The medium-high and high-intensity technology sectors in Mexico and Brazil: a structural decomposition analysis between 2000-2014

Abstract

We develop a structural decomposition analysis (SDA) to identify the importance of manufacturing and services with mid-high and high technological intensity (MH&HT) to the changes in gross output for Brazil and Mexico between 2000 and 2014. We break down the output changes in the composition and level of final demand, the production technique (technical coefficients), and the trade pattern (share of imports in the total supply of inputs and final goods). We use the World Input-Output Tables and the OCDE technological intensity classification data. The results show that the importance of the MH&HT group tends to be pro-cyclical in the two economies, increasing during periods of more remarkable economic growth (2000-2008 for Brazil and 2010-2014 for Mexico). This relation tends to be perceived for manufacturing and less so for services. Also, the increase in the proportion of imported inputs and final goods contributes to reducing the relevance of the MH&HT group.

Keywords: *Brazil; Mexico; Structural decomposition analysis; Input-output models.*

JEL Classiflcation: *Q12; C22; D81.*

1 Introduction

In the literature on economic development, accelerated production and growth trajectories are related to sectors with a greater capacity for technological diffusion. The focus was exclusively on manufacturing; however, several studies have recently shown that business services have also contributed to stimulating productive activity in countries. In this paper, we develop a structural decomposition analysis (SDA) to identify the importance of the mid-high and high technological intensity (MH&HT) industries to the changes in gross output for Brazil and Mexico between 2000 and 2014.

We compare Mexico and Brazil because they are the biggest economies in Latin America. Together, they correspond to two-thirds of Latin America's GDP and are the two most populated countries in the region with significant domestic markets (Alves-Passoni, 2021). Historically, from the point of view of economic development, the two countries share common issues. Between 1960 and 1980, they implemented import substitution processes, reaching similar levels of industrialization, as shown by Aroche-Reyes (2013). Since the 1990s, economic liberalization has changed their economic structure and led the two economies along different paths considering their growth and external insertion strategies. Mexico is included in TLCAN (Treaty of free trade in North America), and Brazil is part of the Southern Common Market (Mercosur).

To identify the differences between the MH&HT industries for the countries' gross output, we decompose the changes in the sectoral gross output according to three structural factors: level and type of final demand, the production technique, and the trade pattern. To do so, we use the World Input-Output Tables (WIOT, release 2016) and classify the sectors using the OECD technological intensity industry classification (Galindo-Rueda & Verger, 2016).

The general hypothesis is that there is a positive relationship between the importance of MH&HT and economic growth, which means that the higher the economic growth, the better the performance of the MH&HT industries. Also, we consider that other factors such as the reduction in the economy's complexity related to the technical coefficients and an increase in the proportion of imported inputs/final goods and services contribute to reducing the relevance of the MH&HT group.

Recent studies have compared Brazil and Mexico, such as Costa, Castilho, and Anyul (2018) and Costa, Castilho, and Puchet (2021). However, they analyze the complexity and integration in the Global Value Chains (GVCs) using qualitative input-output through networks. The results show a loss of complexity between 1995 and 2011 and that Brazil has a more complex structure than Mexico. However, they do not analyze the structural changes concerning the activity level and the sectors with greater technological intensity, nor the importance of these sectors to gross output growth.

The novelty of this study is the comparison of the performance of MH&HT manufacturing and service industries in Brazil and Mexico based on a quantitative input-output model for 2000 and 2014. Although some studies have applied this method to Brazil[1] and Mexico[2] individually, none of them have compared these two countries. Furthermore, we propose a different way to deflate the Input-Output Tables (IOT). With

[1] Messa (2013), Persona and Oliveira (2016), Magacho, McCombie, and Guilhoto (2018), Passoni (2019) and Sousa Filho, Santos, and Ribeiro (2020), mostly for gross output.

[2] See for example the employment decomposition done by Murillo, Puchet, and Fujii (2018), Pérez and Peters (2019) and Pérez (2021)

this, we may find similarities and differences between countries that can be useful for economic policymaking.

Besides this introduction, this paper has four more sections. First, we discuss the importance of mid-high and high technological intensity sectors to economic growth. The third section presents the structural decomposition analysis (SDA) and the data used. Then, we discuss the results of the SDA in the fourth section, followed by some final remarks.

2 Mid-high and high technological intensity industries and economic growth

Historically, one of the main subjects of study on economic development is industrialization because changes in the sectoral composition of the most productive sectors influence growth, the rate of capital accumulation, and economic development, as argued by Rowthorn and Ramaswamy (1999), Chenery and Taylor (1968), and Rostow (1960). According to Kaldorian tradition (Kaldor, 1966), manufacturing is the driver of economic growth and technical progress due to the potential for static and dynamic economies of scale in manufacturing production, higher income elasticity of demand for manufactured goods, and the potential for a catch-up. From Kaldor's second law (also known as the Kaldor-Verdoorn law), manufacturing output growth is positively related to labor productivity growth, and it has a spillover effect on labor productivity from the manufacturing industry to other sectors of the economy.

Recent studies by Haraguchi, Cheng, and Smeets (2017) as well as Felipe, Mehta, and Rhee (2019), have questioned whether manufacturing retains its importance in explaining countries' development levels. They conclude that having a more significant share in employment and production in the manufacturing sector remains important for economic development. Su and Yao (2017) show that the manufacturing sector's role is even more critical for medium-income economies (in countries such as Brazil and Mexico) because it positively influences the rate of technological accumulation and stimulates other sectors, including services.

Regarding Brazil and Mexico in particular, several studies show that the manufacturing industry has lost importance (deindustrialized). Many authors attribute this loss of significance to external events, such as globalization, verticalization, and fragmentation of production, but also due to domestic factors. For Brazil, Marcato and Ultremare (2018), Costa et al. (2021), and Passoni (2019) suggest that deindustrialization is related to the increase in the supply of imported goods in countries as a historical process of technological dependence, plus a result of the chronic appreciation of the local currency. For Mexico, it is related to the trade integration in the Mexican economy, in which TLCAN led to an increase in imported goods and specialization in activities with the low value-added generation, such as the 'maquilas' (Calderón and Hernández (2016), Sánchez, Calderón, and León (2018), Palma (2019), and Fujii and Cervantes (2017)).

Nevertheless, in an era in which services are more connected with manufacturing industries, especially those related to business and innovation, these can also generate the beneficial effects reported in Kaldor’s laws, traditionally only attributed to the manufacturing industry. In particular, Ciarli, Meliciani, and Savona (2012), Meliciani and Savona (2015), and López-González, Meliciani, and Savona (2019) show the importance of business and knowledge-intensive services associated with the backward/forward inter-industry linkages that these sectors have with manufacturing. These services can incorporate, process, accumulate and disseminate codified and implicit information and knowledge to other companies and sectors. Some studies have questioned whether services industries have this capacity in developing countries. Timmer and de Vries (2009) analyzed 19 countries in Asia and Latin America from 1950 to 2005 and found that increased market services productivity in the service sectors accelerates economic growth. di Meglio et al. (2018) found that the productivity of the services was also important to positively explain aggregate productivity in countries in Latin America, sub-Saharan Africa, and Asia. Therefore, according to these authors, manufacturing and certain services can generate development opportunities for these countries.

However, not all manufacturing and service industries have the desirable qualities to generate the positive effects pointed out by Kaldor’s law. For example, traditional manufacturing, natural resource processing industries, and domestic/household services have low technological intensity and income elasticities. Kaldor (1966) and Cornwall (1982) called the “technological sector” those industries with the most significant capacity to develop links and create technological diffusion through investment in research and development and product and process innovations.

3 Methodology

We base this study on a quantitative analysis performed using the input-output model. This methodology is traditionally applied to study productive relatives because it analyzes the existing sectoral linkages related to all inputs needed for production (direct and indirect use in the production process) and the origin of demand regarding the final goods and services required by the economy.

As described in the introduction, this research focuses on the gross output, where we will study the ratios of inputs needed to produce and variations in final demand.

Next, we will demonstrate the methodology of structural decomposition analysis and the data used.

3.1 Structural decomposition analysis

From a general point of view, the structural decomposition method analyzes the change of an economic variable using a set of comparative static changes in the parameters in an input-output table (Rose and Chen, 1991; Rose and Miernyk, 1989). This method decomposes the changes of several economic variables, but the most common are gross output, value-added, employment, and trade (imports and exports).

