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An Extended Structural Analysis of Mexico:

Production, income distribution, and international trade

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A Adán y Manuel: per i solidi anni di amicizia

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Introduction

Currently, the Mexican Economy is one of the most open economies in the world. The index of trade openness of the Mexican economy has grown from 31 to 52, 61, and 82 points, respectively, in 1990, 2000, 2010, and 2018 (World Bank, 2022), which is considerably higher than that of its leading trading partner, the United States, whose index of trade openness for the same period has not exceeded 32 points.

This trade liberalization has allowed Mexico access to the biggest market in the world, the USA, the only country with which Mexico has a trade surplus. However, the success of Mexican exports since 1995 has also generated some structural problems: low economic growth (Ros, 2015; Ros, 2013) and significant vulnerability to external shocks that come from its leading trading partner, the USA (Moreno & Ros, 2010; Ruiz Nápoles, 2017). Furthermore, the flexibilization of the labor market to counteract the productivity gap compared to the USA has contributed to exacerbating inequalities in the Mexican income distribution, which shows a regression.

In this context, the multisectoral structural analysis helps to analyze and identify structural economic restrictions at a disaggregated level and suggests policies to policymakers. In the case of Mexico, many studies use multisectoral analysis, for example, through the open classical Input-Output (I-O) model to analyze structural changes (Aroche-Reyes, 2019; Aroche-Reyes, 2006) or the technological change associated with the Green House Emissions (Ruiz-Nápoles, 2012).

In addition, some studies have recently employed the Social Accounting Matrix (SAM) approach to focus on the case of the Mexican economy. For example, with the Mexican economy official Make and Use tables for 2008, Minzer and Solis (2014) constructed a SAM to analyze the effect of policies affecting income distribution, such as the rise of the value-added tax in 2010. Beltrán-Jaimes et al. (2016) built a SAM based on the I-O table provided by Instituto Nacional de Estadística y Geografía (INEGI) for 2008 to carry out a structural analysis of the Mexican economy. Nuñez-Rodríguez (2018) constructed a SAM for 2008, extending the Input-Output table of 2008, to evaluate the distributive effects of taxes on hydrocarbon extraction in Mexico. With an update of the Input-Output table of 2008 in 2012, Beltran-Jaimes et al. (2017) constructed a SAM for 2003 and conducted a comparative structural analysis with a SAM for 2013, using structural path analysis. Finally, by using the Census of 2014 and the official Make and Use tables for Mexico for 2013, Chapa-Cantú et al. (2019) constructed a subregional SAM for four regions of Mexico.

Regarding Mexican international trade, there exist multisectoral studies for Mexico and the United States, e.g., Aroche-Reyes (2014), Aroche-Reyes and Marquez-Mendoza (2016) constructed a multiregional Input-Output table for North America and, combining some indexes of network analysis, studied the trade network of this region.

On the other hand, Ruiz-Nápoles (2010; 2021) and Ruiz-Nápoles and Gomez-Tovar (2021) (Ruiz-Nápoles & Gómez-Tovar, 2021) use the Input-Output matrices separately or bi-regional Input-Output matrices of WIOD (Timmer, et al., 2015) and classical I-O models, to examine the effects of trade liberalization in the Mexican economy.

However, the study of the Mexican economy can be broadened and deepened with alternative techniques. For example, the Extended Multisectoral Model (EMM) (Ciaschini & Socci, 2006) allows for exploring the multiplier effects of the Mexican economy with more accuracy than the classical I-O model or the Miyazawa model (1963). Moreover, the Pyatt and Round model enables to capture the induced multiplier effects (Pyatt & Thorbecke, 1976; Pyatt & Round, 1985; Pyatt G., 2001). The Extended Multisectoral Model allows for adopting the Macro Multiplier approach (Ciaschini, 1993; Socci, 2004). This approach consists of capturing the n possible structures of final demand, including the final demand that can maximize the rate of growth and income in the economy. These techniques have not been used yet for the Mexican economy.

The EMM can also incorporate the features and variants of inoperability (Extended Inoperability Model, EIM), which describes the level of an economic system dysfunction expressed as a percentage of its Business as Usual production; it means expressing the economic loss in relative terms (Santos & Haimes, 2004). A policy like a lockdown can cause this dysfunction; for a policymaker, it is crucial to know the impact of this kind of policy. Thus, the EIM can quantify the pure effect of a lockdown, allowing for an ex-ante approach, which means providing in advance the estimate of the pure impact before the policy is implemented.

Although the adverse effects of the Covid-19 lockdown in Mexico are already known, the mentioned exercises show how close this type of model can come, with the advantage of capturing the effects on production and income at the disaggregated level and observing changes in variables such as income. Thus, by using an extended multisectoral model with inoperability (EIM), which is built for the Mexican economy for 2018, and simulating the lockdown according to the types of industries and the number of days of standstill, we examine the potential adverse economic effects on GDP, primary, and disposable income by institutional sector. Furthermore, we describe the results of the model simulation of the 75-day lockdown and highlight those productive processes and institutional sectors most affected by the shock. Finally, the main results of the pure impact are shown in aggregate terms (real GDP) and disaggregated terms (industrial final demand and primary and disposable income by institutional sector) without considering any policies to mitigate the negative impact.

In the case of the analysis of Mexican international trade, a Bi-regional SAM between Mexico and the USA will be constructed. Today, it is the first bi-regional SAM for the two countries. The construction of this SAM is not negligible because, according to the INEGI and the Bureau of Economic Analysis (BEA), 80% of Mexican exports have as a destination the USA, and 53% of its imports arrive from this country. In comparison, only 12% of US exports have a destination in Mexico, and 11% of its imports are provided by Mexico (INEGI, 2021; United Census Bureau , 2022). However, this structural restriction on the Mexican economy does not have the same effects in both economic systems, Mexico and the US. So, to understand at a disaggregated level the effects caused to industries and institutional sectors, it is necessary to adopt a multisectoral approach through the extended multisectoral model and the macro multiplier approach (Ciaschini & Socci, 2007).

Therefore, the thesis is divided into three chapters. First, we analyze and compare the open classical Leontief model (1944), the Miyazawa model (Miyazawa & Masegi, 1963) (which endogenizes final consumption), and two versions of the Extended Multisectoral Model (Ciaschini & Socci, 2006) (which endogenizes the secondary distribution and investment). However, in this work, the SAM-based Miyazawa model makes a correction on the primary income allocation that differs from the original model version (without the SAM). In turn, the theoretical implications and the results of the analysis of the multipliers for the three models are analyzed using the Macro Multipliers approach (Ciaschini, 1993; Ciaschini & Socci, 2007).

The first chapter is divided into five sections, the first of which is the introduction. The second section presents the algebraic formalization and economic meaning of the three models already mentioned. The third section exposes the methodology of the Macro multipliers, the fourth section discusses the empirical results for the Mexican economy for 2018, and the last section provides final remarks.

The second chapter aims to measure the vulnerability of the Mexican economy to a blockage of its production system; one of the most recent events that have blocked the productive system (at least partially) in Mexico was the lockdown decreed by the Mexican federal government as an attempt to prevent the spread of the variants of the Coronavirus that triggered the COVID-19 pandemic between 2019-2020. The use of the Extended Multisectoral Model (EMM) (Ciaschini & Socci, 2006) with Inoperability (Ahmed, et al., 2022) (IEM), which follows the logic of a Social Accounting Matrix (Pyatt & Round, 1979), capturing the generation, allocation, distribution, and use of income, allows identifying the effects of the blocking process. Even more, the extended multisectoral model allows for overtaking some criticisms of the classical IIMs.

The second chapter has four sections, excluding the introduction. The first section provides a summary and general discussion of inoperability models, the reason why these models were chosen, and the variant (ex-ante approach). The second section describes the Mexican economy when the Covid-19 pandemic arrived in Mexico and the Mexican federal government enacted the lockdown. The third section describes the assumptions and results of the simulation; finally, the fourth section draws the final remarks of the chapter.

The third chapter analyzes the structural multipliers of income in the Mexico-US Bi-region. The analysis was performed using the Bi-regional Social Accounting Matrix Mexico-US with 63 products, 53 industries, and five institutional sectors for 2017. This SAM is used to implement an extended multisectoral model (EMM) (Ciaschini & Socci, 2006) model, which considers not only income generation but also income redistribution and use, treating them endogenously. The income multiplier analysis is performed with the Macro-Multiplier Approach (Ciaschini, 1993; Ciaschini & Socci, 2007).

The chapter has three sections, excluding the introduction. The first section summarizes the recent history and characterization of the bilateral trade between Mexico and the US. The second section is methodological, it describes the BSAM MEX-US, the use of the extended model for a Bi-region, and the results of the multiplier analysis. Finally, the last section is devoted to the final remarks.

Lastly, a section of final comments on the thesis and possible future lines of research is presented.

1. Real disaggregate multipliers in different approaches: the Mexican case

1.1 Introduction

The concept of the *multiplier* in economics is attributed to Keynes. Even if Khan (1931) had already elaborated the multiplier concept to relate the effects of investment on employment, the earlier chapters in the *General theory of employment interest and money* by Keynes (Keynes, 1936) marked the time when this concept started to have a significant influence in Economics.

However, the Keynesian formulation considers the multiplicative effect of investment on income, but it does not consider the industrial system's multiplicative effects on production processes. The above does not detract from the importance of the analysis of the multiplier effect; the analysis of the industrial system impacts started thanks to the development of the Input-Output model (Leontief, 1941; 1944). The interest in the multiplier effects of the industrial system began in the 1950s, when the theory of development economics became relevant, for example, in the structuralist schools (Prebisch & Cabañas, 1949; Prebisch, 1959), a school that Hirschman (1968) called *Prebisch manifesto*.

Hirschman (1958) introduces the concept of "linkages" to study and analyze the inter-industrial relations in the system to measure the degree of impact of productive investment. Rasmussen's power and sensitive dispersion indexes (1956) had been the most widely used technique applied to the Leontief inverse matrix, the structural matrix **R.** This is the first effort to create an index allow to rank industries by their multiplicative power; it means Rasmussen was the first who use the idea of linkages in a statistical sense (Socci, 2004). After that, Chenery and Watanabe (1958) evaluated the linkages and proposed a method to rank industries by their multiplier power using the Leontief technical coefficient matrix **A.** This idea of linkages is backed by the idea of the multiplier effects; however, it is applied to the matrix **R** and this matrix only considers the multipliers effects into the industrial system.

Thus, Goodwin (1949) endogenized the final consumption of households into the structural matrix but considered this institutional sector as another industry. Subsequently, Miyazawa & Masegi (1963) and Miyazawa (1968; 1970) proposed a model (we will call it the elongated model) which endogenized the primary allocation of income and the final consumption of institutional sectors into the structural matrix. This model was inspired by the Keynesian model (1936) and the Kaleckian-Kaldor income distribution theories (Kaldor, 1955; Kalecki, 1971). Thus, this model incorporated the multiplicative effects of the primary allocation of income and its use into the structural matrix.

However, the Miyazawa model does not consider the primary and secondary distribution of income or the possible endogenization of investment. The EMM (Ciaschini & Socci, 2006) incorporates these topics in the extended model; they endogenize the primary and secondary distribution of income and final demand and can endogenize investment by the institutional sector.

Thus, this paper aims to analyze and compare the multiplier effects of three different multisectoral models: the open classical Input-Output model by Leontief (1944); the Miyazawa model (1970), which endogenizes the primary allocation of income and final consumption; and the extended multisectoral model (Ciaschini & Socci, 2006), which also considers as endogenous the secondary income distribution and investment (optional choose)

To analyze the differences and implications of each model in terms of multiplicative effects, the Macro Multiplier approach (MM) (Ciaschini & Socci, 2007) is an alternative to the classical multiplier approach, which has the restrictive assumption that all exogenous demands increase equally. The MM approach applied to each model's inverse matrices allows isolating all feasible multipliers structures of a policy objective, for example, total output, and all latent structures of the policy control, such as the exogenous final demand, including the structures that maximize the total multiplicative effects. It means that the MM identifies the interactions between the policy objective, for example, total output, and the structure of control policies, without a uniform structure (Ahmed, et al., 2018) through Macro Multipliers (Ciaschini, et al., 2009). The above can help to suggest a structure of the exogenous final demand that stimulates the economy more than disposable income does, one of the main goals of economic policies and policymakers.

The empirical results are estimated for the Mexican economy using a Social Accounting Matrix for 2018 constructed using the information of the INEGI (2021). Thus, the chapter is divided into five sections; first, this introduction; second, a section to present the algebraic formalization and economic sense of the three models already mentioned; third, a section that exposes the methodology of the Macro multiplier; subsequently, a section with empirical results for the Mexican economy for 2018, and in the end, a section with final remarks.

1.2 The concept of multipliers and the multipliers as a matrix: Keynes, Leontief, Goodwin, and Miyazawa

The concept of the *multiplier* is attributed to Keynes, mainly. Indeed, even if Khan (1931) had already used the multiplier concept to relate the effects of investment on employment, the first chapters of the General theory of employment, interest, and money (Keynes, 1936) marked the start of its significant influence. This is because Keynes developed the multiplier concept by linking the effect of exogenous investment on income and final consumption.

However, when investment is endogenous, it is possible to incorporate a statical version of the concept of *the accelerator* of Keynesian inspiration, developed by Harrod (1936; 1939), who proposed a direct relation between aggregate income and savings. Higher-income implies higher demand for savings and, as a result, proves the relation between savings and investment. It means that when endogenizing investment, this ceases to be a mere instrument that increases income, as in Keynes, because it also increases the productive capacity (Domar, 1946). Also, the neoclassical growth theory uses the accelerator concept (Samuelson, 1939).

Since the 1940s, with the pioneer works of Leontief (1944), Goodwin (1949), and Hirschman (1958), the multisectoral analysis's development has increased as a helpful tool for the evaluation of the economic policy's multiplicative effects in addition to the effects of the intermediate input. The macroeconomic multisectoral models allow investigating of the structure of an economic system by considering the interdependence between industries and institutional sectors and assessing the impact of an economic policy at disaggregated levels, capturing the direct, indirect, and even the induced effects, unlike the aggregate macroeconomic models. For example, the inverse Leontief matrix captures the direct and indirect effects, including simple output multipliers. In contrast, when the household income is endogenous, the structural matrix of a multisectoral model also contains the induced effects.

Goodwin (1949) was the first to incorporate the induced effects in the multipliers, inspired by Keynesian theory. However, the author pointed out that one of the several restrictions in the Keynesian model is the aggregate level. Thus, the author, by using the inverse Leontief Matrix $(\mathbf{I}-\mathbf{A})^{-\mathbf{1}}$ in an open system (1944) by n industries, endogenizes household consumption as the $n+1$ "industry", where its input coefficients are the consumer budget proportions. Consequently, Goodwin's inverse matrix $(\mathbf{I}-\mathbf{A}_{\mathbf{G}})^{-\mathbf{1}}$ is of order $n+1$. Solow (2015) argues that in the Goodwin model, the analogy to the Khan-Keynes multiplier is evident because by endogenizing household consumption an aggregate national income multiplier can be calculated; it replicates Khan-Keynes[1]. In the same article, Solow (2015) states that it is "preferable" to treat consumption

[1] However, Solow (2015) questions and makes criticism about the assumption of Goodwin models.

separately from the industrial system, that is, from the Leontief matrix, but admits that the way Goodwin endogenizes it is not a crucial problem.

Miyazawa & Masegi (1963), and later Miyazawa (1968; 1970), also develop a multiplier as a matrix following Keynes (1936), concerning the use of the income multiplier and the Kaleckian-Kaldor (Kaldor, 1955; Kalecki, 1971), concerning functional income distribution multiplier. However, unlike Goodwin, they separated the Leontief multipliers from the income multipliers. The idea of Miyazawa (1970) can be expressed in aggregate terms by the following :

$$x = \frac{1}{1-a}\,\frac{1}{1-\alpha}\,\bar{f}, \qquad [\ 1]$$

where a is the coefficient of intermediate consumption by one gross-output unit x and $\bar{f}$ is the exogenous final demand. It means that gross output can be expressed in terms of the production multiplier $\frac{1}{1-a}$ and in terms of the Keynesian income multiplier $\frac{1}{1-\alpha}$. Miyazawa incorporates the functional income distribution as well as the propensity to consume of "laborers and capitalists" in equation 1; the income multiplier can be expressed by:

$$\frac{1}{1-\alpha} = \frac{1}{1-\left(\frac{c_l}{w}\frac{w}{y}+\frac{c_c}{p}\frac{p}{y}\right)} = \frac{1}{1-(c_w d_w + c_p d_p)} \qquad [2]$$

where c_l and c_c represent the final consumption of workers and capitalists, respectively; w and p represent wages and profits, respectively; c_w and c_p are the consumption propensities of workers and capitalists. Thus, equation 1 can be written as:

$$x = \frac{1}{1-a}\,\frac{1}{1-(c_w d_w + c_p d_p)}\;\bar{f} \qquad [\ 3]$$

Moreover, if v represents the share of value added to the gross output, $\frac{v}{y} = 1 - a$, and v_w and v_p represent the share of wages $\frac{w}{x}$ and profits $\frac{p}{x}$ on gross output, respectively, equation 3 can be defined as:

$$x = \frac{1}{1-a}\,\frac{1}{1-\alpha}\,\bar{f} = \frac{1}{1-a}\,\frac{1}{1-(c_w d_w + c_p d_p)}\bar{f} = \frac{1}{1-a}\,\frac{1}{1-\frac{(c_w v_w + c_p v_p)}{1-a}}\;\bar{f} \qquad [\ 4]$$

Thus, investment can accelerate or decelerate the production capacity of the generated income. Therefore, expressing a statical version of Harrod's(1939) accelerator[2] is possible. Given that investment k can be expressed as a function of income $k = \beta\, y,$ equation 4 can be redefined as:

$$y = \frac{1}{1-\alpha-\beta}(e-m) = \frac{1}{1-\alpha-\beta}\;\bar{f} = f, \qquad [\ 4.1]$$

which $\frac{1}{1-\alpha-\beta}$ can be read as the joint multiplier with the accelerator.

[2] Same Harrod (1939) make the difference between the "relation" in the static version and "the accelerator" in dynamic version, even if in our work we use the concept of accelerator. To depth look at Harrod's life, work, legacy and an interesting reinterpretation of him model see Pérez Caldentey (2019)

In matrix terms, the Miyazawa model starts with the open Leontief model:

$$\mathbf{x} = \mathbf{Ax} + \mathbf{f} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{f} = \mathbf{Rf} \qquad [5]$$

where $\mathbf{x}$ is the vector of gross output, $(\mathbf{I} - \mathbf{A})^{-1}$ represents the inverse Leontief matrix $\mathbf{R}$ that contains the simple production multipliers, and $\mathbf{f}$ is the vector of aggregate final demand. Thus, using the idea of income multiplier in the third definition of equation 4 (4.1), Miyazawa decomposes the vector of final demand $\mathbf{f}$ by:

$$\mathbf{f} = \mathbf{C_M}\mathbf{Vx} + \bar{\mathbf{f}} = \boldsymbol{y} \qquad [6]$$

where $\mathbf{C_M}$ is a matrix of order $[n \times r]$, where n is the number of industries or products, and r is the number of primary factors of production. This matrix represents the final consumption propensity coefficient by primary factor. $\mathbf{V}$ is a matrix of order $[r \times n]$, whose coefficients represent the constant share of *value added by each income group* concerning the gross output of each industry. Thus, by substituting equation 6 in 5, it is possible to obtain[3] the following:

$$\begin{aligned} \mathbf{x} &= \mathbf{Ax} + \mathbf{C_M}\mathbf{Vx} + \bar{\mathbf{f}} \\ \mathbf{x} &= (\mathbf{I} - \mathbf{A} - \mathbf{C_M}\mathbf{V})^{-1}\bar{\mathbf{f}} \end{aligned} \qquad [7]$$

However, this original Input-Output version of the Miyazawa model has an essential assumption: the number of primary factors is the same as consumption "classes." This assumption can imply that households only receive salaries as income that they use for final consumption. However households also receive gross operating surplus or even mixed income when allocating primary income.

