

The Technology Intensity of the Final Demand for Goods and Services: a Value-Added Analysis of the Brazilian Economy

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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.

Resumo: A fragmentação das atividades econômicas está transformando o comércio global em uma rede de cadeias que atravessam fronteiras. Essas tendências e o rápido crescimento econômico de vários países em desenvolvimento, principalmente do Leste Asiático, atribui importância ao estudo da evolução da inserção brasileira na economia mundial. Com este objetivo, este trabalho adota métodos recentemente aprimorados baseados na tradicional análise insumo-produto de Leontief, adaptando-os para avaliar a intensidade tecnológica de fluxos inter-regionais. São enfatizadas as diferenças empregadas nas importações e exportações de bens e serviços finais para o consumo das famílias e para a formação bruta de capital fixo. Os resultados mostram que os gastos da demanda final para o consumo das famílias geram mais valor adicionado na produção brasileira de bens e serviços finais do que os gastos com a formação bruta de capital fixo. Além disto, revelam uma redução no valor adicionado gerado nas indústrias brasileiras de alta intensidade tecnológica tanto para o consumo das famílias como para a formação bruta de capital fixo no período de 2000 a 2014.

Keywords: value-added analysis; global value chains; technology intensity; world input-output database.

Palavras-chave: análise de valor adicionado; cadeias de valor global; intensidade tecnológica; base de dados mundial de insumo-produto.

Área: 2.2 Comércio internacional e cadeias de valor.

JEL: L8; F1; F6.

1. Introduction

The globalization is not a recent phenomenon. However, only recently the quantitative research on the global production fragmentation gained momentum. It has focused on the complex international network of flows of goods, services, know-how and people, the so-called supply-chain trade (Baldwin & Lopez-Gonzalez, 2015). According to the author, after reaching a peak of 67% around the 1990s, by 2010 the G7 World GDP share had decreased to the same value of 1900. Some large emergent economies, led by China, and an aggregate of smaller economies have benefited from the offshoring movement of the 1980-90s based on low-cost factors to production. In general, after receiving production facilities to perform simple assembling activities an upgrade of managerial and manufacturing know-how has also been implemented, frequently through the transference of organizational and technical routine from large multinationals from United States, Europe, and Japan. (Baldwin & Lopez-Gonzalez, 2015).

Brazil is a large emergent economy and belongs to the group called BRICS. Notwithstanding being listed in the top 10 economies according to world GDP share, Brazil has the lowest economic growth rate among the BRICS countries. The Brazilian's industry lack of competitiveness in the international market is pointed as one of the main problems associated with low rates of economic development. Why can't Brazil "upgrade" in the global value chains (GVCs) and become a relevant player in exports of manufactured goods?

Our paper attempts to contribute to this debate while studying one aspect of the question. We focus on the technology intensity of the industries which originated the value-added of the products and services consumed in the Brazilian domestic final demand (locally completed and imported) as well as exported to other countries. We propose to use the value-added trade (VAT) approach based on the final demand side for final goods and services. We also expect to connect to the large international literature on intermediates trade.

After this brief introduction, the next section summarizes the literature on GVCs and recent developments of indicators to measure VAT. The following section presents the database and the methodology applied to this work. Then, the analysis of the Brazilian economy is discussed. We finish the paper with the conclusions.

2. Literature Review

The literature on value-added trade that is explored in this paper is a new strand that takes into account the previous literature on global commodities chains (Bair, 2005; Gereffi, 1994, 1996; Gereffi, Humphrey, & Sturgeon, 2005) and open new venues through the resource to economic models derived from the basic Leontief insights. The research on global commodities chains has focused on 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 intersectoral flows of goods, technology, etc. emphasizing the interaction among sectors and the patterns of behavior of the firms acting in these sectors. The work in these traditions has examined themes like vertical integration, 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 paper while taking into account these strands of technical literature is grounded on recent enhancements of traditional Leontief's decomposition methods. It sees the global value chains not as a set of interacting firms from subsequent sectors on the production chains but as a set of value-added activities. We follow (Timmer, Dietzenbacher, Los, Stehrer, & Vries, 2015) who "...define a GVC of a final good as the set of all value-adding activities needed in its production. It is identified by the country–industry in which the last stage of production takes place, which we call the country–industry-of-completion (such as the transport equipment manufacturing industry in Germany). A GVC includes the value-added in this last industry, as well as in all other industries in the same country or abroad where previous stages of production take place."

Recent research on GVCs in this line has been giving solid evidence of the fragmentation of production across industries (OECD., 2013; Erumban et al., 2014; Johnson & Noguera, 2012; Timmer et al., 2015). It is based on multi-regional input-output models (MRIO), several of which have been recently developed, as the joint WTO-OECD database, EORA database and the World Input-Output Database (WIOD). The data we use comes from the last version of the latter one (November 2016). This project, coordinated by the University of Groningen, is described in Timmer et al. (2015) and Dietzenbacher, Los, Stehrer, & Timmer (2013), who provide the methodology employed to build the model, from national input-output tables and international trade statistics

Our paper focuses on the technology intensity of the industries which generate the value-added absorbed by its final demand. Few studies in that direction have been published in peer-reviewed journals based on the WIOD, but some conference and working papers (Ferraz, Gutierrez, & Cabral, 2015; Sarti & Hiratuka, 2017; Torracca & Castilho, 2015). That gives us the motivation to start our contribution to the GVC literature.

3. Database and Methodology

All calculations in this work are based on the data provided by the recently (2016) released World Input-Output Database (WIOD) (Timmer et al., 2015). To understand how this database is constructed, one should be familiarized with the concept of world input-output tables (WIOT). A simple schematic of a WIOT for N countries and K industry sectors is outlined in Figure 1. The WIOT provides a summary of the trade flows in the global economy. Each row vector contains the values of the output per industry/country of origin. This production is to be consumed as intermediates by other industries/countries or final products by households, government or firms (gross fixed capital formation and stocks). The diagonal cells of intermediate and final consumption matrices contain the values of the domestic demand. The columns contain the information on production processes and can be expressed as shares of inputs (as ratios to gross output given in the last cell in a column) in total costs - (Timmer et al., 2015).

