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

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**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 (composition of imports for intermediate and final demand). We use the data from the World Input-Output Tables and the OCDE technological intensity classification. The results show that the importance of the MH&HT group tends to be pro-cyclical in the two economies increasing during periods of greater economic growth (2000-2008 for Brazil and 2010-2014 for Mexico). This tends to be perceived for manufacturing and less so for services. Also, the increase in the proportion of imported inputs and final goods contribute to reducing the relevance of the MH&HT group.

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

**Resumo**

Desenvolve-se uma análise de decomposição estrutural para identificar a importância da indústria e serviços com média-alta e alta intensidade tecnológica (MH&HT) para as mudanças no valor bruto da produção do Brasil e do México entre 2000 e 2014. As variações do valor bruto da produção são decompostas considerando a composição e o nível da demanda final, a técnica de produção (coeficientes técnicos) e o padrão de comércio (composição das importações para a demanda intermediária e final). São utilizados os dados das World Input-Output Tables e a classificação de intensidade tecnológica da OCDE. Os resultados mostram que a importância do grupo MH&HT tende a ser pró-cíclica nas duas economias aumentando em períodos de maior crescimento econômico (2000-2008 para o Brasil e 2010-2014 para o México). Esse resultado é mais intenso para a indústria e menos para os Isso tende a ser percebido para manufatura e menos para serviços. Além disso, o aumento da proporção de insumos e bens finais importados contribui para reduzir a relevância do grupo MH&HT.

**Palavras-chave**: Brasil; México; Análise de decomposição estrutural; Modelos de insumo-produto.

**Código JEL:** Q12; C22; D81.

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## 1 Introduction

In the literature on development, a more significant portion of the sectors with a greater capacity for technological diffusion is associated with more accelerated production and growth trajectories. For a long time, 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).

In order to identify the differences between the MH&HT industries for the countries' gross output, we decompose the changes of 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. 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.

A few recent studies have compared Brazil and Mexico, such as Costa, Castilho, and Anyul (2018) and Costa, Castilho, and Puchet (2021). However, they used a different approach that analyzes the complexity and integration in the Global Value Chains (GVCs) using qualitative input-output through networks. They 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 level of activity 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 for Brazil[†] and Mexico[‡], none have compared these two countries. Furthermore, the method used to deflate the data the IOT is different from the one already applied in these works. With this, we may find similarities and differences between countries that can be useful for economic policy making.

This paper has four more sections. First, we discuss the importance of mid-high and high technological intensity sectors to economic growth. Then we present the method examining the structural decomposition analysis and the data used. The results of the SDA then follow and some final remarks.

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

Historically, one of the main subjects of study of economic development is industrialization because changes in the sectoral composition for 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 Kaldor-Verdoorn law), manufacturing output growth is positively related to labor productivity growth and 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) and 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.

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[†] Messa (2013), Persona and Oliveira (2016), Magacho, McCombie, and Guilhoto (2018), Passoni (2019) and Sousa Filho, Santos, and Ribeiro (2020), mostly for gross output.
[‡] Murillo, Puchet, and Fujii (2018), Pérez and Peters (2019) and Pérez (2021), all for employment.

Regarding Brazil and Mexico in particular, several studies show that 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 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 from 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 sectors with the greatest capacity to develop links and creates technological diffusion through investment in research and development and product and process innovations.

## 3 Methodology

### 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 is applied to decompose changes in the gross value of production, added value, employment, trade (imports and exports), among others.

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 ($L = (I - A_d)^{-1}$) by the final domestic demand:

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

$$x = L \times f_d \tag{2}$$

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)[§]. In this way,

$$\Omega = A_d \times A^{-1} \tag{3}$$

$$\mu = f_d \times f^{-1} \tag{4}$$

where $\Omega$ represents the share of imported technical coefficient in relation to the technical coefficients for total (domestic plus imported) inputs ($A$); and $\mu$ represents the share of imported final demand in the total final demand ($f$). So, the domestic technical coefficients and the final domestic demand can be expressed as:

$$A_d = \Omega \odot A_d \tag{5}$$

$$f_d = \mu f \tag{6}$$

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

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

$$x = [I - \Omega \odot A_d]^{-1} \times \mu f \tag{7}$$

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

$$\Delta x = x^1 - x^0 \tag{8}$$

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

$$\Delta x = L^1 f_d^1 - L^0 f_d^0 \tag{9}$$

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[§] 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.