We start our decomposition from the definition of gross output in the input-output model ((1)), which is calculated as the multiplication of the inverse of Leontief ($\boldsymbol{L} = (\boldsymbol{I} - \boldsymbol{A_d})^{-1}$) by the final domestic demand:

$$\boldsymbol{x} = (\boldsymbol{I} - \boldsymbol{A_d}) - 1 \times \boldsymbol{f_d} \qquad (1)$$

$$\boldsymbol{x} = \boldsymbol{L} \times \boldsymbol{f_d} \qquad (2)$$

To see the impact of imports on the production structure, we will define domestic (intermediate and final) demand as a fraction of total demand, according to Oosterhaven and Van Der Linden (1997)[3]. In this way,

$$\boldsymbol{\Omega} = \boldsymbol{A_d} \times \boldsymbol{A^{-1}} \qquad (3)$$

$$\mu = \boldsymbol{f_d} \times \boldsymbol{f^{-1}} \qquad (4)$$

where $\boldsymbol{\Omega}$ represents the share of imported technical coefficient concerning the technical coefficients for total (domestic plus imported) inputs ($\boldsymbol{A}$); and μ represents the share of

[3] In an SDA for the Brazilian economy, Magacho et al. (2018) and Sousa Filho et al. (2020) use a different way to compute the role of imported inputs. It defines $\mathbf{A_d} = \mathbf{A}\ \mathbf{A_m}$. However, we argue that this way of calculating the position of imported inputs may contain some bias, because the changes of $\mathbf{A_m}$ can be associated with a change in the technique of production that requires more inputs or related to a change in the trade pattern. The same happens for the final demand.

imported final demand in the total final demand ($\boldsymbol{f}$). So, the domestic technical coefficients and the final domestic demand can be expressed as:

$$\boldsymbol{A_d} = \boldsymbol{\Omega} \otimes \boldsymbol{A_d} \qquad (5)$$

$$\boldsymbol{f_d} = \widehat{\boldsymbol{\mu}}\boldsymbol{f} \qquad (6)$$

where $\otimes$ represents the element-wise Hadamard product.

Using the previous equations, we can express (1) as:

$$\boldsymbol{x} = [\boldsymbol{I} - \boldsymbol{\Omega} \otimes \boldsymbol{A_d}]^{-1} \times \widehat{\boldsymbol{\mu}}\boldsymbol{f} \qquad (7)$$

In the SDA, we analyze the changes ($\Delta\boldsymbol{x}$) of two periods in time, '0' ($\boldsymbol{x^0}$) the initial and '1' ($\boldsymbol{x^0}$) the final period, as follows:

$$\Delta\boldsymbol{x} = \boldsymbol{x^1} - \boldsymbol{x^0} \qquad (8)$$

Putting together (2) and (8), we can express the changes of ($\Delta\mathbf{x}$) in terms of the changes in the Leontief matrix and final demand. So, we have:

$$\Delta\boldsymbol{x} = \boldsymbol{L^1}\boldsymbol{f_d^1} - \boldsymbol{L^0}\boldsymbol{f_d^0} \qquad (9)$$

Due to the diversity of forms, each decomposition may assume we use the mean of the polar decomposition to calculate the changes, following Dietzenbacher and Los (1998). So the decomposition equation for two variables is (Miller and Blair, 2009):

$$\Delta\boldsymbol{x} = \left(\frac{1}{2}\right)\boldsymbol{\Delta L} \times \left(\boldsymbol{f_d^1} + \boldsymbol{f_d^0}\right) + \left(\frac{1}{2}\right)(\boldsymbol{L^1} + \boldsymbol{L^0}) \times \boldsymbol{\Delta f_d} \qquad (10)$$

If we want the sectoral total, we must multiply each change by a summary vector $\boldsymbol{i'}$ (transposed column vector of ones):

$$\boldsymbol{i'}.\Delta\boldsymbol{x} = \boldsymbol{i'}\left[\left(\frac{1}{2}\right)\boldsymbol{\Delta L} \times \left(\boldsymbol{f_d^1} + \boldsymbol{f_d^0}\right) + \left(\frac{1}{2}\right)(\boldsymbol{L^1} + \boldsymbol{L^0}) \times \boldsymbol{\Delta f_d}\right] \qquad (11)$$

To express the changes of $\Delta\boldsymbol{L}$ as changes at $\Delta\boldsymbol{A_d}$, we follow Oosterhaven and Van Der Linden (1997) and Miller and Blair (2009) and use hierarchical SDA:

$$\Delta\boldsymbol{L} = \boldsymbol{L^1}\Delta\boldsymbol{A_d}\boldsymbol{L^0} \qquad (12)$$

If we decompose the changes of $\boldsymbol{A_d}$ based on (5), which is made up of the multiplication of two elements, we have:

$$\Delta\boldsymbol{A_d} = \left(\frac{1}{2}\right)\boldsymbol{\Delta\Omega} \otimes (\boldsymbol{A^1} + \boldsymbol{A^0}) + \left(\frac{1}{2}\right)(\boldsymbol{\Omega^1} + \boldsymbol{\Omega^0}) \times \boldsymbol{\Delta A} \qquad (13)$$

Putting together (12) and (13), the changes of Leontief ($\boldsymbol{\Delta L}$) related to the changes in gross output ($\boldsymbol{\Delta x}$) can be expressed by the variations in the share of imported intermediate inputs ($\boldsymbol{\Delta \Omega}$) and the total inputs used for the production ($\boldsymbol{\Delta A}$):

$$\Delta \boldsymbol{L} \;=\; \boldsymbol{L^1}\left[= \left(\tfrac{1}{2}\right)\boldsymbol{\Delta\Omega} \otimes \left(\boldsymbol{A_d^1} + \boldsymbol{A_d^0}\right) + \left(\tfrac{1}{2}\right)(\boldsymbol{\Omega^1} + \boldsymbol{\Omega^0}) \times \boldsymbol{\Delta A_d}\right]\boldsymbol{L^0} \tag{14}$$

Now, desegregating $\boldsymbol{\Delta f_d}$ considering (6), we have:

$$\Delta \boldsymbol{f_d} \;= \left(\tfrac{1}{2}\right)\boldsymbol{\Delta\hat{\mu}} \times (\boldsymbol{f^1} + \boldsymbol{f^0}) + \left(\tfrac{1}{2}\right)(\boldsymbol{\hat{\mu}^1} + \boldsymbol{\hat{\mu}^0}) \times \boldsymbol{\Delta f} \tag{15}$$

Inserting (14) and (15) in (10), the decomposition of gross output can be expressed by the changes in four variables: $\boldsymbol{\Omega}$, $\boldsymbol{A}$, $\boldsymbol{\mu}$ and $\boldsymbol{f}$. Rearranging the changes, we can attribute the changes in the gross output to three sources: trade pattern, technology, and demand:

$$\boldsymbol{\Delta x} = \left(\frac{1}{2}\right)\left\{\left(\frac{1}{2}\right)[\boldsymbol{\Delta\Omega} \otimes (\boldsymbol{A^1} + \boldsymbol{A^0})]\right\}(\boldsymbol{f_d^1} + \boldsymbol{f_d^0}) \quad \text{Trade pattern – intermediate} \tag{16}$$

$$\left(\frac{1}{2}\right)(\boldsymbol{L^1} + \boldsymbol{L^0})\left[\left(\frac{\boldsymbol{1}}{\boldsymbol{2}}\right)\boldsymbol{\Delta\hat{\mu}} \times (\boldsymbol{f^1} + \boldsymbol{f^0})\right] \quad \text{Trade pattern – final demand} \tag{17}$$

$$\left(\frac{1}{2}\right)\left\{\left(\frac{1}{2}\right)[(\boldsymbol{\Omega^1} + \boldsymbol{\Omega^0}) \otimes \boldsymbol{\Delta A}]\right\}(\boldsymbol{f_d^1} + \boldsymbol{f_d^0}) \quad \text{Technology} \tag{18}$$

$$\left(\frac{1}{2}\right)(\boldsymbol{L^1} + \boldsymbol{L^0})\left[\left(\frac{\boldsymbol{1}}{\boldsymbol{2}}\right)(\boldsymbol{\hat{\mu}^1} + \boldsymbol{\hat{\mu}^0}) \times \boldsymbol{\Delta f}\right] \quad \text{Final demand} \tag{19}$$

The changes in the trade pattern are related to the share of domestic inputs ($\boldsymbol{\Delta\Omega}$) or final demand ($\boldsymbol{\Delta\hat{\mu}}$) in total supply. If its contribution is negative/positive, there was import substitution/penetration, which means the country uses less/more domestic supply to satisfy the total demand in period one compared to period zero. We also present the changes in $\boldsymbol{\mu}$ for each final demand component (consumption ($\boldsymbol{\mu_c}$), gross fixed capital formation ($\boldsymbol{\mu_k}$), government expenditures ($\boldsymbol{\mu_g}$), and exports ($\boldsymbol{\mu_e}$)).

For technology, the changes are related to $\boldsymbol{\Delta A}$. If it is positive/negative, the whole economy (using domestic plus imported goods) uses more/ fewer intermediate inputs to produce. We also show the contributions for each final demand component (consumption ($\boldsymbol{c}$), gross fixed capital formation ($\boldsymbol{k}$), government expenditures ($\boldsymbol{g}$), and exports ($\boldsymbol{e}$)). If this contribution of total final demand ($\boldsymbol{\Delta f}$) or its components is positive/negative, the demand increased/decreased in period one compared to period zero. As the inventories in the national accounts have no economic significance, an empirical adjustment is made to calculate a new final demand, considering all demand components, excluding inventories. Thus, we show the changes in inventories separately to keep the consistency in the model.