Timmer et al. (2016) present an overview of the sources and characteristics of the 2016 WIOD release. The methodology to construct this new release is the same of the 2013 release, described in details by Dietzenbacher et al. (2013) and Timmer et al. (2015). The new WIOD provides a time-series of WIOTs from 2000 to 2014 including 43 countries and 56 industries. It also contains estimated information for the remaining countries of

the world economy – “rest of the world” (RoW). The industry/product classification follows the ISIC Rev. 4 (or equivalently NACE Rev. 2).

The indicators used in our work follow the definitions of the joint OECD–WTO Trade in Value-Added (TiVA) initiative¹. They draw on the recent research of input-output analysis applied to global value chains (Hummels, Ishii, & Yi, 2001; Johnson & Noguera, 2012; Koopman, Powers, Wang, & Wei, 2010; Timmer et al., 2015). All these works are based on the decomposition technique introduced by Leontief (1949).

Figure 1. 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: Authors' elaboration.

Consider X , a vector containing the values of the output of industries, F , a vector of consumption levels, and A , a matrix with intermediates technical coefficients (intermediates quantity needed to produce one unity of output). The elements of A are obtained by dividing each cell in a column of the intermediates matrix by its last cell (gross output per industry and country). One may write $X = (I - A)^{-1} \cdot F$, where $L = (I - A)^{-1}$ is the Leontief inverse and I is the identity matrix. L can be considered the gross output values generated in all stages of production in all countries of one unit of consumption (Timmer et al., 2015).

Now, let V be a diagonal matrix of value-added to gross output ratios in all industries and countries. Then, the product $VA = V(I - A)^{-1}F$ returns the value-added by the consumption of the products and services indicated by final demand F reclassified by country/sector of origin. When F represents the total consumption outside a given country (exports), the $V(I - A)^{-1}F$ is usually referred as VAX , the value-added exports of a given country (Timmer et al., 2015). VAX can be calculated by industry or country.

In the exports perspective, the origin, by country/sector, of the value-added exported from the country of interest and absorbed by the foreign final demand is $VA_FFD_{exp} = V(I - A)^{-1}F_{exp}$. In this case, F_{exp} is the final demand matrix with all the rows set to zero except for the rows of the country of interest. The columns of F_{exp} corresponding to the country of interest should also be set to zero. Therefore, the domestic final demand for final goods and services domestically produced is not included in the global final demand.

In the imports perspective, $VA_DFD_{imp} = V(I - A)^{-1}F_{imp}$ shows the countries/sectors that originate the value-added absorbed in a country by domestic demand for final goods and services produced worldwide (value-added embodied in the imports). The calculation procedure of this indicator is analogous to the one used to VA_FFD_{exp} . The difference is

¹ See <http://www.oecd.org/sti/ind/measuringtradeinvalue-addedanoecd-wtojointinitiative.htm>.

that now F_{imp} corresponds to the global final demand matrix 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 F (instead of 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 is not included in the global final demand.

Finally, $VA_DFD_{local} = V(I - A)^{-1}F_{local}$ shows the value-added from the sectors that originate the value-added absorbed in a country by domestic demand for final goods and services produced by the local economy of the country of interest (value-added embodied in the national trade). F_{local} is defined as the domestic final demand for final goods and services locally produced and it corresponds to the global final demand matrix F with the columns and rows set to zero except for the columns and rows of the country of interest.

4. Analysis of the Brazilian Economy

Recent studies of the Brazilian economy show a declining performance of its competitiveness in the international scenario (Ferraz et al., 2015; Sarti & Hiratuka, 2017; Torracca & Castilho, 2015). The Brazilian manufacturing industry has been losing its share in the global value-added (Sarti & Hiratuka, 2017). Compared to our work, none of those authors used the newly released 2016 WIOD. Another distinction in our methodology is the decomposition of the final demand in two main components, i.e., households' consumption and gross fixed capital formation and the analysis based on the industries technology intensity.

Our analysis starts with an overview of the participation of the Brazilian and other emerging economies in the world value added between 2000 and 2014. The Table 1 lists the shares of the world value-added of the 15 largest economies in 43 countries of the WIOD plus RoW - "Rest of the World". The data reveal the relevant decrease of USA and Japan shares of world value-added. These evidence are contrasted by the growth of China (mostly), Russia, India, Brazil and RoW. That means the advanced economies are losing ground to emergent and smaller economies (in aggregate), which is explained by the continuous fragmentation of production chains in the last decades (Chen, 2016; De Backer & Yamano, 2012; Gereffi, 1999; Gereffi, Humphrey, Kaplinsky, & Sturgeon, 2001; Johnson & Noguera, 2012; Sturgeon, Van Biesebroeck, & Gereffi, 2008). Despite the negative perspective of the Brazilian economy, it remains in the top 10 economies.

In Figure 2, we show the shares of the world value-added for selected regions and China. Even when China is compared in isolation with other regions that aggregate various economies, its performance is significant. The BRIIAT kept growing at the same rate as China only until 2011 (BRIIAT stands for Brazil, Russia, India, Indonesia, Australia, and Turkey).

Analyzing the data of Table 2, we capture the process of deindustrialization in the Brazilian economy. From 2000 to 2014, the manufacturing sector decreased by 4% its share of Brazilian total value-added. The world manufacturing sector has decreased less than that (1,7%) until the world crisis. After that, it stabilized around 16,6%. Regarding the services sector, in Brazil it has grown its share of the total value-added, a different behavior compared to the world services sector.

Table 1. Value-added shares of the world value-added of the 15 largest economies included in the WIOD (ranking is based on the year 2014).