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):

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

If we want the total for each sector, we must sum the changes by sector, and we do so by the multiplication of each change by a summary vector (transposed column vector) **i**:

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

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

$$\Delta L = L^1 \Delta A_d L^0 \tag{12}$$

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

$$\Delta A_d = \left(\tfrac{1}{2}\right) \Delta \Omega \odot \left(A^1 + A^0\right) + \left(\tfrac{1}{2}\right) \left(\Omega^1 + \Omega^0\right) \odot \Delta A \tag{13}$$

And putting together (12) and (13), the changes of Leontief between the period 1 and ($\Delta L$) related to the changes in gross output ($\Delta x$) can be expressed by the variations in the share of imported intermediate inputs ($\Delta \Omega$) and the total inputs used for the production ($\Delta A$):

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

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

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

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

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

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

$$\left(\tfrac{1}{2}\right) \left\{ \left(\tfrac{1}{2}\right) \left[ \left(\Omega^1 + \Omega^0\right) \odot \Delta A\right] \right\} \left(f_d^1 + f_d^0\right) \qquad \text{Technology} \tag{18}$$

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

The changes in the trade pattern are related to the share of domestic inputs $\Delta \Omega$ or final demand $\Delta \mu$ in total supply. If its contribution is negative/positive, there was import substitution/penetration, which means that the country is using less/more domestic supply to satisfy demand. The changes in $\mu$ will also be presented for each final demand component (consumption ($\mu_c$), gross fixed capital formation ($\mu_k$), government expenditures ($\mu_g$), and exports ($\mu_e$)).

For technology, the changes are related to $\Delta A$. 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 ($c$), gross fixed capital formation ($k$), government expenditures ($g$), and exports ($e$)). If this contribution of total final demand ($\Delta f$) or its components is positive/negative, the demand increased/decreased in period 1 compared to period 0. As the inventories in the national accounts have no economic significance, an empirical adjustment will be made to calculate a new final demand, considering all demand components, excluding inventories. Thus, we will show the changes in inventories separately to keep the total change in the gross value of production unchanged.

## 3.2 **Data**

We use the World Input-Output Tables (WIOT, Revision 2016[**]) between 2000 and 2014. These data were preferred over information available in each country's System National Accounts (SNA) because they are computed differently. 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). However, while there is a compatibility of SNA data from countries to WIOT, it is not complete. Therefore, the SDA results for Brazil (with SNA based on linked price indices) have more relative price variations compared to Mexico (fixed basis)[††].

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

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[**]      The data can be downloaded for free at http://wiod.org/database/wiots16. Methodological aspects may be seen at Timmer et. al(2016).
[††]      For statistical reasons related to the price index theory, see UN (2009).

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 in the classification because, in general, other companies implement the technological innovations in these sectors. The classification of the industries of WIOT based on the OCDE's criteria is presented in Table 1, as presented in Appendix. We will focus our analysis on manufacturing and service industries with high and medium-high technology intensity (MH&HT), as presented in Table 2.

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)

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 pharmaceutical preparations |
| | Manufacturing | |
| | 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, sound recording and music publishing activities; programming and broadcasting activities |
| | Service | |
| | Service | Computer programming, consultancy and related activities; information service activities |
| | Service | |
| 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,

electronics). The insertion of medium-high technology intensity industries in this classification is essential because they have a high demand elasticity, a high 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 regulation, 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[‡‡]. 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, we first discuss the structure and evolution of the sectoral composition of gross output, as presented in Table 3.

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 |

Author's elaboration based on WIOT database.

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[§§]. The industries that have a higher share are

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[‡‡]        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.

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

"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 share of the total gross output, especially since 2010[***]. According to Carrillo and Hernández (2020), after the 2008 crisis, the USA's multinational automotive firms changed their strategy, with the transfer of various operations and segments, such as the Premium categories, which contributed to the transfer of multiple operations and segments to the increase in this activity. Although this affected the GFCF, the component of demand that most stimulated this growth was exports.