3.2 Data

We use the World Input-Output Tables (WIOT, Revision 2016[4]) between 2000 and 2014. These data were preferred over the IOTs published by each country's System of National Accounts (SNA) because they have different structures. The Brazilian SNA is published considering chained indices, while Mexico publishes data on a fixed basis. The difference in each SNA makes it impossible to directly compare the two series since different analysis methods are needed, as discussed by (Balk and Reich, 2008) and (Reich, 2008). Although there is an effort in the publication of WIOT to make the different databases compatible, it is almost impossible to change the original data structure. So, this must affect the observed results. Therefore, the SDA results for Brazil (with SNA based on linked price indices) have more relative price variations than Mexico (fixed basis)[5].

Since we are dealing with different points in time, it is necessary to deflate the series to remove the effect of inflation. We follow Reich's (2008) suggestion and deflate all the elements of the WIOT using the gross value deflator, considering 2000 as the base year. This method is the most appropriate when dealing with chained indices since it removes the effect of inflation and preserves the additivity property in the chained IOT (published at current prices and those of the previous year). We prefer this method because it excludes the inflation effect but maintains the relative prices structure and generates fewer distortions if in the presence of imprecise sectoral price indices.

3.3 Sectoral classification

We use the most recent OECD industry classification which is based on technological intensity (Galindo-Rueda and Verger, 2016) for two digits of Rev. 4 of the International Standard Industrial Classification of All Economic Activities (ISIC). It classifies agricultural, manufacturing, and service industries according to the average sectoral expenditures realized in R&D into five categories: high, medium-high, medium, medium-low, and low technological intensity. Also, some sectors (such as health, education, and public services) were not considered because, in general, other companies implement technological innovations in these sectors. We present the complete correspondence between the 56 sectors of WIOT and the OECD's classification in Table

---

[4] The data can be downloaded for free at http://wiod.org/database/wiots16. Methodological aspects may be seen at Timmer et. al(2016).

[5] For statistical reasons related to the price index theory, see UN (2009).

A-1 in the Appendix section. Table 1 below shows the number of sectors included in each category.

Table 1: WIOT groups classification based on OCDE's technological intensity classification

Abrev.	Technological intesinty	Industry type	Number of industries
LT-A	Low	Agriculture	3
LT-P	Low	Public Utilities	3
LT-C	Low	Construction	1
LT-S	Low	Services	17
MLT-M	Medium-low	Manufacturing	9
MLT-S	Medium-low	Services	5
MT-M	Medium	Manufacturing	4
MHT-N	Medium-high	Manufacturing	5
MHT-S	Medium-high	Services	3
HT-M	High	Manufacturing	2
HT-S	High	Services	1
NC-S	Not classified	Services	3

Source: Author's elaboration based on Galindo-Rueda and Verger(2016) and Timmer et al. (2016)

As we will focus our analysis on manufacturing and service industries with high and medium-high technology intensity (MH&HT), we present a detailed description in Table 2 below.

Table 2: WIOT industries of medium-high and high technological intensity according to OCDE's classification

OCDE groups	Industry	Description WIOD
Medium-high	Manufacturing	Manufacture of basic pharmaceutical products and
	Manufacturing	pharmaceutical preparations
	Manufacturing	Manufacture of electrical equipment
	Manufacturing	Manufacture of machinery and equipment n.e.c. and motor vehicles, trailers, and semi-trailers
	Manufacturing	Manufacture of other transport equipment
	Service	Publishing activities
	Service	Motion picture, video and television programme production,
	Service	sound recording and music publishing activities;
	Service	programming and broadcasting activities
	Service	Computer programming, consultancy and related activities;
	Service	information service activities
High	Manufacturing	Manufacture of chemicals and chemical products
	Manufacturing	Manufacture of computer, electronic and optical products
	Services	Scientific research and development

Source: Author's elaboration based on Galindo-Rueda and Verger (2016) and Timmer et al. (2016)

Using this classification is an extrapolation for Brazil and Mexico, but it can show the performance of the technological sectors (according to the technological frontier) in these countries. They represent the most sophisticated activities in terms of technology and organization of the production process, including high-tech and durable consumer industries (such as automobiles and electronics). The insertion of medium-high technology intensity industries in this classification is essential because they have a high demand elasticity, a prominent economic scale in production, a segmented market, and few competitors. Therefore the competition pattern is defined by the capacity to innovate (in process or product). These sectors also have specific government support plans and competition regulations, differentiating them from other industrial groups, supporting technological risk, guaranteeing intellectual property rights, and selective protection.

Despite using this classification, we are aware of the various criticisms of using this classification for middle-income countries. First, as Cassini and Robert (2017) point out, depending on each country's historical and economic context, some sectors that are not traditionally classified as having high technology intensity can play an essential role in the country's innovative effort. For example, for certain countries, "traditional" or resource-intensive industries can also be equally effective in generating product and process innovation[6]. Furthermore, many countries have different insertions in global chains, which prevents traditional classifications from representing countries' R&D efforts, as Durand and Milberg (2020) mentioned.

4 Results

Before analyzing the SDA, using the data presented in Table 3, we first discuss the structure and evolution of the sectoral composition of gross output. Together, MHT and HT industries represented a larger share of gross output in Mexico compared to Brazil. These sectors, in the aggregate, corresponded to around 18.3% of Mexican production in 2000, falling to 16% in 2014[7]. The industries that have a higher share are "Manufacture of motor vehicles, trailers and semi-trailers" (5% on average in total gross output between 2000 and 2014) and "Manufacture of computer, electronic and optical products" (4%). The first mentioned sector is related to the automobile assembly sector, the 'maquiladoras,' which have greater importance in Mexico due to the production and sales agreements with the United States within NAFTA. This sector is the only one among the MH&HT group that has increased its

[6] For example, Marín and Petralia (2018) show for Brazil a high investment in the extraction of oil and some in biotechnology for cellulose production. For Mexico, see INEGI (2013) which are also investing in R&D in the oil sector and for food and beverages.

[7] To see the shares and growth rate of each industry with MHT&HT, see Table A.2 in the Appendix.

share of the total gross output, especially since 2010[8]. According to Carrillo and Hernández (2020), after the 2008 crisis, the USA's multinational automotive firms changed their strategy, transferring various operations and segments to Mexico, such as the Premium categories. This strategy increased the GFCF, but the exports were the most affected demand component.

Table 3: Sectoral share of gross output and growth rates: 2000-2014, 2000-2008, and 2010-2014

Country	Mexico							Brazil						
Variable	Share				Growth			Share				Growth		
Years	2000	2008	2010	2014	2000-2014	2000-2008	2010-2014	2000	2008	2010	2014	2000-2014	2000-2008	2010-2014
LT-A	3.3	3.4	3.3	3.2	-1.2	3.9	-1.0	4.2	4.6	4.1	4.5	7.3	10.1	8.8
LT-P	1.7	1.7	1.9	2.1	28.5	5.7	12.4	3.2	3.0	3.0	2.4	-24.1	-6.6	-17.6
LT-C	8.2	8.2	8.3	8.4	2.2	-0.2	1.4	6.3	5.1	6.8	7.2	14.9	-18.6	6.6
LT-S	34.4	35.1	35.7	35.8	4.2	2.0	0.4	32.1	30.0	31.8	33.6	4.7	-6.4	5.5
MLT-M	19.6	19.4	19.1	18.8	-4.0	-1.3	-1.1	18.7	20.0	18.3	17.4	-7.1	7.1	-5.3
MLT-S	3.2	3.4	3.4	3.5	11.0	9.0	2.1	4.3	4.2	4.5	4.4	1.4	-1.8	-1.8
MT-M	4.4	4.1	4.0	4.0	-10.1	-6.8	-0.4	4.0	4.8	4.0	3.6	-11.7	18.3	-11.6
MHT-M	11.6	10.8	10.6	10.2	-12.2	-6.7	-3.7	8.9	10.7	9.3	8.3	-7.4	19.5	-11.1
MHT-S	0.4	0.5	0.5	0.5	9.6	11.5	0.3	1.9	1.7	1.8	1.8	-7.2	-9.0	-1.6
HT-M	5.9	5.4	5.0	4.9	-16.9	-8.8	-2.3	2.0	1.8	1.6	1.5	-26.1	-8.7	-8.0
HT-S	0.4	0.4	0.4	0.4	12.5	6.4	3.9	0.9	0.8	0.9	0.9	3.6	-4.7	3.9
NT-S	7.0	7.6	7.9	8.1	16.7	8.8	2.4	13.5	13.1	13.9	14.5	7.9	-2.6	4.5

Source: Author's elaboration based on WIOT database.

Although the MTH-S and the HT-S grew between 2000 and 2014, their share was too small (0.5%)to significantly influence the gross output in Mexico. Nonetheless, Carrillo-Carrillo and Alcalde-Heras (2020) and Ruiz and Demmler (2019) show that they have positively impacted the economy's productivity, especially in the manufacturing sectors that require these services.

In Brazil, the MHT and HT industries (services and manufacturing) share fell from 13.7% to 12.4% between 2000 and 2014. MHT-M and MHT-S shares fall by approximately -7%, mainly in chemical products and electrical equipment (see Table A.2, in the Appendix). The HT-M share decreased by -26% (Table 3), related to the degrowth of "Manufacture of basic pharmaceutical products and pharmaceutical preparations" and "Manufacture of computer, electronic and optical products" (Table A.2).