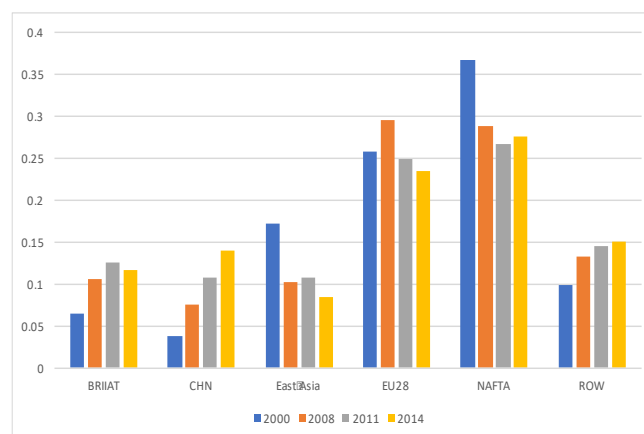
Countries	2000	2008	2011	2014	2000-2014	Rank change
USA	33%	25%	23%	24%	-9%	0
ROW	9%	13%	14%	14%	5%	1
CHN	4%	8%	11%	14%	10%	4
JPN	15%	8%	8%	6%	-9%	-2
DEU	6%	6%	5%	5%	-1%	-1
GBR	4%	4%	3%	4%	-1%	-1
FRA	4%	4%	4%	3%	0%	-1
BRA	2%	2%	3%	3%	1%	3
IND	1%	2%	3%	3%	1%	5
ITA	3%	4%	3%	3%	-1%	-2
CAN	2%	2%	2%	2%	0%	-2
RUS	1%	2%	2%	2%	1%	4
AUS	1%	2%	2%	2%	1%	2
KOR	2%	2%	2%	2%	0%	-1
ESP	2%	3%	2%	2%	0%	-3
MEX	2%	2%	2%	2%	0%	-6

Note: ROW represents "Rest of the World".

Source: Authors' elaboration based on 2016 WIOD.

The Table 3 and the Table 4 show the manufacturing shares of total value-added of the disaggregated industries per technology intensity for the world and Brazil, respectively. A closer look at the data reveals an evidence previously highlighted by recent literature on industrial competitiveness of Brazilian economy. The industry in Brazil, although relatively diversified, has become specialized in low-technology production in the expense of the more dynamic high-technology industries.

Figure 2. Value-added shares of the world value-added of selected regions (all countries in the WIOD are assigned to a region).



Note: BRIIAT - Brazil, Russia, India, Indonesia, Australia and Turkey; ROW- "Rest of the World".

Source: Authors' elaboration based on 2016 WIOD.

Table 2. Sectors value-added shares of the world and the Brazilian total value-added.

	World					Brazil				
Sector	2000	2008	2011	2014	2000-2014	2000	2008	2011	2014	2000-2014
Primary	6%	8%	9%	9%	3%	8%	11%	9%	9%	1%
Manufacturing	18%	17%	17%	17%	-2%	16%	14%	14%	12%	-4%
Services	76%	75%	74%	74%	-2%	77%	75%	77%	79%	3%

Source: Authors' elaboration based on 2016 WIOD.

Table 3. Manufacturing value-added shares of the world value-added disaggregated per technology intensity.

World	2000	2008	2011	2014	2000-2014
Manufacturing	100%	100%	100%	100%	
High-tech	14%	12%	13%	13%	-1%
Medium-high-tech	30%	31%	32%	32%	2%
Medium-low-tech	25%	29%	27%	26%	2%
Low-tech	31%	28%	28%	29%	-2%

Note: Technology intensity defined according to Eurostat indicators on High-tech industry and Knowledge -intensive services (Annex 3).

Source: Authors' elaboration based on 2016 WIOD.

Table 4. Manufacturing value-added shares of the Brazilian total value-added disaggregated per technology intensity.

Brazil	2000	2008	2011	2014	2000-2014
Manufacturing	100%	100%	100%	100%	
High-tech	8%	8%	7%	7%	0%
Medium-high-tech	31%	33%	31%	31%	0%
Medium-low-tech	15%	16%	19%	17%	2%
Low-tech	46%	43%	43%	45%	-2%

Note: Technology intensity defined according to Eurostat indicators on High-tech industry and Knowledge -intensive services (Annex 3).

Source: Authors' elaboration based on 2016 WIOD.

4.1. Origin of the Value-added by Final Demand

Traditional analysis of the international trade compares the impact of the structure of imports with that of the domestic industry's production for the internal market and exports. But this kind of study can only refer to the production which is absorbed by the domestic consumption at home or abroad. Our analysis of the value-added absorbed by the Brazilian economy and the countries to which it exports differs from this usual methodological procedure. The approach followed here reveals the origin of the value-added absorbed by final consumption of goods and services. Knowing the industries of which produced the value-added absorbed in Brazilian domestic demand and exports we were able to measure their technology intensity. We have not found any work in the literature with has followed such approach. Besides, we disaggregate the demand in households' consumption and gross fixed capital formation and study the technology intensity of the sectoral structure of each of these components of final demand.

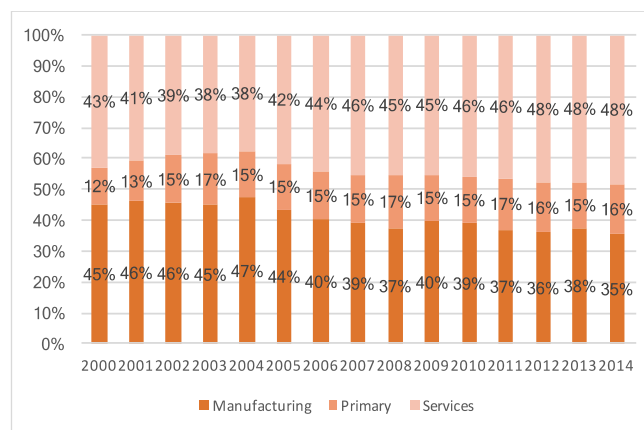
The results for the value-added by the foreign final demand (VA_FFD_{exp}), as defined in Section 2, for the aggregate sectors of primary goods, manufacturing and services are shown in Figure 3 as shares (in percentage) of the total VA_FFD_{exp} (it does not include the internal supply-use trade). From the foreign final demand perspective, we can see that the share of VA_FFD_{exp} for the final goods manufactured in Brazil has substantially decreased from 2000 to 2014. It is another indication of the deindustrialization process in the Brazilian economy, since the value-added in manufacturing industries, according to the foreign final demand, has been transferred to services and primary sectors.

