014. The columns "domestic share" and "foreign share" represent the percentage of DVA and FVA embodied in $\boldsymbol{VA\_FFD_{exp}}$, respectively.
Source: Author's elaboration based on WIOD 2016.

It is possible to confirm that during 2000-2014, not only the manufacturing value-added by the exports reduced its shares in all levels of technology intensity, but also the domestic shares of the value-added by the foreign final demand ($\boldsymbol{VA\_FFD}_{exp}$), mainly in HT manufactures. In particular, the MHT, MT and MLT industries of manufacturing sector presented increases in the foreign content, a result that had been indicated by previous studies that applied decomposition techniques of trade in value-added to evaluate the Brazilian GVCs until 2011.

The next arrangement, hereinafter called "collapsed matrix", is derived from the accounting framework for GVCs presented in the Section 1.2 and provides lots of useful information regarding the inter- and intra-industry linkages and the fragmentation of production. In this specific case of the Table 20, it is built as an 11×11 square matrix containing the value-added composition of the Brazilian GVCs induced by the exports of final goods and services in 2014.

Table 20. "Collapsed matrix" of the value-added composition of the Brazilian GVCs on the exports in 2014.

		Primary		Manufacturing				Services					
	2014	**LT**	**MLT**	**MLT**	**MT**	**MHT**	**HT**	**LT**	**MLT**	**MHT**	**HT**	**Others**	**VA**
P	**LT**	**69.1**	0.3	19.0	1.3	1.1	0.8	1.3	0.3	0.3	0.4	0.5	11
	MLT	3.4	**70.1**	5.7	3.4	4.4	2.3	2.0	1.0	0.8	1.0	0.7	5
M	**MLT**	2.4	1.2	**31.2**	5.8	4.4	2.5	2.1	1.2	2.7	3.6	0.9	16
	MT	1.4	1.9	2.7	**53.6**	6.9	2.3	1.2	1.1	1.4	1.1	0.7	7
	MHT	4.8	2.4	3.2	7.4	**44.5**	3.6	1.0	1.0	0.8	1.0	0.6	15
	HT	0.5	0.3	0.4	0.8	0.8	**50.2**	0.3	0.6	1.1	0.6	0.3	2
S	**LT**	16.9	21.4	34.0	24.9	33.1	32.6	**88.2**	34.2	21.4	45.1	18.9	40
	MLT	0.5	1.0	1.3	1.2	2.0	2.0	1.1	**56.5**	1.2	2.0	1.0	2
	MHT	0.3	0.4	0.7	0.6	0.9	1.0	1.2	1.9	**68.8**	6.1	1.4	1
	HT	0.2	0.2	0.9	0.4	0.7	1.3	0.7	1.1	1.0	**37.7**	0.4	1
	Others	0.4	0.7	1.0	0.7	1.1	1.3	0.9	1.0	0.6	1.3	**74.5**	1
	Output	2	0	44	7	28	3	14	0	0	1	0	**100**

Note: All figures are in percentage points and rounded. The aggregation of the industries per technology intensity follows the OECD 2016 taxonomy. The last column "VA" stands for value-added, containing the productive structure of the value-added induced by the exports of final goods and services. The last row "Output" represents the share of the total value-added captured by each GVC represented in each column.
Source: Author's elaboration based on WIOD 2016.

In this section, the indicator for the value-added by the foreign final demand ($\boldsymbol{VA\_FFD}_{exp}$) is applied to obtain a matrix with the GVCs identified by the country-industry of completion in the columns and the country-industry of origin of the value-added in the rows. The previous results were obtained by summing (collapsing) the rows representing the same industries according to their technology intensity levels. The collapsed matrix not only collapses the rows according to their technology intensity, but also the columns, that is, the GVCs. As there are two levels of technology intensity for primary sector, four to the manufacturing sector and five to the services sector, the resulting 11 levels are collapsed along the columns and the rows to form the collapsed matrix.

There is no obligation to create a square matrix, which will depend on the objectives of the analyses of the productive structure at hand. In the case of the Table 20, the objective is to evaluate the composition of the GVC according to the technology intensity of the final products it exports. Besides, it is possible to observe which industries are linked to each GVC and at what level of contribution to the Brazilian exports.

For instance, an interesting observation to be made is to look at the diagonal cells. In general, compared to the manufacturing sector, the GVCs of the primary and services sector embodies higher shares of value-added originating on the same industries (LT to LT, MLT to MLT, so on), emphasizing a high level of intra-industry trade in value-added. However, it doesn't mean it have a significant impact on the economy, as the "Output" row reveals that most of the value-added embodied in the Brazilian exports are due to manufactures (they sum to more than 80 p.p. of the total output).

The GVCs with the highest shares of the total $\boldsymbol{VA\_FFD_{exp}}$ are the MLT and MHT of the manufacturing sector. It means those industries are the most competitive in terms of participation in the Brazilian exports basket. However, both embodies more LT services than any other inter-sectoral trade in value-added. As those figures for 2014 are the most recent available in the WIOD 2016 database, it seems Brazil still have a high specialization in less skill-intensive supporting activities.

In order to observe the evolution of the structural change during a longer period, the collapsed matrix for 2000 was subtracted from the collapsed matrix for 2014, resulting in the matrix which is shown in Table 21. In the period 2000-2014 the share of the total $\boldsymbol{VA\_FFD_{exp}}$ of the MLT GVC increased by 12.5 p.p., also with an increase of 5.2 p.p. in the LT services it demands for its final goods production, indicates that a process of "downgrading" to less specialized services took place in the period.

Table 21. "Collapsed matrix" with the variations in the value-added composition of the Brazilian GVCs on the exports during 2000-2014.

		Primary		**Manufacturing**				**Services**				
	2000-2014	**LT**	**MLT**	**MLT**	**MT**	**MHT**	**HT**	**LT**	**MLT**	**MHT**	**HT**	**Others**
P	**LT**	**-3.1**	0.0	2.9	-0.1	0.2	0.2	-0.4	0.0	-0.1	0.0	0.0
	MLT	1.0	**2.3**	1.7	0.7	1.1	0.8	0.0	0.2	0.1	0.2	0.2
M	**MLT**	-0.1	-0.5	**-9.3**	-1.9	-0.5	-1.5	-1.1	-0.5	-3.6	-1.9	-0.4
	MT	-0.1	-0.5	-0.1	**0.9**	-0.7	-0.7	-0.6	0.0	-0.6	-0.2	0.0
	MHT	0.2	-1.0	-0.7	-1.2	**-2.3**	-0.9	-0.5	-0.2	-0.5	-0.3	-0.1
	HT	-0.1	-0.1	-0.1	-0.1	0.1	**0.4**	-0.1	-0.9	0.1	-0.2	-0.1
S	**LT**	2.0	0.1	5.2	1.6	2.2	1.8	**2.7**	11.9	1.2	0.9	2.6
	MLT	0.0	-0.3	-0.1	-0.1	-0.2	-0.4	-0.2	**-11.5**	-0.1	-0.2	-0.1
	MHT	0.0	0.0	0.1	0.0	0.0	-0.1	0.0	0.9	**3.6**	-0.1	-0.2
	HT	0.0	0.0	0.2	0.0	0.0	0.1	0.1	0.6	-0.2	**1.5**	0.0
	Others	0.1	0.1	0.3	0.1	0.2	0.3	0.1	-0.4	0.1	0.3	**-1.8**
	Output	-0.2	-0.3	12.5	-5.3	-0.9	-7.5	1.5	-0.7	0.3	0.5	0.1

Note: All figures are in percentage points and rounded. The aggregation of the industries per technology intensity follows the OECD 2016 taxonomy.
Source: Author's elaboration based on WIOD 2016.

3.2.2 Imports of Final Goods and Services

The results for the value-added embodied in the imports by the Brazilian final demand (VA_DFD_{imp}) for the foreign primary, manufacturing and services industries are shown in the Table 22. The values for the aggregate shares of value-added in the imported manufactures are slightly higher when compared to the aggregate values of the exported manufactures (Table 18). It can also be noticed that there is an increase in the value-added in the primary and services sectors at the expense of a decreasing share of the manufacturing sector. The disaggregation per technology intensity reveals that the HT and MHT industries represent most part of the value-added shares of the manufacturing sector. This fact implies that the domestic supply of final manufactures of higher technology intensity is not enough to supply the local demand.

Table 22. Origin of the value-added induced by the final demand for imported final goods and services – VA_DFD_{imp}.

Sectors/Industries	2000	2014	2014-2000
Primary	**7.7**	**12.9**	**5.3**
Medium-low-tech	3.8	7.4	3.6
Low-tech	3.9	5.5	1.7
Manufacturing	**50.7**	**43.8**	**-6.9**
High-tech	14.7	10.5	-4.2
Medium-high-tech	19.9	16.9	-3.0
Medium-tech	6.1	6.1	-0.1
Medium-low-tech	9.9	10.3	0.4
Services	**41.7**	**43.3**	**1.6**
High-tech	0.8	0.4	-0.4
Medium-high-tech	1.8	2.3	0.6
Medium-low-tech	2.6	2.2	-0.3
Low-tech	35.4	37.2	1.8
Others	1.1	1.1	0.0
Total	**100**	**100**	
Total (US$ millions. current prices)	**23,353**	**100,044**	

Source: Author's elaboration based on the WIOD 2016.

It can be observed in the Table 23 that in every level of technology-intensity in the three sectors, the Brazilian industries' domestic value-added (DVA) shares have increased during 2000-2014. From the imports perspective, it indicates that the integration of the Brazilian industries into GVCs, by means of intermediates supply to produce final goods and services, is increasing, although at very slow rates. Besides, the integration is occurring with more intensity in the primary sector.

Table 23. Domestic and foreign value-added (DVA and FVA) embodied in the imported final goods and services - VA_DFD_{imp}.

	VA_DFD_{imp}		DVA		FVA		Domestic share		Foreign share	
	(A) = (C)+(E)	(B) = (D)+(F)	(C)	(D)	(E)	(F)	(C) / (A)	(D) / (B)	(E) / (A)	(F) / (B)
Sectors/Industries per technology intensity	**2000**	**2014**	**2000**	**2014**	**2000**	**2014**	**2000**	**2014**	**2000**	**2014**
Primary	7.7	12.9	0.1	0.2	7.6	12.8	0.8	1.3	99.2	98.7
Medium-low-tech	3.8	7.4	0.0	0.1	3.8	7.3	1.0	1.4	99.0	98.6
Low-tech	3.9	5.5	0.0	0.1	3.8	5.5	0.7	1.3	99.3	98.7
Manufacturing	50.7	43.8	0.1	0.1	50.6	43.7	0.2	0.3	99.8	99.7
High-tech	14.7	10.5	0.0	0.0	14.7	10.5	0.0	0.0	100.0	100.0
Medium-high-tech	19.9	16.9	0.0	0.0	19.9	16.8	0.2	0.3	99.8	99.7
Medium-tech	6.1	6.1	0.0	0.0	6.1	6.0	0.5	0.6	99.5	99.4
Medium-low-tech	9.9	10.3	0.0	0.0	9.8	10.3	0.3	0.4	99.7	99.6
Services	41.7	43.3	0.1	0.2	41.6	43.1	0.2	0.4	99.8	99.6
High-tech	0.8	0.4	0.0	0.0	0.8	0.4	0.2	0.7	99.8	99.3
Medium-high-tech	1.8	2.3	0.0	0.0	1.7	2.3	0.1	0.2	99.9	99.8
Medium-low-tech	2.6	2.2	0.0	0.0	2.6	2.2	0.2	0.4	99.8	99.6
Low-tech	35.4	37.2	0.1	0.2	35.3	37.0	0.3	0.4	99.7	99.6
Others	1.1	1.1	0.0	0.0	1.1	1.1	0.3	0.6	99.7	99.4
Total	100	100	0.3	0.5	99.7	99.5	0.3	0.5	99.7	99.5
Total (US$ millions, current prices)	**23,353**	**100,044**	**61**	**470**	**23,292**	**99,574**				

Note: All figures are in percentage points and rounded, except when explicitly advised. The aggregation of the industries per technology intensity follows the OECD 2016 taxonomy. DVA and FVA stand for domestic value-added and foreign value-added, respectively. The column $\boldsymbol{VA\_DFD_{imp}}$ results from the summation of the columns DVA and FVA for the respective years 2000 and 2014. The columns "domestic share" and "foreign share" represent the percentage of DVA and FVA embodied in $\boldsymbol{VA\_DFD_{imp}}$, respectively.
Source: Author's elaboration based on WIOD 2016.