Compared to the Mexican economy, services represent a more significant part of the MH&HT group in Brazil, with a share of around 20%. The MHT-S share fell by approximately 7%, and the only sector that saw an increase was HT-S, which grew almost

[8] Between 2000 and 2009 there is a downward trend (-24%), which is reversed from 2010 when this sector grew 32% until 2014.

4% but represented a small share of total gross output (0.9%)[9]. Considering the relative importance of these sectors, Santos (2019) and Giovanini and Arend (2019) argue that services intensive in technology had positive effects on the economy from the 2000s onwards. However, Giovanini and Arend (2019) and Lugli et al. (2015) mention that the symbiosis between the service and manufacturing sectors depends on the growth of both sectors, and it declined in recent years, especially from 2014, with the slowdown of the Brazilian growth[10].

The first conclusion is that the MHT&HT share decreased in the total gross output in Mexico and Brazil between 2000 and 2014 and the subperiods. This result was related mainly to the manufacturing sectors, and growth in services was insufficient to offset the fall[11]. However, we must note that the observed change in the gross output of manufacturing industries between sub-periods behaves differently in the two countries. While in Mexico, it is concentrated between 2000-and 2008, in Brazil, this occurs more between 2010-and 2014. In the case of MHT&HT services, there is no generalized decline, and we do not observe a pattern, considering the path of growth in the sub-periods.

To understand which factors are associated with changes in gross output, we analyze the SDA. We first show (Table 4) the SDA for the total gross output for Mexico and Brazil from 2000 to 2014 and two sub-periods: 2000-2008 and 2010-2014. The annual rates are also presented in this table because the periods have different numbers of years. Also, we show three more tables to understand the SDA. Table 5 shows the sectoral contribution to the changes in gross output, both in percentage points and shares. Table 6 (México) and Table 7 (Brazil) show the sources of change to which this shift in the importance of the MH&HT group is related.

Table 4: Totals of the structural decomposition analysis for Brazil and Mexico, 2000-2014, and subperiods

[9] HT-S has a positive effect only between 2010-2014.

[10] As Alves-Passoni and Blancas (2021) show, the Brazilian economy slowed down from 2014, with growth rates in 2014 of 0.5%, 2015 of -3.5%, and 2016 of 3.3%. Despite resuming positive growth from 2017 until 2020, it has been negligible since then.

[11] Corroborating the findings of Lugli et al. (2015) in the Brazilian case.

Unity of measure	p.p.													%
Sources	Trade pattern						Tech	Total final demand					INV.	Gross output
Variables	$\Delta\Omega$	$\Delta\mu_c$	$\Delta\mu_k$	$\Delta\mu_g$	$\Delta\mu_e$	$\Delta\mu_f$	ΔA	Δc	Δk	Δg	Δe	Δf	Δs	Δx
MEXICO														
Accumulated														
2000-2014	-5.89	-3.09	-1.21	-0.18	-0.83	-5.30	4.03	23.76	6.31	5.86	14.78	50.71	-1.01	42.54
2000-2008	-5.02	-2.86	-1.66	-0.26	-1.03	-5.81	4.33	17.43	5.67	2.93	7.45	33.48	-0.46	26.52
2010-2014	-0.43	-0.71	0.13	-0.03	-0.08	-0.68	0.35	6.05	1.79	1.56	4.07	13.47	-0.23	12.47
Yearly														
2000-2014	-0.33	-0.17	-0.07	-0.01	-0.05	-0.30	0.23	1.34	0.35	0.33	0.83	2.85	-0.06	2.39
2000-2008	-0.50	-0.29	-0.17	-0.03	-0.10	-0.58	0.43	1.74	0.57	0.29	0.74	3.34	-0.05	2.65
2010-2014	-0.08	-0.14	0.02	-0.01	-0.01	-0.13	0.07	1.15	0.34	0.30	0.78	2.57	-0.04	2.38
BRASIL														
Accumulated														
2000-2014	-3.58	-1.13	0.21	-0.10	-0.06	-1.07	-0.65	29.89	13.77	10.00	8.56	62.22	-0.32	56.59
2000-2008	-1.62	-0.39	0.48	-0.11	-0.09	-0.12	1.29	10.63	6.46	3.81	8.33	29.23	1.43	30.22
2010-2014	-1.02	0.18	0.02	0.19	0.15	0.53	-0.10	8.18	2.02	2.50	1.94	14.64	-0.30	13.75
Yearly														
2000-2014	-0.19	-0.06	0.01	-0.01	0.00	-0.06	-0.03	1.60	0.74	0.54	0.46	3.34	-0.02	3.03
2000-2008	-0.16	-0.04	0.05	-0.01	-0.01	-0.01	0.13	1.05	0.64	0.38	0.82	2.88	0.14	2.98
2010-2014	-0.19	0.03	0.00	0.04	0.03	0.10	-0.02	1.55	0.38	0.47	0.37	2.78	-0.06	2.61

Source: Author's elaboration based on WIOT database.

Between 2000 and 2014, Brazil grew at a higher annual rate (3%) than Mexico (2.4%), as shown in Table 4. The sectors that most contributed to the gross output in both economies were related to services and construction, such as LT-C, LT-S, and NT-S (Table 5). This result is expected because these countries have big economies with large populations and robust domestic markets. The MH&HT group represents 9% and 10% of gross output in Brazil and Mexico (Table 5). Their contribution is less than the groups' share of the gross output (as shown in Table 3), indicating that these sectors grew slower than the average economy. Although most sectors in the group of MH&HT have a positive contribution to growth in both countries (Table 5), the only industry that contributed negatively was HT-M in Mexico[12] (Table 6).

The final demand is the source of change that most contributed to the gross output growth between 2000 and 2014, with 106% and 110% growth for Brazil and Mexico, respectively (equivalent to 65.5p.p. and 62p.p, Table 7 and 6). In this type of decomposition, it is natural that the final demand corresponds to the most significant share since it has the most considerable magnitude in terms of monetary units. In Mexico, exports and household consumption are the most critical final demand components of gross output growth (Table 6) between 2000 and 2014. From a sectoral perspective, the household contribution is more related to LT-S and MLT-M and exports to MLT-M (machinery and equipment and motor vehicles).

[12] Both industries in this group had a negative contribution to the gross output.

Table 5: Sectoral share of contribution to gross output and growth rates: 2000-2014, 2000-2008, and 2010-2014

Country	Mexico						Brazil					
Variable	Contribution (p.p.)			Share of contribution (%)			Contribution (p.p.)			Share of contribution (%)		
Period	2000-2014	2000-2008	2010-2014	2000-2014	2000-2008	2010-2014	2000-2014	2000-2008	2010-2014	2000-2014	2000-2008	2010-2014
LT-A	0.06	0.05	0.07	2.52	1.72	2.97	0.15	0.18	0.19	5.04	6.02	7.14
LT-P	0.06	0.12	0.02	2.46	4.49	0.71	0.03	0.07	-0.04	1.07	2.30	-1.36
LT-C	0.16	0.33	0.04	6.82	12.40	1.47	0.27	0.04	0.27	8.87	1.25	10.46
LT-S	0.89	0.83	0.99	37.28	31.45	41.52	1.10	0.69	1.21	36.23	23.28	46.33
MLT-M	0.54	0.71	0.43	22.61	26.95	18.07	0.46	0.73	0.27	15.00	24.42	10.37
MLT-S	0.08	0.15	-0.01	3.19	5.52	-0.23	0.14	0.12	0.10	4.48	3.98	3.79
MT-M	0.07	0.11	0.08	2.99	4.24	3.22	0.08	0.21	0.00	2.73	7.22	0.17
MHT-M	0.28	0.10	0.55	11.76	3.78	23.31	0.22	0.49	0.02	7.10	16.46	0.75
MHT-S	0.01	0.01	0.01	0.37	0.41	0.21	0.05	0.03	0.04	1.53	1.17	1.57
HT-M	-0.06	-0.02	-0.07	-2.32	-0.76	-2.77	0.02	0.04	0.01	0.55	1.24	0.53
HT-S	0.01	0.01	0.01	0.40	0.33	0.52	0.03	0.02	0.03	0.97	0.70	1.16
NT-S	0.29	0.25	0.26	11.93	9.46	10.99	0.50	0.36	0.50	16.43	11.98	19.08
Total	2.391	2.648	2.378	100.00	100.00	100.00	3.03	2.98	2.61	100.00	100.00	100.00

Source: Author's elaboration based on WIOT database.

For Brazil, from 2000 to 2014, household consumption and the GFCF represent the largest share of the demand contribution (Table 7). The first component is more related to LT-S and MLT-M; the second is the LT-C (construction) and MHT-M (electrical equipment). However, almost 60% of the contribution of exports is attributed to MLT-M (mining and quarrying) and MHT-M (machinery and equipment and motor vehicles).

Given the contributions of $\boldsymbol{\Omega}$ and $\boldsymbol{\mu}$ for both countries, we observe an import penetration for intermediate and final demand between 2000 and 2014 (Table 4). This result implies that imports grew more than the total supply of goods and services. As shown in Table 4, the contributions of intermediate and final trade patterns were -5.9p.p. and -5.3p.p to gross output, representing 14% and 13% of Mexico's accumulated growth of 42.5% between 2000 and 2014. Since household consumption and GFCF represent the largest share of total imports, it contributes the most to the import penetration of Mexico.