To obtain a more detailed evaluation the deindustrialization, we disaggregate the manufacturing by technology intensity of industries². Figure 4 shows that the value-added

² Aggregation of manufacturing industry according to technology intensity based on NACE Rev. 2 at 2-digit provided by Eurostat indicators on high-tech industry and Knowledge -intensive services (Annex 3).

by high technology final production in Brazil not only has a small share of total VA_FFD_{exp} , but eventually decreased from 11% in 2000 to 5% in 2014. It may indicate that Brazilian industry is becoming specialized in the stages of production of minor complexity, exactly those that pay lower wages (i.e., final assembly).

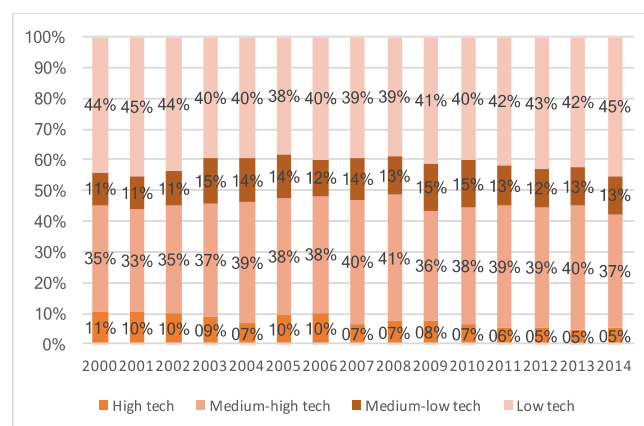
Figure 3. Value-added shares embodied in exports by final demand for Brazilian production of primary, manufacturing and services sectors – VA_FFD_{exp} .



Source: Authors' elaboration based on 2016 WIOD.

The Table 5 lists the disaggregated industries of medium-high and low technology intensity. Together they represent around 80% of the total VA_FFD_{exp} of manufacturing. Among the medium-high technology industries, transport and machinery and nonelectrical equipment have the most representative shares of total VA_FFD_{exp} , summing for more than 25% (more than 65% of all medium-high technology industries). The automobiles industry has a history in the industrialization of Brazilian economy, being established in the country since the 1950-60s. The segment is dominated by transnational corporations. Despite their well-developed production facilities in Brazil, it's hard to keep track of the firms' profits flow, since the WIOD accounts for the production location and not for the ownership.

Figure 4. Value-added shares embodied in exports by final demand for Brazilian production of manufactured goods according to technology intensity – VA_FFD_{exp} .



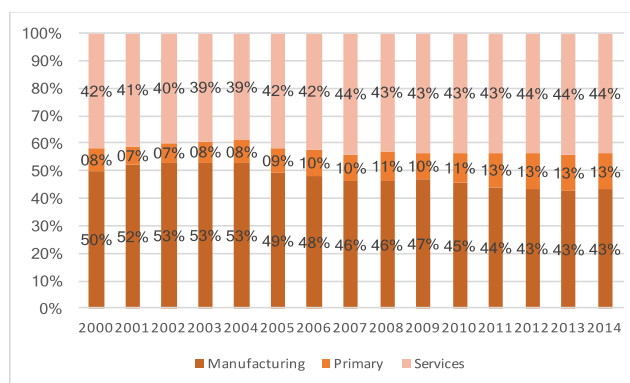
Note: Technology intensity defined according to Eurostat indicators on High-tech industry and Knowledge -intensive services (Annex 3).

Source: Authors' elaboration based on 2016 WIOD.

The low technology industries – a.k.a. natural resource based goods – together they represent almost half of the total VA_FFD_{exp} of manufacturing, as shown in Table 5. The

manufacturing of food products, beverages, and tobacco products had the only positive variation in the share of the total VA_FFD_{exp}. The other industries, mostly textiles (12.8 to 3.8%), have diminished their share. This tendency follows the indicator of industry domestic value-added contribution to gross exports from 1995 to 2011 of textiles, which decreased from 4.1 to 1.1% (obtained in the TiVA initiative database).

Figure 5. Value-added shares embodied in exports by final demand for Brazilian production of primary, manufacturing and services sectors – VA_FFD_{exp}.



Source: Authors' elaboration based on 2016 WIOD.

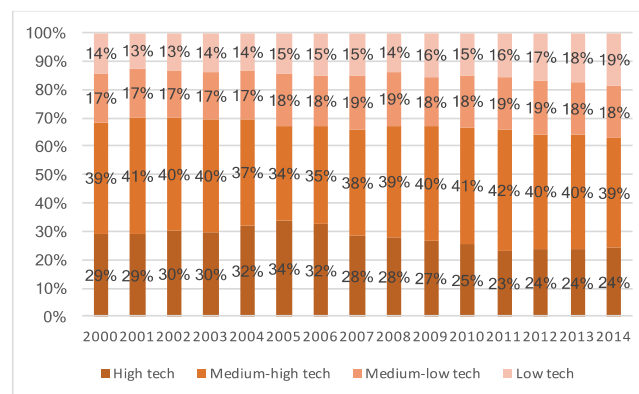
Table 5. Technology intensity of the industries which generated the value-added in the Brazilian exports of manufacturing goods for foreign final demand - VA_FFD_{exp}.

	2000	2014	2000-2014
Manufacturing	100%	100%	
Medium-high-tech	35%	37%	3%
Chemicals and chemical products	6%	6%	1%
Electrical equipment	3%	3%	0%
Machinery and equipment n.e.c.	8%	11%	2%
Motor vehicles, trailers and semi-trailers	12%	10%	-2%
Other transport equipment ¹	6%	7%	1%
Low-tech	44%	45%	1%
Food products, beverages and tobacco products	12%	27%	16%
Furniture; other manufacturing	16%	12%	-4%
Paper and paper products	2%	1%	-1%
Textiles, wearing apparel and leather products	13%	4%	-9%
Wood and of products of wood and cork, except furniture; articles of straw and plaiting materials	1%	1%	-1%
Printing and reproduction of recorded media	1%	1%	0%

Note: ¹Includes railroad equipment (medium-high), aircraft and spacecraft (high), and shipbuilding (medium-low). Technology intensity defined according to Eurostat indicators on High-tech industry and Knowledge-intensive services (Annex 3).