Although the MTH-S and the HT-S grew between 2000-2014, their share was too small to significantly influence the gross output since they correspond to only 0.5% in Mexico. Nonetheless, Carrillo-Carrillo and Alcalde-Heras (2020) and Ruiz and Demmler (2019) show that they have had a positive impact on expanding 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 HT-M saw their share fall by approximately -7%, mainly 'chemical products and electrical equipment. The HT- M also reduced its share (-26%), related to the degrowth of similar rates of "Manufacture of basic pharmaceutical products and pharmaceutical preparations" and "Manufacture of computer, electronic and optical products."

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

| Unity of measure | | | | | | | p.p. | | | | | | | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sources | | | Trade pattern | | | | Tech | | Total final demand | | | | INV. | Gross output |
| Variables | $\Delta\Omega$ | $\Delta\mu_c$ | $\Delta\mu_k$ | $\Delta\mu_g$ | $\Delta\mu_e$ | $\Delta\mu_f$ | $\Delta A$ | $\Delta c$ | $\Delta k$ | $\Delta g$ | $\Delta e$ | $\Delta f$ | $\Delta s$ | $\Delta x$ |
| **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 |

Author's elaboration based on WIOT database.

Compared to the Mexican economy, services represent a more significant part of the

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

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 4% but represented a small share in total gross output (0.9%)[†††]. Considering the relative importance of these sectors, Santos (2019) and Giovanini and Arend (2019) argue that technological services 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, when the Brazilian economy slowed[‡‡‡].

The first conclusion is the share in the total gross output of the MHT&HT group decreased in both economies between 2000 and 2014 and the subperiods. This was largely caused by manufacturing sectors, and growth in services was insufficient to offset the fall[§§§]. However, we must note that 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 2000-2008, in Brazil, this occurs more between 2010-2014. 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.

In order 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 for 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. Table 5 shows the sectoral contribution to the changes in gross output. Finally, Table 6 and Table 7 show the sources of change with which this shift in the importance of the MH&HT group is related.

Between 2000 and 2014, Brazil grew at a higher annual rate (3%) than Mexico (2.4%). The group of sectors which most contributed to the gross output in both economies are related to services and construction, such as LT-C, LT-S, and NT-S. This is because these countries have big economies with a large population and a robust domestic market, all of which contribute to services representing a relevant share of the gross value of production. If we consider MH&HT, they contribute together 9% and 10% in Brazil and Mexico. Their contribution is less than the groups' share in the gross output, 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, the only industry

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[†††] HT-S has a positive effect only between 2010-2014.
[‡‡‡] 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.
[§§§] Corroborating the findings of Lugli et al. (2015) in the Brazilian case.

that contributed negatively was HT-M in Mexico[****].

The final demand is the source of change that most contributed to the gross output growth between 2000 and 2014, 106% and 110% growth for Brazil and Mexico respectively (equivalent to a contribution of 65.5p.p. and 62p.p). In this type of decomposition, it is natural that the final demand corresponds to the most significant share since, in terms of monetary units, it has the most significant magnitude. In Mexico, exports and household consumption are the most critical final demand components to gross output growth. For Brazil, household consumption and the GFCF represent the largest share of the demand contribution. The first component is more related to LT-S and MLT-M, the second one, the LT-C (construction), and MHT-M (electrical equipment), have the most importance. However, while the contribution of household consumption is more related to LT-S and LT-C, almost 60% of the contribution of exports is attributed to MLT-M (mining and quarrying) and MHT-M (machinery and equipment and motor vehicles).

*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.

Given the contributions of $\Omega$ and $\mu$ for both countries, there is import penetration for intermediate and final demand, indicating that a more significant proportion of goods and services is being imported. Note that the increase is not in absolute terms but proportional, showing that imports grew more than the total supply of goods and services.

The intermediate and final trade pattern in Mexico declined -5.9p.p. and -5.3p.p. which represents 14% and 13% to Mexico's accumulated growth of 42.5%. Since household consumption and GFCF represent the largest share of total imports, it contributes the most to the import penetration of Mexico. It can be observed that the effect of import penetration is more significant during the period 2000 to 2008 compared to 2010-2014.