In Brazil, the contribution of $\boldsymbol{\Omega}$ and $\boldsymbol{\mu}$ correspond to -3.58p.p. and -1.1p.p., equivalent to 6% and 2% of 56.6% growth between 2000 and 2014 (Table 4). This negative contribution is related to consumption, government, and exports. The GFCF contribution is positive, indicating that more domestic goods are being used[13].

[13] As mentioned by Aroche-Reyes (2021), this may indicate two phenomena: a reduction in the complexity of the economy and a more efficient use of inputs. Unfortunately, the absence of sectoral capital stock for Brazilmakes a deeper analysis difficult to identify whether this process was related to an increase in productivity orwhy the economy reduced sectoral connections. However, several studies, such as Costa et al. (2021) , point out that this reduction is related to a reduction in Brazilian economic complexity.

Table 6: Shares of the sectoral contribution to the gross output according to the source of change: Mexico, 2000-2014 and sub-periods

Changes	Trade pattern						Tech	Total final demand					INV.	Gross output
Variables	$\Delta\Omega$	$\Delta\mu_c$	$\Delta\mu_k$	$\Delta\mu_g$	$\Delta\mu_e$	$\Delta\mu_f$	ΔA	Δc	Δk	Δg	Δe	Δf	Δs	Δx
2000-2014														
MHT-M	-25.02	-3.73	-5.61	-0.04	-4.79	-14.17	13.27	32.01	7.06	1.06	98.70	138.82	-12.91	100.00
MHT-S	-0.50	3.35	-0.79	-0.02	-0.52	2.02	-27.54	103.13	12.13	15.07	-4.64	125.68	0.34	100.00
HT-M*	84.50	21.65	14.69	0.32	12.55	49.22	21.31	0.50	1.11	-6.99	-77.74	-83.12	28.10	100.00
HT-S	41.81	-6.32	-2.03	43.24	-1.35	33.54	-81.33	61.44	7.17	16.64	22.43	107.68	-1.71	100.00
MH&HT	-46,37	-9,34	-9,90	1,58	-8,44	-26,10	6,25	42,90	8,59	4,01	132,01	187,51	-21,30	100,00
2000-2008														
MHT-M	-131.02	-26.23	-47.61	-0.27	-27.85	-101.97	31.56	85.17	5.71	2.80	212.51	306.18	-4.75	100.00
MHT-S	-2.55	-3.38	-1.79	-0.42	-1.05	-6.65	-7.82	106.56	10.06	11.75	-10.82	117.55	-0.53	100.00
HT-M*	326.96	63.10	64.19	2.90	87.67	217.86	10.96	-81.05	5.35	-24.20	-380.35	-480.25	24.48	100.00
HT-S	85.50	-12.08	-4.43	76.75	-3.09	57.15	-163.26	89.79	8.08	8.01	17.48	123.36	-2.75	100.00
MH&HT	-190,58	-40,54	-61,42	5,79	-46,09	-142,27	14,43	121,45	6,46	9,68	290,85	428,44	-10,02	100,00
2010-2014														
MHT-M	3.51	-0.29	3.78	-0.01	-0.73	2.75	10.25	23.16	8.07	0.40	59.65	91.28	-7.79	100.00
MHT-S	-1.36	6.32	0.93	-0.40	-0.19	6.65	-70.43	102.15	27.53	23.33	11.10	164.11	1.03	100.00
HT-M*	-17.41	8.81	-4.85	0.05	2.90	6.93	21.84	17.68	-0.46	-3.14	47.88	61.96	26.68	100.00
HT-S	-8.82	-3.24	0.83	-0.49	-0.31	-3.21	30.77	29.39	8.15	27.92	16.44	81.89	-0.63	100.00
MH&HT	5,88	-1,49	4,80	-0,03	-1,19	2,09	8,45	24,81	9,38	1,77	59,64	95,59	-12,01	100,00

Source: Author's elaboration based on WIOT database.
Note: Each column sum up 100% of the changes in the contributions of each sector to the total gross output.
*Since the contribution of this sector is negative, the effects should be interpreted oppositely.

What stands out here is the significant role of the trade pattern as a factor that reduced the gross output by 26% in Mexico compared to 6% in Brazil between 2000-and 2014. This result demonstrates the greater importance of imports for the productive structure in the Mexican economy than in the Brazilian one. However, for both countries, penetration represents a more significant negative contribution between 2000 and 2008 compared to 2010 and 2014.

There are different movements for each country if we consider the contribution of $\boldsymbol{A}$ to the gross output (see Table 4). For Mexico, changes in technical coefficients positively impacted the growth in the gross output, contributing approximately 7% (4.03p.p.). It indicates an increase in the total production inputs sectoral relationship, especially related to MLT-M (Table 6). However, the contribution of $\boldsymbol{\Omega}$ is more remarkable than $\boldsymbol{A}$, indicating that the increase in linkages came from imports. In other words, this suggests that domestic producers were unable to take advantage of the increase in sectorial production relations to offer more domestic inputs.

In Brazil, between 2000 and 2014, there was a reduction in the sectoral ratio of total production inputs, negatively contributing to the gross output by 1% (Table 4). Since the total (direct and indirect) linkages decreased, the economy needed fewer inputs to produce goods[14]. This drop was particularly associated with medium-low technological intensity manufacturing. All industries with MH&HT contributed negatively to the gross output growth (Table 7).

[14] However, this result seems to have an effect on relative prices. By making a decomposition for Brazil between 2010-2014 that considers relative prices from a different approach, Passoni (2019) demonstrates an import penetration for this component of demand.

Table 7: Shares of the sectoral contribution to the gross output according to the source of change: Brazil, 2000-2014 and sub-periods

Changes	Trade pattern						Tech	Total final demand					INV.	Gross output
Variables	$\Delta\Omega$	$\Delta\mu_c$	$\Delta\mu_k$	$\Delta\mu_g$	$\Delta\mu_e$	$\Delta\mu_f$	ΔA	Δc	Δk	Δg	Δe	Δf	Δs	Δx
2000-2014														
MHT-M	-18.59	-0.54	0.36	-0.04	-0.21	-0.44	-2.10	52.23	48.02	2.38	17.63	120.26	0.87	100.00
MHT-S	-10.14	-4.82	-2.22	-0.19	-0.07	-7.30	-14.59	35.78	65.97	19.62	10.58	131.95	0.09	100.00
HT-M	-38.78	-39.54	72.53	-2.87	-0.32	29.80	-36.86	119.25	39.15	16.74	-47.81	127.33	18.50	100.00
HT-S	-6.49	-2.81	0.56	-0.17	-0.10	-2.52	10.19	54.50	17.19	13.50	13.85	99.03	-0.21	100.00
MH&HT	-17,26	-3,53	3,92	-0,23	-0,18	-0,02	-4,70	53,62	47,29	6,82	12,64	120,37	1,61	100,00
2000-2008														
MHT-M	-6.19	1.02	3.96	-0.03	-0.30	4.66	7.37	26.44	35.94	0.84	24.73	87.94	6.21	100.00
MHT-S	-12.57	-5.80	-1.67	-0.54	-0.24	-8.25	-41.89	39.30	79.82	18.87	21.93	159.92	2.79	100.00
HT-M	7.22	-12.63	36.31	-0.84	-0.54	22.30	-6.71	47.26	18.55	5.12	-7.46	63.48	13.71	100.00
HT-S	-8.35	-2.80	2.36	-0.41	-0.36	-1.21	-16.62	53.06	23.49	12.96	31.17	120.68	5.50	100.00
MH&HT	-5,80	-0,38	5,61	-0,12	-0,31	4,80	2,69	29,47	37,00	2,62	22,76	91,86	6,46	100,00
2010-2014														
MHT-M	-429.03	25.80	-66.53	1.27	18.82	-20.63	48.47	339.07	2.48	21.55	108.94	472.03	29.16	100.00
MHT-S	2.05	0.74	1.01	1.36	0.66	3.77	-0.29	13.20	52.95	18.57	9.51	94.23	0.24	100.00
HT-M	-83.53	-25.34	15.98	-2.60	2.10	-9.86	-20.93	174.35	41.12	13.78	-31.46	197.80	16.52	100.00
HT-S	0.76	0.45	-0.39	0.81	0.81	1.68	23.73	43.50	6.50	11.93	13.19	75.12	-1.29	100.00
MH&HT	-89,94	1,85	-9,97	0,66	4,27	-3,19	13,01	104,08	28,50	16,56	23,63	172,77	7,34	100,00

Source: Author's elaboration based on WIOT database.

Note: Each column sum 100\% of the changes in the contributions of each sector to the total gross output.

*Since the contribution of this sector is negative, the effects should be interpreted in the opposite way.

After an overview of the period (2000-2014), we highlight some differences between the two analyzed subperiods: 2000-2008 and 2010-2014. The reason for comparing the two sub-periods is to see whether the behavior of the sectors has changed over time. Alves-Passoni and Blancas (2021) show that Brazil grew the most between 2003 and 2008, while Mexico had the most remarkable growth between 2011-and 2014. The Brazilian growth in this period is associated with a “developmental” strategy of expanding productive activity based on direct government intervention through fiscal spending and an income transfer policy. On the other hand, the growth in Mexico was related to the export sector, connected with the incentives given by the Mexican government (tax and exchange devaluation) and the increase in the demand for Mexican exports of manufactured products by the USA.