Source: Authors' elaboration based on 2016 WIOD.

Figure 6. Value-added shares embodied in imports by final demand for manufactured goods according to technology intensity – VA_DFD_{imp} .



Note: Technology intensity defined according to Eurostat indicators on High-tech industry and Knowledge -intensive services (Annex 3).

Source: Authors' elaboration based on 2016 WIOD.

Table 6. Technology intensity of the industries which generated the value-added in the imports of manufacturing products to Brazilian final demand - VA_DFD_{imp} .

	2000	2014	2000-2014
Manufacturing	100%	100%	
High-tech	29%	24%	-5%
Basic pharmaceutical products and pharmaceutical preparations	6%	7%	1%
Computer, electronic and optical products	23%	18%	-6%
Medium-high tech	39%	39%	-1%
Chemicals and chemical products	5%	6%	1%
Electrical equipment	6%	5%	-1%
Machinery and equipment n.e.c.	13%	14%	1%
Motor vehicles, trailers and semi-trailers	8%	11%	3%
Other transport equipment ¹	8%	4%	-5%

Note: ¹Includes railroad equipment (medium-high), aircraft and spacecraft (high), and shipbuilding (medium-low). Technology intensity defined according to Eurostat indicators on High-tech industry and Knowledge -intensive services (Annex 3).

Source: Authors' elaboration based on 2016 WIOD.

The results for the VA_DFD_{imp} shares of manufacturing indicate the higher value-added content of the imports of final goods, compared to the numbers of the VA_FFD_{exp} . The disaggregation per technology intensity, shown in Figure 6, reveals a similar behavior of the low-technology industries and a slight increase in the mean value of the medium-low-technology (a difference of around 5%). As per the high and medium-high-technology industries, from 2000 to 2014 both represent the most part of the total VA_DFD_{imp} (min. 63%; max. 70%). This result is due mainly to the greater shares of the total VA_DFD_{imp} in the high-technology industries, meaning that the domestic supply of manufactured final goods of higher technology intensity is not enough. Besides, our final demand for manufactured goods is generating high value-added participation for foreign industries. The highest variations were in high- and medium-high-technology industries. Based on the disaggregated information shown in Table 6, electronics and machinery and equipment n.e.c. presents the highest shares of total VA_DFD_{imp} .

According to Ferraz et al. (2015), the share of imported intermediates on total consumption of imported intermediates in all manufacturing industries, also in services, have substantially increased from 1995 to 2011. The authors used the 2013 WIOD release

in their research. They conclude that the Brazilian economy has become relatively more specialized in the production of low- and low-technology intermediates. The considerable value-added share in the imports of final manufactured goods of higher technology intensity found in our work leads us to an analogous conclusion to the one presented by Ferraz et al. (2015), although we use the more recent release of the WIOD (from 2000 to 2014). As for the case of intermediate goods, Brazil is deeply dependent on the imports of medium-high- and high-technology final goods.

4.2. Origin of the Value-added by Final Demand Components

In Section 4.1, we have reached several results related to the origin of the value-added generated by the aggregate expenditures of the Brazilian final demand between the years 2000 and 2014. Now, we present an analogous analysis but disaggregating the Brazilian final demand in its two main components, i.e., households' consumption and gross fixed capital formation. This exercise of simulation will allow us to show the differences in the value-added originated from both sources. Although there are other three expenditures categories in the WIOD (government, non-profit organizations serving, changes in inventories and valuables), they are not as relevant as the households and the gross fixed capital formation. These two components together represent at least 95% of the value-added embodied in imports (VA_DFD_{imp}), as shown in Table 7.

Table 7. Value-added shares embodied in imports by final demand components – VA_DFD_{imp} .

Final demand component	2000	2008	2011	2014
Gross fixed capital formation	45%	49%	44%	42%
Households	50%	47%	52%	54%
Other categories	5%	4%	4%	4%
Total	100%	100%	100%	100%
Total (US\$ millions, current prices)	22,700	59,544	96,975	97,485

Note: Includes manufacturing, primary and services sectors.

Source: Authors' elaboration based on 2016 WIOD.

Table 8 and Table 9 present analogous statistics, respectively related to households' consumption and gross fixed capital formation. They show the technology intensity of the value-added originated in final demand for Brazilian exports, and in the Brazilian final demand of imports and domestically produced and consumed final primary and manufactured goods and services.

For instance, in Table 8, the former shows the technology intensity of the origin of the value-added of the Brazilian products and services purchased by the households from all the other 43 countries that are imported from Brazil column "Exports for consumption abroad". In this case, Brazil is the country of completion, but the country in which this value-added was generated is not necessarily the same (country of completion is the country in which the last stage of production takes place).

The next column details the technology intensity of the value-added originated in the imports from Brazil that are destined to the country's final demand. In this case, the country which exported to Brazil is the country of completion. But the original value-added may be Brazilian. For instance, if a Brazilian family imported a German car and it is made with Brazilian steel, the technology intensity of the value-added of the steel production is taken into account.

The last column shows the technology intensity of the sectors which originated the value-added of the products and services completed in Brazil and consumed by Brazilian final demand. If a Brazilian family purchases a Brazilian car and some parts come from China, the technology intensity of the Chinese auto industry is taken into account, as well as that of the assembly of the car in Brazil etc, on a proportional basis.

At first, let's discuss the results for the value-added embodied in the exports for households' consumption abroad. The structure of the value-added shares by technology intensity reveals changes in the structure of primary, manufacturing and services sectors.

Table 8, from 2000 to 2014, shows that the value-added incorporated in the exports of primary goods for household final demand has increased by 4%. It was followed by a decrease in the shares of participation of the manufacturing aggregated figures, that decreased 7% during the same period. That decrease in the manufacturing industries consistently occurred for each level of technology intensity. It can also be noticed a relative small participation of the high-technology industries, which is consistent with the aggregated results obtained in Section 4.1. In the case of the services sector, it also absorbed part of the decrease in the manufacturing sector participation in the total value-added, accounting for a 4% raise.