3.2.3 Domestic Final Demand for Goods and Services

This section is dedicated to analyzing the structural change in the Brazilian economy in the perspective of the domestic final demand for the Brazilian output of final goods and services.

The aggregate values of the manufacturing share of the total value added by the domestic final demand $\boldsymbol{VA\_DFD}_{local}$ shown in the Table 24 reveal that there is a decrease of 2.6 p.p. in the period 2000-2014. The decreasing trend is present in all levels of technology intensities of the manufacturing industries. The participation of the HT industries is very low, accounting for 1.7 p.p. and 1.4 p.p., in 2000 and 2014, respectively. As it was shown in previous sections, the decrease of manufacturing participation in the value-added is a trend in most regions worldwide, with a few exceptions.

The literature traditionally evaluates the manufacturing competitiveness by the exports perspective. What should also be considered, in this case, by reminding the results of the

Section 3.2.1, is that the results shown in the analysis of the value added by the foreign final demand ($\boldsymbol{VA\_FFD}_{exp}$) revealed an increase in the HT services in the period 2000-2014 (see Table 18). Besides, the Table 19 showed that this growth in the HT services is occurring with an increase in the share of the DVA, which is positive in terms of upgrading to higher value-adding activities in services.

Some remarks are required at this point. The services sector generates more than 75.0% of the total $\boldsymbol{VA\_DFD}_{local}$ in the period 2000-2014, in a growing trend. In the Table 25, it is shown that the DVA share of the HT intensive services remained stable on the final domestic demand perspective ($\boldsymbol{VA\_DFD}_{local}$), at 0.5%. But as explained before, it was revealed an increase both on the value added by the final foreign demand ($\boldsymbol{VA\_FFD}_{exp}$) and on the value added by final domestic demand for imports ($\boldsymbol{VA\_DFD}_{local}$). This growth in the services contribution to the DVA should be carefully analyzed, as it could reveal a positive side of the structural change when this growth occurs in services that require high-skilled workers.

Table 24. Origin of the value-added induced by the domestic final demand for the Brazilian final goods and services - $\boldsymbol{VA\_DFD}_{local}$.

Sectors/Industries	2000 (%)	2014 (%)	2014-2000 (%)
Primary	**7.1**	**7.3**	**0.2**
Medium-low-tech	2.6	3.3	0.7
Low-tech	4.5	3.9	-0.6
Manufacturing	**17.4**	**14.8**	**-2.6**
High-tech	1.7	1.4	-0.3
Medium-high-tech	5.6	5.0	-0.6
Medium-tech	3.3	3.1	-0.2
Medium-low-tech	6.9	5.4	-1.6
Services	**75.4**	**77.9**	**2.5**
High-tech	0.6	0.6	0.0
Medium-high-tech	1.8	1.7	-0.1
Medium-low-tech	2.8	2.4	-0.3
Low-tech	52.0	53.6	1.6
Others	18.3	19.6	1.3
Total	**100**	**100**	
Total (US$ millions. current prices)	**605,753**	**2,210,697**	

Source: Author's elaboration based on the WIOD 2016.

The figures in the Table 25 confirms that the Brazilian industries remain with high DVA shares in the perspective of the final domestic demand ($\boldsymbol{VA\_DFD}_{local}$), above 90.0% in the aggregate. The exceptions are the HT and MHT manufacturing industries, that presented higher FVA shares in both years, 2000 and 2014, than the manufacturing industries lower technology intensity. In the case of the HT industries, the FVA shares were 26.5 and 29.3, in 2000 and 2014, respectively. For the MHT, the FVA shares were 18.6 and 23.4.

Anyhow, all manufacturing industries increased their FVA share during 2000-2014. It indicates that, in the trade of final goods and services, the lack of competitiveness of the manufacturing sector is increasing. In the following investigation, this observation can be confirmed with additional results.

Table 25. Domestic and foreign value-added (DVA and FVA) embodied in the final goods and services completed by Brazilian industries to final consumption in Brazil - $\boldsymbol{VA\_DFD_{local}}$.

	VA_DFD_{local}		DVA		FVA		Domestic share		Foreign share	
	(A) = (C)+(E)	(B) = (D)+(F)	(C)	(D)	(E)	(F)	(C) / (A)	(D) / (B)	(E) / (A)	(F) / (B)
Sectors/Industries per technology intensity	**2000**	**2014**	**2000**	**2014**	**2000**	**2014**	**2000**	**2014**	**2000**	**2014**
Primary	7.1	7.3	6.0	5.5	1.1	1.7	84.4	76.4	15.6	23.6
Medium-low-tech	2.6	3.3	1.8	1.9	0.8	1.4	68.8	57.8	31.2	42.2
Low-tech	4.5	3.9	4.2	3.6	0.3	0.3	93.4	92.3	6.6	7.7
Manufacturing	17.4	14.8	15.0	12.1	2.5	2.7	85.9	81.5	14.1	18.5
High-tech	1.7	1.4	1.2	1.0	0.4	0.4	73.5	70.7	26.5	29.3
Medium-high-tech	5.6	5.0	4.5	3.8	1.0	1.2	81.4	76.6	18.6	23.4
Medium-tech	3.3	3.1	2.9	2.6	0.4	0.5	87.4	83.5	12.6	16.5
Medium-low-tech	6.9	5.4	6.4	4.7	0.6	0.7	91.8	87.7	8.2	12.3
Services	75.4	77.9	72.3	74.2	3.2	3.8	95.8	95.2	4.2	4.8
High-tech	0.6	0.6	0.5	0.5	0.0	0.0	92.9	94.6	7.1	5.4
Medium-high-tech	1.8	1.7	1.7	1.6	0.1	0.2	94.2	91.2	5.8	8.8
Medium-low-tech	2.8	2.4	2.5	2.2	0.2	0.2	91.6	89.9	8.4	10.1
Low-tech	52.0	53.6	49.3	50.3	2.7	3.2	94.8	93.9	5.2	6.1
Others	18.3	19.6	18.2	19.5	0.1	0.1	99.6	99.5	0.4	0.5
Total	100.0	100.0	93.3	91.8	6.7	8.2	93.3	91.8	6.7	8.2
Total (US$ millions, current prices)	605,753	2,210,697	564,910	2,029,018	40,842	181,679				

Note: All figures are in percentage points and rounded, except when explicitly advised. The aggregation of the industries per technology intensity follows the OECD 2016 taxonomy. DVA and FVA stand for domestic value-added and foreign value-added, respectively. The column $\boldsymbol{VA\_DFD_{local}}$ results from the summation of the columns DVA and FVA for the respective years 2000 and 2014. The columns "domestic share" and "foreign share" represent the percentage of DVA and FVA embodied in $\boldsymbol{VA\_DFD_{local}}$, respectively.
Source: Author's elaboration based on WIOD 2016.

The next analysis of this section shows the interesting conclusions delivered by the collapsed matrices originated by the indicator of value-added by the final domestic demand ($\boldsymbol{VA\_DFD}_{local}$). The Brazilian GVCs, the industries of completion in the columns of the collapsed matrices, are analyzed by the contributions of value-added induced by the domestic final demand.

The figures of the Table 26 reveal that the GVCs of the primary and services sector received, in 2014, more value-added contributions from the industries of the same technology intensity. This is confirmed by the value-added shares in the diagonal cells. For instance, for the MLT GVC of the primary sector (in the column of the collapsed matrix), 69.4% of the value-added came from the output of the MLT industries of the primary sector (in the row of the collapsed matrix). The LT GVC of the services sector received 87.0% of value from the output of the LT services.

In the case of the manufacturing GVCs, the figures confirm the importance of the sector to the economy as a whole. The lower shares in the diagonal cells mean that the manufacturing of final goods demands much more contributions of other industries. And this higher interindustry integration occurs not only within the manufacturing sector but also across the primary and services sector. A negative observation in terms of competitiveness is the confirmation that the LT services are much more demanded by the manufacturing GVCs, which reveal the specialization in lower value-adding activities, for instance, in assembly.

Table 26. “Collapsed matrix” of the Brazilian GVCs for the final domestic demand in 2014.

		Primary		Manufacturing				Services					
	2014	**LT**	**MLT**	**MLT**	**MT**	**MHT**	**HT**	**LT**	**MLT**	**MHT**	**HT**	**Others**	**VA**
P	**LT**	69.4	0.3	13.8	1.5	1.8	0.8	1.0	0.3	0.3	0.4	0.6	4
	MLT	3.3	70.1	10.2	5.4	5.1	2.4	2.5	1.0	0.8	1.0	0.7	3
M	**MLT**	2.4	1.2	32.5	5.0	4.2	2.7	2.2	1.2	2.5	3.6	1.0	5
	MT	1.3	1.9	2.6	50.1	6.5	2.6	2.6	1.1	1.3	1.1	1.0	3
	MHT	4.8	2.4	3.4	7.0	42.3	3.7	1.6	1.0	0.8	1.0	0.7	5
	HT	0.5	0.3	0.4	0.7	0.7	48.9	0.2	0.6	1.1	0.6	0.6	1
S	**LT**	16.7	21.4	33.4	27.2	34.4	33.4	87.0	33.6	21.1	45.1	18.4	54
	MLT	0.5	1.0	1.2	1.3	2.1	2.0	0.9	57.1	1.2	2.0	0.9	2
	MHT	0.3	0.4	0.7	0.6	0.9	1.0	0.8	1.8	69.4	6.1	1.2	2
	HT	0.2	0.2	0.8	0.4	0.8	1.2	0.5	1.1	0.9	37.7	0.4	1
	Others	0.4	0.7	0.9	0.8	1.2	1.2	0.6	1.1	0.6	1.3	74.5	20
	Output	2	0	11	1	8	2	46	2	1	0	26	**100**

Note: All figures are in percentage points and rounded. The aggregation of the industries per technology intensity follows the OECD 2016 taxonomy. The last column “VA” stands for value-added, containing the productive structure of the value-added induced by the exports of final goods and services. The last row “Output” represents the share of the total value-added captured by each GVC represented in each column.
Source: Author’s elaboration based on WIOD 2016.

The Table 27 reveals that the GVCs of MLT, MHT and HT have increased their trade intensity with other industries. This is indicated by the negative figures in the respective diagonal cells of the manufacturing GVCs, which confirms they are embodying more value added by other industries (a sign of more fragmentation within the GVC). As the figures of almost all manufacturing industries outside the diagonal of the manufacturing submatrix have slightly decreased, that means the value-added contribution of the primary and services sector industries have increased. The positive figures in the primary and services industries cells along the rows, which contributes to the manufacturing GVCs (columns) confirms those facts. In the case of the primary sector, the MLT industries of the primary sector increased their share for all manufacturing GVCs (2.6, 0.8, 1.0 and 1.0 p.p.). In the case of services, the higher increases came from the LT industries.

Table 27. "Collapsed matrix" with the variations, during 2000-2014, in the value-added shares of the Brazilian GVCs for the final domestic demand.