Even though some sectors, especially MHT-M and HT-M, have lost their share of gross output (Table 3) in both countries, their contributions have not always been negative (Table 5). Only the HT-M sector contributed negatively in the three analyzed periods for Mexico, explained primarily by the increase in the proportion of imported inputs in its intermediate and final demand (Table 6). On the demand side, this is also related to the fall in the GFCF in this sector. It is worth emphasizing a selective specialization in the production of MHT-M goods in Mexico, which offset the fall of those with greater technological intensity, especially in the “Manufacture of motor vehicles, trailers, and semi-trailers” sector (See Table A.2).

Despite the positive contributions of these sectors in Brazil (Table 5), their importance decline is connected with the slowdown in economic growth. On the other hand, the services sector increased its relative importance (Table 6), positively contributing to technology and consuming a smaller proportion of imported inputs, goods, and services (Table 7).

In Mexico, the MH&HT group contributed a larger share to the gross value growth between 2010 and 2014 (21.5%) compared to 2000-2008 (4%), as shown in Table 6. The opposite occurred in Brazil, which between 2000 and 2008 contributed 20%, while in the second period corresponded only 4% (Table 7). The MHT-M group had the most significant contribution in both cases and was almost entirely related to the "Manufacture of motor vehicles, trailers, and semi-trailers." Another sector of great importance in Brazil is the" Manufacture of machinery and equipment n.e.c."

As we see in Table 4, exports and consumption mainly explain the changes in the gross output in Mexico and household consumption and GFCF for Brazil for both subperiods (2000-2008 and 2010-2014). Therefore, the MH&HT group will be more important in explaining gross output changes when exports and consumption grow faster in the Mexican case. Similarly, this will occur when consumption and GFCF grow more in Brazil. This result corroborates the findings of Alves-Passoni and Blancas (2021) that where the external sector is more important for the Mexican economy, while the domestic sources of change explain Brazilian growth.

However, something familiar to both countries is a negative contribution to gross output growth associated with HT-M exports (see Table 6 for Mexico and Table 7 for Brazil). This result demonstrates that exports of more sophisticated goods, generally associated with greater value-added and technological incorporation, decreased in both sub-periods. Based on it, we must question the type of international insertion that countries carry out, especially considering the destination of exports[15]. Torracca (2017) argues that Brazil exports fewer products of high technological intensity due to the loss of market share of Brazilian exports in Mercosur.

In Mexico, the import penetration of intermediate and final imports observed in 2000-2014 concentrates its growth between 2000 and 2008 (the negative contribution corresponds to 332% of the changes in the sector, Table 4). It focuses on intermediate goods, mainly related to the MHT-M industry, which contains the 'maquila' sector (Table 6). In this MHT-M sector, there is also an import penetration for final demand components related to

GFCF and exports. As this sector represents the majority of the total MH&HT for Mexico proportionally (Table 3), it is crucial in determining the group's influence on the entire economy.

For the Brazilian case, the contribution of $\boldsymbol{A}$ indicates that more inputs were required in the two sub-periods. Between 2000 and 2008, an exchange rate appreciation may have led to an increase in intermediate inputs[16] domestically. This result corroborates the findings in Magacho et al. (2018)[17] between 1995-2008 and by Sousa Filho et al. (2020) from 2000 to 2005 and from 2010 to 2015[18]. However, between 2010 and 2014, the imported penetration is more pronounced. Added to the deceleration of demand components, this was another factor that corroborates the loss of importance of the MH&HT group between 2010 and 2014 (Table 7).

Regarding technological change, there is a positive contribution to gross output in Mexico for the MH&MT group in both sub-periods (Table 6), mainly related to MHT-M. The other sectors had a reduction in linkages[19]. However, in the Brazilian case (Table 6), it is only possible to observe an increase in relations between 2000 and 2008. Interestingly, only the MHT-M positively affected this sub-period, which predominated against the negative contribution to the MHT-S, HT-M sectors, and HT-S.

5 Final remarks

The main conclusion is that the importance of the MH&HT group, as seen using SDA, tends to be pro-cyclical in both economies, which means that it tends to increase when the economic growth is higher and reduce when there is a slowdown. The result corroborates the hypothesis raised throughout this work. However, the importance of MH&HT is more associated with the growth of the final demand component, whose production is more related to this group of sectors. The MH&HT group in Brazil showed the most significant importance between 2000 and 2008, when household consumption, GFCF, and the economy had the highest growth. In Mexico, while the production grew more between 2000 and 2008, the MH&HT group represented a more significant portion

[16] Due to the changes of relative prices in the period because of the changes of exchange rate and domestic prices, this result should be analyzed carefully. For the changes of the Brazilian relative prices, see Passoni (2019).
[17] They use data from WIOT, version 2013.
[18] They use data from the Brazilian SNA, reference 2000 and 2010.
[19] Between them, only HT-S had a positive effect between 2010-2014.

of the gross production value between 2010 and 2014[20]. The second period's growth is mainly associated with exports, which is the demand component that requires the most from the MH&HT group.

This pro-cyclical behavior is mainly associated with manufacturing medium-high technology intensity for both countries. In the case of services, they positively affect output growth, but it is small and contributes in a minor way to the entire economy (the MHT-S and HT-S are more critical in Brazil compared to Mexico). However, the input-output model cannot measure the indirect effects that services may have on the productivity of the manufacturing sectors and thus on the entire economy.

From a theoretical point of view, this result corroborates what is expected by the Kaldorian tradition, based on Kaldor (1966). According to Kaldor's laws, there is a positive relationship between the growth of the components of capital accumulation (for Brazil) and exports (for Mexico). Furthermore, it is also possible to relate it to the relationship between the growth rate and productivity, as described by the Kaldor-Verdoorn law. The causal relationship goes from growth to productivity and thus to the excellent performance of the sectors.

Another significant result is that the MH&HT group trade pattern has been more dependent on imported inputs to supply the production process and final demand to fulfill the total supply. This result is more remarkable for Mexico (mostly related to MHT-M), but it is also valid for Brazil (especially for the HT-M sector). Concerning technology, the technical coefficients show a positive contribution of these factors to gross output growth, especially in the periods of highest growth. However, from the point of view of the domestic technical coefficients, there is a reduction in the linkages in Mexico and Brazil, since the negative contribution of the intermediate trade pattern offsets the contribution of the total technical coefficients. This means that the increase in sectoral interrelations originates from imported inputs, demonstrating that the local economy cannot absorb the generation of connections created in the period.

We also observed that the manufacturing sectors of high technological intensity (pharmaceutical and electronic products) had lost importance in terms of exports, indicating a loss of these sectors for the external insertion of these countries. Although medium-high manufacturing has increased its exports, this has happened in activities with lesser

[20] Although exports play the role in increasing the participation of this group of sectors, several studies indicate that the capacity to generate added value/employment for this component of final demand is low. See Fujii and Cervantes (2017) and Murillo, Fujii and Puchet. (2018).

capacity to generate added value, such as motor vehicles, trailers, semi-trailers sectors (most important for Mexico), and chemicals.

The results discussed in this work have some limitations. Despite being widely used, the construction of international input-output databases and the technological intensity classification involves simplifying hypotheses that can contribute to biased results. The categorization of industries may not represent the technology flows in developing countries, but still, there are some spillover benefits from these sectors to the economy. In the database case, the problem is related to the changes in relative prices present within the input-output system.

Given the results found in this work, for the MH&HT group to play a more predominant role in the Mexican and Brazilian economies, macroeconomic policies that favor a sustainable growth path over time are needed first. At this point, the most appropriate thing would be to take advantage of the capabilities of these countries as a source of growth (for example, a large export market or a large domestic market). However, stimulating the capital accumulation rate (investment rate to the GDP growth rate) is fundamental to building adequate productive capacities for a system that generates positive structural changes.

The observed results of an increase in the share of imported goods to meet final demand and intermediate demand go back to a loss of competitiveness associated with a low investment rate in capital and investments in innovation. They must be linked to industrial and innovation policies that favor national competitiveness, and these should reduce dependence on imported inputs and final goods and increase domestic producers' intersectoral relationships.

These policies should advance and not only defend the current structure of the national industry through traditional industrial policy mechanisms (devaluations, exchange rate devaluations, increase in import tariffs, subsidized interest rates). For a generalized case of loss of competitiveness, the most appropriate would be transversal policies, such as those mentioned by Andreoni (2017), which create an overall technological development structure through key technologies per a knowledge base. These policies can be sector-oriented, but the most significant advantage is to explore the synergy between all economic sectors, either manufacturing or services.

References

Alves-Passoni, P., Blancas, Andrés (2021). Determinants of growth in Mexico and Brazil between 2003 and 2018: a demand-led decomposition of growth using input-output tables. *Proceedings of International Meeting of the Brazilian Keynesian Association, 14*. https://even3.blob.core.windows.net/anais/375500.pdf

Andreoni, A. (2017). Industrial ecosystems and policy for innovative industrial renewal: A new framework and emerging trends in Europe. *London: SOAS University of London*.