In the case of the imports for households' consumption in Brazil, it can be verified a similar behavior from 2000 to 2014 compared to the observed in the exports in the change of the structure of the aggregate participation on the total value-added of the primary, manufacturing and services sector. That means an increase in the value-added participation of the primary sector at the expense of a decrease in the manufacturing sector. In the services sector, the participation remained stable during the observed period.

However, a slight difference should be highlighted for the distribution of the value-added embodied in the imports of manufactured goods. The high-, medium-high- and medium-low-technology industries present a higher share of the total value-added, compared to the exports. That can be partly explained by the decrease in the participation of the low-technology industries.

When it comes to the value-added in the domestically produced goods and services for final consumption of Brazilian households (VA_DFD_{local}), we noticed some significant differences compared to the figures of the exports (VA_FFD_{exp}) and imports (VA_DFD_{imp}). The domestic final demand of Brazilian households generates considerably higher value-added in the services sector. And that fact consistently increased after the 2008 global financial crisis. Again, that increase verified in the services sector came at the expense of a reduction of the value-added participation of the manufacturing industries and a slight increase in the primary sector. It is worth to mention that the amount of value-added (in US\$ dollars) generated by Brazilian households at the domestic production is considerably higher (around 18x in the worst case – 2008) than the amount of value-added generated by the exports. It's an evidence that the Brazilian production of final goods and services for households is highly dependent on the domestic final demand.

In Table 9, the figures of the value-added generated by the final demand for gross fixed capital formation are highlighted. Both for the exports (VA_FFD_{exp}) and the imports

(VA_DFD_{imp}), the manufacturing sector absorbs more than half of the total value-added generated by the final demand abroad and in Brazil, respectively. In the case of the domestic production, the value-added generated in the manufacturing industries by the Brazilian final demand is lower than in the services sector. When it comes to the services sector, both for exports and imports, its activities present lower participation in the total value-added for gross fixed capital formation (below 40%) in comparison to the households' consumption (above 45%), shown in Table 8. Nonetheless, the services sector increases its overall participation when compared to the constant slowing down of the manufacturing sector from 2000 to 2014.

The figures of the total value-added in US dollars reveals that the final demand expenditures for households' consumption generate much more value-added in the Brazilian production of final goods and services compared to the gross fixed capital formation. It leads us to conclude that Brazilian policymakers should develop long-term strategies and policies to foster the increment of the expenditures in gross fixed capital formation. Besides, that expenditures increment should be followed by industrial and technology policies to upgrade the business firms' activities to be integrated into higher value-added global chains.

When we look at the technology intensity of the manufacturing industries which generated the value-added for households' consumption and gross fixed capital formation (Figure 7 and Figure 8, respect.), we verify that the latter is responsible for the results observed in the aggregate analysis we provided in Section 4.1. Most of the value-added generated by the exports are concentrated in the medium-high-technology industries, basically due to the participation of the automobiles and nonelectrical machinery and equipment industries. We also observe a reduction of the value-added shares of the high-technology industries both for the households' consumption (4%) and for gross fixed capital formation (9%).

In the Table 10 and the Table 11, the technology intensity of the final demand is shown for the exports, the imports and the domestically produced and consumed final goods and services for the households' consumption and the gross fixed capital formation, respectively. In both cases, it is demonstrated that the domestic production of final goods and services was by large consumed in Brazil. Besides, the final demand for manufactured goods of high- and medium-high technology intensity are expressive, especially in the case of gross fixed capital formation (see Table 11).

In the Table 10, it can be observed that most part of the exports basket of final goods and services for households' consumption concentrates in the low-technology manufacturing industries. In the case of the exports for gross fixed capital formation, as shown in the Table 11, the exports basket is highly concentrated in the medium-high technology manufacturing industries (mainly, autos, machinery and equipment). Both for the exports and imports for the households' consumption and the gross fixed capital formation, the services sector presents a very low share of the final demand. A good explanation for that is the fact that most of the services activities are embodied in the value of the final manufactured goods. Another reason resides in the type of services activities domestically produced and consumed. As one may notice, from 2000 to 2014, the services sector consistently responded for more than 60% for households' consumption (see Table 10) and for more than 65% for gross fixed capital formation (Table 11). For the latter, the construction activities are the most representative segment in the services sector.

Table 8. Technology intensity of the industries which generated the value-added embodied in the (a) exports, in the (b) imports and in the (c) domestically produced and consumed final goods and services for households' consumption – VA_FFD_{exp}, VA_DFD_{imp}, VA_DFD_{local}.

	a. Exports for consumption abroad				b. Imports for local consumption				c. Domestic production for local consumption			
Sector	2000	2008	2011	2008	2000	2008	2011	2014	2000	2008	2011	2014
Primary	16%	21%	20%	20%	13%	17%	18%	18%	9%	11%	10%	10%
Manufacturing	38%	31%	33%	31%	40%	35%	35%	34%	18%	16%	16%	14%
High-tech	4%	2%	2%	2%	9%	9%	8%	8%	2%	2%	2%	1%
Medium-high-tech	9%	9%	9%	8%	11%	10%	10%	12%	5%	5%	5%	4%
Medium-low-tech	4%	3%	4%	3%	13%	9%	10%	8%	2%	2%	2%	2%
Low-tech	22%	17%	18%	18%	7%	7%	6%	6%	9%	7%	8%	7%
Services	45%	48%	48%	49%	47%	48%	48%	47%	73%	73%	74%	76%
Knowledge-intensive	18%	20%	19%	20%	19%	20%	20%	19%	25%	27%	27%	27%
Less knowledge-intensive	24%	25%	26%	27%	25%	24%	24%	24%	44%	42%	43%	46%
N/A	3%	3%	3%	2%	3%	4%	4%	4%	5%	4%	4%	3%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Total VA (US\$ millions, current prices)	12,886	43,042	47,503	44,808	11,362	27,801	50,349	52,457	343,308	797,353	1,221,340	1,171,655

Note: Technology intensity defined according to Eurostat indicators on High-tech industry and Knowledge -intensive services (Annex 3). N/A 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).

Source: Authors' elaboration based on 2016 WIOD.