Currently, according to the System of National Accounts (United Nations, 2008) and the Make and Use table framework, it is hard for a national statistical office to offer matrices of value added and final demand corresponding to the order of the Miyazawa Input-Output model. In general, the value-added matrix is reported with an order $[r \times n]$, where r is the number of components of value-added in the economy, for example, wages, salaries, direct taxes, etc., and n is as above. Final demand is expressed in one vector of order $[n \times 1]$,or, as a matrix $[n \times \mathrm{k}]$ in which k is the number of institutional sectors.

Consequently, the product $\mathbf{C_M V}$ in Miyazawa Input-Output model is not possible because the matrices are not conformable unless restrictive assumptions are used (Emonts-Holley, et al., 2021). Pyatt (2001) suggests adopting a version of this model based on a SAM framework. However, he exposes some critics we will enlist in the following subsection.

[3] It is important to point out that in the original model the exogenous aggregate final demand only takes into consideration investment, similarly to the Keynesian model for a closed economy.

1.3 Multipliers in the modified Miyazawa and the SAM framework for the extended multisectoral model

The above restriction of Miyazawa I-O model can also be solved if it is used and a Social Accounting Matrix approach - see the Stones' contributions (1954; 1961), Pyatt & Thorbecke (1976), and Pyatt & Round (1979) - as shown in Figure 1.

Figure 1.1 *Structure of the Social Accounting Matrix for Mexico 2018.*

	Commodities (1, ..., i)	Industries (1, ..., j)	Trade Margins (1, ..., i)	Primary Factors (1,...,r-1)	Taxes on products (1, ..., i)	Taxes on income (1,...,k)	Institutional Sectors (1,...,k)	Capital Formation	Rest of the World
Commodities (1, ..., i)		*Intermediate consumption* **B**					*Final consumption by institutional sectors* **F**	*Gross Investment* $\boldsymbol{k}$	*Exports* **e**
Industries (1, ..., j)	*Gross Output* **X**								
Trade Margins (1, ..., i)	*Vector of trade margins* **tm**								
Primary Factors (1,...,r-1)		*Value Added to basic prices* $\mathbf{VA}_{bp} = \mathbf{V}_{bp}\mathbf{x}$							
Taxes on products (1, ..., i)	*Vector of taxes on products* **tp**								
Taxes on income (1,...,k)							*Vector of paid taxes on income* **t.inc**		
Institutional Sectors (1,...,k)				*Primary income by institutional sector, including taxes on products* $\mathbf{P} = \mathbf{P}_{tot}\hat{\mathbf{p}}^{-1}$		*Revenues from taxes on income*	*Transfers from/to institutional sectors, without taxes on income* $\mathbf{T}_{int}$		*Transfers from the Rest of the World*
Capital Formation							*Vector of savings* **s**		*Current Balance*
Rest of the World	*Imports* **m**						*Transfers to the Rest of the World*		

Source: Own elaboration.

By transforming the Make and Use tables into a symmetric product-by-product Input-Output table, it is possible to obtain the aggregate final demand by institutional sector, which means a matrix of order $[n \times k]$ in which k is the number of institutional sectors, and n is the number of products. Nevertheless, with the SAM structure, it is possible to obtain the matrix for the primary allocation of income P of order $[k \times r]$, which considers the $r-1$ primary factors plus one category of taxes on products, resulting in the gross value added.

Thus, it is possible to obtain the matrix $\mathbf{P}$, which has dimension $[k \times r]$ and represents the constant share of each component of value added by the institutional sector. Finally, if the Matrix $\mathbf{F_c}$ of order $[n \times k]$ represents the final consumption propensity by the institutional sectors. Using the SAM framework and the theoretical ideas expressed in equations 5 to 7, the Miyazawa SAM model is defined by:

$$\begin{aligned} \mathbf{x} &= \mathbf{Ax} + \mathbf{F_c PVx} + \bar{\mathbf{f}} \\ &= (\mathbf{I} - \mathbf{A} - \mathbf{F_c PV})^{-1}\bar{\mathbf{f}} \\ &= \mathbf{M}\bar{\mathbf{f}} \end{aligned} \qquad [8]$$

Thus, the Miyazawa SAM model, equation 8, embraces Leontief's theory of the *circular flow of income* (1928), at least partly, unlike the classical open model (Leontief, 1944). This theory states that causal relationships link the individual elements of any economic system, consequently:

- Interactions between the *cost items* (*inputs*) and the *returns items* (*outputs*) create interdependence between the elements of an economic system.
- The interdependence between the production processes where the inputs are involved also generates income allocated between primary inputs.
- The income is used to consume or invest part of the outputs, and the diverse production processes must satisfy this final demand.
- Once the final demand is satisfied, the process returns to the "initial starting" points.

As a result, the theory of the circular flow of income allows an understanding of the step-by-step ***reproduction*** of an economic system (Leontief, 1991). The SAM is constructed under the circular flow of income by adding the distribution and redistribution stages. However, as said above, the open Leontief model does not capture *the circular flow of income* because the final demand is entirely exogenous. Thus, an exogenous shock on this model enters the production process to stimulate the interindustry system, but the income generation and use do not return to the starting point of stimulus; it means the aggregate final demand.

The modified Miyazawa model incorporates *the circular flow of income* by considering the *functional income distribution*, its allocation, and its partial endogenous use. However, the functional income distribution is not irrelevant. For example, Atkinson (2016) draws attention to the reasons why the functional distribution of income should be studied; also, Onaran and Obst (2016) warn about the consequences of high inequality that begins with the contraction of wages and salaries in national income, which creates significant barriers to growth.

However, Pyatt (2001) argues that the Miyazawa model (1976) precludes transfers between institutional sectors; it does not consider the secondary distribution process of income. The Miyazawa model recipients of wage income cannot receive interests and dividends, which suggests a Ricardian world of rentiers who own everything, and tenants, who work for a living wage that prevents them from saving. This assumption is very restrictive in empirical terms. For these reasons, Pyatt (2001) argues that the Miyazawa model cannot be considered a general model of the income distribution among institutional sectors, and, in any case, it must be considered as a subset of the multipliers by Pyatt and Round (1979). However, the decomposition of the Pyatt and Round multipliers cannot be expressed in a synthetic matrix.

The effects of the primary and secondary income distribution on income are negligible. These processes transform primary income into disposable income, which is susceptible to being used or saved. Moreover, income distribution entails transfers between institutional sectors, and the fiscal policy, particularly the taxation system, is an instrument to change the income distribution determined by the functional income distribution and the institutional framework (Lustig, 2017; 2020).

Thus, it is crucial to capture how the taxes and transfer structure changes the distribution between primary and disposable income, not only for theoretical and modeling aims. Since the 1970s, the functional income distribution has had a regressive process; for example, in the case of developed countries, the share of workers' income in the National Income dropped from 55 percentage points to 39.5 percentage points between 1970 and 2014; in the case of an emerging market or developing countries, the share was over 50 percentage points (Karabarbounis & Neiman, 2014). Therefore, it becomes relevant to ***synthetically*** capture the effects of the tax and transfer structure on income distribution and the link between the latter and its uses or savings.

Ciaschini and Socci (2006; 2007) follow and extend the Miyazawa (1970) approach using the SAM framework shown in Figure 1. This Extended Multisectoral Model (EMM) traces the circular flow of income, where it is possible in the demand-drive version, to take as a "starting point" the gross value added by commodity $\mathbf{v^c}$ in the following form, when it is possible to obtain the primary distribution of income by institutional sectors:

$$\mathbf{v_{is}} = \mathbf{P\,V\,x} \qquad [9]$$

where $\mathbf{P}$ is as above and has dimension $[k \times r]$; k is the number of institutional sectors, and r is as above. Thus, p_{ij} represents the constant share of value added by the

$j - th$ income factor attributed to the $i - th$ institutional sector. In turn, where $\mathbf{V}$ is a matrix of order $[r \times n]$, where its coefficients represent the constant share of gross value added of each primary factor relative to gross output for each industry.

Up to equation 9, the EMM model follows Miyazawa's ideas. In addition, the EMM incorporates the secondary distribution of income, that is, the processes that describe the taxes and transfer structure that converts primary income into disposable income by institutional sector, including the respective distribution, and it is defined as:

$$\mathbf{y} = (\mathbf{I} + \mathbf{T})\, \mathbf{v}^{si} = (\mathbf{I} + \mathbf{T})\mathbf{P}\,\mathbf{V}\,\mathbf{x} \qquad [10]$$

where $\mathbf{T}$ is a matrix of dimension $[k \times k]$ that contains net taxes, including taxes on income, and constant shares of transfers that each institutional sector receives from the remaining institutional sectors, and $\mathbf{I}$ is the identity matrix.

Let us consider the $\mathbf{F^0}$ matrix of dimensions $[n \times k]$, whose elements are the share of consumption expenditure for each produced commodity relative to the disposable income of each institutional sector. Moreover, let $\mathbf{C}$ the diagonal matrix of dimensions $[k \times k]$ with the consumption propensity by institutional sector. So, the endogenous final demand for consumption can be written as:

$$\mathbf{F}_{\tilde{c}} = \mathbf{F^0 y} = \mathbf{F^1 C\, y}, \qquad [11]$$

where $\mathbf{F^1}$ is a matrix of dimension $[n \times k]$, which represents the share of final demand for each commodity relative to the disposable income of each institutional sector. Differently from the Miyazawa SAM model, in the case of the extended model, it is also possible to endogenize investment; it implies that the extended model not only takes into consideration the multiplier of income inspired by Khan (1931) and the Keynesian theory (1936) - see equation 7. It also captures the effect of the static accelerator in Harrod's version, in equation 4.1, when the gross capital formation is endogenized.

Let $\mathbf{K^1}$ the matrix of dimension $[n \times k]$, whose elements represent the demand or investment by each institutional sector to each industry as a share of investment expenditure of each institutional sector. Moreover, we find the scalar $\dot{s}$, which represents the parameter of *active saving* and the ratio between gross fixed capital formation and national saving. The scalar can take three values: if $\dot{s} < 1$, the economy is a net lender to the Rest of the World; while, if $\dot{s} > 1$, the economy is a net borrower; finally, if $\dot{s} = 1$, national saving equals gross capital formation. However, this last case can only occur in a closed economy[4]. So, we can express the account of *capital formation* in the following way:

[4] This is not the case of this article, but for a summary about the importance of the current balance see Corden (1993; 2007). For the implications between the "Keynesian" approach and the "Johnsonian" of the balance of payments see Polak & Plessner (2002), and Thirwall (2001).For the debates on the implications of chronic deficits see Shaikh (2016).

$$\mathbf{K} = \mathbf{K^1}\acute{s}(\mathbf{I} - \mathbf{C}) \quad [12]$$

At this point, the endogenous final demand is given by $\mathbf{F} = \mathbf{F}_{\tilde{C}} + \mathbf{K}$. If the investment is exogenous as in the elongated model (Miyazawa and SAM model), thus $\mathbf{F} = \mathbf{F}_{\tilde{C}}$. Therefore, it is possible to conform the vector of final demand as follows:

$$\mathbf{f} = \mathbf{Fy} + \bar{\mathbf{f}} \quad [13]$$

where $\bar{\mathbf{f}}$ represents exogenous demand. The complete equation becomes:

$$\mathbf{f} = \mathbf{F}(\mathbf{I} + \mathbf{T})\mathbf{P}\,\mathbf{V}\,\mathbf{x} + \bar{\mathbf{f}}. \quad [14]$$

Retaking equation 5 and substituting 14 into it, gross output is defined in the extended model as:

$$\mathbf{x} = [\mathbf{I} - \mathbf{A} - \mathbf{F}(\mathbf{I} + \mathbf{T})\,\mathbf{P}\,\mathbf{V}\,]^{-1}\,\bar{\mathbf{f}} = \widehat{\mathbf{R}}\bar{\mathbf{f}} = \mathbf{x} > \mathbf{0} \quad [15]$$

where $\widehat{\mathbf{R}}$ is the structural matrix of the system, or the matrix of extended multipliers, which overtakes the functional income distribution and consumption as the Miyazawa (1970) model, under the concept of the Keynesian multiplier generalized in a Kalecki-Kaldor approach (Kaldor, 1955; Kalecki, 1971) but, it adds the distribution income process. It considers the transformation of primary income into disposable income. Even more, the Ciaschini and Socci (2006; 2007) model has the advantage of choosing the account of aggregate final demand that will be endogenized without losing the structure of the circular flow of income. The equation result of equation 15 shows that $\mathbf{x} > \mathbf{0}$. It means at least the structural matrix $\widehat{\mathbf{R}}$ is nonnegative; the determinant of the structural matrix $|\widehat{\mathbf{R}}|$ is positive.

Table 1 summarizes the characteristics of the three diverse open models: short, elongated, and extended. It is possible to observe that the Ciaschini and Socci model has advantages in the level of detail of the income use, which means they also lead to the determination of the disposable income of each institutional sector; their model allows endogenizing the investment and takes into consideration savings by each institutional sector and the borrower or lender status of the economy concerning the Rest of the World.

Table 1.1 Characteristics of the multisectoral models.

	Model		
	Leontief (1944)	**Miyazawa SAM (1968,1976)**	**Extended Multisectoral Model (2004,2006)**
Interdependence	✓	✓	✓
Technological function production	Fixed coefficients	Fixed coefficients	Fixed coefficients
Use of income	✓	✓	✓
By type of use (Consumption or accumulation)	✓	✓	✓
By institutional sector	✓	✓	✓
Income distribution		✓	✓
Primary allocation		✓	✓
Secondary distribution			✓
Disposable Income			✓
Aggregated			✓
By institutional sectors			✓
Aggregated Final Demand			
Consumption	Exogenous	Endogenous	Endogenous
Gross Investment	Exogenous	Exogenous	Could be Endogenous
Concept of circular flow	Implicit	Semi-explicit	Explicit
Causality	Implicit	Semi-explicit	Explicit
The structural inverse matrix	$\mathbf{R}$	$\mathbf{M}$	$\hat{\mathbf{R}}$
Incorporated :		✓	✓
1) Matrix Leontief multipliers	✓	✓	✓
2) Matrix of income multipliers		✓	✓ With a statical "*accelerator*," when the investment is endogenous, inspired by Harrod's ideas (1936,1939)

Source: Own elaboration.

1.4 The Singular Value Decomposition on the structural matrices' multipliers

The classical approach of multiplier Input-Output analysis (Chenery & Watanabe, 1958; Rasmussen, 1956) uses the sum of columns of structural matrices to analyze the multiplier effects in the multisectoral models. In this case, the analysis assumes that the exogenous final demand in each sector or product grows uniformly. However, neither the demand vector nor its changes will ever assume a structure of this type. Therefore, some authors conclude that multipliers should never be used (Skolka, 1986).

As a result, Ciaschini (1993) and Ciaschini and Socci (2007) suggest an alternative method to evaluate the multiplier effects in a structural matrix. This approach is called the Macro-Multipliers (MM) and uses the Singular Value Decomposition (SVD) (Lancaster & Tismenetsky, 1985) that can be applied to positive or semi-positive definite matrices, as are the structural matrices $\mathbf{R},\mathbf{M},$ or $\widehat{\mathbf{R}}$, which are nonnegative matrices[5]. It is possible to follow the propagation of induced effects from final demand to gross output or income. For example, the structural matrix $\mathbf{R}$ has a square matrix $\mathbf{W}$ defined by:

$$\mathbf{W} = \mathbf{R}'\mathbf{R} \qquad [16]$$

Where $\mathbf{W}$ has a positive definite or semidefinite square root $\mathbf{W}^{\frac{1}{2}}$**,** it implies that its eigenvalues are real and nonnegative (Lancaster & Tismenetsky, 1985). Simultaneously, the eigenvalues of $\mathbf{W}$ and $\mathbf{W}'$ coincide (Ciaschini & Socci, 2007)**.** Therefore, it is possible to decompose a structural matrix as the matrix $\mathbf{R}$ by

$$\mathbf{R} = \mathbf{USV}' \qquad [17]$$

where $\mathbf{U} \in \mathbb{R}$ and $\mathbf{V} \in \mathbb{R}$ are orthogonal matrices**;** $\mathbf{U}$ contains the left singular vectors, which are the eigenvectors of the matrix $\mathbf{R}'\mathbf{R}$ **;** $\mathbf{V}$ contains the right singular vectors, the eigenvectors of matrix $\mathbf{W}$ (Biswa-Nath, 2004).

The matrix $\mathbf{S} \in \mathbb{R}$ has essential properties. It is a diagonal matrix with nonnegative diagonal entries in decreasing order. These elements are called singular values $\{s_j | \, j = 1, \dots, n \rightarrow s_i > 0\}$ of $\mathbf{R}$**,** and they are the square roots of the eigenvalues of matrix $\mathbf{W}$**.** At the same time, these singular values coincide with the $\mathbf{R}'$ (Stone, 1947). By using the Perron-Frobenius theorem or the Frobenius version of the Perron Theorem, it is possible to state that the highest eigenvalue of the matrix $\mathbf{W}^{\frac{1}{2}}$, it means, the singular value s_1 of $\mathbf{R}$**,** associates with a right and a left eigenvector whose elements have

[5] However, the SVD is not exclusive to the square nonnegative matrices. Stewart (1993) makes a summary on the developing on this topic to the real matrices and the contributions of Beltrami (1873), Jordan in 1874, Sylvester in 1889 and Schmidt 1889. The SVD can be applied also to the Hermitian matrices and the non-Hermitian matrices (Eckart & Young, 1939) .

concordant signs (Hawkins, 2008; Nikaido, 1960). Therefore, $\mathbf{S} = \{\mathbf{s}_j\}$ contains the n elements.

In economic terms, for the case of matrices $\mathbf{R}, \mathbf{M}$, or $\widehat{\mathbf{R}}$, the respective matrix $\mathbf{V}'$ indicates the n reference structures for final demand - the policy control- and $\mathbf{U}$ indicates the n reference structures of the gross output- the policy objective-, and it implies that the elements of the respective matrix $\mathbf{S}$ include the ***macro multipliers of gross output***.

Therefore, using the j^{th} columns of matrices $\mathbf{S}$ and $\mathbf{U}$ and the i^{th} rows of matrix $\mathbf{V}'$ in equation 17, $\mathbf{R}$ can be defined as:

$$\mathbf{R} = \sum_{i,j=1}^{n} \mathrm{s}_j \, \mathbf{u}_j \mathbf{v}_i' \,, \tag{18}$$

By taking the vectors and the scalar of equation 2.2 when $\boldsymbol{i}, \boldsymbol{j} = \mathbf{1}$, the first structure of the SVD is defined as:

$$\mathbf{R_1} = \mathrm{s}_1 \mathbf{u_1} \mathbf{v}_1' \,, \tag{19}$$

where $\mathbf{v}_1'$ and $\mathbf{u_1}$ represent the structure of the policy control (final demand) and the structure of the policy objective (gross output) that are most sensitive to the respective macro multiplier s_1 (Socci, 2004). The matrix $\mathbf{R_1}$ is the first structural matrix of the Mexican economy. In the case of equation 19, when a unit of final exogenous demand takes the structure $\mathbf{v}_1'$, the ratio between the Euclidian module of the resultant vector of gross output $\|\mathbf{x_1}\|$ and the vector of the input variable $\|\mathrm{v}_1\|$, of structure $\mathbf{R_1}$, is equal to s_1. But the observed exogenous final demand vector f^* may take the structure of v_1', resulting in a new vector $\bar{\mathrm{f}}_1$: it means that final demand is expressed in terms of the structures suggested by $\mathbf{v}_1'$. On the other side, the ratio between the Euclidian module of the resultant policy objective $\|\mathbf{x_1}\|$ and the Euclidian module of the policy control $\|\bar{\mathbf{f}}_1\|$ is the same, it means it equals s_1.