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

In Brazil, the contribution of $\Omega$ and $\mu$ correspond to -3.58p.p. and -1.1p.p., equivalent to 6% and 2% of 56.6%. This negative contribution is related to consumption, government, and exports. The GFCF contribution is positive, indicating that more domestic goods are being used in production[††††].

What stands out here is the significant role of the trade pattern as a factor that reduced the gross value of production by 26% in Mexico compared to 6% in Brazil between 2000-2014. This demonstrates the greater importance of imports for the productive structure for Mexico than for Brazil. However, for both countries, penetration represents a greater negative contribution in the first period when compared to the second period.

*Table 6: Shares of sectoral contribution of 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 | $\Delta\Omega$ | $\Delta\mu_c$ | $\Delta\mu_k$ | $\Delta\mu_g$ | $\Delta\mu_e$ | $\Delta\mu_f$ | $\Delta A$ | $\Delta c$ | $\Delta k$ | $\Delta g$ | $\Delta e$ | $\Delta f$ | $\Delta s$ | $\Delta x$ |
| **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 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.

There are different movements for each country if we consider the contribution of *A* to the gross output. For Mexico, changes in technical coefficients positively impacted the growth in the gross value of production, contributing approximately 7% (4.03p.p.). This indicates an increase in the total production inputs sectoral relationship, especially related to MLT-M. However, as the contribution of $\mathbf{\Omega}$ is more remarkable than $\mathbf{A}$, this indicates that the increase in linkages is related to 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 value of production by 1%. This indicates a decrease in total linkages; that is, the economy needed fewer inputs to produce goods[‡‡‡‡]. This drop was

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[††††] 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 Brazil makes a deeper analysis difficult to identify whether this process was related to an increase in productivity or why 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.
[‡‡‡‡] 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

particularly associated with medium-low technological intensity manufacturing. Regarding the industries with MH&HT, all contributed negatively to the gross output growth.

*Table 7: Shares of sectoral contribution of 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 | $\Delta\Omega$ | $\Delta\mu_c$ | $\Delta\mu_k$ | $\Delta\mu_g$ | $\Delta\mu_e$ | $\Delta\mu_f$ | $\Delta A$ | $\Delta c$ | $\Delta k$ | $\Delta g$ | $\Delta e$ | $\Delta f$ | $\Delta s$ | $\Delta x$ |
| **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.

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 2011-2014. 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 in terms of contribution to growth, this contribution has not always been negative for both countries. In fact, only the HT-M sector contributes negatively in the three periods for Mexico, explained primarily by the increase in the proportion of imported inputs in its intermediate and final demand. 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, which offset the fall of those with greater technological intensity, with the advance especially in the "Manufacture of motor vehicles, trailers, and semi-trailers" sector. In the Brazilian case, despite the contributions being positive, they

demand.

decline overtime for the manufacturing sectors, related to the pace of economic growth. On the other hand, the services sector increased its relative importance, positively contributing to technology and consuming a smaller proportion of imported inputs, goods, and services.

In Mexico, the MH&HT group contributed a larger share to the gross value growth between 2010-2014 (21.5%) compared to 2000-2008 (4%). The opposite occurred in Brazil, which between 2000-2008 contributed 20%, while in the second period corresponds only 4%. In both cases, the biggest contribution is from the MHT-M group, 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." sector.

In the Mexican economy, exports and consumption mainly explain the changes in the gross output in both sub-periods. Conversely, the most critical components are household consumption and GFCF for Brazil. 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, in Brazil, this will occur when consumption and GFCF grow more. This corroborates the findings of Alves-Passoni and Blancas (2021), in which the external exports were found to be more important for the Mexican economy, while the domestic sources of change explain Brazilian growth to a greater extent.

However, something common to both countries is a negative contribution to gross output growth associated with HT-M exports. This demonstrates that exports of more sophisticated goods, generally associated with greater added value and technological incorporation, decreased in both sub-periods. This raises the question of the type of international insertion that countries carry out, especially considering the destination of exports. 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 the period 2000-2014 concentrates its growth between 2000-2008 (the negative contribution corresponds to 332% of the changes in the sector). It focuses on intermediate goods, mainly related to the MHT-M sector, which contains the 'maquila' sector. 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, it is of fundamental importance in determining the group's influence on the entire economy.