		Primary		Manufacturing				Services				
	2000-2014	**LT**	**MLT**	**MLT**	**MT**	**MHT**	**HT**	**LT**	**MLT**	**MHT**	**HT**	**Others**
P	**LT**	-1.4	0.0	-1.2	-0.3	-0.3	0.2	0.0	0.1	-0.1	0.0	-0.1
	MLT	0.9	2.3	2.6	0.8	1.0	1.0	0.5	0.4	0.1	0.2	0.1
M	**MLT**	-0.2	-0.5	-4.4	-1.5	-0.6	-0.8	-0.4	-0.3	-3.4	-1.9	-0.5
	MT	-0.2	-0.5	-0.2	2.7	0.2	0.0	0.1	0.0	-0.5	-0.2	-0.2
	MHT	-0.3	-1.0	-0.7	-1.7	-3.0	-0.4	-0.3	-0.1	-0.5	-0.3	-0.2
	HT	-0.2	-0.1	-0.1	-0.1	0.0	-3.4	-0.1	-0.1	0.1	-0.2	-0.2
S	**LT**	1.3	0.2	3.8	0.3	2.4	3.8	0.3	5.5	1.2	0.9	0.2
	MLT	0.0	-0.3	-0.2	-0.2	-0.1	-0.3	-0.2	-6.2	-0.1	-0.2	-0.2
	MHT	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	0.1	3.3	-0.1	-0.2
	HT	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.2	-0.2	1.5	0.0
	Others	0.1	0.1	0.2	0.1	0.2	0.1	0.1	0.3	0.1	0.3	1.4
	Output	-0.2	0.2	-1.8	-0.4	0.2	-0.3	1.1	0.0	0.0	0.0	1.2

Note: All figures are in percentage points and rounded. The aggregation of the industries per technology intensity follows the OECD 2016 taxonomy.
Source: Author's elaboration based on WIOD 2016.

3.3 IMPACTS OF THE FINAL DEMAND COMPONENTS

The objective of his section is to observe the impacts on the origin of the value-added caused by components of the final demand for goods and services. The analysis compares the households' consumption and the gross fixed capital formation (GFCF). This exercise of simulation allows to search for the differences in the value-added induced by the final demand of those components.

Before focusing on these two components, Table 28 shows the evolution of the total expenditures per all components of the domestic final demand for goods and services (including imports). The only other significant component are the government's expenditures. But although the government's expenditures level oscillates close to GFCF during 2000-2014, it is highly concentrated in three domestic services: Education, Human health, Public administration and defense; compulsory social security. In 2000, for instance, those expenditures represented 98.7% of the government total demand.

Table 28. Expenditures per component of the domestic final demand for selected years during 2000-2014.

	2000		2004		2008		2011		2014	
Components	**Expend.**	**Share**	**Expend.**	**Share**	**Expend.**	**Share**	**Expend.**	**Share**	**Expend.**	**Share**
Households	382,993	60.9	372,871	56.9	906,091	57.4	1,388,654	56.9	1,332,315	57.7
NPISH	8,838	1.4	8,980	1.5	19,466	1.2	37,513	1.5	34,281	1.5
Government	126,304	20.1	127,028	19.9	316,255	20.0	486,347	19.9	471,879	20.4
GFCF	101,432	16.1	107,362	20.5	301,655	19.1	499,077	20.5	452,584	19.6
Inventories	9,555	1.5	4,616	1.2	36,062	2.3	28,353	1.2	19,724	0.9
Total	629,122	100	620,857	100	1,579,529	100,0	2,439,944	100,0	2,310,783	100

Note: All values are rounded, with expenditures in US$ millions (current prices) and the shares in percentage points. NPISH stands for non-profit organizations serving households. Each year has the value of.
Source: Author's elaboration based on WIOD 2016.

During 2000-2014, the literature shows that Brazil faced two different phases. The interval of accelerated growth, 2004-2011, and the period of slowdown, 2011-2014. The structure of the aggregate demand, mainly the two components under investigation (households' consumption and GFCF), played relevant roles during both periods, affecting the whole economy. As an attempt to understand what occurred with the origin of the value-added in those periods, the following analyses concentrates in the same periods, applying the specific indicators per component defined in the Section 2.1.2:

- $\boldsymbol{VA\_DFD_{local}^{households}}$: Value-added produced in the country by the domestic final demand from households;
- $\boldsymbol{VA\_DFD_{local}^{GFCF}}$: Value-added produced in the country by the Gross Fixed Capital Formation;

- $\boldsymbol{VA\_DFD_{imp}^{households}}$: Value-added produced abroad by the domestic final demand from households;
- $\boldsymbol{VA\_DFD_{imp}^{GFCF}}$**:** Value-added produced abroad by the Gross Fixed Capital Formation.

The Table 29 shows the results obtained for the households' consumption and GFCF in 2004, 2011 and 2014. It is possible to analyze how the structural changes evolved during 2004-2014, in terms of value-added.

Table 29. Structural changes in the value-added by the domestic final demand (VA_DFD_{local}) for GFCF and households' consumption during 2004-2014.

	GFCF - $VA\_DFD_{local}^{GFCF}$						**Households - $VA\_DFD_{local}^{households}$**					
	Value-added shares			Variation			Value-added shares			Variation		
Sectors/Industries	2004	2011	2014	04-11	11-14	04-14	2004	2011	2014	04-11	11-14	04-14
Primary	8.0	7.4	6.7	-0.6	-0.7	-1.3	10.3	9.6	9.6	-0.7	-0.1	-0.7
MLT	5.3	5.5	5.0	0.2	-0.5	-0.3	3.4	3.6	3.7	0.2	0.1	0.3
LT	2.7	1.9	1.7	-0.8	-0.2	-1.0	6.9	6.0	5.8	-0.8	-0.2	-1.0
Manufacturing	25.3	23.2	21.2	-2.1	-1.9	-4.0	22.0	18.8	17.1	-3.2	-1.7	-4.9
HT	1.1	1.3	1.3	0.2	0.1	0.3	2.4	1.7	1.7	-0.7	-0.1	-0.8
MHT	11.8	10.4	9.3	-1.4	-1.1	-2.5	7.1	5.4	5.1	-1.8	-0.3	-2.1
MT	7.6	7.4	6.9	-0.2	-0.4	-0.6	3.0	2.8	2.7	-0.2	-0.1	-0.3
MLT	4.8	4.1	3.6	-0.7	-0.5	-1.2	9.4	8.9	7.6	-0.5	-1.3	-1.7
Services	66.7	69.4	72.0	2.7	2.7	5.3	67.8	71.6	73.4	3.8	1.8	5.6
HT	0.4	0.5	0.5	0.0	0.0	0.0	0.6	0.7	0.7	0.1	0.0	0.0
MHT	4.4	4.2	4.2	-0.2	0.0	-0.2	1.5	1.2	1.1	-0.3	-0.1	-0.4
MLT	3.5	3.5	3.5	0.0	-0.1	-0.1	3.6	3.0	2.7	-0.6	-0.3	-0.8
LT	56.6	59.4	62.1	2.8	2.7	5.5	57.0	61.3	62.9	4.3	1.6	5.9
Others	1.7	1.8	1.8	0.1	0.1	0.1	5.1	5.4	5.9	0.4	0.5	0.8
Total	100	100	100				100	100	100			
Total	96,394	454,997	410,273				361,952	1,336,909	1,278,540			

Note: All figures are rounded and in percentage points, except the last row which is in US$ millions (current prices). The value-added shares result from the total domestic final demand, excluding the imports.
Source: Author's elaboration based on WIOD 2016.

The observed structural changes for both components are quite similar to the case of the aggregate domestic final demand ($\boldsymbol{VA\_DFD_{local}}$), discussed in the Section 3.2.3, with most of the value-added originating in the services sector. In fact, during 2004-2014, the participation of the services sector in the total value-added increases 5.3 and 5.6 p.p., for the value-added produced in the country by the Gross Fixed Capital Formation ($\boldsymbol{VA\_DFD_{local}^{GFCF}}$) and the value-added produced in the country by the domestic final demand from households ($\boldsymbol{VA\_DFD_{local}^{households}}$), respectively, during 2004-2014. Those increases came mainly at the expense of decreases in the manufacturing sector of 4.0 and 4.9 p.p., but also in the primary sector of 1.3 and 0.7 p.p..

In the imports perspective, the results are presented in the Table 30. It shows a decrease of the participation of the manufacturing sector in favor of the other two sectors. In the case of the GFCF, the higher shares of imported value-added are for manufactures, mostly from the HT and MHT industries. This result is in line with the conclusions of the previous section, when it was found indications of the loss of competitiveness of the manufacturing sector for industries of higher technology intensity. However, during 2004-2011, the share of HT manufactures decreased 7.9 p.p., at the expense of increases in the primary sector.

Table 30. Structural changes in the value-added by the domestic final demand for imports for GFCF and households' consumption during 2004-2014.

	GFCF - $VA\_DFD_{imp}^{GFCF}$						Households - $VA\_DFD_{imp}^{households}$					
	Value-added shares			Variation			Value-added shares			Variation		
Sectors/Industries	2004	2011	2014	04-11	11-14	04-14	2004	2011	2014	04-11	11-14	04-14
Primary	3.1	7.2	6.8	4.0	-0.3	3.7	12.9	17.2	18.1	4.3	0.9	5.3
MLT	2.6	6.2	5.7	3.6	-0.5	3.1	5.0	9.4	8.9	4.5	-0.6	3.9
LT	0.6	1.0	1.2	0.4	0.2	0.6	7.9	7.7	9.2	-0.2	1.5	1.3
Manufacturing	61.0	55.4	54.6	-5.6	-0.8	-6.4	46.0	35.7	35.2	-10.3	-0.5	-10.8
HT	20.8	12.9	13.7	-7.9	0.8	-7.1	13.3	8.0	8.1	-5.3	0.1	-5.2
MHT	26.3	28.5	27.1	2.2	-1.4	0.8	13.6	10.6	8.6	-3.0	-1.9	-5.0
MT	7.7	8.0	7.7	0.3	-0.3	0.0	5.7	4.8	4.5	-0.9	-0.3	-1.2
MLT	6.2	6.0	6.2	-0.2	0.2	0.0	13.4	12.3	13.9	-1.1	1.6	0.5
Services	35.9	37.4	38.6	1.5	1.1	2.7	41.1	47.1	46.6	6.0	-0.4	5.6
HT	1.1	0.4	0.4	-0.7	0.0	-0.6	0.8	0.4	0.5	-0.4	0.0	-0.4
MHT	2.0	3.5	3.7	1.5	0.2	1.7	1.3	1.5	1.3	0.3	-0.2	0.0
MLT	2.9	2.5	2.5	-0.4	0.0	-0.4	2.5	2.1	2.0	-0.5	-0.1	-0.6
LT	28.8	29.9	30.8	1.1	0.9	2.0	35.4	42.0	41.8	6.6	-0.2	6.4
Others	1.1	1.0	1.0	0.0	0.0	-0.1	1.0	1.1	1.1	0.0	0.0	0.1
Total	100	100	100				100	100	100			
Total	10,962	44,062	42,293				10,908	51,682	53,714			

Note: All figures are rounded and in percentage points, except the last row which is in US$ millions (current prices). The value-added shares result from the total domestic final demand for imports.
Source: Author's elaboration based on WIOD 2016.

Table 31. Origin of the value-added induced by the foreign final demand for the Brazilian final goods and services during 2004-2014 - $\boldsymbol{VA\_FFD_{exp}}$.

	Exports - VA_FFD_{exp}					
	Value-added shares			Variation		
Sectors/Industries	2004	2011	2014	04-11	11-14	04-14
Primary	13.9	15.6	15.3	1.6	-0.3	1.3
MLT	4.6	5.9	4.6	1.3	-1.2	0.1
LT	9.3	9.7	10.6	0.4	0.9	1.3
Manufacturing	51.1	41.0	39.9	-10.0	-1.2	-11.2
HT	3.6	2.2	2.0	-1.4	-0.2	-1.7
MHT	20.1	16.1	14.8	-4.0	-1.3	-5.4
MT	9.6	6.8	7.4	-2.8	0.5	-2.2
MLT	17.6	15.9	15.7	-1.8	-0.1	-1.9
Services	35.0	43.4	44.9	8.4	1.5	9.9
HT	0.7	1.0	1.0	0.3	0.0	0.3
MHT	0.9	1.0	1.1	0.1	0.1	0.3
MLT	2.0	1.6	1.6	-0.4	0.0	-0.4
LT	30.5	38.8	40.0	8.3	1.1	9.5
Others	1.0	1.0	1.2	0.0	0.3	0.2
Total	100	100	100			
Total	39,243	74,683	69,699			

Note: All figures are rounded and in percentage points, except the last row which is in US$ millions (current prices). The value-added shares result from the total foreign final demand.
Source: Author's elaboration based on WIOD 2016.