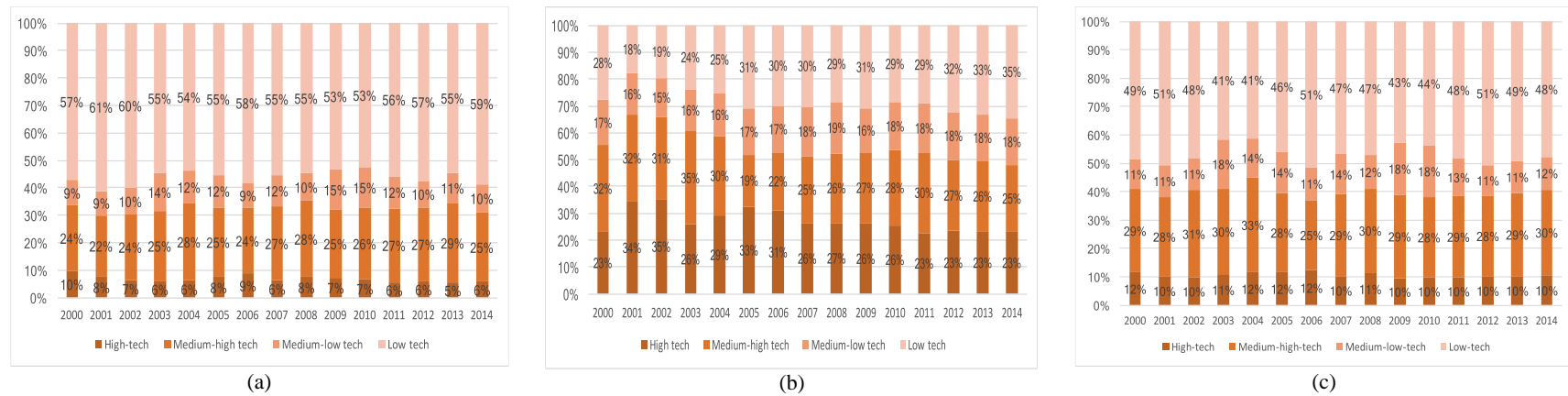
Table 9. Technology intensity of the industries which generated the value-added embodied in the (a) exports, in the (b) imports and in the (c) domestically produced and consumed final goods and services for gross fixed capital formation – VA_FFD_{exp}, VA_DFD_{imp}, VA_DFD_{local}.

	a. Exports for consumption abroad				b. Imports for local consumption				c. Domestic production and local consumption			
Sector	2000	2008	2011	2014	2000	2008	2011	2014	2000	2008	2011	2014
Primary	4%	8%	8%	6%	3%	6%	7%	7%	7%	8%	10%	7%
Manufacturing	58%	54%	53%	53%	61%	56%	55%	54%	21%	23%	23%	19%
High-tech	7%	4%	2%	2%	21%	17%	13%	13%	1%	1%	1%	1%
Medium-high-tech	28%	32%	33%	31%	27%	26%	28%	27%	9%	11%	11%	8%
Medium-low-tech	7%	9%	9%	9%	10%	11%	11%	10%	7%	8%	7%	7%
Low-tech	17%	9%	9%	11%	3%	3%	3%	3%	4%	3%	3%	3%
Services	37%	38%	39%	42%	37%	37%	38%	39%	72%	69%	67%	74%
Knowledge-intensive	15%	15%	16%	17%	16%	17%	17%	18%	18%	18%	19%	19%
Less knowledge-intensive	19%	20%	21%	22%	17%	17%	17%	18%	18%	17%	19%	20%
N/A	3%	3%	3%	3%	3%	3%	3%	3%	37%	34%	29%	35%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Total VA (US\$ millions, current prices)	7,074	18,171	15,770	13,798	10,266	29,112	42,739	41,093	83,264	244,679	412,601	371,780

Note: Technology intensity defined according to Eurostat indicators on High-tech industry and Knowledge -intensive services (Annex 3). N/A 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).

Source: Authors' elaboration based on 2016 WIOD.

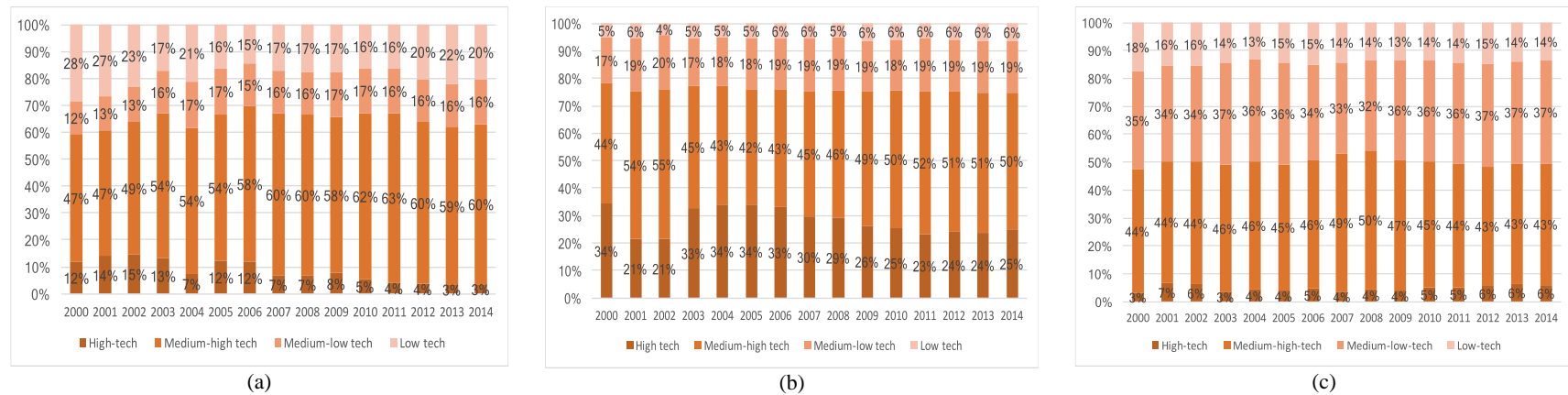
Figure 7. Value-added shares embodied in the (a) exports, in the (b) imports and in the (c) domestically produced and consumed final goods and services for households' consumption per technology intensity of manufacturing industries – VA_FFD_{exp} , VA_DFD_{imp} , VA_DFD_{local} – 2000 to 2014.