However, how many structures are adequate to evaluate the multipliers effects under the MM approach? Following Basilevsky (1983), Socci (2004) states that the macro multipliers can be read as the percentage of the degree of the association explained from the representation made through the relative eigenvectors. In summary, the MM approach allows for identifying the interactions between a policy objective, for example, *total output*, and the structure of the policy measure or *policy control* (Ahmed, et al., 2018), for example, final demand, through Macro Multipliers (Ciaschini, et al., 2009).

1.5 Results

The empirical analysis of this work consists of constructing a Social Accounting Matrix for Mexico for 2018 following the structure of Table 1, with 76 industries, 18 primary factors (labor divided by age and skills), and 22 institutional sectors. The SAM was constructed, taking the Social Accounting Matrix by accounts published by INEGI (2021) and the Institutional Accounts. This SAM allowed calculating the inverse structural matrices ($\mathbf{R}, \mathbf{M}$ and, $\widehat{\mathbf{R}}$) for the four models: the Leontief Input-Output model, the

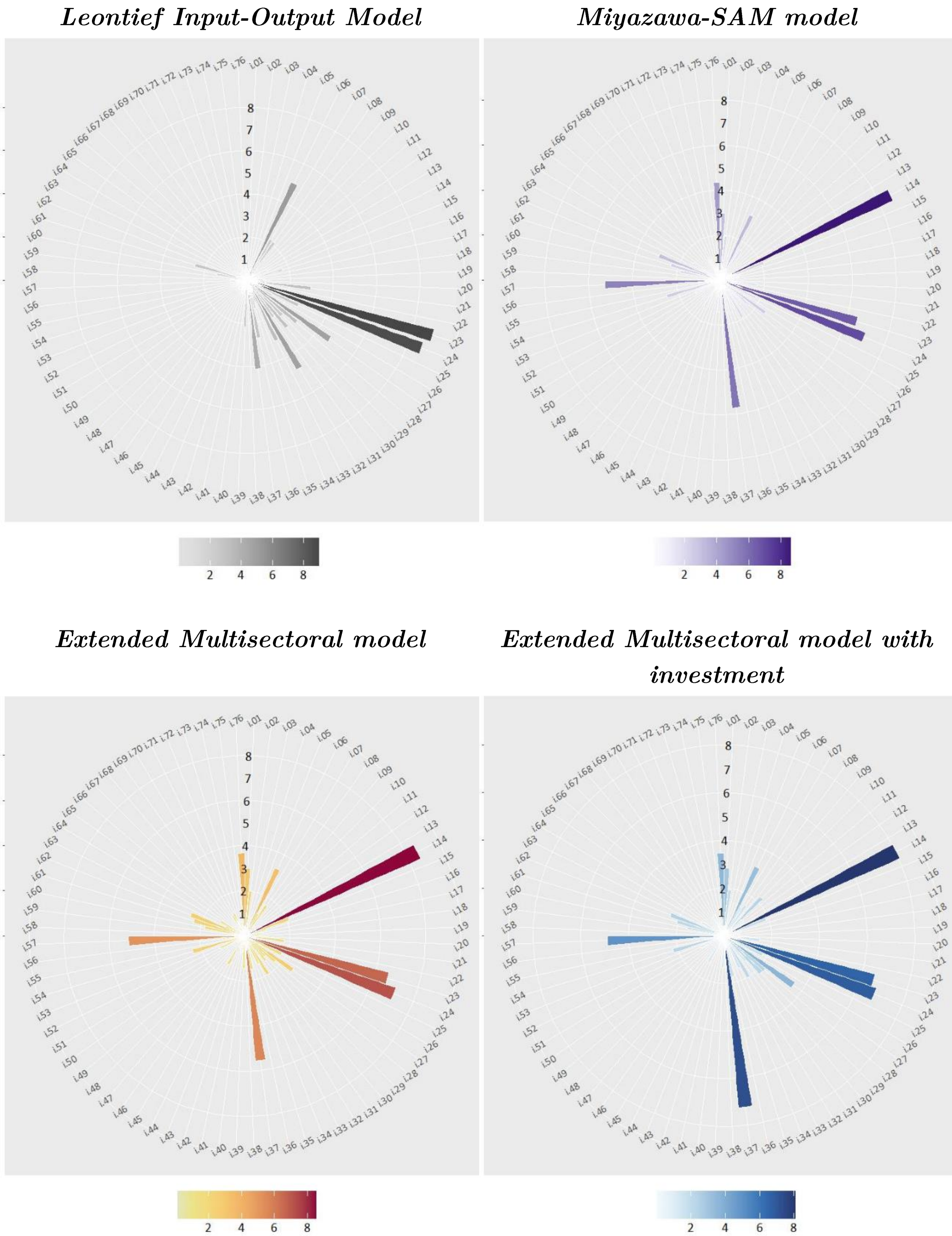
Miyazawa SAM model, which endogenizes the primary income allocation and final consumption, and the two versions of the Extended Multisectoral model. The first EMM, which only has the endogenous final consumption (which represents 35% of the Mexican gross output), is endogenous, and the second, which endogenizes final consumption and investment (which represent 15% of Mexican gross output).

The models were programmed using the free software R, and the SVD for each model was programmed using the library Linear Algebra Package (Anderson, et al., 1999). In addition, the Macro multiplier approach was used to compare the multiplicative effects of a policy control on a policy objective for each model. In this case, the structure that maximizes total output, the policy objective, associates with the policy control on the final exogenous demand, the first structure suggested by the MM approach for each model.

Figure 1.2 shows the share by industry in the policy objective, which is associated with the first structure of the MM approach for the respective model. Again, the share is expressed in percentage points. The structure of the multiplicative effects of the SAM-based models (Miyazawa and the Extended Multisectoral models), and the policy objective, have a qualitative similarity. Miyazawa and the Extended Multisectoral models rectify the multiplicative effects regarding the Leontief Input-Output model. Either by endogenizing income generation and final consumption or; by endogenizing the disposable income and the total or partial domestic final demand, respectively.

In the Leontief Input-Output model, six industries stand out with a share above four percentage points*: i.6 Petroleum and gas extraction (4.99%), i.23 Manufacture of petroleum and coal products (8.95%), i.24. Chemical industry (8.66%) i.27 Basic metal industry (4.69%) i.32 Manufacturing of audio and video (4.13%), and i.37 Manufacturing of transport equipment (4.13*). These six industries represent 36.19% of the total multiplicative effect of the policy objective, $\mathbf{x_1}$. With the Leontief Input-Output model, the industries with the highest multiplicative effects are associated with one extractive industry and five manufacturing industries, which record high demand for intermediate inputs. The name of all industries are in Table AII-1 in Appendix I

Figure 1.2 *Share by industry of the multiplicative effects associated with the policy objective for each model.*



Source: Own elaboration based on the results of the models and the MM approach.

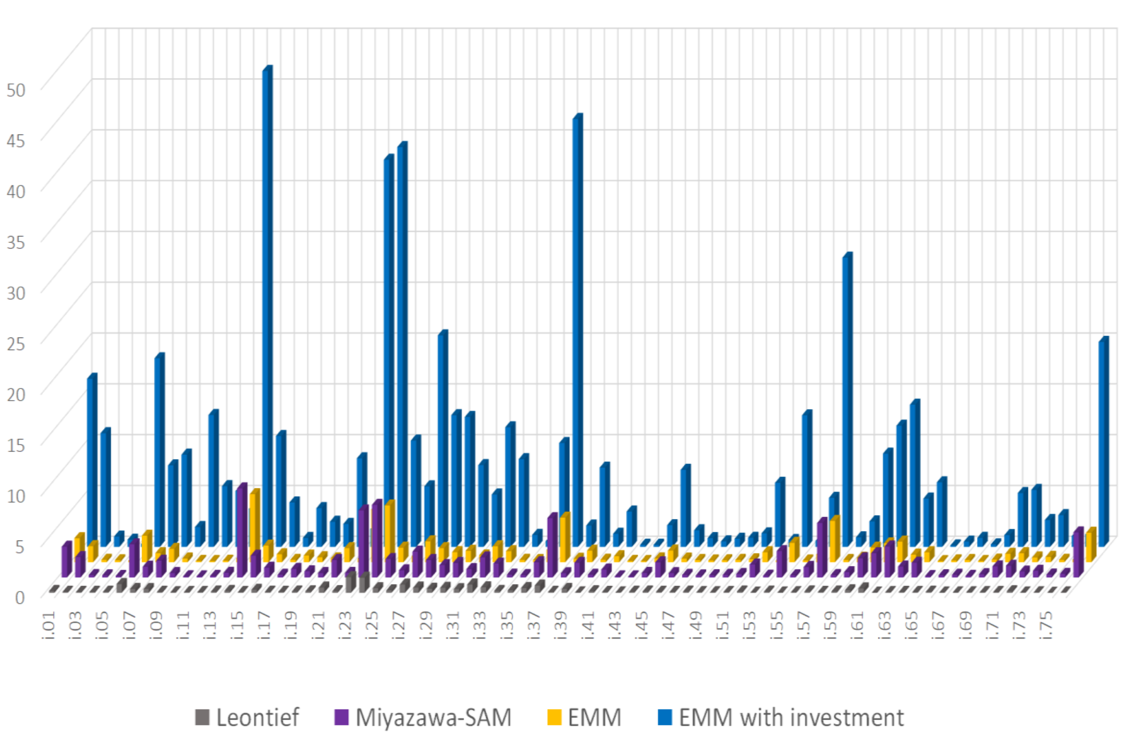
On the other hand, in the Miyazawa-SAM model, there are six industries with a share above four percentage points, but not all of them are the same as in the Leontief model. These industries are *i.14. Food industries (8.6%), i.23 Manufacturing of* *petroleum and coal products (6.47%), i.24. Chemical industries (7.01%), i.37 Manufacturing of transport equipment (5.72%), i.57 Real Estate Services (5.26%), and i.76. Legislative, governmental, and law enforcement activities (4.35%).* These six industries represent 37.32% of the total multiplicative effect of the policy objective $\mathbf{x_1}$ associated with this model. In the case of the EMM, which endogenizes for the use of disposable income, final consumption only, the industries with a share above four percentage points are five: *i.14. Food industries (8.49%), i.23 Manufacturing of petroleum and coal products (6.57%), i.24. Chemical industries (7.07%), i.37 Manufacturing of transport equipment (5.56%), and i.57 Real Estate Services (5.14%).* These five industries represent 32.84% of the total multiplicative effect of the policy objective $\mathbf{x_1}$ associated with this model.

It is not surprising that the Miyazawa-SAM model and the EMM (with endogenous final consumption) have qualitatively similar structures. The version of the Miyazawa model used in this paper is based on a SAM, implying that the entire phenomenon of primary income allocation is observable, i.e., the gross operating surplus allocated to households. Regarding the gross operating surplus as an example, in a Miyazawa model based on an Input-Output table, one must either assume that no gross operating surplus is allocated to households or make adjustments to estimate how much of it would be allocated among them. However, the extended multi-industry model smooths the participation of the sectors with the highest multiplicative effects concerning the Miyazawa model, redistributing this participation to other industries, which is explained by the income redistribution processes among the institutional sectors that transform primary income into disposable income, which changes the proposals to be consumed by the various institutional sectors.

Finally, in the case of the EMM, which endogenizes investment, the structure is similar to its other version. Indeed, the industries with a share above four percentage points are five: *i.14. Food industries (8.04%), i.23 Manufacturing of petroleum and coal products (6.54%), i.24. Chemical industries (6.75%), i.37 Manufacturing of transport equipment (7.23%), and i.57 Real Estate Services(5.26%).* These five industries represent 33.46% of the total multiplicative effect of the policy objective $\mathbf{x_1}$ associated with this model.

Given that the structures of the SAM-based models are qualitatively similar, it is worth pointing out the differences between them. These differences are the dimension of the policy objective in each model and the policy control structure in each model. Figure 1.3 shows the dimension of the multiplicative effect associated with each policy objective $\mathbf{x_1}$.

Figure 1.3 *Multiplicative effects associated with the policy objective by model.*



Source: Own elaboration based on the results of the models and the MM approach.

As expected, it is possible to observe that the multiplicative effects of the Leontief Input-Output model are the lowest. In the case of the models that endogenize final consumption, the Miyazawa-SAM model and the EMM, it can be seen that the dimensions of the policy objective are similar. Therefore, the effect of the redistributive processes that the EMM endogenizes can be appreciated; for the case of Mexico, these processes reduce the dimension of the policy objective concerning the Miyazawa model, that is, when disposable income is taken into account and not primary income, the dimension of the maximum policy objective is smaller in the case of the EMM concerning the Miyazawa-SAM model. The above means that if redistribution is not considered, the multiplicative effects could be underestimated or overestimated, this depends if the redistribution process increases or decreases the disposable income of the institutional sectors.

However, in the second version of the EMM, where investment is endogenous, it is possible to observe a significant difference in the dimension of multipliers of the objective policies. Although the three models are qualitatively similar in their structure, the multiplicative effects on the policy objective are considerably more significant for each industry in the EMM with endogenous investment. The above is because the investment can "*accelerate*" or reinforce the multiplicative effects, as was suggested in sections one (equation 4.1) and two; it means the investment activates the productive process and generates income, which can be redistributed and used, reinforcing the multiplicative process.

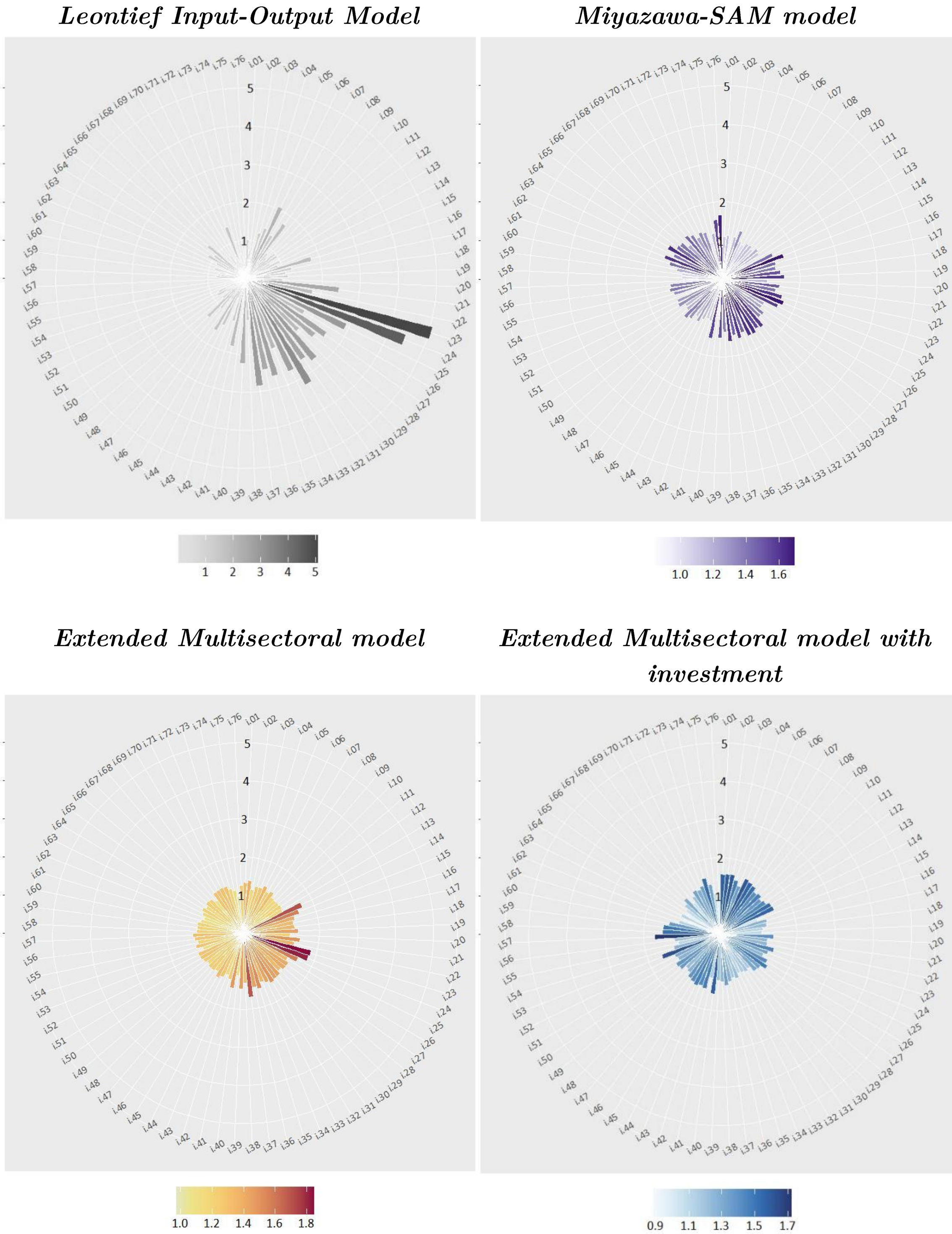
Thus, when investment is endogenized, the multiplicative effects are reinforced and reshaped (see Figures 1.2 and 1.3) compared to models that only endogenize consumption.

As mentioned, the policy objective for this case study is the maximization of production, which is obtained by analyzing the first structure suggested by the MM approach. It yields the interactions between the policy objective, *total output*, and the structure of the *policy control*, the exogenous final demand, through Macro Multipliers. The policy control structures associated with the policy objective analyzed above are represented in Figure 1.4.

Figure 1.4 shows that the structures of policy controls are less similar to each other than the policy objective structures. However, they are more homogeneous if compared among them without being uniform, as the Macro Multiplier approach suggests. As in the case of policy objectives, the policy control of the Leontief Input-Output model suggests stimulating manufacturing activities, and its structure is less homogeneous than in the SAM-based models. It can be observed that the structures of the SAM-based models have more homogeneous distributions than the structures of their respective policy objectives. However, each model stimulates each industry differently, i.e., the policy control structures are not as similar as in the case of the similarity between the structures of the target policies. Even between the two versions of the EMM, the policy control structures change, comparing industry by industry, but the structures have a more homogeneous distribution. Although they create quantitatively different rankings, the difference between the industry with the highest participation and the one with the lowest participation in achieving the target of total output is no more than one percentage point in each industry for each model, excluding the Input-Output Leontief model.

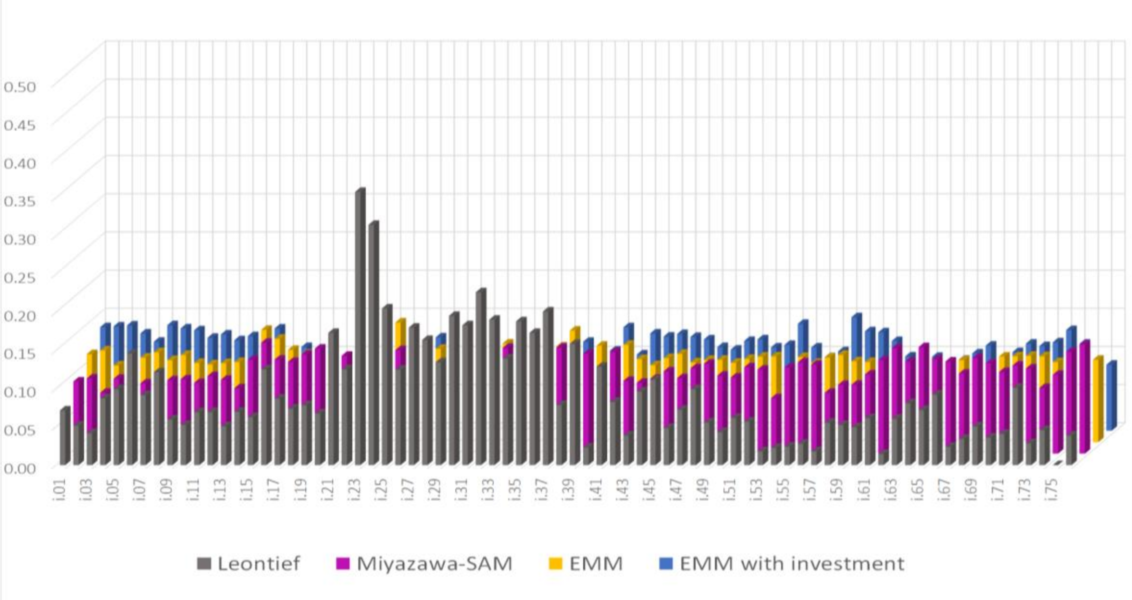
Finally, comparing the amounts of the policy controls in Figure 1.5, It is possible to observe that they are not so different from each other, neither in the total Amount nor each industry amount; at least they are not as large as between the amounts of the policy objectives (see Figure 3). The above means that similar policy control amounts can produce policy targets of substantially different amounts, mainly when endogenizing investment in the structural inverse matrix to analyze, i.e., in the EMM with endogenous investment. This difference is captured by the Macro Multiplier approach, which allows us to observe that despite the four policy controls having a similar amount, they can create considerably different multiplicative effects since each structure is associated with a different Macro Multiplier and policy control structure, subject to the assumptions of the model.