In the sequence, the results for the exports perspective are obtained with the same procedure of the Section 3.2.1, but also to the years 2004 and 2011, as shown in the Table

31[63]. The detailed analysis of the impacts of the foreign final demand ($\boldsymbol{VA\_FFD_{exp}}$) was made in previous section. The results indicated in the Table 31 are going to be used to calculate the values of the Imported Coefficient of the Final Demand in Value-Added ($\boldsymbol{ICFD_{VA}}$), as it was defined in the Section 2.1, and expressed as

$$ICFD_{VA} = \frac{\boldsymbol{VA\_DFD_{imp}^{households}} + \boldsymbol{VA\_DFD_{imp}^{GFCF}}}{\boldsymbol{VA\_DFD_{local}^{households}} + \boldsymbol{VA\_DFD_{local}^{GFCF}} + \boldsymbol{VA\_DFD_{imp}^{households}} + \boldsymbol{VA\_DFD_{imp}^{households}} + \boldsymbol{VA\_FFD_{exp}}}$$

The Table 32 shows the results of the imported coefficient of the final demand ($\boldsymbol{ICFD_{VA}}$). The figures reveal that the imported coefficient increased for almost all the industries of the three sectors, which is a result in line with previous findings in the literature (SERRANO; SUMMA, 2015).

The Table 33 contains the DVA embodied in the final goods and services completed by Brazilian industries to GFCF and household's consumption. It can be observed that the HT and MHT manufacturing industries have increased their share of DVA. The same tendencies are observed in the HT services. Those increases occurred both for the domestic final demand for GFCF and households' consumption, which represent a positive side of the period of accelerated growth during 2004-2011.

Table 32. Imported Coefficient of the Final Demand in Value-Added (ICFD_VA) during 2004-2014.

	ICFD_VA			Variation		
Sectors/Industries	2004	2011	2014	04-11	11-14	04-14
Primary	3.4	6.5	7.3	3.1	0.8	3.9
MLT	4.1	8.9	9.1	4.8	0.2	5.0
LT	2.9	4.4	5.8	1.5	1.4	2.9
Manufacturing	8.6	10.0	11.2	1.3	1.2	2.6
HT	24.8	24.3	26.5	-0.5	2.2	1.7
MHT	8.8	12.1	12.4	3.3	0.3	3.6
MT	6.3	7.3	7.7	1.0	0.4	1.4
MLT	4.5	5.7	7.6	1.2	1.9	3.1
Services	2.5	3.0	3.2	0.5	0.1	0.6
HT	6.6	3.2	3.7	-3.4	0.5	-2.9
MHT	3.5	6.1	6.6	2.7	0.5	3.1
MLT	3.4	3.7	4.1	0.3	0.4	0.7
LT	2.5	3.0	3.2	0.5	0.1	0.7
Others	1.1	1.2	1.2	0.1	0.0	0.1
Total	4.2	4.9	5.2	0.7	0.3	1.0

Note: All figures are rounded and in percentage points.
Source: Author's elaboration based on WIOD 2016.

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Table 33. Domestic value-added (DVA) embodied in the final goods and services completed by Brazilian industries to GFCF and household's consumption.

	GFCF						**Households**					
	Domestic value-added (DVA)			Variation in the DVA			Domestic value-added			Variation in the DVA		
Sectors/Industries	2004	2011	2014	04-11	11-14	04-14	2004	2011	2014	04-11	11-14	04-14
Primary	78.9	73.9	70.0	-5.0	-3.9	-8.9	82.9	80.8	78.9	-2.1	-1.9	-4.0
MLT	71.2	68.3	64.1	-3.0	-4.2	-7.1	58.8	58.1	55.9	-0.7	-2.2	-2.9
LT	94.0	90.2	87.4	-3.8	-2.8	-6.6	94.7	94.2	93.6	-0.5	-0.6	-1.2
Manufacturing	82.6	84.2	79.9	1.6	-4.3	-2.7	85.2	86.8	83.2	1.7	-3.7	-2.0
HT	49.0	65.4	59.3	16.4	-6.1	10.3	75.8	80.4	75.1	4.6	-5.3	-0.7
MHT	82.9	84.9	80.6	2.0	-4.3	-2.3	79.4	79.5	75.2	0.1	-4.4	-4.2
MT	86.0	87.2	84.7	1.2	-2.5	-1.3	83.7	85.9	83.1	2.1	-2.7	-0.6
MLT	83.9	82.9	76.5	-1.0	-6.4	-7.5	92.5	92.8	90.3	0.3	-2.5	-2.2
Services	94.1	93.9	93.2	-0.2	-0.7	-0.9	95.3	95.3	94.7	0.0	-0.6	-0.6
HT	86.7	93.8	91.9	7.1	-1.9	5.2	91.9	96.2	95.1	4.3	-1.2	3.1
MHT	97.4	96.6	96.0	-0.8	-0.5	-1.3	93.3	89.1	86.6	-4.2	-2.6	-6.8
MLT	91.2	90.4	89.3	-0.9	-1.1	-2.0	93.7	92.8	91.2	-0.9	-1.5	-2.4
LT	94.1	93.9	93.3	-0.2	-0.6	-0.8	95.2	95.2	94.6	0.0	-0.6	-0.5
Others	93.7	94.0	93.2	0.3	-0.8	-0.5	98.4	98.5	98.3	0.1	-0.1	0.0
Total	90.0	90.2	88.8	0.2	-1.3	-1.1	91.8	92.3	91.2	0.5	-1.1	-0.6

Note: All figures are rounded and in percentage points.

Source: Author's elaboration based on WIOD 2016.

3.4 CONCLUDING REMARKS

This chapter has presented two aspects of the structural changes of the Brazilian economy in terms of value-added during 2000-2014. The first one regards the application of recent enhanced decomposition techniques applied to GVCs. The second is the evaluation of the effects of the aggregate demand components in the domestic context. In both cases, the focus was the origin of the value added by the final demand for goods and services.

In the first part, the context of the GVCs, it was presented an overview of the structural changes in the world economy, revealing which countries and regions are capturing the changes in value production. In terms of value-added, the process of “primarization” is still occurring, although this was observed with more emphasis during 2000-2011. In the second phase, during 2011-2014, the process of “primarization” has stabilized, with a slight decrease. The Chinese economy was the clearest evidence of an exception to this process, showing increasing participation in all segments of manufacturing during 2000-2014.

Besides China, the region “Rest of the World”, a region representing other economies not explicitly available in the WIOD, presented increasing shares of value-added in HT, MHT and MLT services. Those increases occurred in parallel with increases in manufacturing industries, which the strand of research dedicated to study the integration of services and manufacturing has already emphasized the relevance of that integration to increase international competitiveness and economic growth.

Turning to the Brazilian economy and its GVCs, the decomposition techniques of the production chains, it was obtained a set of evidences of the structural changes in the sectoral and industrial levels, according to the foreign and domestic final demand for final goods and services. It was possible to observe that the process of “primarization” of the Brazilian economy is still occurring during 2000-2014. This finding adds to the results found by Torracca and Castilho (2015), whose analyses of the Brazilian structural changes in the context of the GVCs phenomenon, provided results until 2011. In the manufacturing sector, the results showed that the Brazilian industries still generate more value-added in the industries of lower technology intensity.

The exports of Brazilian final manufactures have substantially lost participation in the total value-added in the economy, for all levels of technology intensities. Those evidences are even more disappointing, when the value-added by the foreign final demand ($\boldsymbol{VA\_FFD}_{exp}$) is divided in shares of DVA (domestic value-added) and FVA (foreign value-added). The levels of FVA increased mostly for the HT manufactures, but also for MHT, MT and MLT. Those findings also contribute to the recent works the made similar analysis, but only until 2011.

Still on the exports perspective, in the case of the services sector, an interesting observation could be made. The analyses revealed an increase in the shares of value-added by the foreign final demand in HT services during 2000-2014. The positive side of that finding, is that this increase was more significant in the DVA share, which reveals a tendency of upgrading to higher value-adding activities in services.

The proposed technique to arrange the "collapsed matrix" provided new insights of the composition of the Brazilian exports across GVCs. For instance, it could be verified that the GVCs of the primary and services sectors have much more intra-industry trade in value-added (according to the aggregation of industries per technology intensity), than the manufacturing sector. It could also be confirmed that the MLT and the MHT industries increased their level of inter-industry trade in value-added, as the former presented a reduction of 9.3 p.p. in the inter-industry trade, and the latter, a reduction of 2.3 p.p., during 2000-2014. It reveals an increase of the fragmentation of its activities throughout other industries. Anyhow, in general, it could be confirmed that the manufacturing sector works as the main driver of the economy, as it demands much more inter-industry output value than the industries of the primary and services sector.

Perobelli, Bastos and de Oliveira (2017) proposed an index to measure the "industrial integration", with a different methodology, but also based on IO analysis. The results in this Chapter are in line with their findings, as they conclude that the manufacturing sector in aggregate terms is more integrated to its own productive process, but lost intensity during 1995-2009. The Thesis results adds to their findings, as it evaluates the problem and confirmed that he tendency continues until 2014. Perobelli, Bastos and de Oliveira (2017) also conclude that the industries of lower technology intensity have higher loses of "industrial integration". This result is also observed in this chapter, which means, the tendency still continues until 2014, but with the difference that the evaluation of this chapter is made both for the exports and the domestic demand perspective (as shown by the "collapsed matrices"). Perobelli, Bastos and de Oliveira (2017) also mention that their index could be used as a measure of deindustrialization. If that is to be confirmed, the techniques applied in this chapter could also be used in future studies on deindustrialization.

In the domestic perspective, the evidences showed that the aggregate share of the manufacturing decreased during 2000-2014. It could be verified that it occurred with the manufactures of all levels of technology intensity. The participation of the HT industries in the total value added by the domestic final demand ($\boldsymbol{VA\_DFD}_{local}$) is very low, variating between 1.7% and 1.4%, in 2000 and 2014, respectively. The services sector presented the highest share of the total value added by the domestic final demand ($\boldsymbol{VA\_DFD}_{local}$), accounting for more than 75.0% during 2000-2014, with an increasing tendency. In terms of participation in the value-added, it could be concluded that the Brazilian economy is in a continuous process of deindustrialization[64].

In the case of the impacts of the domestic final demand components on structural changes, for GFCF and households' consumption, the productive structure in terms of value-added presented quite similar results, with the services sector capturing the highest shares, with an increasing tendency. Manufactures, in general, lost participation, but in the case of GFCF, a slight increase in the share of HT industries was observed. In the imports side, the GFCF induced higher shares in the HT and MHT manufactures, which is another indication of the lack of competitiveness of Brazilian manufacturing sector, given the importance of this component to drive economic growth. An interesting observation is that during the period of rapid growth, 2004-2011, the share of value-added of HT manufactures induced by the imports, decreased considerably (7.9 p.p.).

A positive finding for the Brazilian economy was observed in the results of the DVA shares of the domestic final demand for GFCF and households' consumption. The HT and MHT manufactures have increased their share of DVA during the period of accelerated growth, 2004-2011. Those findings confirms what some works in the literature argued in favor of the positive relationship between increasing expenditures in GFCF and economic growth (SERRANO; SUMMA, 2015), including econometric analyses (FOSTER; STEHRER; TIMMER, 2013; HERMIDA; XAVIER; SILVA, 2016).

In this chapter, it was applied an indicator adapted from Morceiro (2012). In this case, the indicator was adapted to calculate the imported coefficient of the final demand in terms of value-added, what is a different approach applied by Morceiro (2012) and by Serrano and Summa (2015). The latter found aggregate values of import content in the Brazilian economy

[64] If the deindustrialization is measured by participation in the value-added.

of 11.6%, 10.9% and 12.5% respectively in 2004, 2011 and 2014. In this chapter, the imported coefficient of the final demand in terms of value-added ($ICFD_{VA}$) resulted in aggregate figures of 4.2%, 4.9% and 5.2%. It could be an indication in line with the findings of many works that have been highlighting the fact that the measurement of trade in gross terms may not reflect the reality when compared to the statistics of trade measured in value-added. In addition, the application of the $ICFD_{VA}$ provided disaggregated measures of the imported coefficient of the final demand, showing that the manufacturing industries of higher technology intensity present the higher levels of imported content. The only significant exception was the decrease of the imported content of the HT services. However, in general, the results confirmed the fragility of the competitiveness of the Brazilian economy during 2000-2014.