Aroche-Reyes, F. (2013). La estructura económica del (sub) desarrollo y el equilibrio general o ¿qué ocurrió con la teoría del desarrollo y con las estructuras económicas? *Brazilian Journal of Political Economy*, *33*(3), 538. https://doi.org/10.1590/S0101-31572013000300010

Aroche-Reyes, F. (2021). On growth regimes, structural change and input coefficients. *Economic Systems Research*, *33*(1), 114–131. https://doi.org/10.1080/09535314.2020.1730769

Balk, B. M., Reich, U.-P. (2008). Additivity of national accounts reconsidered. *Journal of Economic and Social Measurement*, *33*(2-3), 165–178. https://doi.org/10.3233/JEM-2008-0303

Calderón, C., Hernández, L. (2016). Cambio estructural y desindustrialización en México. *Panorama Económico*, *12*(23), 153–190. http://yuss.me/revistas/panorama/pano2016v12n23a02p029_054.pdf

Carrillo, J., Hernández, A. K. (2020). Evolución y límites de la maquila en México frente al nuevo contexto político económico. In J. C. Neffa E. de la Garza Toledo (Eds.), *Trabajo y crisis de los modelos productivos en amé rica latina* (p. 151–182). CLACSO. https://doi.org/10.2307/j.ctv1gm02dh.9

Carrillo-Carrillo, F., Alcalde-Heras, H. (2020). The role of technology-based knowledge-intensive business services in the innovation performance of manufacturing firms in Mexico. *International Journal of Knowledge-Based Development*, *11*(4), 357–381. https://doi.org/10.1504/IJKBD.2020.115034

Cassini, L., Robert, V. (2017). Oportunidad versus complejidad en los procesos de aprendizaje: criterios para clasificación n de sectores según los atributos de los regímenes sectoriales de innovación. *La Encuesta Nacional de Dinámica de Empleo e Innovación n (ENDEI) como herramienta de análisis: la innovación y el empleo en la* *industria manufacturera argentina. Santiago: CEPAL, 2017. LC/TS. 2017/102. p. 119-144*. http://hdl.handle.net/11362/44135

Chenery, H. B., Taylor, L. (1968). Development patterns: among countries and over time. *The Review of Economics and Statistics*, 391–416. https://doi.org/10.2307/1926806

Ciarli, T., Meliciani, V., Savona, M. (2012). Knowledge dynamics, structural change and the geography of business services. *Journal of Economic Surveys*, *26*(3), 445–467. https://doi.org/10.1111/j.1467-6419.2012.00722.x

Cornwall, J. (1982). *Modern capitalism: its growth and transformation*. Routledge.

Costa, K. G. V., Castilho, M. R., Puchet, M. (2018). Productive structure and the linkage effects in the era of global value chains: An input-output analysis. *Revue d'economie industrielle,* (3), 147-186. https://doi.org/10.4000/rei.7369

Costa, K. G. V., Castilho, M. R., Puchet, M. (2021). Fragmentación productiva, comercio exterior y complejidad estructural: análisis comparativo del Brasil y México. *Revista CEPAL*. https://hdl.handle.net/11362/47081

Dietzenbacher, E., Los, B. (1998). Structural decomposition techniques: sense and sensitivity. *Economic Systems Research*, *10*(4), 307–324. https://doi.org/10.1080/09535319800000023

Di Meglio, G., Gallego, J., Maroto, A., Savona, M. (2018). Services in developing economies: The deindustrialization debate in perspective. *Development and Change*, *49*(6), 1495–1525. https://doi.org/10.1111/dech.12444

Durand, C., Milberg, W. (2020). Intellectual monopoly in global value chains. *Review of International Political Economy*, *27*(2), 404–429. https://doi.org/10.1080/09692290.2019.1660703

Felipe, J., Mehta, A., Rhee, C. (2019). Manufacturing matters… But it's the jobs that count. *Cambridge Journal of Economics*, *43*(1), 139–168. http://hdl.handle.net/11540/4216

Fujii-Gambero, G., Cervantes-Martínez, R. (2017). The weak linkages between processing exports and the internal economy. the Mexican case. *Economic Systems Research*, *29*(4), 528–540. https://doi.org/10.1080/09535314.2017.1351332

Galindo-Rueda, F., Verger, F. (2016). OECD taxonomy of economic activities based on R&D intensity. *OECD Science, Technology and Industry Working Papers*, *2016*(4), 1. https://doi.org/10.1787/5jlv73sqqp8r-en

Giovanini, A., Arend, M. (2019). Simbiose entre indústria e serviços intermediários: a mudança na dinâmica setorial contemporânea brasileira. *Revista de Economia*, *39*(68). http://dx.doi.org/10.5380/re.v39i68.61145

Haraguchi, N., Cheng, C. F. C., Smeets, E. (2017). The importance of manufacturing in economic development: Has this changed? *World Development*, *93*, 293–315. https://doi.org/10.1016/j.worlddev.2016.12.013

INEGI. (2013). *Encuesta sobre investigación y desarrollo tecnológico 2010* (Tech. Rep. No. vii). Instituto Nacional de Estadística y Geografía. https://www.inegi.org.mx/programas/esidet/2010/

Kaldor, N. (1966). *Causes of the slow rate of economic growth of the United Kingdom: an inaugural lecture*. Cambridge University Press.

López González, J., Meliciani, V., Savona, M. (2019). When Linder meets Hirschman: inter-industry linkages and global value chains in business services. *Industrial and Corporate Change*, *28*(6), 1555–1586. https://doi.org/10.1093/icc/dtz023

Lugli, V. M., et al. (2015). Mudança estrutural e o setor de serviços no Brasil. PhD Thesis, Campinas, Instituo de Economia, Universidade Federal de Campinas. http://repositorio.unicamp.br/jspui/handle/REPOSIP/286451

Magacho, G. R., McCombie, J. S., Guilhoto, J. J. (2018). Impacts of trade liberalization on countries' sectoral structure of production and trade: A structural decomposition analysis. *Structural Change and Economic Dynamics*, *46*, 70–77. https://doi.org/10.1016/j.strueco.2018.04.003

Marcato, M. B., Ultremare, F. O. (2018). Produção industrial e vazamento de demanda para o exterior: uma análise da economia brasileira. *Economia e sociedade*, *27*, 637–662. https://doi.org/10.1590/1982-3533.2017v27n2art10

Marín, A., Petralia, S. (2018). Sources and contexts of inter-industry differences in technological opportunities: the cases of Argentina and Brazil. *Innovation and development*, *8*(1), 29–57. https://doi.org/10.1080/2157930X.2018.1429191

Meliciani, V., Savona, M. (2015). The determinants of regional specialisation in business services: agglomeration economies, vertical linkages and innovation. *Journal of Economic Geography*, *15*(2), 387–416. https://doi.org/10.1093/jeg/lbt038

Messa, A. (2013). Structural change in the Brazilian economy in the 2000s. *Revista de Economia Contemporânea*, *17*, 452–467. https://revistas.ufrj.br/index.php/rec/article/viewFile/24111/13358

Miller, R. E., Blair, P. D. (2009). *Input-output analysis: foundations and extensions*. Cambridge University Press.

Murillo, B., Puchet, M., Fujii, G. (2018). Exportaciones manufactureras mexicanas por nivel tecnológico y su efecto sobre el empleo en 2008 y 2012: un análisis de descomposición estructural. *Revista de Economía del Rosario*, *21*(2), 409–433. https://doi.org/10.12804/revistas.urosario.edu.co/economia/a.7206

Oosterhaven, J., Van Der Linden, J. A. (1997). European technology, trade and income changes for 1975–85: an intercountry input–output decomposition. *Economic Systems Research*, *9*(4), 393–412. https://doi.org/10.1080/09535319700000033

Palma, J. G. (2019). Desindustrialización, desindustrialización “prematura” y “síndrome holandés”. *El trimestre económico*, *86*(344), 901–966. https://doi.org/10.20430/ete.v86i344.970

Passoni, P. A. (2019). *Deindustrialization and regressive specialization in the Brazilian economy between 2000 and 2014: a critical assessment based on the input-output analysis*. PhD thesis, Rio de Janeiro, IE-Universidade Federal do Rio de Janeiro. http://objdig.ufrj.br/43/teses/PatieeneAlvesPassoni.pdf

Pérez, L. (2021). La relación comercial México-china y el empleo sectorial: un análisis de descomposición estructural. *México y la Cuenca del Pacífico*, *10*(30), 83– 112. https://doi.org/10.32870/mycp.v10i30.737

Pérez, L., Peters, E. D. (2019). Efectos del comercio internacional con EE.UU. y China en el empleo manufacturero en México. *Paradigma Económico*, *11*(2), 39–66. https://doi.org/10.36677/paradigmaeconomico.v11i2.11979

Persona, H. L., Oliveira, M. A. S. (2016). Cambios estructurales en la industria brasileña (1995-2009). *Revista Cepal*, 201. http://hdl.handle.net/11362/40797

Ramírez Sánchez, J. C., Calderón, C., Leó n, S. S. (2018). Is NAFTA really advantageous for Mexico? *The International Trade Journal*, *32*(1), 21–42. https://doi.org/10.1080/08853908.2017.1387623

Reich, U.-P. (2008). Additivity of deflated input–output tables in national accounts. *Economic Systems Research*, *20*(4), 415–428. https://doi.org/10.1080/09535310802551455

Rose, A., Chen, C.-Y. (1991). Sources of change in energy use in the US economy, 1972–1982: a structural decomposition analysis. *Resources and Energy*, *13*(1), 1–21. https://doi.org/10.1016/0165-0572(91)90017-W

Rose, A., Miernyk, W. (1989). Input–output analysis: the first fifty years. *Economic Systems Research*, *1*(2), 229–272. https://doi.org/10.1080/09535318900000016

Rostow, W. W. (1960). *The process of economic growth.* (Tech. Rep.).