For the Brazilian case, proportionally 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[§§§§] domestically. This corroborates the findings in Magacho et al. (2018)[*****] between 1995-2008 and in Sousa Filho et al. (2020) for 2000-2005 and 2010-2015[†††††]. However, between 2010-2014 the effect 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.

Regarding technological change, there is a positive contribution to gross output in Mexico for the MH&MT group in both sub-periods. This is mainly related to MHT-M, since the other sectors saw a reduction in linkages[‡‡‡‡‡]. However, in the Brazilian case, it is only possible to observe an increase in relations between 2000 and 2008. Interestingly, only the MHT-M had a positive effect in 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, corroborating 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 associated with this group of sectors. The MH&HT group in Brazil showed the most significant importance between 2000-2008, 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 larger portion of the gross production value between 2010-2014[§§§§§]. This is because while in the first sub-period, consumption and GFCF grew more (but not demand from the MH&HT sectors), the growth in the second period is more associated with this group.

For both countries, this pro-cyclical behavior is mostly associated with the manufacturing of medium-high technology intensity. 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 important 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

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[§§§§] 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).

[*****] They use data from WIOT, version 2013.

[†††††] They use data from the Brazilian SNA, reference 2000 and 2010.

[‡‡‡‡‡] Only HT-S had a positive effect between 2010-2014.

[§§§§§] Although exports play the role in increasing the participation 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).

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, described by the Kaldor-Verdoorn law. The causal relationship goes from growth to productivity, and thus to the good performance of the sectors.

Another important 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 is more intense 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 national technical coefficients, there is a reduction in the linkages of the two economies, 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 does not have the capacity to absorb the generation of connections created in the period.

We also observed that the manufacturing sectors of high technological intensity (pharmaceutical and electronic products) have 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 capacity to generate added value, such as motor vehicles, trailers, and 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 classification of industries may not represent the technological 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. Furthermore, they must be linked to industrial policies that favor national competitiveness. These should focus on reducing dependence on imported inputs and final goods and on increasing the intersectoral relationship of domestic producers.

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Appendix A

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

| OCDE groups | Industry | Code WIOD | Description WIOD |
|---|---|---|---|
| | 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 | | Sewerage; waste collection, treatment and disposal activities; |
| | Service | E37-E39 | materials recovery; remediation activities and other waste |
| | Service | | 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 |
| LT | 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- |
| | Service | | and services-producing activities of households for own use |
| | Service | U | Activities of extraterritorial organizations and bodies |
| | 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 | | Manufacture of wood and of products of wood and cork, except furniture; |
| | Manufacturing | C16 | 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 |
| MLT | Manufacturing | C25 | Manufacture of fabricated metal products, except machinery and equipment |
| | Manufacturing | C31_C32 | Manufacture of furniture; other manufacturing |
| | Service | J61 | Telecommunications |
| | Service | | Legal and accounting activities; activities of head offices; |
| | Service | M69_M70 | 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 |
| | Manufacturing | C22 | Manufacture of rubber and plastic products |
| MT | Manufacturing | C23 | Manufacture of other non-metallic mineral products |
| | Manufacturing | C24 | Manufacture of basic metals |
| | Service | C33 | Repair and installation of machinery and equipment |
| | 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 |
| MHT | Service | J58 | Publishing activities |
| | Service | | Motion picture, video and television programme production, |
| | Service | J59_J60 | sound recording and music publishing activities; |
| | Service | | programming and broadcasting activities |
| | Service | | Computer programming, consultancy and related activities; |
| | Service | J62_J63 | information service activities |
| | Manufacturing | | Manufacture of basic pharmaceutical products and |
| HT | Manufacturing | C21 | pharmaceutical preparations |
| | Manufacturing | C26 | Manufacture of computer, electronic and optical products |
| | Service | M72 | Scientific research and development |
| | Service | O84 | Public administration and defence; compulsory social security |
| NC | 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)