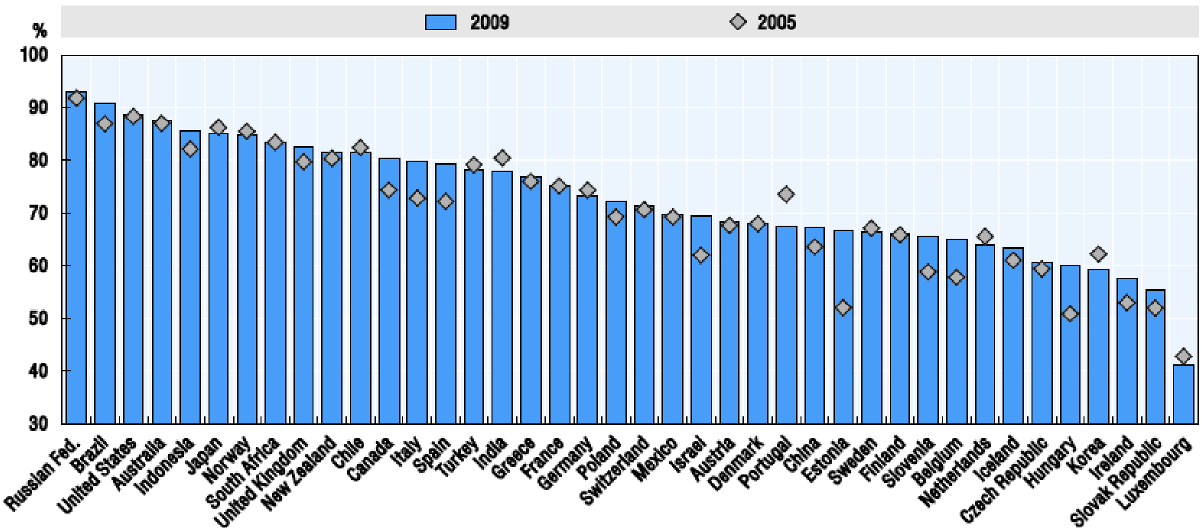
4. COMPARISON BETWEEN AUSTRALIA, BRAZIL AND CANADA

4.1 INTRODUCTION

As it was discussed in previous sections, Brazil faces socio-economic and political challenges to promote its economic growth. Applying the recent enhanced decomposition techniques to analyzing the GVCs and trade in value-added, including a careful use of MRIO databases such as the WIOD, the challenges faced by every country in comparative perspective in the new context of GVCs can be revisited.

Based on the OECD/WTO statistics on TiVA, OECD (2013, p.17) proposes that sizable economies and exporters of natural resources tend to have the highest ratios of domestic value-added to gross exports, as shown in Figure 6.

Figure 6. Domestic value-added to gross exports ratios of OECD and selected economies in 2005 and 2009.



Source: OECD (2013, p.17).

However, among those countries with at least 80% of domestic value-added to gross exports ratio, countries like Japan, Spain, United Kingdom and Italy, although being sizable economies, are not exporters of natural resources. On the other hand, Chile, Norway and New Zealand, for instance, traditional exporters of natural resources, are much smaller economies than the other counterparts in the group.

The OECD's proposition implies that big resource-rich economies have a low level of integration to the GVCs, as most of the value-added is domestically generated, although the literature has also shown that the fragmentation of production is a growing trend in the global economy and among regional blocks (BALDWIN; LOPEZ-GONZALEZ, 2015; DAUDIN;

RIFFLART; SCHWEISGUTH, 2009; JOHNSON; NOGUERA, 2012b). Those facts confirm that the GVCs landscape is far from being completely understood, and comparative studies are useful as methodological tools to help in that task.

As shown in the Section 3.1, Australia, Brazil and Canada are among the 15 largest economies, according to their share of the world value-added in 2014 (Brazil – 7th; Canada – 10th; Australia – 12th). Different from Canada and Australia, both considered to be developed economies, Brazil is classified as a developing country. The roadmap for developing countries to enhance their participation in GVCs, capturing the potential gains to promote the economic growth remains a challenge for policymakers and scholars.

In this chapter, the comparative analysis between Brazil and two other resource-rich economies, Australia and Canada, has the objective to provide new evidences about the integration of sizable resource-rich countries to GVCs. It is done by the application of some of the techniques proposed in this work which were applied to the Brazilian economy in the previous Chapter. The comparative approach provides an evaluation of the structural changes in those two countries, Australia and Canada.

4.2 TECHNOLOGY INTENSITY AND STRUCTURAL CHANGES OF THE GVCs

In this section, it will be applied an approach similar to the one which has been undertaken in the Chapter 3, focusing on the technology intensity of the industries which generate the value-added absorbed by the final demand for goods and services. It follows and enhances the analysis of Ramos and Prochnik (2017a), who provide a comparative analysis of the GVCs of resource-rich economies based on IO decomposition techniques and trade in value-added. Some results presented in the Chapter 3 for Brazil are repeated here to validate the comparison among the three economies.

4.2.1 Changes in the Value-Added Induced by the Foreign Final Demand

From the foreign final demand perspective, Table 34 shows the comparative results of the structural changes in Brazil, Australia and Canada, based on the value-added by the foreign final demand ($\boldsymbol{VA\_FFD}_{exp}$). The participation of the primary sector in the Australian economy remained stable, although a slight decrease has occurred in the MLT (mining and quarrying). Although presenting a smaller participation in the total $\boldsymbol{VA\_FFD_{exp}}$ compared to Brazil and Australia, the primary sector of the Canadian economy had an aggregate increase of 3.1 points, mainly due to the MLT industries. In that case, this increasing trend in the primary sector came at the expense of a decrease of 8.8 points of the participation in the manufacturing sector.

Table 34. Structural changes in Brazil, Australia and Canada per technology intensity of the industries which generated the value-added by the exports of final goods and services – VA_FFD_{exp}.

	BRAZIL		**AUSTRALIA**		**CANADA**		**BRAZIL**		**AUSTRALIA**		**CANADA**	
Sectors	**2000**	**2014**	**2000**	**2014**	**2000**	**2014**	**2014-2000**	**Var.**	**2014-2000**	**Var.**	**2014-2000**	**Var.**
Primary	**11.1**	**15.3**	**14.8**	**14.8**	**5.8**	**8.9**	**4.2**	**37.7**	**0.0**	**-0.2**	**3.1**	**54.0**
MLT	3.4	4.6	4.2	4.0	3.4	5.6	1.2	34.9	-0.2	-4.6	2.2	63.0
LT	7.6	10.6	10.6	10.7	2.3	3.3	3.0	38.9	0.2	1.5	0.9	40.6
Manuf.	**48.6**	**39.9**	**33.3**	**27.4**	**52.7**	**41.0**	**-8.8**	**-18.0**	**-5.9**	**-17.7**	**-11.7**	**-22.1**
HT	5.7	2.0	4.4	2.9	8.5	6.0	-3.7	-65.5	-1.5	-34.1	-2.5	-29.1
MHT	16.6	14.8	7.8	5.3	26.0	19.5	-1.8	-11.1	-2.5	-32.5	-6.5	-25.1
MT	10.4	7.4	4.0	2.4	7.7	6.4	-3.0	-28.8	-1.6	-39.6	-1.3	-16.4
MLT	15.9	15.7	17.2	16.9	10.5	9.1	-0.2	-1.2	-0.3	-1.7	-1.4	-13.4
Services	**40.3**	**44.9**	**51.9**	**57.8**	**41.6**	**50.1**	**4.6**	**11.4**	**5.9**	**11.4**	**8.6**	**20.6**
HT	1.7	2.2	2.5	2.4	1.8	3.0	0.5	28.2	-0.1	-2.8	1.3	71.7
MLT	2.3	1.6	1.9	1.4	2.8	3.1	-0.7	-31.8	-0.5	-25.1	0.3	10.1
LT	35.4	40.0	43.3	48.5	34.7	41.2	4.6	13.0	5.2	12.0	6.5	18.7
Others	1.0	1.2	4.2	5.5	2.3	2.8	0.3	26.1	1.3	30.3	0.5	23.6
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**						
Total (1)	**23,249**	**69,699**	**22,050**	**44,709**	**118,333**	**171,767**						

Note 1: US$ millions, current prices. All values are in percentage points and rounded. "Var." stands for "Variation" which means the relative increase/decrease between the shares in 2000 and 2014.
Source: Author's elaboration based on the WIOD 2016.

The share of value-added by the foreign final demand ($\boldsymbol{VA\_FFD_{exp}}$) for the final goods manufactured in the three countries decreased from 2000 to 2014 irrespective of the industries' technology intensity. Proportionally, the decreases in the HT industries are higher in Brazil (65.6 points) than in Australia (34.1 points) and Canada (29.1 points). The aggregate results of the manufacturing sectors in the three countries indicates the same trend, since the value-added in manufacturing industries, according to the foreign final demand, has been transferred to services and/or primary sectors.

Regarding the services sector, increasing trends in the aggregate shares of value-added are observed in all countries. In Australia, for instance, the services industries accounts for more than 50% of the total value-added by the foreign final demand ($\boldsymbol{VA\_FFD_{exp}}$) of the country´s economy, including an increase of 5.9 points (a relative increase of 11.4 points) from 2000 to 2014. In Canada, the increase in the services sector was even higher, that is, 8.6 p.p. (a relative increase of 20.6%). What seems to be good news to Brazil and Canada is the fact that the services of high-technology intensity increased their participation, respectively, 28.2% and 71.7% of relative increase. Although the shares of the total value-added by the foreign final demand ($\boldsymbol{VA\_FFD}_{exp}$) are still small in 2014, 2.2% in Brazil and 3.0% in Canada, those increasing trends indicate that more specialized services are being used by the manufacturing industries, a fact considered as a positive sign of structural changes in the economy, especially if that evidence is being fostered by specific policies designed to increase productivity of those specialized services.

At this point, it is presented in which regions/industries the foreign final demand is inducing the generation of value-added.

Australian Economy

In the left-side of the Table 35, it´s shown the shares of DVA and FVA in the value-added by the foreign final demand ($\boldsymbol{VA\_FFD}_{exp}$). In the primary sector, the MLT industries (mining and quarrying) present higher shares of FVA, and it´s an increasing trend from 2000 to 2014, which shows a decrease of 11.1 points in the DVA in Australia. In the right-side of the table, that decrease of participation is accounted for the increase demonstrated by BRIIT (2.2 points), China (2.7 points) and "Rest of the World" (6.4 points). Meanwhile, most of the value-added in the LT industries originates in domestic industries.

Table 35. Participation of selected regions/industries per technology intensity which generated the value-added induced by the foreign final demand in Australia – VA_FFD_{exp}.