Rowthorn, R., Ramaswamy, R. (1999). Growth, trade, and deindustrialization. *IMF Staff papers*, *46*(1), 18–41. https://www.imf.org/external/pubs/ft/staffp/1999/03-99/pdf/rowthorn.pdf

Ruiz, F. A. T., Demmler, M. (2019). El rol de los KIBS en la economía del conocimiento y su función como fuentes de innovación. *RAITES*, *5*(11). http://raites.tecpurisima.edu.mx/index.php/raites/article/view/228/221

Santos, C. H. M. d., Cieplinski, A., Pimentel, D. M., Bhering, G. (2017). Por que a elasticidade-preço das importações é baixa no brasil? Evidências a partir das desagregações das importações por categorias de uso. *Economia e Sociedade*, *26*, 141–164. https://doi.org/10.1590/1982-3533.2017v26n1art5

Santos, J. B. (2019). Knowledge-intensive business services and innovation performance in Brazil. *Innovation &Management Review*, *17*(1), 58-74. https://www.revistas.usp.br/rai/article/view/168533/160173

Sousa Filho, J. F. d., Santos, G. F. d., Ribeiro, L. C. S. (2020). Structural changes in the Brazilian economy 1990–2015. *Economic Systems Research*, 1–21. https://doi.org/10.1080/09535314.2020.1802234

Su, D., Yao, Y. (2017). Manufacturing as the key engine of economic growth for middle-income economies. *Journal of the Asia Pacific Economy*, *22*(1), 47–70. https://doi.org/10.1080/13547860.2016.1261481

Timmer, M., Los, B., Stehrer, R., De Vries, G. (2016). *An anatomy of the global trade slow-down based on the WIOT 2016 release* (Tech. Rep.). Groningen Growth and Development Centre, University of Groningen https://ideas.repec.org/p/gro/rugggd/gd-162.html#download .

Timmer, M. P., De Vries, G. J. (2009). Structural change and growth accelerations in Asia and Latin America: a new sectoral data set. *Cliometrica*, *3*(2), 165–190. https://doi.org/10.1007/s11698-008-0029-5

Timmer, M. P., Dietzenbacher, E., Los, B., Stehrer, R., De Vries, G. J. (2015). An illustrated user guide to the world input–output database: the case of global automotive production. *Review of International Economics*, *23*(3), 575–605. https://doi.org/10.1111/roie.12178

Torracca, J. (2017). *Coevolução das estruturas de produção e comércio exterior da indústria brasileira: convergência ou desarticulação*. PhD thesis, Rio de Janeiro, IE-Universidade Federal do Rio de Janeiro. http://objdig.ufrj.br/43/teses/JuliaTorracca.pdf

UN (United Nations) (2009). *System of national accounts 2008*. New York, NY. https://unstats.un.org/unsd/nationalaccount/docs/SNA2008.pdf

Appendix A

Table A.1: WIOT industries classification based on OCDE's technological intensity classification

OCDE groups	Industry	Code WIOD	Description WIOD
LT	Agriculture and related	A01	Crop and animal production, hunting and related service activities
	Agriculture and related	A02	Forestry and logging
	Agriculture and related	A03	Fishing and aquaculture
	Service	D35	Electricity, gas, steam and air conditioning supply
	Service	E36	Water collection, treatment and supply
	Service	E37-E39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services
	Construction	F	Construction
	Service	G45	Wholesale and retail trade and repair of motor vehicles and motorcycles
	Service	G46	Wholesale trade, except of motor vehicles and motorcycles
	Service	G47	Retail trade, except of motor vehicles and motorcycles
	Service	H49	Land transport and transport via pipelines
	Service	H50	Water transport
	Service	H51	Air transport
	Service	H52	Warehousing and support activities for transportation
	Service	H53	Postal and courier activities
	Service	I	Accommodation and food service activities
	Service	K64	Financial service activities, except insurance and pension funding
	Service	K65	Insurance, reinsurance and pension funding, except compulsory social security
	Service	K66	Activities auxiliary to financial services and insurance activities
	Service	L68	Real estate activities
	Service	N	Administrative and support service activities
	Service	R_S	Other service activities
	Service	T	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use
	Service	U	Activities of extraterritorial organizations and bodies
MLT	Extractive	B	Mining and quarrying
	Manufacturing	C10-C12	Manufacture of food products, beverages and tobacco products
	Manufacturing	C13-C15	Manufacture of textiles, wearing apparel and leather products
	Manufacturing	C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
	Manufacturing	C17	Manufacture of paper and paper products
	Manufacturing	C18	Printing and reproduction of recorded media
	Manufacturing	C19	Manufacture of coke and refined petroleum products
	Manufacturing	C25	Manufacture of fabricated metal products, except machinery and equipment
	Manufacturing	C31_C32	Manufacture of furniture; other manufacturing
	Service	J61	Telecommunications
	Service	M69_M70	Legal and accounting activities; activities of head offices; management consultancy activities
	Service	M71	Architectural and engineering activities; technical testing and analysis
	Service	M73	Advertising and market research
	Service	M74_M75	Other professional, scientific and technical activities; veterinary activities
MT	Manufacturing	C22	Manufacture of rubber and plastic products
	Manufacturing	C23	Manufacture of other non-metallic mineral products
	Manufacturing	C24	Manufacture of basic metals
	Service	C33	Repair and installation of machinery and equipment
MHT	Manufacturing	C20	Manufacture of chemicals and chemical products
	Manufacturing	C27	Manufacture of electrical equipment
	Manufacturing	C28	Manufacture of machinery and equipment n.e.c.
	Manufacturing	C29	Manufacture of motor vehicles, trailers and semi-trailers
	Manufacturing	C30	Manufacture of other transport equipment
	Service	J58	Publishing activities
	Service	J59_J60	Motion picture, video and television programme production, sound recording and music publishing activities; programming and broadcasting activities
	Service	J62_J63	Computer programming, consultancy and related activities; information service activities
HT	Manufacturing	C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
	Manufacturing	C26	Manufacture of computer, electronic and optical products
	Service	M72	Scientific research and development
NC	Service	O84	Public administration and defence; compulsory social security
	Service	P85	Education
	Service	Q	Human health and social work activities

Source: Author's elaboration based on Galindo-Rueda and Verger (2016) and Timmer et. al (2016)

Table A.2: Sectoral share of gross output and growth rates of medium-high and high technological intensity industries: 2000-2014, 2000-2008 and 2010-2014

Country	Mexico							Brazil						
Variable	Share				Growth			Share				Growth		
C20	3.2	3.3	2.7	2.6	-17.2	3.5	-3.9	3.3	3.2	2.8	2.7	-19.0	-3.1	-5.0
C27	1.5	1.2	1.3	1.2	-21.0	-21.7	-9.6	1.1	1.0	0.9	0.8	-34.3	-12.0	-15.4
C28	0.8	0.8	1.1	1.1	38.9	3.3	-5.0	1.3	1.8	1.5	1.4	7.7	38.2	-6.8
C29	5.9	4.5	4.8	6.4	8.1	-24.2	32.3	2.8	4.1	3.6	3.0	7.1	47.0	-16.9
C30	0.2	0.2	0.2	0.3	59.7	-6.6	115.9	0.4	0.6	0.5	0.5	16.7	47.0	-9.5
J58	0.2	0.1	0.1	0.1	-28.9	-9.9	-14.4	0.5	0.4	0.3	0.2	-51.3	-24.0	-31.8
J59_J60	0.2	0.2	0.3	0.3	9.7	3.0	-2.7	0.5	0.4	0.4	0.4	-11.2	-15.8	-1.4
J62_J63	0.0	0.0	0.0	0.0	6.0	6.8	0.8	0.9	1.0	1.0	1.1	17.2	2.0	8.6
C21	1.0	0.9	0.8	0.5	-46.0	-13.7	-28.8	0.7	0.7	0.6	0.5	-26.2	-3.1	-13.4
C26	4.9	3.6	3.5	2.9	-40.7	-25.7	-16.1	1.3	1.1	1.0	0.9	-26.0	-12.0	-4.7
M72	0.37	0.36	0.36	0.38	2.0	-2.6	4.8	0.9	0.8	0.9	0.9	3.6	-4.7	3.9

Source: Author’s elaboration based on Galindo-Rueda and Verger(2016) and Timmer et. al (2016)