Note: Technology intensity defined according to Eurostat indicators on High-tech industry and Knowledge-intensive services (Annex 3).

Source: Authors' elaboration based on 2016 WIOD.

Figure 8. Value-added shares embodied in the (a) exports, in the (b) imports and (c) domestically produced and consumed final goods and services for gross fixed capital formation per the technology intensity of manufacturing industries – VA_FFD_{exp} , VA_DFD_{imp} , VA_DFD_{local} – 2000 to 2014.



Note: Technology intensity defined according to Eurostat indicators on High-tech industry and Knowledge-intensive services (Annex 3).

Source: Authors' elaboration based on 2016 WIOD.

Table 10. Technology intensity of the final demand in the (a) exports, in the (b) imports and in the (c) domestically produced and consumed final goods and services for households' consumption.

	a. Exports for consumption abroad				b. Imports for local consumption				c. Domestic production for local consumption			
Sector	2000	2008	2011	2008	2000	2008	2011	2014	2000	2008	2011	2014
Primary	5%	3%	4%	3%	3%	3%	3%	3%	4%	4%	3%	3%
Manufacturing	77%	82%	80%	81%	72%	69%	68%	69%	33%	35%	33%	31%
High-tech	8%	5%	3%	3%	16%	18%	15%	16%	4%	3%	3%	3%
Medium-high-tech	15%	18%	17%	15%	21%	16%	19%	14%	8%	10%	8%	8%
Medium-low-tech	4%	6%	5%	5%	10%	11%	11%	12%	4%	4%	4%	4%
Low-tech	51%	52%	54%	58%	25%	23%	23%	28%	18%	17%	17%	16%
Services	18%	15%	17%	16%	26%	28%	29%	28%	63%	62%	64%	66%
Knowledge-intensive	8%	7%	7%	6%	10%	12%	12%	10%	22%	23%	23%	23%
Less knowledge-intensive	10%	8%	9%	10%	16%	16%	17%	17%	38%	35%	37%	40%
N/A	0%	0%	0%	0%	0%	1%	0%	0%	4%	3%	3%	3%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Gross Total (US\$ millions, current prices)	14,416	49,282	53,850	50,850	11,665	28,790	51,720	53,745	371,328	877,301	1,336,934	1,278,570

Note: Technology intensity defined according to Eurostat indicators on High-tech industry and Knowledge -intensive services (Annex 3). N/A 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).

Source: Authors' elaboration based on 2016 WIOD.

Table 11. Technology intensity of the final demand in the (a) exports, in the (b) imports and in the (c) domestically produced and consumed final goods and services for gross fixed capital formation.

	a. Exports for consumption abroad				b. Imports for local consumption				c. Domestic production and local consumption			
Sector	2000	2008	2011	2014	2000	2008	2011	2014	2000	2008	2011	2014
Primary	0%	3%	4%	1%	0%	0%	0%	0%	4%	6%	4%	3%
Manufacturing	97%	95%	92%	94%	95%	94%	92%	92%	18%	28%	23%	20%
High-tech	15%	8%	4%	2%	38%	32%	24%	24%	0%	2%	2%	2%
Medium-high-tech	55%	71%	74%	73%	53%	57%	63%	61%	15%	23%	18%	16%
Medium-low-tech	2%	2%	2%	3%	3%	3%	3%	4%	1%	2%	1%	1%
Low-tech	24%	13%	11%	16%	2%	2%	2%	2%	2%	2%	2%	2%
Services	3%	2%	4%	5%	5%	6%	8%	8%	78%	66%	74%	77%
Knowledge-intensive	1%	0%	3%	3%	3%	4%	5%	5%	9%	10%	10%	10%
Less knowledge-intensive	1%	1%	1%	2%	2%	2%	3%	3%	7%	8%	8%	8%
N/A	1%	1%	0%	1%	0%	0%	0%	0%	62%	48%	55%	59%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Gross Total (US\$ millions, current prices)	8,013	20,918	17,939	15,768	10,595	30,308	44,072	42,303	90,837	271,347	455,004	410,282

Note: Technology intensity defined according to Eurostat indicators on High-tech industry and Knowledge -intensive services (Annex 3). N/A 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).

Source: Authors' elaboration based on 2016 WIOD.

5. Conclusions

In this work, we analyzed the Brazilian economy in the perspective of the technology intensity of the value-added originated by its final demand components (imports, exports and goods and services completed and consumed in Brazil) in the period 2000-2014. This is a less explored approach than traditional studies on the intermediates supply-use chains and their relevance to exports trade balance of a country. We emphasized the aggregation of industries by the technology intensity and used the recent release of the 2016 World Input-Output Database to measure the value-added by the final foreign demand for Brazilian exports and by the domestic final demands in Brazil. Therefore, we have provided a novel contribution to the literature since, as far as we are concerned, no studies have used that novel database to analyze the Brazilian economy so far. In addition, our methodology offered an analysis of value-added trade flows in contrast to conventional gross measures of trade flows.

We found evidence of the lack of competitiveness of Brazilian exports of final goods, mainly in the industries of higher technology intensity. We came to this conclusion based on the small share of value-added by foreign final demand, compared to the industries of lower technology intensity. The results of the significant value-added shares in the imports of final manufactured goods of higher technology intensity indicated that Brazil is still deeply dependent on the imports of medium-high- and high technology final manufactured goods.

The disaggregation of the final demand into households' consumption and gross fixed capital formation revealed that Brazilian policymakers should develop a long-term strategy in order to promote the increment of the expenditures in gross fixed capital formation. Also, it will be necessary to rebuild the industrial and technology policies of the 2000's to create the foundations to foster the upgrade of the business firms' activities to integrate global production chains of higher value-added.

Our further research will perform an integrated analysis of the intra-industries intermediates trade so that we can improve our understanding of the Brazilian economy as a whole based on the value-added trade approach.

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