Figure 1.4 *Share by industry of the multiplicative effects associated with the policy control f1 in percentage points.*



Source: Own elaboration based on the results of models and the MM approach.

Figure 1.5 *Amount of policy control, f1, by model.*



Source: Own elaboration based on the results of models and the MM approach.

1.6 Final Remarks

Considering the theoretical and empirical sections presented above, it is possible to suggest some advantages that the multisectoral models based on a SAM (Miyazawa-SAM and the EMM) have compared to the Input-Output models (Leontief and Miyazawa Input-Output models). First, the SAM-based models allow endogenizing the primary income and its allocation without restrictions on the allocation of gross operating surplus since using the SAM framework tracks how it is allocated, even to households.

The endogenization of primary income and its use modulate the multiplicative effects in the Leontief Input-Output model. In the Mexican economy, by using the Macro Multiplier approach, it is possible to observe that the Leontief Input-Output model suggests a significant stimulus on the manufacturing industries in comparison to the Miyazawa-SAM and the Extended Multisectoral Model (which only endogenizes final consumption), which suggest a significant stimulus on a policy control on industries associated with final consumption. However, in the Extended multisectoral model, the multipliers are modulated by income redistribution, with multiplicative effects close to the Miyazawa model. Although smaller, in our case, while one works with disposable income, the other works with primary income, i.e., depending on the redistributive process of a society. Thus, the Miyazawa model could overestimate or underestimate the multiplicative effects.

Moreover, not only do these models modulate the structure of the policy control but also the size of the multiplicative effects is more significant than the classical Leontief model. Moreover, the Miyazawa-SAM and the Extended multisectoral models allow endogenized final consumption, representing 35% of the Mexican Gross Output for the Mexican case. Given the circular flow of income, capturing the induced effects associated with primary income and final consumption is possible.

When the analysis is incorporated, the Multisectoral Extended model with endogenous investment, although the control structure is not substantially different from the Miyazawa-SAM model and the first version of the EMM, shows substantially more significant multiplicative effects. It suggests that the impulse or "acceleration" that the investment gives to the multipliers can be appreciated in this model. Furthermore, investment activates the productive process and generates income, which can be redistributed and used, reinforcing the multiplicative process. Thus, when investment is endogenous, the multiplicative effects are reinforced and reshaped relative to models that only endogenize consumption.

The results described above are not surprising since they are expected and consistent with the theoretical framework. However, when comparing the amounts of the control policies suggested for each model, these are similar among the three models, although with different structures. Instead, the results of their multiplier effects associated with the policy objective, in our case, the maximization of production, are substantially different.

Policies of similar amounts retrieve substantially different results in the multiplier effects when the assumptions change, the Leontief model being the model with the lowest multipliers, followed by the EMM (which only endogenizes consumption), the Miyazawa model, and, in the end, with a substantial difference in the multiplier effects, the EMM with endogenized investment. This last phenomenon is not trivial: for a policymaker, the multiplicative effects of control policies are not trivial because it faces budget restrictions. Therefore, choosing a model that captures the total multiplier effect is preferable, especially if these allow capturing the effects by industry and institutional sector, which is possible with a SAM framework. The above does not mean that Input-Output models should be discarded since the unavailability of information often limits the possibility of working on a SAM framework. However, the possible under or overestimates that the Input-Output models may incur must be considered, as well as the effects that are ignoring the income redistribution could have in analyzing the multipliers. Even more so, if it is considered that the redistribution of income is a phenomenon of institutional agreement, it is formed exogenously to the production process and can be captured more clearly in a SAM. The limits that we consider can be overcome by using the EMM which endogenizes the generation, allocation, redistribution, and use of income (including investment and the boost it gives to multipliers).

2. The multiplicative effects of production disruption: the case of Covid-19 on Mexican income groups

2.1 Introduction

Spillover effects, which are the indirect and induced effects of positive (or negative) shocks in an economic system, have always been within the main aims of the analysis of multisectoral models. For example, the original Leontief's open model (1944) and its application (Leontief, 1946) analyzed the effects of export variations on employment and output in the USA during the war period. The advantage of his model lies in its taking into account the interdependence and the use of income within an economic system, capturing the indirect or spillover effects. However, spillovers can also be harmful; in fact, Bollard (2019) argues that the US Office of Strategic Service used the Leontief Input-Output model to choose German targets to attack during the Second World War. Leontief himself suggested this in an interview with Foley.

Thus, the interest in measuring the negative economic spillovers of a shock in an economic system is not new. The causes of a production process's disruption of an economy, and therefore in the generation, distribution, and use of income, may be natural, such as earthquakes. Conversely, the causes may depend on human activities like military conflicts, which impact the installed capacity of an economy; trade wars, which create supply shocks in production chains; or pandemic events such as Covid-19, where a considerable number of countries imposed a lockdown to prevent the spread of the virus.

During the first two decades of the twentieth century, the interest in measuring the indirect effects of adverse shocks through multisectoral models increased, with two techniques standing out in particular: first, estimates based on the Hypothetical Extraction Method (HEM) (Paelinck, et al., 1965; Strassert, 1968; Schultz, 1977); and the second, based on the so-called "inoperability models" (Haimes & Jiang, 2001; Santos & Haimes, 2004).

The HEM assumes the disappearance of an industry or product's flows in a production system and recalculates the difference between the output with this extraction and the before-extraction observed output. Several extensions and applications to this technique have been developed recently. First, Dietzenbacher et al. (1993) apply to multiregional Input-Output matrices (MRIO), an extension of the method proposed by Strassert. Subsequently, Dietzenbacher & Lahr (2013) compare the effects of the so-called generalized extraction (Schultz, 1977; Strassert, 1968) with partial extraction, i.e., when the extraction does not involve total transactions of an industry or product in the productive system but only a percentage of these. The HEM and its extensions have been used to assess the potential effects of economic disruptions such as Brexit (Los, et al., 2016; Chen, et al., 2018). Finally, Dietzenbacher et al. (2019) proposed a variant of the generalized extraction with relocation for the global automotive industry, i.e., some countries block their exports to other countries, but in this case, those exports are reallocated to other countries. Finally, a variant of the HEM can be found in Bolea et al. (2021), who use it to model a potential "non-integration" of Eastern European countries into the production chains of the continent. These two last works assume that there is substitutability among the suppliers of inputs or final goods.

Second, the so-called Input-Output models of inoperability (IIM) (Haimes & Jiang, 2001; Santos & Haimes, 2004) are based on the open Leontief Input-Output model under algebraic transformations. These models incorporate a vector of *inoperability*, defined as unrealized production caused by a shock in the production system, i.e., the expected production level minus the actual production level divided by the expected production level. These shocks are of different kinds. They can be natural, like an earthquake, or social, like a terrorist attack or a war. Haimes & Jiang (2001) call this quantity a measure of probability and degree (percentage) of the inoperability of a system. Although these models have not been free of criticism, they have been one of the most accepted in risk analysis in the last thirty years. Moreover, the variation of the structural Input-Output matrix they use is one of the most accepted in fields such as business economics (De Mesnard, 2001), although deemed as controversial in the Input-Output field, i.e., a matrix of elasticities (Auray, et al., 1979; Dietzenbacher, 1997) or allocation coefficients.

Thus, the chapter aims to measure the vulnerability of the Mexican economy to a blockage of its production system. One of the most recent events that have blocked (at least partially) the productive system in Mexico was the lockdown decreed by the Mexican federal government to try to prevent the spread of the variants of the Coronavirus that triggered the COVID-19 pandemic between 2019-2020. The use of the extended multisectoral model (Ciaschini & Socci, 2006) with inoperability (Ahmed, et al., 2022), which follows the logic of a Social Accounting Matrix (Pyatt & Round, 1979), capturing the generation, allocation, distribution, and use of income, allows us to identify the effect of the blocking process. Moreover, the extended multisectoral model allows for overcoming some criticisms of IIM.

The chapter has four sections, excluding this introduction. Section 2.2 provides a summary and general discussion of inoperability models, the reason why these models are chosen, and the variant (ex-ante approach). Section 2.3 describes the Mexican economy when the Covid-19 Pandemic arrived in Mexico, and the Mexican federal government enacted the lockdown. Section 2.4 describes the simulation's assumptions and results; Section 2.5 provides some final considerations.

2.2 The Inoperability Input-Output model: a critical review and an inoperability extended multi-sectorial model alternative.

Even if the Input-Output Inoperability models (IIM) have not been free of criticism, they have been one of the most accepted in risk analysis in the last three decades (Greenberg, et al., 2012), and their applications have been prolific. Haimes and Jiang (2001) presented the first so-called Inoperability Input-Output model. They present the formalization of the static version of the Input-Output model of inoperability and a primitive idea of the dynamic model of inoperability. Santos and Haimes (2004) re-express and synthesize the equations of the inoperability model. The IIM equations in their paper are the most common in the IIM literature; in this work, the authors use multi-regional Input-Output matrices (MRIO) to analyze the impacts of a hypothetical terrorist attack in the US.

Crowther and Haimes (2005) define the relevance of the concept of interdependence in an economic system by evaluating and managing risks through the application of the IIM. Anderson et al. (2007) use the IIM to estimate the adverse economic effects of the so-called Northeast blackout of 2003, which revealed vulnerabilities in the US electrical grid system. Finally, Jung et al. (2009) carry out an inoperability exercise in international trade. They evaluate the impact of reducing the capacity of ports of entry, including ports and airports in the USA, and reducing the flows of tradable goods.

Although the original idea of the dynamic version of the IIM is in Haimes and Jiang (2001), it is in Lian and Haimes (2006) that the formalization of this version can be found. In addition, the economic effects of interruptions in production processes associated with epidemic phenomena have also been evaluated through the dynamic and probabilistic version of the IIM (Orsi & Santos, 2009).

2.2.1 A critical review of static IIM models

The IIM (Haimes & Jiang, 2001) is based on the open Leontief Input-Output model. The authors adapt the open Leontief I-O model to develop what they call the Leontief-based Input-Output infrastructure model: $\mathbf{q} = [\mathbf{I} - \mathbf{A}^*]^{-1}\tilde{\mathbf{f}}$ The Inoperability vector $\mathbf{q}$ can be a continuous or discrete variable of values between 0 and 1. Concretely, it can be defined as unrealized production, i.e., the planned production level minus the actual production level divided by the planned production level. Haimes & Jiang (2001) call this quantity a measure of probability and degree (percentage) of the inoperability of a system.

Following Santos and Haimes (Santos & Haimes, 2004; Okuyama & Santos, 2014), the inoperability model is defined by:

$$\mathbf{q} = [\mathbf{I} - \mathbf{A}^{*}]^{-1}\tilde{\mathbf{f}} = \mathbf{D}\,\tilde{\mathbf{f}} \qquad \text{[II. 1]}$$

where vector $\tilde{\mathbf{f}}$ is a function of the difference between the vectors of expected final demand $\mathbf{f}$ and the vector, $\breve{\mathbf{f}}$,of the attained final demand in the inoperability situation. Thus, $\tilde{\mathbf{f}}$ is defined by:

$$\mathbf{D}^{-1}\mathbf{q} = \mathbf{D}^{-1}\hat{\mathbf{x}}^{-1}\Delta\mathbf{x} = \hat{\mathbf{x}}^{-1}(\mathbf{f} - \breve{\mathbf{f}}) = \hat{\mathbf{x}}^{-1}\Delta\mathbf{f} = \tilde{\mathbf{f}} \qquad \text{[II. 2]}$$

where the matrix $\hat{\mathbf{x}}^{-1}$ represents the inverse of the diagonalized vector of gross output, $\Delta\mathbf{f}$ is the change of final demand. The matrix $\mathbf{D}$ in equation [II. 1] is the inverse of the *interdependency square matrix* (Lian & Haimes, 2006), which represents the interdependencies among all the economic sectors, where $\mathbf{A}^{*} = \hat{\mathbf{x}}^{-1}\mathbf{A}\,\hat{\mathbf{x}}$ is analogous to the technical coefficients matrix $\mathbf{A}$ in the static I–O model, even more us a similar matrix. However, in the classical Input-Output analysis, the matrix $\mathbf{A}^{*}$ is the allocation coefficients matrix, which means that the matrix $\mathbf{D}$ represents the Gosh inverse matrix (Dietzenbacher & Miller, 2015).

The use of the allocation coefficients matrix, $\mathbf{A}^{*}$, encourages one of the debates, at least tangentially, of the IIM models. The Gosh model or the supply-driven Input-Output model, also known as the price model, has been widely discussed within in the field of Input-Output analysis. For example, Oosterhaven (1988; 1996; 2012) points out that the *supply-driven model* assumes that demand is perfectly elastic, which implies that final consumption and investment react to any change in supply. In turn, in the case of intermediate inputs, it implies that the values of the input ratios arbitrarily depend on the supply. Thus, the production function is a non-existent concept in the model, even if consuming features are added to the model.

To Oosterhaven (2017), the primary limit of inoperability models is that a disaster produces a direct loss of production capacity on the gross output, which means a supply shock; Therefore, the reduction of final demand is an ex-post analysis (after the disaster), and it is probably not very useful when we want to estimate the economic impact of a disaster on GDP. The main objective of this critique is that the IIM transforms the exogenous drop in output into an exogenous final demand drop $\mathbf{f} - \breve{\mathbf{f}}$ such that translating into an endogenous output drop is not possible. Thus, no total fall in the final demand of an industry or product will produce an endogenous fall in the industry or product's output that is large enough to incorporate any exogenous fall in that output.

When the IIM is considered in relative terms (see equation [II. 2]), Oosterhaven (2017) argues that the traditional IIM does not incorporate the analysis that, in that case, the exogenous percentage drop in production capacity has to be transformed into a percentage drop in the exogenous final demand that projects an endogenous percentage drop in production that correctly and accurately incorporates the exogenous drop in the output. The IIM literature has not tried this equivalent problem. Thus, the empirical solution consists of using a uniform reduction in the final exogenous demand $\tilde{\mathbf{f}}$. Ignoring the non-uniform upper limits of the exogenous final demand has two consequences. First, applying a uniform reduction in the exogenous final demand $\tilde{\mathbf{f}}$ suggests that the resulting ranking of industries is neutral to a potential negative shock. Second, it results in a systematic overestimate of the backward inoperability effects.

To Oosterhaven's critics of the use of the coefficient allocation matrix in the IIM, it is possible to add De-Mesnard's critics, which is not based on the use of the allocation coefficient matrix itself, as for the implausibility argument of its use (Oosterhaven, 1988; 1996; 2012), but on its interpretation and on the ambiguity of using the said matrix to derive a price model. In turn, Auray et al. (1979) argue that the so-called technical coefficients matrix, $\mathbf{A} = \{a_{ij}\}$, is invariant, which means, there is not substitution between intermediate inputs and the existence of a production function with constant returns; therefore, $(\mathbf{I} - \mathbf{A})^{-1} = \mathbf{L}$ is a matrix of ***absolute elasticities***, which means that the coefficients r_{ij} represent the change of output in the i^{th} industry caused by a variation of a monetary unit of final demand in the industry j^{th}. While the allocation coefficient matrix $\mathbf{A}^* = \{a^*_{ij}\}$ implies that the proportions of uses (intermediate and final) of an industry are invariable when the total use of this industry varies, hence, $(\mathbf{I} - \mathbf{A}^*)^{-1} = \mathbf{D}$ describes the ***relative elasticities***, where the coefficient d^*_{ij} represents the variation of output in the i^{th} industry in per cent caused by the variation in the final demand of industry j^{th} by 1 per cent of the original output of this industry (Dietzenbacher, 1997). A similar lecture on the allocation coefficient matrix $\mathbf{A}^*$ is in De Mesnard (2001).

However, the main difference between De Mesnard (2001; 2009; 2019) and Dietzenbacher (1997) regarding the allocation coefficient matrix, $\mathbf{A}^*$, is that while for Dietzenbacher, such a matrix can be used to derive a dual price model to that of Leontief, for De Mesnard, it is not possible to do so. Mesnard (2009) argues that the Ghosh model cannot separate quantities and prices or values and price indices; hence, it cannot be a price model. In turn, there is confusion because the Gosh value model is the physical version, so it cannot be compared to the primal Leontief model. Although in the end, interpreting the Ghosh model as a model of propagation of cost variations to prices (Dietzenbacher, 1997) is acceptable (De Mesnard, 2009; Oosterhaven, 2023), allowing one to read the matrix of allocation coefficients as a matrix of relative elasticities. The Leontief price model performs the same task more straightforwardly (De Mesnard, 2016).

Dietzenbacher & Miller (2015) also argue that the inoperability model and its applications are fascinating and relevant to assess disaster impacts. However, it is a straightforward application of the standard Input-Output model with a minor tweak[6].

[6] These authors are more critical with the dynamic IIM than the static model.

2.2.2 The Extended Multisectoral Model with a negative supply shock: a reinterpretation of the *inoperability*

Considering the above criticisms of the IIM, we will propose an alternative extended multisectoral model for a disaster or supply shock analysis. Our approach is not based on the standard Leontief model but on an extended multisectoral model based on the Social Accounting Matrix. This allows us to obtain results in disaggregated terms that consider the circular flow of income: generation, primary and secondary distribution, and use of income (not allowed by the classic open Input-Output models with inoperability). At the same time, the classic approach implies that the reduction in final demand is an ex-post analysis (after the disaster), and it is probably not very useful when the objective is to estimate the economic impact on GDP of a natural disaster or, in our case, of a pandemic due to public policy intervention.

Ciaschini & Socci (2006; 2007) follow and extend the Miyazawa (1970) approach using the SAM framework, as shown in Figure 1. This model, the extended multisectoral model (EMM), captures the circular flow of income, starting from the Leontief model. It is defined by:

$$\mathbf{x} = \mathbf{A}\mathbf{x} + \mathbf{f}$$
$$\mathbf{x} = \mathbf{A}\mathbf{x} + [\mathbf{F}(\mathbf{I} + \mathbf{T})\mathbf{P}\mathbf{V}]\mathbf{x} + \bar{\mathbf{f}}, \qquad \text{[II. 3]}$$

where $\mathbf{x}$ is the vector of gross output; $(\mathbf{I} - \mathbf{A})$ is the matrix of Leontief**,** where $\mathbf{A}$ is the matrix of technical coefficients; $\mathbf{f}$ is the vector for the aggregate final demand. However, Ciaschini & Socci (2006; 2007) re-express the aggregate final demand. It is composed of the endogenous plus the exogenous final demand, and endogenizes the disposable income. Thus, the aggregate final demand can be expressed by:

$$\mathbf{f} = [\mathbf{F}(\mathbf{I} + \mathbf{T})\mathbf{P}\mathbf{V}]\mathbf{x} + \bar{\mathbf{f}} \qquad \text{[II. 4]}$$

It is possible to start with the primary income by institutional sector, to understand the endogenization of disposable income and its use. The vector of primary income by institutional sector is defined by:

$$\mathbf{v}_{\mathbf{is}} = \mathbf{P}\mathbf{V}\mathbf{x} \qquad \text{[II. 5]}$$

where $\mathbf{V}$ is a matrix of order $[r \times n]$, where its coefficients represent the constant share of gross value added of each primary factor relative to gross output for each industry; $\mathbf{P}$, which has dimension $[k \times r]$ and represents the constant share of each component of value added by institutional sector, and $\mathbf{x}$ as above.