	2000	2014	2000	2014	Origin of the FVA in Australia (variation 2000-2014)					
Sectors/Industries	**DVA**	**DVA**	**FVA**	**FVA**	**BRIIT[(1)]**	**CHN**	**East Asia**	**EU28**	**NAFTA**	**ROW**
Primary	**84.9**	**80.9**	**15.1**	**19.1**	**0.8**	**1.4**	**-0.1**	**-0.2**	**-0.1**	**2.2**
Medium-low-tech	58.0	46.9	42.0	53.1	2.2	2.7	0.0	-0.2	0.0	6.4
Low-tech	95.6	93.6	4.4	6.4	0.3	0.9	-0.1	-0.1	0.0	1.1
Manufacturing	**81.7**	**83.0**	**18.3**	**17.0**	**0.2**	**2.5**	**-1.3**	**-1.4**	**-1.8**	**0.4**
High-tech	76.5	79.4	23.5	20.6	0.0	4.5	-1.9	-0.8	-4.5	-0.2
Medium-high-tech	70.8	67.0	29.2	33.0	0.7	4.4	-1.6	-0.6	-1.5	2.4
Medium-tech	72.7	66.1	27.3	33.9	1.4	5.6	-2.0	-0.6	-0.4	2.5
Medium-low-tech	90.1	91.1	9.9	8.9	0.0	1.3	-0.2	-1.1	-0.8	0.0
Services	**87.9**	**90.6**	**12.1**	**9.4**	**0.1**	**0.7**	**-1.0**	**-0.9**	**-1.4**	**-0.3**
High-tech	89.5	89.0	10.5	11.0	0.2	0.5	-0.9	-1.0	-1.0	2.6
Medium-low-tech	79.3	80.5	20.7	19.5	0.5	1.6	-1.6	-0.8	-2.1	1.3
Low-tech	87.5	90.2	12.5	9.8	0.1	0.7	-1.0	-0.8	-1.4	-0.3
Others	93.9	97.3	6.1	2.7	0.1	0.1	-0.3	-0.2	-0.6	-2.4
Total	**85.4**	**87.1**	**14.6**	**12.9**	**0.2**	**1.3**	**-1.1**	**-1.0**	**-1.4**	**0.3**

Note: All values are in percentage points and rounded. (1) The contribution of Australia was excluded from the BRIIAT block, here re-named to BRIIT. The Non-EU region is summed to the ROW.
Source: Author's elaboration based on WIOD 2016.

In the case of the manufacturing sector, Australia increased its aggregate share of DVA in 1.3 point. In the HT industries, the participation of domestic industries increased 2.8 points and in the MLT industries increased 1.0 point. Significant changes occurred in the

MHT and MT industries, where the participation of Australian industries decreased, 3.8 and 6.6 points, respectively, mainly due to higher shares of FVA being originated in China and the "Rest of the World" at the expense of decreasing shares of the other regional blocks.

In the Australian services sector, the concentration of the $\boldsymbol{VA\_FFD}_{exp}$ on the domestic industries were higher in 2000 and increased even more until 2014, especially in the LT and the non-classified services ("Others"), with increases of 2.7 and 3.4 points, respectively. A slight "leakage" to foreign industries occurred in the HT services (0.4 point), mainly to the Chinese services.

Canadian Economy

The Canadian economy shows a different distribution of the $\boldsymbol{VA\_FFD}_{exp}$, as shown in Table 36. In general, it becomes clear that the country's industries show a higher level of fragmentation of production across GVCs. The overall share of DVA increased from 67.8 to 69.8%, remaining below 70% until 2014. Brazil, in Section 3.2.1, and Australia, in the Table 35 presented an overall share of 86.2 and 87.1% in 2014, respectively.

The primary sector in Canada, for instance, presents lower aggregate shares of DVA compared to Australia in 2000 and 2014 (at least, less than 20.0%). What both countries show in common is the decreasing trend of DVA shares of the MLT and LT industries, with a higher decrease in the former (8.3 points). China and NAFTA (in this case, composed by Mexico and US) were the origin where occurred increases of the FVA in the primary sector. In the case of NAFTA, the MLT industries (mining and quarrying) significantly increased its share at the expense of the decrease in Canada and other regions/countries (East Asia, EU28 and RoW).

In the manufacturing sector, Canada's HT and MHT industries increased their share of DVA in 3.2 points and 5.7 points, respectively. As the MLT industries are intensive in natural resources as inputs, the increase in the share of the Chinese and NAFTA's primary industries partially explains those structural changes.

Regarding the services sector, Canada presents promising results, as the structural changes reveals a significant increase in the share of DVA in services of higher technology-intensity.

Table 36. Participation of selected regions/industries per technology intensity which generated the value-added induced by the foreign final demand in Canada – VA_FFD_{exp}.

	2000	2014	2000	2014	Origin of the FVA in Australia (variation 2000-2014)					
Sectors/Industries	**DVA**	**DVA**	**FVA**	**FVA**	**BRIIAT**	**CHN**	**East Asia**	**EU28**	**NAFTA(1)**	**ROW**
Primary	**64.5**	**57.5**	**35.5**	**42.5**	**0.9**	**2.4**	**-0.2**	**-2.2**	**7.9**	**-1.7**
Medium-low-tech	54.2	45.9	45.8	54.1	1.0	2.4	-0.2	-3.7	12.8	-4.0
Low-tech	79.8	77.4	20.2	22.6	0.6	2.4	-0.3	0.0	-0.8	0.4
Manufacturing	**64.1**	**63.8**	**35.9**	**36.2**	**0.7**	**2.5**	**-0.2**	**0.7**	**-3.6**	**0.3**
High-tech	61.0	64.2	39.0	35.8	0.1	3.2	-1.4	2.4	-7.0	-0.5
Medium-high-tech	68.5	64.5	31.5	35.5	0.3	1.9	0.8	1.1	-0.7	0.5
Medium-tech	54.8	54.3	45.2	45.7	0.8	3.8	-1.0	0.0	-4.8	1.6
Medium-low-tech	62.8	68.5	37.2	31.5	1.5	2.2	-1.0	-1.2	-6.6	-0.5
Services	**72.9**	**76.9**	**27.1**	**23.1**	**0.2**	**1.3**	**-0.9**	**0.1**	**-4.9**	**0.3**
High-tech	71.8	81.1	28.2	18.9	-0.1	0.5	-2.0	-2.8	-5.2	0.3
Medium-low-tech	71.4	75.7	28.6	24.3	0.3	0.9	-1.0	0.0	-4.8	0.3
Low-tech	72.6	76.1	27.4	23.9	0.2	1.4	-0.9	0.2	-4.9	0.3
Others	80.9	85.5	19.1	14.5	0.3	0.4	-0.2	0.3	-4.9	-0.4
Total	**67.8**	**69.8**	**32.2**	**30.2**	**0.5**	**1.9**	**-0.7**	**0.1**	**-4.4**	**0.7**

Note: All values are in percentage points and rounded. (1) The contribution of Canada was excluded from the NAFTA block. The Non-EU region is summed to the ROW.
Source: Author's elaboration based on WIOD 2016.

4.2.2 Changes in the Value-Added Induced by the Domestic Final Demand

This section shows the results according to the domestic final demand perspective. In the Table 37, the structural changes from 2000 to 2014 in Brazil, Australia and Canada, based on the indicator $\boldsymbol{VA\_DFD}_{local}$ are presented.

The shares of $\boldsymbol{VA\_DFD}_{local}$ of the primary sectors in the three countries show that only the MLT industries (mining and quarrying) increased their participation. In the case of the services sector, there are negative evidences for the three countries. The LT industries, which represent most part of the services sector, increased their participation at the expense of a decreasing participation of the HT industries.

The shares of $\boldsymbol{VA\_DFD_{local}}$ of the manufacturing industries in the three countries present lower shares, in relative terms, when they are compared to the value-added originated in the manufacturing sector induced by the exports of goods and services ($\boldsymbol{VA\_FFD}_{exp}$), as shown in the previous section.

The productive structure in terms of value-added of each country reveals that the $\boldsymbol{VA\_DFD}_{local}$ is predominantly originated in the services activities, as it is shown in Table 37. Those distributions of the $\boldsymbol{VA\_DFD}_{local}$, present a similar pattern to what was calculated to the value-added induced by the world final demand in the Table 12 of the Section 3.1. It is another indication of the relevance of the services sector, in this case, to generate a large amount of the countries' wealth.

Table 37. Structural changes in Brazil, Australia and Canada per technology intensity of the industries which generated the value-added induced by the domestic final demand in Australia for domestic goods and services – VA_DFD_{local}.

	BRAZIL		AUSTRALIA		CANADA		BRAZIL		AUSTRALIA		CANADA	
Sectors	**2000**	**2014**	**2000**	**2014**	**2000**	**2014**	**2014-2000**	**Var.**	**2014-2000**	**Var.**	**2014-2000**	**Var.**
Primary	**7.1**	**7.3**	**5.0**	**5.1**	**3.9**	**5.9**	**0.2**	**2.1**	**0.1**	**1.6**	**1.9**	**49.6**
MLT	2.6	3.3	2.5	3.0	2.5	4.6	0.7	27.6	0.5	20.0	2.0	79.9
LT	4.5	3.9	2.5	2.1	1.4	1.3	-0.6	-12.7	-0.4	-16.4	-0.1	-5.9
Manuf.	**17.4**	**14.8**	**12.7**	**8.8**	**10.9**	**10.7**	**-2.6**	**-15.2**	**-3.8**	**-30.2**	**-0.2**	**-1.9**
HT	1.7	1.4	1.3	0.9	1.6	1.5	-0.3	-18.4	-0.3	-25.7	-0.2	-11.3
MHT	5.6	5.0	3.3	2.3	2.1	2.5	-0.6	-10.2	-1.0	-30.5	0.4	18.3
MT	3.3	3.1	2.7	1.6	2.6	2.6	-0.2	-5.8	-1.0	-39.0	0.0	1.5
MLT	6.9	5.4	5.4	4.0	4.6	4.2	-1.6	-22.7	-1.4	-26.8	-0.4	-9.7
Services	**75.4**	**77.9**	**82.3**	**86.1**	**85.2**	**83.4**	**2.5**	**3.3**	**3.8**	**4.6**	**-1.7**	**-2.0**
HT	2.3	2.3	3.1	2.6	2.6	2.6	-0.1	-2.7	-0.6	-18.9	0.0	-0.8
MLT	2.8	2.4	2.3	1.7	4.3	4.4	-0.3	-11.4	-0.6	-25.5	0.1	2.2
LT	52.0	53.6	59.5	63.1	53.0	53.2	1.6	3.0	3.6	6.0	0.2	0.5
Others	18.3	19.6	17.4	18.8	25.3	23.2	1.3	7.2	1.4	7.8	-2.1	-8.1
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**						
Total (1)	**605,753**	**2,210,697**	**342,021**	**1,259,357**	**562,445**	**1,471,069**						

Note 1: US$ millions, current prices. All values are in percentage points and rounded. "Var." stands for "Variation" which means the relative increase/decrease between the shares in 2000 and 2014.
Source: Author's elaboration based on the WIOD 2016.

Australian Economy

In the left-side of the Table 38, it´s shown that for the primary sector most of the aggregate DVA in Australia. The sector presented a decrease of 10.6 points from 2000 to 2014, which was transferred mostly to China (3.3) and the "Rest of the World" (6.0). The MLT industries (mining and quarrying) generates more VA_DFD_{local} in foreign industries than the low-technology industries, but both present the same trend to increase the share of FVA.

Although a decrease of 6.9 points occurred in the period, the LT industries are predominantly domestic, which is also observed in Brazil and Canada. But in both technology-intensity levels, the trend is the same, which is, the DVA is being increasingly transferred to foreign industries, mainly to China and to the blocks BRIIT and "Rest of the World". For the manufacturing sector, the corresponding aggregate figures are 69.4% (2000) and 61.7% (2014), presenting a similar decreasing behavior to the primary sector.

In the case of Canada, regarding the total value-added originated domestically and in foreign industries, the country presents a balance of 50.0%, respectively, considering the domestic final demands during 2000-2014, as shown in the Table 39.

Table 38. Participation of selected regions/industries per technology intensity which generated the value-added induced by the domestic final demand in Australia for domestic goods and services – VA_DFD_{local}.