When the secondary distribution is incorporated, which means when the taxes and transfers between the institutional sectors are incorporated, it is possible to transform primary income by each institutional sector into disposable income by institutional sectors:

$$\mathbf{y} = (\mathbf{I} + \mathbf{T})\mathbf{v_{is}} = (\mathbf{I} + \mathbf{T})\mathbf{PVx} \qquad \text{[II. 6]}$$

where $\mathbf{T}$ is a matrix of dimension $[k \times k]$ that contains net taxes, including taxes on income, and transfers at constant shares each institutional sector receives from the remaining institutional sectors, and $\mathbf{I}$ is the identity matrix. This disposable income is used in the aggregate final demand, where the endogenous final consumption demand can be written as:

$$\mathbf{F}_{\tilde{c}} = \mathbf{F^0 y} = \mathbf{F^1 C\, y} \qquad \text{[II. 7]}$$

where $\mathbf{F^0}$, is a matrix of dimensions $[n \times k]$, whose elements are the share of consumption expenditure for each commodity produced relative to the disposable income of each institutional sector; $\mathbf{C}$ is a diagonal matrix of dimension $[k \times k]$ with the consumption propensity by institutional sector. $\mathbf{F^1}$ is a matrix of dimension $[n \times k]$, which represents the share of final demand of each commodity concerning the disposable income of each institutional sector. In the case of the extended multisectoral model, it is possible to endogenize investment. Therefore, the extended model does not only consider the multiplier of income inspired by Khan (1931) and the Keynesian theory (1936). However, it is also possible to capture the effect of the static accelerator in Harrod's version, as in equation 4.1, when the gross capital formation is endogenized.

Let $\mathbf{K^1}$ a matrix of dimension $[n \times k]$, whose elements represent the demand for the investment of each institutional sector to each industry as a share of investment expenditure of each institutional sector. Moreover, we find the scalar $\dot{s}$, which represents the parameter of *active saving* as the ratio between gross fixed capital formation and national saving. The scalar can take three values: if $\dot{s} < 1$, the economy is a net lender to the Rest of the World; if $\dot{s} > 1$, the economy is a net borrower; if $\dot{s} = 1$ in the economy, national saving equals gross capital formation. However, this last case can only occur in a closed economy[7]. So, we can express the account of *capital formation* in the following way:

$$\mathbf{K} = \mathbf{K^1}\dot{s}(\mathbf{I} - \mathbf{C}) \qquad \text{[II. 8]}$$

[7] This is not the case of this article, but for a summary about the importance (or not) of the current balance see Corden (1993; 2007), even more the implications between the "Keynesian" approach and the "Johonsonian" of the balance of payments to consult Polak & Plessner (2002), Thirwall (2001) or; the debates on the implications of chronic deficits to consult Shaikh (2016) .

at this point, the endogenous final demand is given by $\mathbf{F} = \mathbf{F}_{\tilde{C}} + \mathbf{K}.$ If investment is exogenous as in the elongated model, thus $\mathbf{F} = \mathbf{F}_{\tilde{C}}$. Therefore, it is possible to conform the vector of final demand as:

$$\mathbf{f} = \mathbf{F}\mathbf{y} + \bar{\mathbf{f}} \qquad [\text{II. } 9]$$

where $\bar{\mathbf{f}}$ represents the exogenous demand. The complete equation becomes:

$$\begin{aligned} \mathbf{f} &= \mathbf{F}(\mathbf{I} + \mathbf{T})\mathbf{P}\,\mathbf{V}\mathbf{x} + \bar{\mathbf{f}} \\ \mathbf{f} &= \bar{\mathbf{F}}\mathbf{x} + \bar{\mathbf{f}} \end{aligned} \qquad [\text{II. } 10]$$

Taking equation [II. 3], and substituting [II. 10], we obtain:

$$\begin{aligned} \mathbf{x} &= \mathbf{A}\mathbf{x} + \mathbf{f} \\ \mathbf{x} &= \mathbf{A}\mathbf{x} + [\mathbf{F}(\mathbf{I} + \mathbf{T})\mathbf{P}\mathbf{V}]\mathbf{x} + \bar{\mathbf{f}} \\ \mathbf{x} &= \mathbf{A}\mathbf{x} + \bar{\mathbf{F}}\mathbf{x} + \bar{\mathbf{f}}, \end{aligned} \qquad [\text{II. } 11]$$

The solution for the gross output is defined by the extended model as:

$$\begin{aligned} \mathbf{x} - \mathbf{A}\mathbf{x} - \bar{\mathbf{F}}\,\mathbf{x} &= \bar{\mathbf{f}} \\ (\mathbf{I} - \mathbf{A} - \bar{\mathbf{F}})\,\mathbf{x} &= \bar{\mathbf{f}} \\ (\mathbf{I} - \mathbf{E})\,\mathbf{x} &= \bar{\mathbf{f}} \\ \mathbf{x} &= (\mathbf{I} - \mathbf{E})^{-1}\,\bar{\mathbf{f}} = \bar{\mathbf{f}} \\ \Delta\mathbf{x} &= \mathbf{R}\,\Delta\bar{\mathbf{f}}, \end{aligned} \qquad [\text{II. } 12]$$

where $\mathbf{R}$ is the structural matrix of the system or the matrix of extended multipliers, which endogenizes the functional income distribution and consumption as the Miyazawa (1970) model under the concept of the Keynesian multiplier generalized in a Kalecki-Kaldor approach (Kaldor, 1955; Kalecki, 1971) taking in account the transformation of primary income into disposable income. The matrix $\mathbf{R}$ shows the total effects of the exogenous final demand on output via interindustry and induced consumption activities. Furthermore, the Ciaschini-Socci (2006; 2007) model has the advantage of choosing the account of aggregate final demand that will be endogenized without losing the structure of the circular flow of income. The result of equation 15 shows that at least $\mathbf{x} > \mathbf{0}$ implies that the structural matrix $\mathbf{R}$ is nonnegative. The determinant of the structural matrix $|\mathbf{R}|$ is positive.

Following Santos & Haimes (2004) and Haimes (2009) who extended the Input-Output Inoperability Model in an international trade inoperability Input-Output model (IT-IIM), it is possible to incorporate the inoperability into the EMM to elaborate the Inoperability Extended Multisectoral Model (IEMM) (Socci, et al., 2021; Ahmed, et al., 2022). The authors defined the inoperability vector as $\mathbf{q} = \hat{\mathbf{x}}^{-1}\Delta\mathbf{x}$, as above. The inoperability describes the level of an economic system dysfunction expressed as a percentage of its Business as Usual production, as the economic loss in relative terms.

Thus, taking equation [II. 12], the extended multisectoral model with inoperability is defined by:

$$\begin{gathered}
\hat{\mathbf{x}}^{-1}\Delta\bar{\mathbf{f}} = \hat{\mathbf{x}}^{-1}\mathbf{R}^{-1}\,\Delta\mathbf{x} \\
\hat{\mathbf{x}}^{-1}\Delta\bar{\mathbf{f}} = \hat{\mathbf{x}}^{-1}(\mathbf{I}-\mathbf{E})\,\Delta\mathbf{x} \\
\hat{\mathbf{x}}^{-1}\Delta\bar{\mathbf{f}} = \hat{\mathbf{x}}^{-1}\Delta\mathbf{x} - \hat{\mathbf{x}}^{-1}\mathbf{E}\Delta\mathbf{x} \\
\hat{\mathbf{x}}^{-1}\Delta\bar{\mathbf{f}} = \hat{\mathbf{x}}^{-1}\Delta\mathbf{x} - \hat{\mathbf{x}}^{-1}\dot{\mathbf{Z}}\hat{\mathbf{x}}^{-1}\,\Delta\mathbf{x} \\
\hat{\mathbf{x}}^{-1}\Delta\bar{\mathbf{f}} = \left(\mathbf{I} - \hat{\mathbf{x}}^{-1}\dot{\mathbf{Z}}\right)\hat{\mathbf{x}}^{-1}\Delta\mathbf{x} \\
\hat{\mathbf{x}}^{-1}\Delta\bar{\mathbf{f}} = (\mathbf{I}-\mathbf{E}^{*})\hat{\mathbf{x}}^{-1}\Delta\mathbf{x} \\
\hat{\mathbf{x}}^{-1}\Delta\bar{\mathbf{f}} = \dot{\mathbf{R}}^{-1}\,\mathbf{q} \\
\mathbf{q} = \dot{\mathbf{R}}\,\bar{\bar{\mathbf{f}}}
\end{gathered} \qquad [\text{II. } 13]$$

Where the vector $\bar{\bar{\mathbf{f}}} = \hat{\mathbf{x}}^{-1}\Delta\bar{\mathbf{f}} = \hat{\mathbf{x}}^{-1}(\bar{\mathbf{f}} - \breve{\bar{\mathbf{f}}})$ is a function of the difference between the vectors of the expected exogenous final demand $\bar{\mathbf{f}}$ and the vector $\breve{\bar{\mathbf{f}}}$ of actually attained by the exogenous final demand in the inoperability situation, analogic-like equation [II. 2]. $\dot{\mathbf{Z}}$ is the matrix of inter-industry intermediate flows plus the flows of endogenous aggregate final demand by industry associated with the disposable income of institutional sectors. Thus, this matrix describes the interindustry flows with the endogenous final demand and the income distribution process incorporated. Consequently, the matrix $\mathbf{E}^{*}$ is analogic to $\mathbf{A}^{*}$, and the matrix $\dot{\mathbf{R}}$ is analogic to $\mathbf{D}$. Both are matrixes of relative elasticities where the coefficients $\dot{r}_{ij}$ or d_{ij} represent the variation of output in the i^{th} industry in per cent terms caused by the variation in the exogenous final demand of industry j^{th} by 1 percent of the actual output of this industry. The matrix $\dot{\mathbf{R}}$ endogenizes the induced relative effects of disposable income and its use.

From equation [II. 13], assuming that there is not any change in the exogenous final demand, then $\bar{\bar{\mathbf{f}}} = \hat{\mathbf{x}}^{-1}\bar{\mathbf{f}}$, and this implies that $\mathbf{q}$ is a unitary vector $\mathbf{i}$. It implies that:

$$\begin{gathered}
\mathbf{q} = \dot{\mathbf{R}}\,\hat{\mathbf{x}}^{-1}\bar{\mathbf{f}} = \mathbf{i} \\
\hat{\mathbf{x}}^{-1}\bar{\mathbf{f}} = \dot{\mathbf{R}}^{-1}\,\mathbf{i}
\end{gathered} \qquad [\text{II. } 14]$$

However, equation [II. 14] is a mathematical identity, as De Mesnard (2009) argued. Thus, using the mathematical identity, it is possible to use equation [II. 13] to estimate a negative shock in the production of an economic system, i.e., a supply shock, to calculate the impact it will have on the final exogenous demand, defined as:

$$\bar{\bar{\mathbf{f}}} = \dot{\mathbf{R}}^{-1}\,\mathbf{q}, \qquad [\text{II. } 15]$$

The exogenous variable is represented by the vector $\mathbf{q}$ and the result vector is $\bar{\bar{\mathbf{f}}}$. Thus, given a negative shock in outputand the resulting vector $\bar{\bar{\mathbf{f}}}$, the change in the exogenous aggregate final demand in the inoperability situation will correspond to the fall in output respecting the mathematical identities expressed in equation [II. 13]. This approach is similar to the assumption in the partial hypothetical extraction method (Dietzenbacher & Lahr, 2013; Dietzenbacher & Miller, 2015).

Equations [II. 13] and [II. 15] are only the mathematical identities that a model using the allocation coefficient matrix should fulfill (De Mesnard, 2009). However, in the approach expressed in equation [II. 15] where the vector $\mathbf{q}$ represents the exogenous variable, the economic system receives the inoperability shock on the supply side, making it possible to overcome two main criticisms made by Oosterhaven (2017). First, equation [II. 15] allows modeling a partial and gradual supply-side shock, i.e., selecting each industry or product's degree of production inoperability. Second, this allows a more realistic estimation of the impact of final demand, which corresponds to the assumed relative fall in output (this does not occur in the classical IIMs that suppose a homogeneous fall in final demand).

In the case of economic interpretation, the proposed multisectoral extended model (MEM) with *inoperability* should be interpreted differently from the classic IIMs. First, the matrix $\mathbf{E}^*$, unlike matrix $\mathbf{A}^*$, adds to the inter-industry allocation coefficients the respective allocation coefficients of the use of disposable income, i.e., the allocation coefficients of the final endogenous demand. Matrix $\mathbf{E}^*$, as well as the matrix $(\mathbf{I}-\mathbf{E}^*)$ incorporates the interdependence of an economic system, already described by Leontief in his doctoral dissertation, reprinted in an article from the 1990s (Leontief, 1991) and modeled as early as the first Input-Output tables (Leontief, 1941; Leontief, 1944), and extended in the Social Accounting Matrices (Pyatt & Thorbecke, 1976; Pyatt & Round, 1979). Hence, this is not a new contribution by the IIM models.

Finally, the IEM's inverse matrix, $\dot{\mathbf{R}} = \{\dot{r}_{ij}\}$ must be read as a matrix of relative elasticities, where $\dot{r}_{ij}$ represents the change in the output in the i^{th} industry in percent caused by the inoperability or block of the industry j^{th} in its final demand by 1 percent of the observed output of this industry. Thus, IEM can help measure the relative adverse effects of a supply-side shock, such as events that block production, i.e., inoperability, e.g., wars, trade wars, terrorist attacks, natural disasters, or policies like the lockdown associated with pandemics, like Covid-19.

2.3 The main aspects of the conjuncture and structure of the Mexican economy in the context of Covid-19

The lockdown in Mexico associated with Covid-19 arrived in an economy with several structural economic problems. There are three main problems: first, the trend of low GDP growth in the last decade; second, an intense precariousness process in the labor market; and, consequently, high inequality in income distribution. Thus, the pandemic exacerbated a slowed-down economic growth in Mexico. According to INEGI, between 2009-2019, after the crisis of 2008, the annual real GDP growth in Mexico was 1.96% on average (INEGI, 2020a), while the emerging markets economies grew at an average annual growth of 4.87%, and the advanced economies at 1.53% in the same period (IMF, 2020). This Mexican average annual growth rate was lower than in 1980-2008, with an average of 2.2% (Loría, 2009), and even less than in 1969-1980, which was 6.5% (Ros, 2013)[8].

Total employment had an interannual average growth of 1.75% during 2013-2019; and, in 2019 (2.75%), when a negative change occurred in the real GDP (-0.1%), this helped to recover the level of employment after the crisis of 2008. Tertiary industries are those that have had the highest growth in employment, particularly the activities of *Restaurants and accommodation services* (4.01%), *Transport, communications, mail, and storage* (2.75%), and *trade* (1.59%), followed by *Manufacturing Industries* (2.94%). Trade activity has a share of total employment of 19.14%, and manufacturing activities have a share of 16.07% in the same period.

Between 2013-2018, the average share of value added of informal industries on total Value Added was 22.78% (INEGI, 2020b), and the share of informal employment in 2019 on total employment was 56.2% (INEGI, 2020c). However, Samaniego (2018) argues that even if in 2018 employment had this performance, it recovered to 2008 pre-crisis levels. However, this recovery was at the expense of solid precariousness because the number of employees with low salaries increased concerning workers with high incomes. Furthermore, the employment rate was still below the 2008 pre-crisis levels. Coupled with this, although the informal employment rate decreased, it is still one of the highest in Latin America. Thus, the flexibility and impoverishment of the labor market explain this performance, according to Salazar & Azamar (2014).

Puyana & Romero (2013) had already warned about these structural problems in the labor market in Mexico. They measure the informal employment for manufacturing activities and show that the number of workers and establishments in the informal sector in Mexico grew at a higher rate than those in the formal sector and even more than the total.

In Mexico, only 6 of 10 paid workers have social protection (Samaniego, 2018), so the high level of informal employment in Mexico implies that a significant share of employed people is highly vulnerable to different types of risk: accidents that make it impossible to continue working, or loss of income caused by sickness as in the COVID-19 pandemic. Furthermore, there is not any unemployment insurance or universal income in Mexico.

Inequality concerns the population's vulnerability to a GDP shock associated with income distribution. Cortes (2017) argues that between 1963-2014, Mexico had three different periods in the income distribution process. First, the period 1963-1984 had a

[8] One of most relevant and critic discussion about causalities of the slow growth and the inequality in Mexico can be read in Ros (2013), whom two years later (Ros, 2015) wrote a book with some proposes to Mexican policies makers to overcome the slow growth and the high inequality

slow but persistent decline in inequality in income distribution, mainly due to the increase in the share of deciles IV to VII. Then, between 1984-1989, the relative participation of the tenth decile increased, starting a regressive process in the income distribution; thus, for the period 1989-2000, it was necessary to join the income of 30 to 34 people or 14 to 17 households in the first decile to equal one person or household in the tenth decile, respectively. Finally, for the period starting in 2000, the mentioned proportion was the income of 25 people or 13 households, respectively. However, Cortes (2017) points out that this last down in inequality does not imply a change in the structural mechanism of redistribution but some transitory political events.

The Coronavirus pandemic arrived in Mexico at the end of February 2020. The first case of contagion was a 35-year-old man from Mexico City who had just returned from Italy. On February 27, 2020, President Andrés Manuel López Obrador officially communicated the detection of the so-called case zero to the nation. Thus, it was only six days after the pandemic outbreak in Italy, considered as the first country to be infected after China. The first decision of the Mexican Federal Government was taken three weeks after case zero on March 14, 2020, and it had effectiveness as of March 23, as it extended the Holy Week vacations from March 23 to April 20 for all educational institutions. The shutdown of educational activities involved 36 million students and two million professors, about 29% of the total population. However, the number of cases in the first three weeks of the pandemic increased from 51 average cases between March 18 and 25 to 468 average cases between April 11 and 18.

On March 18, 2020, the Ministry of Health confirmed the first death by COVID-19 in Mexico. On that same day, there were 118 confirmed and 314 alleged cases. The Ministry of Health's recommendations concerned sneezing rules, hand sanitation, and disinfection of public areas. People with coronavirus-related symptoms or a declared diagnosis had to wear the facemask but were allowed to circulate. As of March 26, non-essential activities of the federal government were suspended except those involving the ministries of health, hygiene, energy, and safety. On March 30, the General Health Council (CSG, Spanish acronym) declared a national health emergency.

Moreover, on March 31, the Ministry of Health (Mexican Federal Government, 2020a), in agreement with the General Health Council, enacted a decree stating a one-month lockdown (April 1 to April 30), which meant an immediate suspension of industrial production in all (public and private) “non-essential activities.” This decree contained a list of 20 “indispensable activities,” for example, energy distribution, agriculture activity, and essential financial activities. Also, the decree affected the economic activity, not the mobility or assembly’s freedom, except massive events.

Despite the lockdown restrictions, on April 21, 2020 the number of coronavirus cases surged from 10,000 to 10,544 with 970 total deaths; on April 23, the death toll surpassed 1,000. Since the number of infections was not decreasing, as well as the number of deaths number by COVID-19, the Mexican government decided to extend the lockdown to May 30 for some industries and to start the reopening for others from May 17, for example, the automotive industry and its suppliers as textile, glasses, iron opened. However, the reopening of production activities was gradual: for some cities, such as Mexico City, the almost total reopening occurred only in mid-June 2020.

Mexico is one of those countries in which the spread of the Coronavirus pandemic hit an already weak economy. For example, according to the National Institute of Statistics (INEGI, by Spanish acronym), the quarterly GDP interannual growth in the first quarter of 2020 was -0.05% with respect to 2019. However, by that time, the first effects of the lockdown on the Mexican economy were already evident: the GDP interannual growth in the second quarter of 2020 was -1.37% respect to 2019 (INEGI, 2020a).

After just two months of lockdown declaration, its consequences could also be seen in the number of employees. Esquivel (2020) showed an interannual variation of the total position jobs of -11.00%. Samaniego (2020) argues that this crisis is unprecedented in the worldwide labor market and Mexico because, during the lockdown, the informal labor market also stopped its function as a temporary refuge for those who lost their jobs in the formal sector. However, the informal market also has considerable mobility, and for this reason, informal employment grew with the process of reopening. As shown by the number of occupation and employment telephone surveys for June 2020 carried out by INEGI (2020b), informal employment had a positive variation of 13% in June 2020 compared to May of the same year.

The National Council for the Evaluation of Social Development Policy (CONEVAL, Spanish acronym) reported that between 2018 and 2020, the households' ratio S90/S10[9] in Mexico of current income, which means monetary income (labor remuneration, self-employment income, self-consumption, income from property rental and transfers) plus nonmonetary income (transfers in kind and gifts received in kind), passed from 24 to 22 (CONEVAL, 2021).

The CONEVAL argues that this fall in the S90/S10 ratio is due to a generalized fall in current income (6.9%) that affected decile X to a greater extent since its average income decreased by 10.6%, while that of decile I decreased by 3.0%, i.e., social transfers have helped, although they have not solved inequality, not to deepen it during the pandemic period. However, the OECD reports that the ratio of the population (divided into nine groups) S90/S10 for Mexico is the second highest of all member countries, three times higher than the best-positioned country, Denmark, and 1.5 times higher than the

[9] It iscalculated as the difference between the income received by the 10% of the households with the highest income (the top decile) and those who receive the lowest income (the bottom decile).

average of member countries. In turn, as expected between 2018 and 2020, the component of monetary income that had the second largest drop was remuneration for subordinate work (10.3%); likewise, monetary transfers stood out with an increase of 16.2% (CONEVAL, 2021).

These data have been taken ex-post from the lockdown policy as part of COVID-19; however, for policymakers, it is crucial to know the aggregate impact of the lockdown (ex-ante, when the policy is about to be implemented). In turn, while knowing the aggregate effects of public intervention is essential, it is more helpful to know how the shock acted at a disaggregated level, either by industry or by institutional sector. Thus, multisectoral models that allow the effects of the lockdown to be calculated at the industry level, allowing disaggregated results to be considered, prove useful. In addition, this approach, through interoperability, helps to estimate the economic impact of a natural hazard, terrorist acts, or external events that disrupt the system, such as the lockdown.

2.1 The impact of the Covid-19 lockdown on Mexican income groups

Using the IEM presented in section 2.2; it is possible to simulate the ex-ante impact of the lockdown associated with Covid-19 in Mexico. To do that, we constructed a Social Accounting Matrix for Mexico for 2018, following the structure of Table 1, with 76 industries, 18 primary factors (labor divided by age and skills), and 22 institutional sectors. The SAM was constructed taking as a basis the Social Accounting Matrix by accounts published by the INEGI (2021) and the information of Institutional Accounts.

Thus, we calculate the vector of the production shock. Notably, we find the vector of daily production $\mathbf{x_d}$ by dividing the vector $\mathbf{x}$ of total gross output by 365. Then, we build a diagonal matrix $\widetilde{\mathbf{X}}$ of dimension $[n\ x\ n]$: its elements are 0 if the industry was not closed during the lockdown; otherwise, they can be assumed -1. These conditions can be written as follows:

$$\widetilde{\mathbf{X}} = \begin{cases} -1 \leq \widetilde{\mathbf{x}}_{ii} < 0 \text{ if the } i\text{-}th \text{ industrial sector was closed during the lockdown} \\ \widetilde{\mathbf{x}}_{ii} = 0 \text{ if the } i\text{-}th \text{ industrial sector was not closed during the lockdown,} \end{cases}$$

where $\widetilde{\mathbf{x}}_{ii}$ represents the sum of the gross output shares of the sub-industries affected by the lockdown, nonessential sub-industries, within each industry. Its construction was possible through the Symmetric Input-Output table, industry by industry, of size $[262 \times 262]$ (INEGI, 2013), given a vector $\boldsymbol{\gamma}$ which contains the days of lockdown for each industry considering the Government decisions. Therefore, the vector that records changes in production caused by the lockdown can be written as follows:

$$\Delta\mathbf{x}_{l} = \boldsymbol{\gamma}\,\widetilde{\mathbf{X}}\,\mathbf{x_d}, \qquad \text{[II. 16]}$$

consequently, if $\mathbf{\Delta x}_l$ is the vector of output change caused by the lockdown, it is possible to incorporate the inoperability or the relative supply shock in the following way:

$$\hat{\mathbf{x}}^{-1}\Delta\mathbf{x}_l = \hat{\mathbf{x}}^{-1}\,\widetilde{\mathbf{X}}\,\mathbf{x}_\mathbf{d} = \mathbf{q}_\mathbf{l}\ , \qquad \text{[II. 17]}$$

thus, the IEM allows to estimate the change (in percentage terms) in the exogenous final demand in Mexico caused by the lockdown associated with Covid-19, and it is defined by:

$$\tilde{\tilde{\mathbf{f}}}_l = \dot{\mathbf{R}}^{-1}\boldsymbol{q}_l, \qquad \text{[II. 18]}$$

once the relative variation has been calculated, the variation under inoperability respects the mathematical identities and returns the corresponding change with the assumed drop in production, defined by:

$$\mathbf{q}_\mathbf{l} = \dot{\mathbf{R}}\,\tilde{\tilde{\mathbf{f}}}_l, \qquad \text{[II. 19]}$$

Consequently, the new vector of output is defined by:

$$\mathbf{x}_l = \mathbf{x}\,\mathbf{q}_\mathbf{l} = \mathbf{x}\,\hat{\mathbf{x}}^{-1}\Delta\mathbf{x}_l = \mathbf{x}\,\dot{\mathbf{R}}\,\tilde{\tilde{\mathbf{f}}}_l, \qquad \text{[II. 20]}$$

Using equation [II. 20], it is possible to estimate the change in Gross Value Added by primary income:

$$\Delta\mathbf{G}_\mathbf{l} = \mathbf{G}\,\mathbf{q}_\mathbf{l} = \mathbf{G}\,\hat{\mathbf{x}}^{-1}\Delta\mathbf{x}_\mathbf{l} = \mathbf{G}\,\dot{\mathbf{R}}\,\tilde{\tilde{\mathbf{f}}}_\mathbf{l}, \qquad \text{[II. 21]}$$

where $\mathbf{G}$ is the matrix of Gross Value Added observed (expected) before the shock or in levels:

$$\mathbf{G}_\mathbf{l} = \mathbf{V}\mathbf{x}_\mathbf{l} = \mathbf{V}\mathbf{x}\,\dot{\mathbf{R}}\,\tilde{\tilde{\mathbf{f}}}_\mathbf{l} \qquad \text{[II. 22]}$$

An analogous procedure allows for determining the disposable income of each institutional sector.

Thus, we use this version of the Extended Multisectoral Model with inoperability (IEM), considering the model's economic reinterpretation and mathematical identities described in the previous section. Table AII-1 (Appendix II) shows the types of economic activities that the Mexican Federal Government declared as "indispensable" to carry ordinary social life on March 31, 2020, through the agreement of the General Health Council and the Ministry of Health (Mexican Federal Government, 2020a), and its correspondence with the industries of the Mexican SAM for 2018. The same table shows the value of $\boldsymbol{\gamma_i}$ by each industry that was assumed in the simulation of the lockdown; in turn, using the IEM we assumed government consumption and Gross Fixed Capital Formation as exogenous. This assumption is justified by the fact that in the face of a supply shock, the government can adjust its consumption more quickly than households; conversely, corporations tend to reduce investments.

Regarding the duration of the lockdown, we assumed a generalized lockdown of 75 days for most industries, with only one industry with 90 days of lockdown, *37. Transportation Equipment Manufacturing*, and five industries with 125 days of lockdown, *67. Performing Arts, Spectator Sports, and Related Industries; 68. Museums, Historical Sites, and Similar Institutions; 69. Amusement, Gambling, and Recreation Industries; 70. Accommodation;71. Food Services and Drinking Places.*

Thus, 37 industries of the Mexican SAM correspond to the "indispensable economic activities", and they represent 49% of the industrial system; 21 industries do not have any lockdown, meaning 27% of the industrial system; and 73% of the Mexican industrial system was affected by partial or complete lockdown.

Table 2-1 GDP change estimation by Lockdown in Mexico 2020.

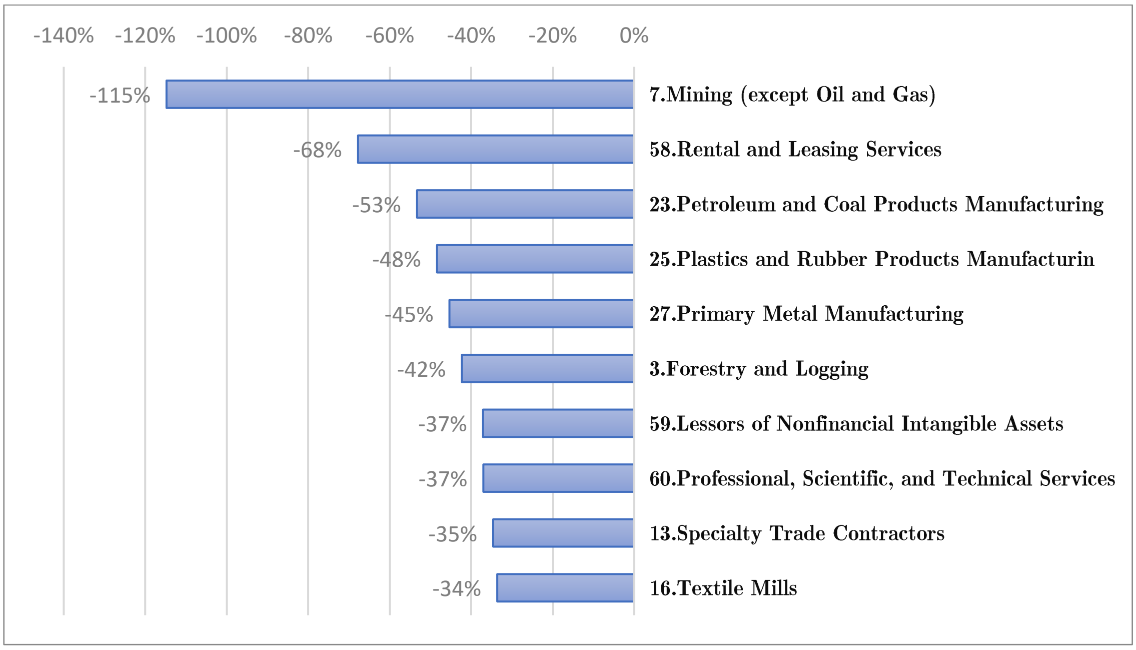
	Percentage Points
GDP change in the simulation	-7.2%
Production change	-15.2%
Observed GDP change	-8.5%

Source: Own elaboration based on the simulation and INEGI (INEGI, 2021).

Table 2 shows the simulation results using IEM of the impact of the lockdown associated with the Covid-19 pandemic. The drop in GDP in the simulation is -7.2%, corresponding to a difference of 1.3% from the observed decline. It should be noted that the simulation does not assume any changes in the behavior of institutional sectors. For example, it does not suppose any changes in the propensity to consume. In this work, the simulation aims to estimate the pure lockdown's impact, which should be the first estimate that a policymaker is interested in when a policy such as a lockdown is considered. The above suggests that the IEM model, under realistic assumptions, performs well. The advantage is that it provides results in disaggregated terms at the industry level and by each institutional sector.

In Figure 2.1, it is possible to observe, using the supply shock approach of the IEM, estimated final demand drops of more than 100%, which, according to Oosterhaven's criticism, is not possible in the classical IIM approach. However, in economic terms, it can happen, and it can only be observed if the modeling of inoperability involves the supply side, as in our simulation.

Figure 2.1 *IEM estimates of the top 10 industries with the greatest impact on aggregate final demand caused by the Covid-19 lockdown in Mexico.*



Source: Own elaboration based on the simulation.

According to the simulation results, an over 100% drop occurred in industry *7. Mining (except Oil & Gas)* can be explained by a trade deficit caused by the effects of the interruption of its production. It is followed by industry *58. Rental and Leasing Services*, subject to a fall of 68% in its aggregate final demand. This contraction was expected as the lockdown introduced telecommuting in several industries. The third industry with the most significant drop in aggregate final demand is *23. Petroleum and Coal Products Manufacturing* (-53%), followed by industry *25. Plastics and Rubber Products Manufacturing (-48%).* In other words, these three industries are susceptible to lockdown shocks like the others in Figure 2.1. This information could be helpful for policymakers, particularly in designing targeted intervention policies for each industry.

Examining the system's sensitivity to each industry's effects is also essential. In this case, the analysis focuses on which industries contribute more significantly to the fall in GDP. Again, this is associated with variations in final demand and the relative weight of each productive sector in GDP. In Table 2-2, it is possible to observe the 10 industries that cause the most significant drops in GDP according to the simulation.

Table 2-2 IEM estimates the top 10 industries with the most significant contribution to the total change of Mexican GDP.

Industry	Contribution to the GDP
40. Trade	-4.2%
37. Transportation Equipment Manufacturing	-1.8%
10. Residential Building Construction	-1.2%
57. Real Estate Services	-0.9%
44. Truck Transportation	-0.6%
11. Nonresidential Building Construction	-0.6%
12. Heavy and Civil Engineering Construction	-0.5%
71. Food Services and Drinking Places	-0.4%
70. Accommodation	-0.4%
45. Transit and Ground Passenger Transportation	-0.3%
Total top 10	-11.0%
Other industries	3.8%
Total Changes	-7.2%

Source: Own elaboration based on simulation.

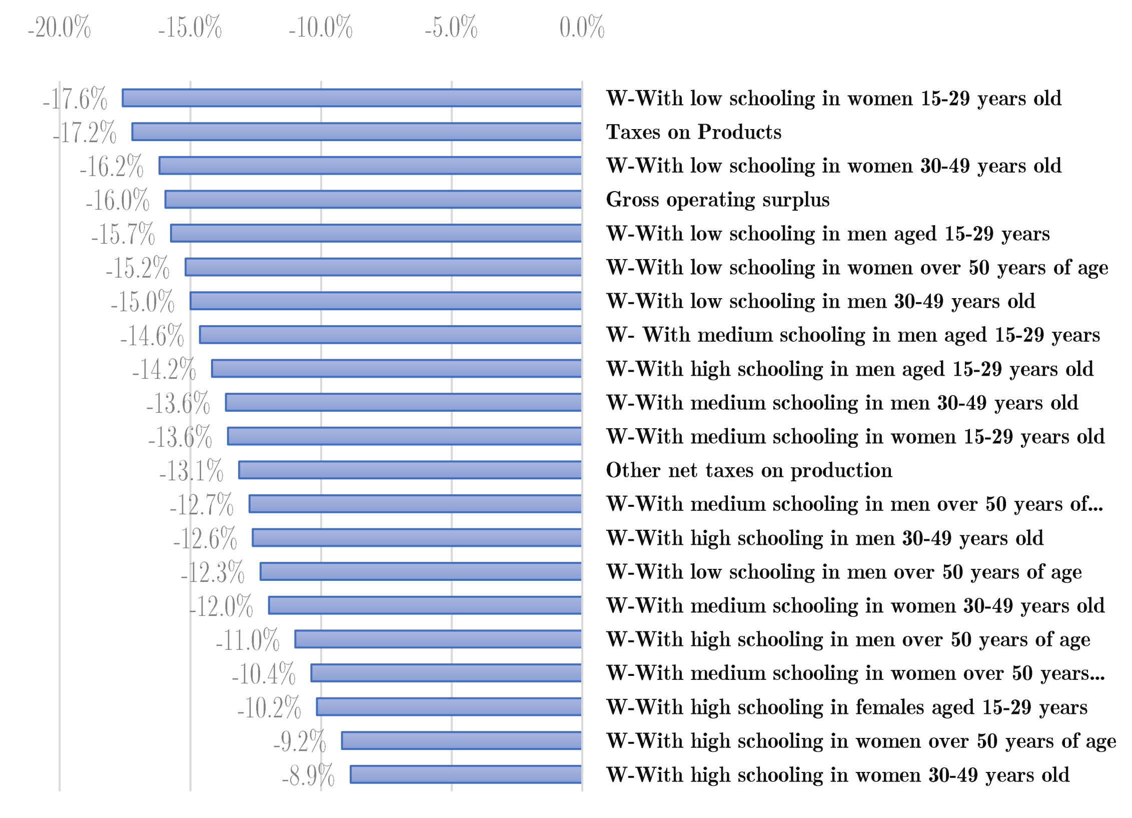
The industry with the highest contribution to GDP change is *40. Trade* (-4.2%). This effect of 40.Trade can be explained because commerce is "the bridge" between production and final demand. COVID-19 and its respective lockdown braked not only production but also final consumption. Thus, an adverse change in commercial trade significantly impacts the national GDP. In turn, as mentioned in the previous section, it is one of the productive sectors where more people are employed.

The second activity with the highest impact on the drop in GDP is Transportation Equipment Manufacturing, with a contribution of -1.8%. Mexico has a surplus trade only with a country, the USA, and 37*. Transportation Equipment Manufacturing* represents 90% of this surplus. Regarding the Rest of the World, Mexico has a trade deficit in this product, which is not surprising. Since the consolidation of NAFTA, the Mexican assemblers and maquiladoras of motor vehicles counted from 1,909 to 3,001 in 2003 and 2018, respectively. Thus, in 2021 Mexico was the seventh largest producer of motor vehicles after China. An adverse change in *37. Transportation Equipment Manufacturing* significantly impacts the Mexican GDP and the current balance.

Industries associated with real estate activities are among the top 10 industries with the greatest impact on Mexican GDP, according to the IEM simulation, including *57. Real estate services* with -0.9%. As seen above, this industry is the most affected by its final demand. *10. Residential Building Construction* entails a fall of -1.2% of Mexican GDP, while *11. Non-residential Building Construction* contributes by -0.6%. These four industries mentioned sum to -7.8%, more than the total estimated drop, offset by the direct, indirect, and induced positive effects that the lockdown caused to some industries.

Concerning variations in the generated income, results can be seen in Figure 2.2, where changes in primary inputs are observed. Regarding salary (W), the salaries associated with women between 15 and 29 years old with low schooling record the highest negative impact. Between this last and the salaries associated with women between 30-49 years of age with low education, which varies by -16.2%, taxes on products are in second place with a variation of -17.2%. Gross operating surplus ranks fourth with a fall of -16%.

Figure 2.2 *IEM estimates of the impact on primary income by institutional sector caused by Covid-19' lockdown in Mexico.*



Source: Own elaboration based on simulation.

The first male subgroup appears in fifth place. As in the case of women, the most affected are the salaries of young people with low education (-15.7%), followed by wages for men over 50 years of age (-15.2%) and wages for men with little schooling between 20 and 49 years of age (-15.0%). Only two groups have a drop in primary income of less than ten percentage points; in both cases, it is the salary for women with a high level of education. The least affected are those between 30-49 years of age; the second least affected are those with age greater than 50 years old.

These results coincide with the results obtained in a report for OECD member countries, which mentions that young people and people with low schooling are two overrepresented groups in jobs that cannot be carried out remotely during the pandemic period. The other group includes migrant workers with low wages and ethnic minorities (OECD, 2022). In addition, Deaton (2020) warned that this pandemic could be different from other centuries since pandemics historically tend to reduce inequality within an economic system.

However, this pandemic could be different, the author suggested, since the inequality of health systems and the precariousness of young workers with little education already existing prior to the pandemic make it difficult for inequality gaps to close, even more, when these groups of people are the least able to do remote work. In turn, the more unequal the functional distribution of income and its primary allocation, the more difficult it will be for a country to implement policies that reduce inequality.