	2000	2014	2000	2014	Origin of the FVA in Australia (variation 2000-2014)					
Sectors/Industries	**DVA**	**DVA**	**FVA**	**FVA**	**BRIIT**	**CHN**	**East Asia**	**EU28**	**NAFTA**	**ROW**
Primary	**73.7**	**63.1**	**26.3**	**36.9**	**1.7**	**3.3**	**-0.1**	**-0.2**	**-0.1**	**6.0**
Medium-low-tech	55.9	48.0	44.1	52.0	1.9	3.0	0.0	-0.3	-0.4	3.7
Low-tech	91.2	84.3	8.8	15.7	0.8	3.4	-0.1	0.0	-0.2	3.2
Manufacturing	**69.4**	**61.7**	**30.6**	**38.3**	**1.1**	**7.0**	**-0.6**	**-0.4**	**-2.2**	**2.7**
High-tech	38.7	47.1	61.3	52.9	0.1	12.1	-5.3	-2.2	-12.5	-0.5
Medium-high-tech	58.9	50.0	41.1	50.0	1.2	7.9	-1.8	-0.3	-1.9	3.8
Medium-tech	72.8	58.0	27.2	42.0	2.0	8.2	-0.7	0.9	0.0	4.4
Medium-low-tech	81.4	73.6	18.6	26.4	1.1	4.9	1.2	-0.5	-1.0	2.1
Services	**94.5**	**95.0**	**5.5**	**5.0**	**0.1**	**0.4**	**-0.4**	**-0.2**	**-0.6**	**0.2**
High-tech	93.4	90.5	6.6	9.5	0.2	0.4	-0.4	0.2	-0.4	2.9
Medium-low-tech	87.4	87.2	12.6	12.8	0.3	1.1	-0.8	-0.1	-1.4	1.1
Low-tech	93.6	94.1	6.4	5.9	0.1	0.5	-0.4	-0.2	-0.7	0.2
Others	98.7	99.3	1.3	0.7	0.0	0.0	0.0	0.0	-0.1	-0.5
Total	**90.3**	**90.4**	**9.7**	**9.6**	**0.2**	**1.1**	**-0.6**	**-0.5**	**-0.9**	**0.5**

Note: All values are in percentage points and rounded. The Non-EU region is summed to the ROW.
Source: Author's elaboration based on WIOD 2016.

Table 39. Participation of selected regions/industries per technology intensity which generated the value-added induced by the domestic final demand in Canada for domestic goods and services – VA_DFD_{local}.

	2000	2014	2000	2014	Origin of the FVA in Canada (variation 2000-2014)					
Sectors/Industries	**DVA**	**DVA**	**FVA**	**FVA**	**BRIIAT**	**CHN**	**East Asia**	**EU28**	**NAFTA**	**ROW**
Primary	**62.2**	**60.8**	**37.8**	**39.2**	**0.9**	**2.1**	**-0.1**	**-3.6**	**10.6**	**-8.6**
Medium-low-tech	52.6	58.5	47.4	41.5	0.8	1.6	-0.1	-5.6	13.2	-15.9
Low-tech	79.7	68.9	20.3	31.1	1.3	3.9	-0.1	0.6	2.6	2.4
Manufacturing	**51.3**	**48.6**	**48.7**	**51.4**	**1.3**	**4.9**	**-0.8**	**1.3**	**-4.2**	**0.3**
High-tech	35.1	18.8	64.9	81.2	0.4	7.4	-0.1	9.3	-1.0	0.4
Medium-high-tech	23.8	33.1	76.2	66.9	0.6	5.5	-1.0	-0.9	-13.8	0.3
Medium-tech	55.4	52.4	44.6	47.6	1.1	5.9	-1.3	0.7	-4.5	1.2
Medium-low-tech	67.3	65.8	32.7	34.2	2.1	3.0	-0.8	-0.5	-1.9	-0.3
Services	**94.8**	**93.3**	**5.2**	**6.7**	**0.2**	**0.4**	**-0.1**	**0.4**	**0.2**	**0.3**
High-tech	91.3	87.9	8.7	12.1	0.1	0.3	-0.3	0.8	1.4	1.1
Medium-low-tech	91.1	90.2	8.9	9.8	0.1	0.3	-0.2	0.4	0.1	0.2
Low-tech	93.1	91.3	6.9	8.7	0.2	0.6	-0.1	0.5	0.1	0.5
Others	99.2	99.0	0.8	1.0	0.0	0.0	0.0	0.1	0.1	-0.1
Total	**88.8**	**86.6**	**11.2**	**13.4**	**0.3**	**1.0**	**-0.2**	**0.4**	**0.4**	**0.2**

Note: All values are in percentage points and rounded. The Non-EU region is summed to the ROW.
Source: Author's elaboration based on WIOD 2016.

4.3 CONCLUDING REMARKS

In relation to sizable economies, the literature argues and provide evidences that the domestic market works as an important driver to economic growth (VERSPAGEN; KALTENBERG, 2015). This argument applies to Australia, Brazil and Canada, based on the high shares of the countries' total value-added that are generated by the final demand of their own domestic market.

According to the quantitative evidences presented in this Chapter, policymakers should design strategies and public policies that take two issues into consideration: the relative size of the domestic final demand and the role of services to improve the competitiveness of the manufacturing industries[65]. Although the previous analyses do not confirm causal relations, these exploratory evaluations can be the starting point to deeper investigations.

Naturally, in the case of countries such as Canada, the integration in GVCs should be carefully evaluated. Canada has preferential trade agreements with the US, like Mexico, for instance. The American economy is the biggest Canada's trade partner and its performance tends to be influenced by the US economy.

[65] Similar conclusions were presented literature (FORNARI; GOMES; HIRATUKA, 2016; MIROUDOT, 2017; PENEDER; STREICHER, 2018).

CONCLUSION

The concept of Global Value Chain (GVC) and the methods to estimate trade in value-added are at the forefront of the research to develop decomposition methods to measure the international flows of goods and services across the global trade. The work in these lines has examined themes like vertical integration, structural change, diverse forms of interaction among firms from subsequent sectors, like the sharing of the development of innovations by users and producers, governance strategies of the leading firms and upgrading possibilities open for smaller firms and developing countries.

This work focused on the IO based strand of research on GVCs, applying new enhanced decomposition techniques to evaluate the structural changes caused by the impact of final demand for goods and services. It followed the perspective of the industries which originate the value-added embodied in the final goods and services for domestic and foreign final consumption. It provided novel ways to measure and observe the structural changes affecting the economy. The use of a method of estimation based on trade in value-added was adopted to avoid the shortcomings of measures of traditional trade, usually measured in gross terms.

In the methodological approach, among the main contributions, the Thesis offered two valuable analytical tools. The first one, the "collapsed matrix", a flexible and useful way to analyze the GVCs and the fragmentation of the production stages of the final goods and services, including the intra- and inter-industry integration. The second one, the Imported Coefficient of the Final Demand in Value-Added ($ICFD_{VA}$), an adaptation of a well-known coefficient available in the literature. However, the $ICFD_{VA}$ advances towards the calculation of the imported content in terms of value-added, which provides an alternative way to analyze the competitiveness of the industries, based on the final demand components for goods and services.

Based on the methodology and the decomposition techniques proposed in this work, the results of the empirical chapters 3 and 4, discussed in the partial conclusions of both chapters, were sufficient to achieve the Thesis main objectives and to answer the research questions.

First, based on the IO decomposition techniques and the proposed indicators of trade in value-added, the methodology was applied to evaluate the Brazilian economy to understand the structural changes caused by the final demand for goods and services, according to the technology intensity of the industries. Among other findings, the Thesis confirmed a process of decrease in the participation of the manufacturing industries in the total value-added of the Brazilian economy during 2000-2014. It could also be revealed that differences are being employed in structural changes between industries depending on their level of technology intensity. The services sector presented some indications of increasing participation in the economy, including a surprising, although slight, increase in HT services in some cases.

Besides, in the Brazilian economy, the results are divergent when the final goods and services are traded for households' consumption and gross fixed capital formation. The results confirmed previous findings of the relevance of GFCF to the economy as a whole. In this case, the approach gave a novel contribution in the traditional way of analyzing the effects of the aggregate demand, by adopting new IO decomposition techniques of trade in value-added, usually adopted by the international trade research on GVCs. It can be further explored in the future in the studies of Keynesian models of economic growth.

The comparison of Brazil with Australia and Canada, two sizable resource-rich countries, revealed increasing trends in the aggregate shares of value-added in the services sector. A positive finding was that, although the shares of high-technology services of the total value-added by the foreign final demand are still small, in Brazil and in Canada, increasing trends indicated that more specialized services are being used by the manufacturing industries, a fact considered as a positive sign of structural changes in both countries' economies. The methodology applied to analyze the three countries, separating the domestic demand from the exports demand, proved to be useful as it showed that there are large differences in the productive structures for domestic and exports supply. Besides, it could provide a more detailed view of the structural changes in the countries, which is useful to policymakers of developing countries trying to design strategies to catch-up with more developed and industrialized nations.

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APPENDIX 1 – SUPLEMENTARY DATA

This Appendix contains additional data that were generated during the development of this work, but for space limitation were kept to the Appendix. Some of the tables shown along the chapters are a summarizes the information available in the tables of this Appendix.

Table 40. Variation in the value-added shares of the world total value-added per country (rows) and sector (columns) during 2000-2014.

	Primary	Manufacturing	Services
Country	2000-2014	2000-2014	2000-2014
AUS	0.07	-0.02	0.59
AUT	0.00	-0.02	-0.01
BEL	-0.01	-0.06	0.01
BGR	0.00	0.01	0.03
BRA	**0.12**	**0.09**	**0.87**
CAN	0.08	-0.12	0.08
CHE	0.00	0.02	0.08
CHN	**1.30**	**2.93**	**5.80**
CYP	0.00	0.00	0.00
CZE	0.00	0.02	0.05
DEU	-0.03	-0.20	-0.60
DNK	-0.01	-0.02	-0.02
ESP	-0.03	-0.10	0.08
EST	0.00	0.00	0.01
FIN	0.00	-0.04	0.02
FRA	-0.04	-0.24	-0.17
GBR	-0.08	-0.35	-0.41
GRC	-0.01	-0.01	-0.07
HRV	0.00	0.00	0.01
HUN	0.00	0.01	0.02
IDN	**0.13**	**0.10**	**0.37**
IND	**0.13**	**0.21**	**0.97**
IRL	0.00	-0.02	0.04
ITA	-0.05	-0.28	-0.40
JPN	-0.18	-1.93	-6.35
KOR	-0.03	0.08	0.12
LTU	0.00	0.01	0.02
LUX	0.00	0.00	0.02
LVA	0.00	0.00	0.01
MEX	-0.02	-0.12	-0.18
MLT	0.00	0.00	0.00
NLD	-0.01	-0.07	-0.07
NOR	0.02	0.00	0.12
POL	0.00	0.04	0.13
PRT	-0.01	-0.02	-0.03
ROU	0.00	0.03	0.10
ROW	**1.37**	**0.39**	**3.15**
RUS	**0.20**	**0.20**	**1.13**
SVK	0.00	0.01	0.05
SVN	0.00	0.00	0.00
SWE	0.00	-0.05	0.01
TUR	0.00	0.00	0.15
TWN	-0.01	-0.06	-0.25
USA	0.24	-2.05	-7.04

Note: All figures are in percentage points and rounded. The figures in the last three columns represent the variation in the respective period for each sector. The countries' acronyms of the WIOD 2016 are presented in the Section 2.2. The rows in bold represent the countries which increased their shares in the three sectors at least by 0.1 p.p.

Source: Author's elaboration based on the WIOD 2016.

Table 41. Sum of the value-added shares generated in all supplying industries for the production of the final goods and services delivered to the world final demand during 2000-2014.