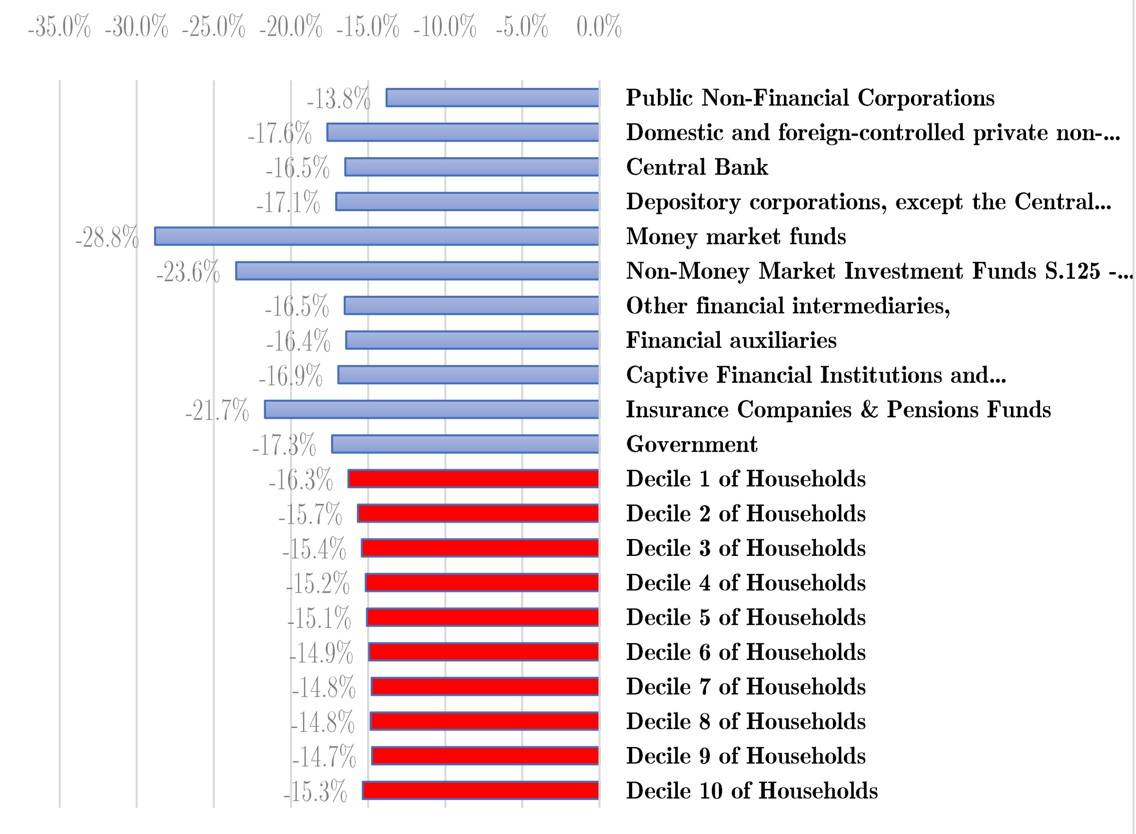
Remembering that the simulation carried out in this section does not contemplate the redistributive policies that the Mexican government implemented to help institutional sectors, particularly low-income households, to face the effects caused by the lockdown (i.e., by the interruption of income generation) it is possible to analyse the change in disposable income by institutional sector according to the IEM simulation. Figure 2.3 shows the change in disposable income in each institutional sector.

Although we focus on the analysis of household disposable income, it is worth highlighting some of the most significant changes in the rest of the subsectors. For example, the sector that varies its disposable income the least is *Public Non-Financial Corporations*. The above may be since a large part of the income of the economic units belonging to this subsector is set up in the federal expenditure budget. Three of the subsectors related to financial activities, *Financial auxiliaries; Other financial intermediaries; Captive Financial Institutions, and Moneylenders*, are the second that fell the least, with -16.4%, -16.5%, and -16.9%, respectively. In contrast, Money market funds are the sector with the most significant change (-28.8%).

In the case of households, the pure effect of the lockdown associated with Covid-19, that is, not taking into account the fiscal policies carried out by the Mexican government, results in the fact that decile I experience the most significant drop in disposable income (-16.3%). Meanwhile, decile X has a change of -15.3%. Furthermore, when the S90/S10 ratio is calculated, the estimated result shows that inequality would increase since the change in the said index is from 18.96 to 19.17. Furthermore, the *Palma index* (2014) augmented from 2.60 to 2.61[10]; both indices suggest a slight increase in inequality.

[10]The index is the ratio between the income share of the top 10% and the bottom 40%.

Figure 2.3 *IEM estimates of the impact on disposable income by institutional sector caused by Covid-19' lockdown in Mexico*



Source: Own elaboration based on simulation.

However, as mentioned in the previous section, the data observed are different. The Consejo Nacional de Evaluación de la Política de Desarrollo Social (CONEVAL), taking into account the transfers received from households to deal with the adverse effects caused by the lockdown, reported that the households' ratio S90/S10 in Mexico in terms of current income[11] passed from 24 to 22 (CONEVAL, 2021). However, this index was the same in the urban zones and equal to 20.

At this point, it is necessary to clarify that the ratios are not the same for 2018 because CONEVAL works with data from the Household Income Expenditure Surveys in Mexico, while the SAM works with the National Accounts. Moreover, given the high inequality in Mexico, matching the two data sources faces problems such as truncation and bias. This phenomenon occurs in almost all countries; to deepen this topic, see Atkinson et al. (2017), Alvaredo et al. (2021), and Törmälehto (2019).

CONEVAL argues that this fall in the S90/S10 ratio is due to a generalized fall in current income (-6.9%) that affected decile X to a greater extent since its average

[11] which means monetary income (labor remuneration, self-employment income, self-consumption, income from property rental and transfers) plus nonmonetary income (transfers in kind and gifts received in kind

income decreased by -10.6 %, while that of decile I decreased by -3.0%. In turn, between 2018 and 2020, the component of monetary income that had the second largest drop was remuneration for subordinate work (10.3%). Likewise, monetary transfers stood out with an increase of 16.2% (CONEVAL, 2021); these transfers made it possible to attenuate the pure effect of the lockdown that the IEM simulation shows. Another phenomenon that could have helped mitigate this pure effect is the growth in monetary income experienced by decile I, representing 4.2% of total current income to 50% (SHCP, 2022).

Although these economic policies could be captured in the IEM, however, the main objective of this work is to demonstrate the relevance of using the IEM to model supply shocks in an economy, with the advantages of having the circular flow of income endogenized in the system's structural matrix, the matrix of multiplier effects. It is possible to argue that the IEM has replicated the trends of the lockdown effects in Mexico, with an error of 1.1% in GDP estimation. The results in primary and disposable income by institutional sector correspond to the observed trends in the 'households' surveys, except for the phenomena, for example, the extraordinary transfers to households, that corrected economic policies that are not considered in our simulation.

2.2 Final Remarks

In this chapter, the pure impact of the COVID-19 lockdown was estimated for the Mexican economy using an inoperability extended multisectoral (IEM) model. The model parameters and lockdown duration are chosen in these simulations to represent 'the current state of the economy and government decisions. Indeed, this pandemic has put many countries worldwide in difficulty: governments have often prioritized the population's health or the economic crisis that will arise and which will, in any case, harm the population.

The simulation aims to estimate the "pure" impact of the lockdown', which should be the first estimate that a policymaker is interested in when a policy such as a lockdown is considered. The results suggest that the IEM model, under realistic assumptions, performs well. The advantage is that it provides results in disaggregated terms at the industry level and by each institutional sector.

In the case of GDP, the IEM's estimation equals a change of -7.2%, while the observed data was -8.5% (INEGI, 2020a). Therefore, our estimate is very close to other estimates close to the observed data. For example, the IMF (2020) forecasted a drop in Mexican GDP between -7.54 and -10.5%. On the other hand, Esquivel (2020) estimated, calculating the arithmetic mean, a fall in the Mexican GDP between -8.5% and -10.5%.

However, our estimation has desegregated results, so it is possible to identify the most affected industries or institutional sectors.

As expected, the most affected productive activities are those closed during the lockdown, but indirect impact effects can also be detected. Besides, the most affected industries are the most important regarding aggregate contribution to employment and GDP. Also, tertiary activities are more affected than the secondary and primary industries.

These results seem to be very realistic. Indeed, the IEM is helpful when the aim is to simulate an exogenous shock to quantify its pure effect (without considering the effect of economic policy that smooths the adverse lockdown consequences, which can be an extension of the model). It is possible to argue that the IEM has replicated the trends of the lockdown's effect in Mexico, with an error of 1.3% on the GDP estimation. The results in primary and disposable income by households correspond to the observed trends in the 'households' surveys, except for the phenomena, for example, the extraordinary transfers to households or the adjustment of the marginal propensity to consume of households given the fall in their disposable income, that corrected economic policies that are not considered in our simulation.

Besides, there is the advantage of understanding the direct and indirect effects of each productive activity through the interdependence between the different industries, linking the process of production with the processes of generation, distribution, redistribution, and use of income. Thus, the extended multisectoral model can highlight the impact and contribution of each industry at the macroeconomic level.

3. Mexico and the US: an analysis of the bi-regional income Macro Multipliers.

Introduction

North America has concluded two free trade agreements: the North American Free Trade Agreement (NAFTA), valid from 1994 to 2020, and the United States, Mexico, and Canada Agreement (USMCA), effective from 2020. Both excluded a free labor mobility. The agreements implied an accelerated economic opening of the goods and capital markets of the Mexican economy. Thus, the Mexican trade openness index has grown from 31 to 52, 61, and 82 points, respectively, for 1990, 2000, 2010, and 2018 (World Bank, 2022), which is considerably higher than that of its leading trading partner, the United States, whose index of trade openness for the same period has not exceeded 32 points.

NAFTA opened the door to the most significant market for Mexican goods. Although the NAFTA period (1994-2020) was characterized by a trade surplus for Mexico with the US, the US trade balance with Mexico varied from a surplus of 5.3 billion dollars in 1992 to a deficit of 123 billion dollars in 2014 (Ruiz-Nápoles, 2021). This shift was one of the main reasons the United States pushed to substitute NAFTA with the USMCA.

However, NAFTA created an economic constraint for the Mexican economy, subject to supply and demand shocks from the US. As a result, 80% of Mexican exports had the US as the destination, and 53% of its imports arrived from North America, while nearly 12% of total US exports had Mexico as the destination, and almost 11% of its imports supplied from Mexico, between 2015 and 2020 (INEGI, 2021; United Census Bureau , 2022).

This structural restriction on the Mexican economy does not have homogeneous effects on the economic system. Therefore, to understand at a disaggregated level the effects caused not only at the industrial level but also by each institutional sector(households, corporations, government), it is necessary to use a multisectoral approach.

However, recently, right after the start of the warlike conflict between Russia and Ukraine, if we consider the indirect relations between the US and China with Europe and Russia respectively, another front in the current trade war, high-tech goods, particularly semiconductors, could be considered. In this context, diplomatic tensions have risen between China and the United States, particularly over the Taiwan region, which controls 60% of the world's semiconductor production. The US is interested in reducing its trade deficit with Asia, particularly with China, as well as the dependence of this area on goods such as semiconductors or rare minerals, of which Mexico has some reserves.

Although USMCA has entered into force, many disputes continue to be resolved through bilateral visits between the US and Mexico. The industries involved are diverse: from the energy industry to mining, agriculture, and the automotive industry, and particular discussions concern the labor market. Notwithstanding these controversies, given the need for the US to reconfigure its pattern of trade partners and Mexico's high trade dependence on the United States, the only country with which it has a trade surplus, both countries have admitted that trade collaboration is desirable**Fuente especificada no válida.**. The idea of strengthening these relationships is to strengthen bi-regional production chains and increase their income.

This chapter studies the multipliers of income in the Mexico-U.S. Bi-region. The analysis was performed using a Bi-regional Social Accounting Matrix for Mexico-U.S. with 63 products, 53 industries, and five institutional sectors for 2017. The construction of this bi-regional SAM, using official information from INEGI and BEA, allowed the implementation of an extended multisectoral model (EMM) (Ciaschini & Socci, 2006), which considers not only income generation but also income redistribution and its use, treating them endogenously. The income multiplier analysis is performed with the Macro-Multiplier Approach (Ciaschini, 1993; Ciaschini & Socci, 2007).

There exist multisectoral studies for Mexico and the United States, e.g., Aroche-Reyes & Marquez-Mendoza (2016), Aroche-Reyes (2014), Ruiz-Nápoles (2010) use the Input-Output matrices separately or use bi-regional Input-Output matrices and thus classical I-O models. The innovation of this work consists of the use of the bi-regional Social Accounting Matrix and the application to the extended multisectoral model for this region. As mentioned above, this model captures the circular flow of income, endogenizing its redistribution and use for each of the economies considered.

The chapter has three sections, excluding this introduction. The first section summarizes the recent history and characterization of the bilateral trade between Mexico and the US. The second section, the methodological part, describes the BSAM MEX-US, its use in the extended model, and the results of the multiplier analysis. Finally, the last section collects the final remarks.

3.1 Characterization of the recent trade liberalization in Mexico and its bi-regional trade with the US

3.1.1 The effects of trade and financial liberalization in Mexico

The 1970s crisis that began in Europe, whose main characteristic was the rise in oil prices, impacted Latin America until the 1980s. The second oil crisis had substantial implications for developed economies, increasing the benchmark interest rate and provoking a rise in interest rates on bank debt by up to 20%. The decline of exports in Latin America and the high levels of indebtedness acquired during the previous decade would trigger the 1982 debt crisis in that region, thus ending the period of growth through indebtedness (Bulmer-Thomas, 2017).

Liberal macroeconomic adjustments were conducted on the International Monetary Fund's (IMF) impulse. The package of policies was called the Structural Adjustment Programme (SAP), which brought into force trade liberalization characterized by the depreciation of the real exchange rate and unification of nominal exchange rates, the emphasis on the private sector as a source of growth, including privatization of State enterprises, and a general reduction of all forms of State intervention in primary factors markets, and strictly control on the overall level of taxes and government expenditures (Sachs, 1987). Mexico implemented the Structural Adjustment after two economic shocks. The first was the debt crisis in 1982, which limited the external credit for Mexico; the second was the oil crisis in 1986, which limited one of the primary sources of Mexican government revenue. Thus, the 1980s were called the lost decade (Moreno & Ros, 2004).

The Mexican open trade process was intensified with the signature and implementation of the North American Free Trade Agreement (NAFTA) in 1993 and 1994, which created a free trade zone between the United States, Mexico, and Canada, excluding the labor market and energy resources. As a result, many works studied the economic impact of Mexico's accelerated and indiscriminate trade liberalization and financial deregulation.

Moreno-Brid & Ros (2004) summarize the intense privatization process that started in 1983. The argument was that Foreign Direct Investment (FDI) attracts high technology and generates employment, increasing competitiveness. However, the privatization process caused a contraction of public investment, representing 43% of total investment in 1980, to levels close to 13% in 2003. In 1989, a new FDI law was enacted abolishing the 1973 law restrictions (Lustig, 2000), followed by a more ambitious reform in 1993 that abolished the limit of 49% of FDI participation in the investment. The above prepared the field for NAFTA, which increased by 554% in FDI in 1994 compared to 1980.

The FDI flows, as the primary destination, the Northern part of Mexico, where the manufacturing process occurs through maquiladoras. During the 1990s, the maquila's participation in manufacturing passed from 15% to 40% at the end of the decade (Rodríguez, 2009). Subsequent reforms have liberalized the capital market. According to UNCTAD (2014), Mexico ranked 13th as a recipient country of FDI in 2014.

The NAFTA allowed an increase in Mexican exports by accessing the largest market in the world (the US). Thus, the average annual variation of Mexico's exports was 11.9%, 6.1%, and 8.4% for the periods 1970-1981,1982-1993 and 1993-2000, respectively, which implies that the trade balance of the United States concerning Mexico went from a surplus of 5.3 billion dollars in 1992 to a deficit of 123 billion dollars in 2014 (Ruiz-Nápoles, 2021).

However, Ruíz-Nápoles (2017) shows that this "boom" in Mexican exports was not accompanied by a proportional increase in the average annual variation of Gross Domestic Product (GDP) since the average annual variation of GDP was 6.9%, 1.7 %, and 2.6% for the periods 1970-1981,1982-1993, and 1993-2000, respectively. In the case of employment, the individual variations were 4.8%, 2%, and 1.4%. In other words, the increase in exports of goods did not imply proportional employment and economic growth in the case of Mexico.

As for the labor market, the boom in Mexican exports entailed a substitution of domestic employment with foreign employment (Ruiz-Nápoles, 2004; 2021) and the precariousness of the remuneration of the jobs created in Mexico during the period of commercial and financial liberalization (Romero, et al., 2005; Ros, 2015). Valle (1994) argues that the following mechanism can explain the contraction in real Mexican salaries. First, the maquiladoras import semi-finished materials from the US, the most productive country, and add a significant part of the wage cost in Mexico, a low-wage country. The above means that the difference in productivity implies that Mexico makes its labor market more flexible to keep its labor costs substantially lower than the US.

However, the wages began to stagnate in 1987, with the Economic Solidarity Pact, an unorthodox measure for rising inflation; that is, they stopped seeking to index wages to price levels, whose annual inflation rate had reached 160% in that year. Thus, the pact aimed to control inflation by freezing the exchange rate, wages, and prices of goods consumed by workers, mainly public rates (Moreno & Ros, 2010). The rhetoric that the salary should correspond to labor productivity started from these changes. However, Romero, Puyana, & Dieck (2005) show that real wages declined between 1980 and 1988. Between 1988-2000, real wages recovered without reaching the previous levels, and they warn that this recovery of real wages would indicate that structural reforms had results and, therefore, productivity and wages began to grow. However, it is not so.

Regarding labor productivity, various studies were carried out at different industrial levels and for different periods between 1970 and 2009. In general terms, these studies indicate that, in the case of Mexico, there is a correspondence between the movements of productivity and wages (Cruz, 1993) in the boom and bust periods of the ISI model (1979-1980). In the liberalization period, there was a drop in productivity, especially in the 1980s (Ros, 1994), offset by an increase in the population's share of employment to produce a practically constant per capita income (Romero, Puyana, & Dieck, 2005).

In turn, the sectoral behavior is heterogeneous. Tradable goods, for example, transport equipment, oil and derivatives, chemical products (Dussel Peters, 1994), or capital goods (Moreno & Ros, 2010), show improvements in labor productivity. However, these improvements were punctual and not sustainable in the long term (Ros, 1995).

Katz (2000) characterized Mexico's new export vocation: the Mexican maquila generated nearly a million new jobs during the 1990s. Maquiladoras produce almost entirely to satisfy the corporate strategy of large US, Japanese and Korean companies that compete closely in the US domestic market. They used state-of-the-art technologies and sophisticated supply logistics based on synchronization with demand (just-in-time) for parts and components, total quality techniques, Kanban, and others, but paying salaries that are only a fraction not greater than 10% of wages in developed countries.

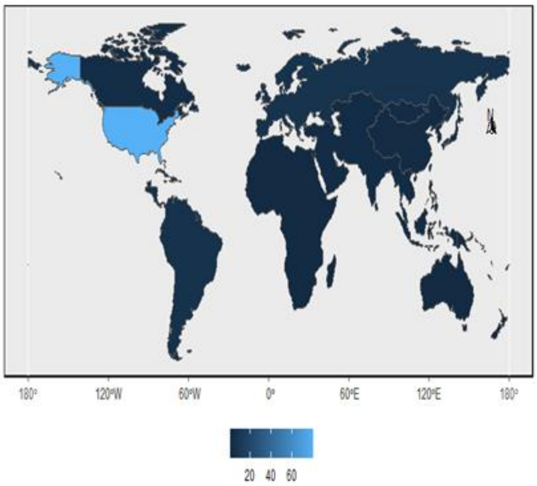
3.1.2 The recent trade between Mexico and the US

The precedent section allows us to understand why the Mexican trade surplus with the US imposes a vulnerability with respect to any economic shock in the US on the Mexican economy. The Mexican trade volume exacerbates vulnerability, and the deficit status with the Rest of the World, except the US Figure 3.1 shows the goods export and import structure by share and destination and the trade balance as a share of GDP for Mexico and the US for 2015-2020.