Type	Tech. Int.	Sectors	2000	2008	2011	2014	2000-2008	2008-2011	2011-2014	2000-2014
Primary	MLT	Mining and quarrying	2.2	4.5	4.8	4.5	2.2	0.4	-0.3	2.2
	LT	Crop and animal production, hunting and related service activities	2.9	3.2	3.7	3.8	0.3	0.4	0.1	0.9
		Fishing and aquaculture	0.2	0.3	0.3	0.4	0.0	0.1	0.0	0.1
		Forestry and logging	0.3	0.3	0.3	0.3	-0.1	0.0	0.0	0.0
Manufacturing	HT	Basic pharmaceutical products and pharmaceutical preparations	0.6	0.6	0.6	0.6	0.0	0.0	0.0	0.0
		Computer, electronic and optical products	2.0	1.5	1.5	1.6	-0.5	0.0	0.0	-0.4
	MHT	Chemicals and chemical products	1.4	1.3	1.4	1.4	-0.1	0.1	0.0	0.0
		Electrical equipment	0.8	0.8	0.7	0.7	-0.1	0.0	0.0	-0.1
		Machinery and equipment n.e.c.	1.4	1.5	1.5	1.4	0.1	0.0	0.0	0.0
		Motor vehicles, trailers and semi-trailers	1.5	1.3	1.4	1.4	-0.2	0.1	0.0	-0.1
		Other transport equipment	0.5	0.5	0.6	0.6	0.0	0.0	0.0	0.0
	MT	Basic metals	1.0	1.3	1.3	1.1	0.3	0.0	-0.2	0.2
		Furniture; other manufacturing	0.9	0.7	0.6	0.6	-0.2	-0.1	0.0	-0.3
		Other non-metallic mineral products	0.8	0.7	0.8	0.8	0.0	0.0	0.0	0.0
		Repair and installation of machinery and equipment	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0
		Rubber and plastic products	0.8	0.6	0.6	0.6	-0.2	0.0	0.0	-0.2
	MLT	Coke and refined petroleum products	0.7	1.0	1.0	0.9	0.4	0.0	-0.1	0.3
		Fabricated metal products, except machinery and equipment	1.3	1.2	1.0	1.0	-0.2	-0.1	0.0	-0.3
		Food products, beverages and tobacco products	2.4	2.2	2.3	2.3	-0.2	0.1	0.0	-0.1
		Paper and paper products	0.6	0.4	0.4	0.4	-0.2	0.0	0.0	-0.2
		Printing and reproduction of recorded media	0.5	0.3	0.3	0.3	-0.2	0.0	0.0	-0.2
		Textiles, wearing apparel and leather products	1.1	0.9	0.9	0.9	-0.2	0.0	0.0	-0.2
		Wood and of products of wood and cork, except furniture; articles of straw and plaiting materials	0.4	0.3	0.3	0.4	0.0	0.0	0.0	0.0
Services	HT	Scientific research and development	0.6	0.6	0.6	0.6	0.0	0.0	0.0	0.0
	MHT	Computer programming, consultancy and related activities; information service activities	1.3	1.5	1.5	1.6	0.2	0.0	0.1	0.3
		Publishing activities	0.7	0.6	0.5	0.5	-0.1	-0.1	0.0	-0.2
	MLT	Advertising and market research	0.5	0.4	0.3	0.3	-0.1	-0.1	0.0	-0.2
		Architectural and engineering activities; technical testing and analysis	0.9	1.0	0.8	0.8	0.0	-0.1	0.0	-0.1
		Other professional, scientific and technical activities; veterinary activities	0.9	0.8	0.9	0.8	0.0	0.0	0.0	0.0
		Telecommunications	1.9	1.9	1.8	1.8	0.0	-0.2	0.0	-0.2
	LT	Accommodation and food service activities	2.7	2.5	2.4	2.5	-0.2	-0.1	0.0	-0.2
		Activities auxiliary to financial services and insurance activities	0.7	0.5	0.5	0.6	-0.2	0.0	0.0	-0.1
		Activities of extraterritorial organizations and bodies	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0
		Administrative and support service activities	3.3	3.3	3.0	3.0	0.0	-0.3	0.0	-0.3
		Air transport	0.4	0.3	0.3	0.4	-0.1	0.0	0.0	-0.1
		Construction	5.6	5.9	5.6	5.7	0.3	-0.3	0.1	0.1
		Electricity, gas, steam and air conditioning supply	2.1	2.2	2.2	2.1	0.1	0.0	0.0	0.1
		Financial service activities, except insurance and pension funding	3.6	3.7	3.9	4.1	0.0	0.2	0.2	0.5
		Insurance, reinsurance and pension funding, except compulsory social security	1.6	1.3	1.2	1.3	-0.3	0.0	0.1	-0.2

	Land transport and transport via pipelines	2.6	2.7	2.7	2.7	0.1	0.0	0.0	0.2
	Legal and accounting activities; activities of head offices; management consultancy activities	2.3	2.5	2.4	2.5	0.2	-0.1	0.1	0.2
	Motion picture, video and television programme production, sound recording and music publishing activities; programming and broadcasting activities	0.6	0.5	0.5	0.5	-0.1	0.0	0.0	-0.1
	Other service activities	2.8	2.5	2.5	2.6	-0.3	0.0	0.1	-0.2
	Postal and courier activities	0.4	0.3	0.3	0.3	-0.1	0.0	0.0	-0.1
	Real estate activities	9.1	9.0	9.1	9.0	-0.2	0.1	-0.1	-0.1
	Retail trade, except of motor vehicles and motorcycles	5.0	4.5	4.4	4.4	-0.5	0.0	-0.1	-0.6
	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0
	Warehousing and support activities for transportation	0.8	1.0	1.0	1.0	0.2	0.0	0.0	0.2
	Water collection, treatment and supply	0.2	0.3	0.3	0.3	0.0	0.0	0.0	0.0
	Water transport	0.3	0.4	0.3	0.3	0.1	-0.1	0.0	0.0
	Wholesale and retail trade and repair of motor vehicles and motorcycles	1.5	1.3	1.2	1.1	-0.2	-0.1	-0.1	-0.4
	Wholesale trade, except of motor vehicles and motorcycles	6.1	6.1	6.1	6.4	0.0	0.0	0.2	0.3
Others	Education	3.2	3.4	3.5	3.5	0.2	0.1	0.0	0.3
	Human health and social work activities	4.9	5.1	5.2	5.1	0.2	0.1	-0.1	0.3
	Public administration and defence; compulsory social security	8.4	8.0	8.0	7.7	-0.4	0.0	-0.3	-0.7
Total		**100.0**	**100.0**	**100.0**	**100.0**				

Note: All figures are in percentage points and rounded. The last four columns represent the variation in the respective period. The aggregation of the industries per technology intensity follows OECD 2016 taxonomy. HT: high-technology; MHT: medium-high-technology; MT: medium-technology; MLT: medium-low-technology; LT: Low-technology; Others: non-classified.

Source: Author’s elaboration based on the WIOD 2016.

Table 42. Regional distribution of the value-added per sector/industry of origin induced by the world final demand during 2000 and 2014.

	BRA		BRIIAT		CHN		East Asia		JPN		EU28		NAFTA		RoW		Total	
Sector	2000	2014	2000	2014	2000	2014	2000	2014	2000	2014	2000	2014	2000	2014	2000	2014	2000	2014
Primary	**2.4**	**2.8**	**16.5**	**17.7**	**13.2**	**23.2**	**1.7**	**0.6**	**4.8**	**1.0**	**13.6**	**5.9**	**17.2**	**14.6**	**33.0**	**37.0**	**100.0**	**100.0**
MLT	2.0	2.3	11.7	14.5	8.4	16.9	0.3	0.1	1.7	0.2	10.2	3.6	24.8	20.4	42.9	44.3	100.0	100.0
LT	2.7	3.3	19.6	20.9	16.4	29.7	2.6	1.2	6.7	1.8	15.7	8.2	12.4	8.7	26.6	29.6	100.0	100.0
Manuf.	**1.5**	**2.0**	**6.1**	**9.4**	**6.6**	**24.7**	**4.0**	**4.4**	**16.9**	**6.8**	**26.4**	**22.0**	**31.1**	**20.5**	**8.8**	**12.1**	**100.0**	**100.0**
HT	0.8	1.1	2.2	3.8	4.8	21.8	7.5	11.0	19.4	8.2	22.1	21.1	38.1	24.9	5.9	9.3	100.0	100.0
MHT	1.6	1.9	4.9	7.3	6.0	24.2	4.2	4.9	16.3	6.5	28.1	23.9	32.8	21.7	7.7	11.6	100.0	100.0
MT	1.7	2.5	7.4	10.9	8.5	27.9	3.1	2.9	14.7	5.6	28.4	22.4	27.6	16.6	10.4	13.6	100.0	100.0
MLT	1.7	2.0	8.0	12.5	6.9	24.5	2.9	2.6	17.7	7.3	25.6	20.3	29.0	20.0	9.9	12.8	100.0	100.0
Services	**1.8**	**3.0**	**5.9**	**11.5**	**2.4**	**10.4**	**2.4**	**2.2**	**14.9**	**6.4**	**26.6**	**25.8**	**39.5**	**30.6**	**8.4**	**13.1**	**100.0**	**100.0**
HT	1.7	2.8	1.7	2.8	1.3	8.6	3.9	7.2	8.4	2.9	32.8	32.4	46.8	37.5	5.2	8.6	100.0	100.0
MHT	1.6	2.2	4.7	9.6	0.4	4.0	2.1	1.7	15.2	6.4	31.6	32.7	41.9	37.5	4.0	8.0	100.0	100.0
MLT	1.2	1.7	3.6	7.4	2.0	12.2	1.8	1.8	21.2	11.3	25.6	23.1	40.3	31.2	5.6	13.0	100.0	100.0
LT	1.8	3.0	6.3	12.2	2.7	11.4	2.4	2.1	14.8	6.0	26.2	25.2	38.4	28.9	9.2	14.2	100.0	100.0
Others	2.0	3.5	5.5	10.7	1.8	7.8	2.2	2.4	13.5	6.8	27.4	27.4	42.1	34.5	7.4	10.5	100.0	100.0
	1.8	**2.8**	**6.6**	**11.7**	**3.8**	**13.9**	**2.6**	**2.4**	**14.7**	**6.0**	**25.8**	**23.4**	**36.6**	**27.4**	**9.9**	**15.1**	**100.0**	**100.0**

Note: All figures are in percentage points and rounded. The sum along the rows for each year in the columns (2000 and 2014) must add to 100 in the respective year in the two last columns (Total), excluding the values in the columns of Brazil (already added in the BRIIAT region). Technology intensity defined according to OECD's taxonomy.

Source: Author's elaboration based on WIOD 2016.

APPENDIX 2 – PAPERS PUBLISHED DURING THE THESIS DEVELOPMENT

The papers published during the development of this thesis are presented below.

RAMOS. R. R.; PROCHNIK. V. **The Technology Intensity of the Final Demand for Goods and Services: a Value-Added Analysis of Five Resource-Based Economies**. VII Jornadas de Análisis Input-Output. **Anais**...Merida. México: Sociedad Hispanoamericana de Análisis Input-Output. 2017.

Abstract: The fragmentation of economic activities is reshaping global trade into a network of cross-borders chains. These trends and the rapid economic growth of several developing countries. mainly from East Asia. have made it important to study the evolution of any country's insertion in the world economy. Pursuing this objective, the paper applies recently enhanced methods based on Leontief's traditional input-output analysis to five natural resource-rich economies: Australia, Brazil, Canada, Mexico and Norway. We have adapted them to study the technology intensity of inter-regional flows based on the origin of the value-added generated by the final demand for goods and services. Final demand was also splited into final goods and services consumed by domestic final demand and goods exported to the final demand of other countries. The results show significant variations among the analyzed economies when the technological intensity of the sectors which originated the value added is taken into consideration. The evidences also suggest that exports specialization. sectoral policies and trade agreements still have a role to play.

RAMOS. R. R.; PROCHNIK. V. **The Technology Intensity of the Final Demand for Goods and Services: a Value-Added Analysis of the Brazilian Economy**. Blucher Engineering Proceedings. **Anais**...São Paulo: Editora Blucher. set. 2017. Disponível em: <http://www.proceedings.blucher.com.br/article-details/26659>

Abstract: The fragmentation of economic activities is reshaping global trade into a network of cross-borders chains. These trends and the rapid economic growth of several developing countries, mainly from East Asia. have made it important to study the evolution of the Brazilian's insertion in the world economy. Pursuing this objective, the paper applies recently enhanced methods based on Leontief's traditional input-output analysis. adapting them to study the technology intensity of interregional flows. It emphasizes differences are being employed in imports and exports of final goods and services to households' consumption demand and to gross fixed capital formation. The results show that the final demand

expenditures to households' consumption generate much more value-added in the Brazilian production of final goods and services compared to the gross fixed capital formation. Besides, it reveals a reduction of the value-added generated in Brazilian high-technology industries both for the households' consumption and for gross fixed capital formation from 2000 to 2014.