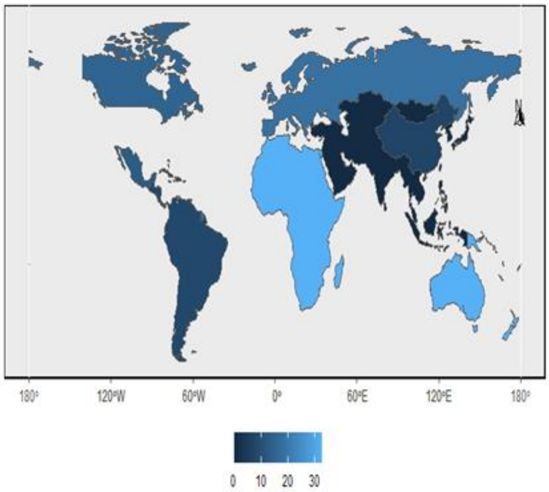
In Figure 3.1 *Mexico and the US Structure of International trade of goods of 2015-2020*, it is possible to observe that Mexican international trade depends almost exclusively on the US market: 80% of Mexican exports as the destination to the US; Mexican exports to Europe represent nearly 5% of the total, the same case for the exports to Latin-America; exports to Canada represent close to 2.7% of the total, exports to China represent1.79% of the total. In the case of Mexican imports, the United States is the leading supplier with 57% of total imported goods, the second supplier of Mexican imports is China, with a share of 16% of total imports, and Europe has a share of 11% of Mexican imports.

Figure 3.1 *Mexico and the US Structure of International trade of goods of 2015-2020.*

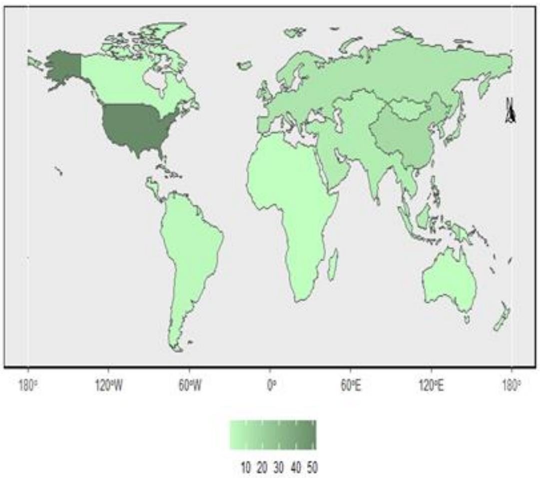
Mexico. Structure of the exports
(Percentage points)



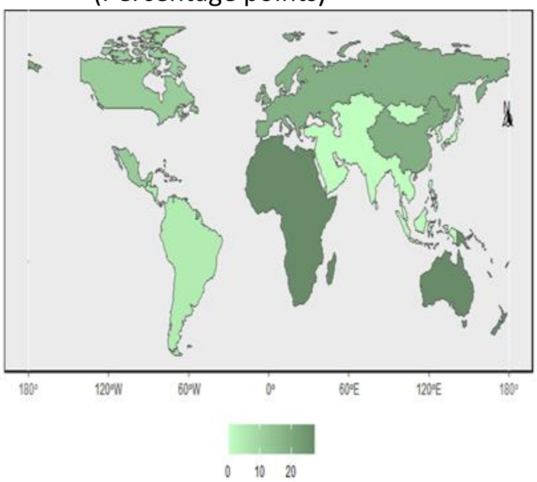
The US Structure of the exports
(Percentage points)



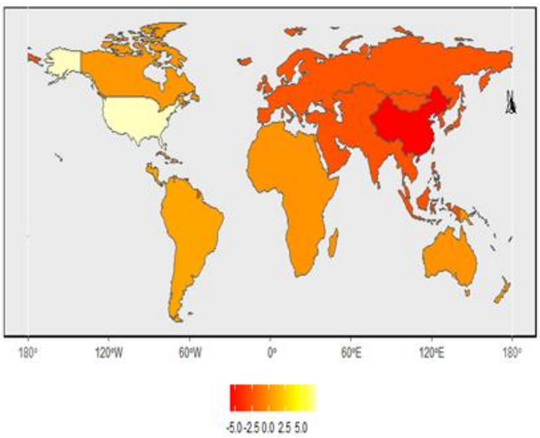
Mexico. Structure of the imports
(Percentage points)



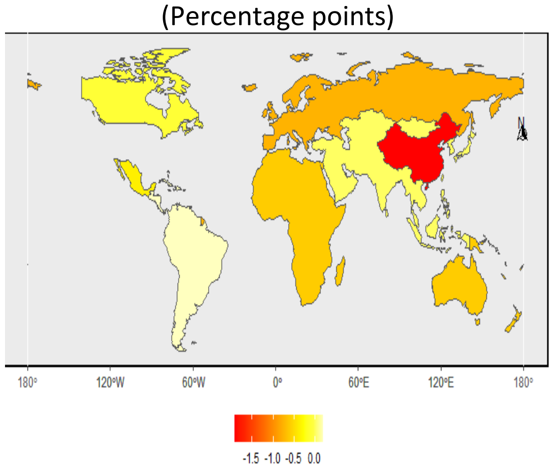
The US Structure of the imports
(Percentage points)



Mexico. Trade Balance by region as a share of GDP
(Percentage points)



The US Trade Balance by region as a share of GDP
(Percentage points)



Source: Authors' elaboration based on INEGI, Banxico, and BEA information.

Thus, in the case of the trade balance, Mexico has a surplus with the US, Canada, and Latin America. As a result, the surplus as a proportion of Mexican GDP is close to 6.0%, 0.13%, and 0.71%, respectively. However, Mexico has a trade deficit with China, Asia (excluding China), and Europe that represents nearly -5.0%, -2.6%, and 2.5% of Mexican GDP, nullifying the effect of the surplus with the United States. Thus, the total trade deficit of Mexico represents close to -2% of its GDP.

Regarding the US, it is possible to observe that its structure of international trade is more diversified, unlike Mexico: 32% of total US exports has as a destination Africa and Oceania, 18% of the US exported goods have as a destination Europe; the US exports to Canada represent close to 15% of the total, and Mexico represents 12%, and the exports to China represent 7%. In the case of the US imports, Africa and Oceania are the leading suppliers, with a share of 27% of total US imports, and China is the second supplier with 19% of total imported goods, followed by Europe with a share of 16% of the total US imports, and Canada and Mexico with a share of 11%, respectively. Unlike Mexico, the US has a deficit with all countries; the most significant regards China, which represents close to 1.9% of the US GDP, followed by the deficit with Europe, which represents -0.76% of the US GDP. It is essential to clarify that this deficit of the US is reduced when the US services trade balances are included. However, the status of the deficit does not change.

Figure 3.2 *The mean annual trade balance 2011-2021 by-product between Mexico and the US as percentage points of their respective GDP*shows the mean annual trade balance 2011-2021, by product[12], between Mexico and the US in percentage points of their respective GDP. Again, it is evident that the Mexican economy trade surplus with the US is significant, representing close to 6% of its GDP. On the other hand, in the case of the US economy, the trade deficit with Mexico represents only -0.4% of its GDP. Nevertheless, the heterogeneity of this participation gives more information about the trade structure between Mexico and the US.

Also, Figure 2 shows the heterogeneity of the trade structure between Mexico and the US. Although, for example, Transportation equipment explains 90% of the surplus with the US, with the Rest of the World, Mexico has a trade deficit in this product; this is not a surprise. Since the consolidation of NAFTA, the Mexican assemblers and maquiladoras of motor vehicles passed from 1,909 to 3,001 in 2003 and 2018, respectively. Thus, in 2021 Mexico was the seventh largest producer of motor vehicles after China, the US, Japan, Germany, Korea, and India (Carrillo & De los Santos, 2022). The reform of FDI in 1993 (Moreno & Ros, 2004), the closeness with the US market, and the salary gap concerning the US motor vehicle industry (Valle, 1994; Crossa & Wise, 2022), and

[12] In Figure 3.2 the products classification corresponds to the North America Industrial classification to 3 digits, while for the Bi-regional Mexico-USA Social Accounting Matrix the same code was extended to 4 digits, so that it is more disaggregated. The level of disaggregation does not change the qualitative characteristics of the trade structure but only gives more detail.

consequently, the functional distribution in favor of gross operating surplus and not salaries in Mexico (Ruiz-Nápoles, 2021) can explain the growth of this Mexican product and its importance in the trade with the US.

Figure 3.2 *The mean annual trade balance 2011-2021 by-product between Mexico and the US as percentage points of their respective GDP.*

Product by North American Industrial System (3 digits)	U.S trade balance with Mexico as a percentage of its GDP	Mexico's trade balance with the U.S. as a percentage of its GDP
Farms	-0.02	0.3
Forestry Products	0	0
Fish, Fresh/chilled/frozen & Other Marine Products	0	0.04
Oil & Gas	-0.08	1.2
Minerals & Ores	0.01	-0.14
Food & Kindred Products	0.02	-0.24
Beverages & Tobacco Products	-0.02	0.36
Textiles & Fabrics	0.01	-0.22
Textile Mill Products	0	0.02
Apparel & Accessories	-0.01	0.23
Leather & Allied Products	-0.01	0.1
Wood Products	0	-0.04
Paper	0.02	-0.3
Printed Matter And Related Products, Nesoi	0	-0.01
Petroleum & Coal Products	0.1	-1.61
Chemicals	0.1	-1.52
Plastics & Rubber Products	0.03	-0.4
Nonmetallic Mineral Products	-0.01	0.1
Primary Metal Mfg	0	0
Fabricated Metal Products, Nesoi	0.01	-0.14
Machinery, Except Electrical	0.01	-0.12
Computer & Electronic Products	-0.1	1.51
Electrical Equipment, Appliances & Components	-0.06	0.94
Transportation Equipment	-0.36	5.65
Furniture & Fixtures	-0.01	0.17
Miscellaneous Manufactured Commodities	-0.02	0.29
Newspapers, Books & Other Published Matter, Nesoi	0	0
Waste And Scrap	0	-0.02
Used Or Second-hand Merchandise	0	0
Used Or Second-hand Merchandise	0	-0.04
Goods Returned (exports For Canada Only)	-0.03	0.5
Other Special Classification Provisions	0.02	-0.39
Total	-0.4	6.23

Source: Authors' elaboration based on INEGI, Banxico, and BEA information.

Two other products with which Mexico has a considerable trade surplus with the USA are Machinery, except Electrical, and Oil and Gas. The second product is particular for the Mexican economy. Even if Mexico does not belong to the top 10 countries which conform to the 86% (BP, 2021) of the global oil proved reserved for 2020, the Mexican oil proved reserves represent 0.3% of them.

The above allows Mexico to export crude oil, but Mexico needs to import gasoline because it does not have a domestic refining system. Therefore, imports of gasoline mainly come from the USA; thus, in the case of products with a trade deficit with the USA, Mexico has the most significant deficit in Petroleum and Coal Products, explaining 31% of the negative balance with the USA, while Chemical products explain 29% of the same variable. The above means that the trade between Mexico and USA is highly concentrated in five products, where the product Transportation equipment represents an essential product for Mexico in its direct trade with the USA for the trade surplus it generates. In contrast, Petroleum and Coal Products represent a counterbalance for this surplus.

In summary, associated with this heterogeneous and concentrated Mexican trade structure, the Mexican economy has the following structural problems: low capital accumulation and, consequently, low growth (Ros, 2015; Ros, 2013); vulnerability to external shocks (Moreno & Ros, 2010; Ruiz Nápoles, 2017) that comes, mainly, from its leading trading partner, the USA; the flexibilization of the labor market in the Mexican economy to counteract the productivity gap and low capital accumulation (Cerezo-García, et al., 2022) , which contributed to increase the inequality of income distribution in Mexico, which has regressive process since 1963 (Cortés, 2017).

3.2 Income Macro multiplier analysis on a Bi-regional Mexico-US Social Accounting Matrix for Mexico and the US

3.2.1 An extended multisectoral model for Mexico and US

It is becoming increasingly crucial for economic studies to consider that the effect of the primary and secondary income distribution on disposable income is not irrelevant. This process transforms primary income into disposable income, which is susceptible to being used or saved. Moreover, the distribution of income involves transfers between institutional sectors, where the State, through fiscal policy, particularly the taxation system, could have a powerful instrument to change the income distribution determined by the functional income distribution and the institutional framework (Lustig, 2017; 2020).

Therefore, it is crucial to capture how the taxes and transfer structure changes the distribution between the primary and disposable income, not only for theoretical and modeling aims. From 1970 to 2014, the functional income distribution was regressive. For example, in the case of developed countries, the share of workers' income in the

National Income went from 55 percentage points to 39.5 percentage points. In the case of emerging markets or developing countries, the share was never over 50 percentage points (Karabarbounis & Neiman, 2014). Therefore, it becomes relevant to synthetically capture the effects of the tax and transfer structure on income distribution and the link between the latter and its use or saving.

The case of studies that implement multisectoral models cannot be the exception. They should also consider the distributive processes that better capture the direct, indirect, and induced effects caused by a shock in an economic system, unlike classical open Input-Output models. Under this consideration, Ciaschini & Socci (2006; 2007) proposed an extended multisectoral model using the Social Accounting Matrix.

Socci (2004) applied the extended multisectoral model to a bi-regional SAM for Italy. This work will apply to a Bi-regional Social Accounting Matrix Mexico-USA for 2017, which considers 63 products (see Appendix III) and five institutional sectors: households, non-financial corporations, financial corporations, the federal government, and local and state governments. This SAM was constructed by using the information of BEA and INEGI.

Figure 3.3 shows the structure of the Bi-regional Social Accounting Matrix Mexico-USA, where, $\mathbf{X^{i,j}}$ is the supply table of order 53×63, which contains the output used by region j and supply for region i; $\mathbf{Z^{i,j}}$ is the intermediate use table of order 63×53 that contains the intermediate inputs used by region j and supply for region i; $\mathbf{tm^{i,j}}$ is the vector of trade margins; $\mathbf{t^{i,j}}$ is the vector of taxes on products; $\mathbf{t.inc^{i,j}}$ is the vector of taxes on income; $\mathbf{F^{i,j}}$ is the matrix of Final Demand of order 63×5; $\mathbf{K^{i,j}}$ is the matrix of Gross Fixed Capital Formation of order 63×5; $\mathbf{V^{i,i}}$ is the matrix of gross Value Added to order 4×5 ; $\mathbf{H^{i,j}}$ is the matrix of primary allocation of income of order 5×4, or well $\mathbf{h^{i,j}}$ is a vector; $\mathbf{T^{i,i}}$ is the matrix of transfers between institutional sectors or well as vector[13] $\mathbf{t^{i,j}}$; $\mathbf{imp^{i,j}}$ Is the vector of imports from region i to region j , in the analogous form $\mathbf{exp^{i,j}}$, the vector of exports; $\mathbf{s^{i,j}}$ is the vector of saving and; $\mathbf{a^{i,j}}$, the current balance vector.

By using the Bi-regional Social Accounting Matrix Mexico-USA described in Figure 3.3 and transforming its Make and Use framework into a Symmetric product by product Bi-regional SAM of order 63×63, it is possible to apply the bi-regional extended multisectoral model, which is described as follows[14]:

[13] In our study case, $\mathbf{T^{MX,USA}}$ captures the remittances from USA to Mexico. According to the Central Bank of Mexico, total remittances from the US to Mexico represented 1.7% of Mexican GDP. In 2017, it raised to 2.7% and in 2021 it represented 4% of GDP. Therefore, the main source of this income is the US, close to 95% of the total.

[14] The construction and development of the model can be found in detail and explicitly in Socci (2004) and in the first two chapters of this thesis.

$$\begin{bmatrix}\mathbf{x}^{\mathrm{MX}}\\ \mathbf{x}^{\mathrm{USA}}\end{bmatrix}=\left\{\begin{bmatrix}\mathbf{I}-\mathbf{A}^{\mathrm{MX,MX}} & -\mathbf{A}^{\mathrm{MX,USA}}\\ -\mathbf{A}^{\mathrm{USA,MX}} & \mathbf{I}-\mathbf{A}^{\mathrm{USA,USA}}\end{bmatrix}-\begin{bmatrix}\mathbf{F}^{\mathrm{MX,MX}} & \mathbf{F}^{\mathrm{MX,USA}}\\ \mathbf{F}^{\mathrm{USA,MX}} & \mathbf{F}^{\mathrm{USA,USA}}\end{bmatrix}(\mathbf{I}+\mathbf{T})\mathbf{PWL}\right\}^{-1}\mathbf{f}^{*} \qquad \text{[III. 1]}$$

$$\begin{bmatrix}\mathbf{x}^{\mathrm{MX}}\\ \mathbf{x}^{\mathrm{USA}}\end{bmatrix}=\left\{\begin{bmatrix}\mathbf{I}-\mathbf{A}^{\mathrm{MX,MX}} & -\mathbf{A}^{\mathrm{MX,USA}}\\ -\mathbf{A}^{\mathrm{USA,MX}} & \mathbf{I}-\mathbf{A}^{\mathrm{USA,USA}}\end{bmatrix}-\begin{bmatrix}\mathbf{F}^{\mathrm{MX,MX}} & \mathbf{F}^{\mathrm{MX,USA}}\\ \mathbf{F}^{\mathrm{USA,MX}} & \mathbf{F}^{\mathrm{USA,USA}}\end{bmatrix}(\mathbf{I}+\mathbf{T})\mathbf{PV}\right\}^{-1}\mathbf{f}^{*} \qquad \text{[III. 2]}$$

$$\begin{bmatrix}\mathbf{x}^{\mathrm{MX}}\\ \mathbf{x}^{\mathrm{USA}}\end{bmatrix}=\begin{bmatrix}\mathbf{R}^{\mathbf{MX,MX}} & \mathbf{R}^{\mathbf{MX,USA}}\\ \mathbf{R}^{\mathbf{USA,MX}} & \mathbf{R}^{\mathbf{USA,USA}}\end{bmatrix}\mathbf{f}^{*} \qquad \text{[III. 3]}$$

$$\begin{bmatrix}\mathbf{x}^{\mathrm{MX}}\\ \mathbf{x}^{\mathrm{USA}}\end{bmatrix}=\begin{bmatrix}\mathbf{x}^{\mathrm{MX}}\\ \mathbf{x}^{\mathrm{USA}}\end{bmatrix}=\mathbf{R}_{\mathrm{B}}\,\mathbf{f}^{*} \qquad \text{[III. 4]}$$

Where $\mathbf{x}^{i}$ represents the gross output vector of country i; $\mathbf{A}^{\mathbf{i,j}}$ is the matrix of intermediate consumption of region i of intermediate goods from the region j. $\mathbf{F}^{\mathbf{i,j}}$ is the matrix of endogenous aggregate final demand coefficients by the institutional sectors of region i for final products from region j. $\mathbf{T}$ is a matrix that contains net taxes and transfers constant shares that each institutional sector receives from the remaining institutional sectors, and $\mathbf{I}$ is the identity matrix. In turn, $\mathbf{P}$ is a matrix that represents the constant share of value added by each institutional sector in the process of the primary allocation of income. $\mathbf{W}$ is a matrix of the value-added components in the bi-regional economy; $\mathbf{L}$ is a diagonal matrix whose elements give the constant share of value added relative to gross output for each product in the bi-regional economy. Finally, $\mathbf{V} = \mathbf{WL}$.

$\mathbf{R}_{B}$ is the structural matrix of the Bi-regional system, where the subindex B represents the bi-regional dimension. Thus, the matrix of extended multipliers, which describes the functional income distribution and consumption, adds to the process of the income distribution, which means taking into account the transformation of primary income into disposable income and its use expressed in the endogenous final demand and in $\mathbf{f}^{*}$, is the vector of the exogenous final demand. The vector of the exogenous final demand allows the model to capture potential shocks and effects on both economies.

Following Miyazawa & Masegi (1963) and the theorem in Hoffman, Kunze, & Finsterbusch **Fuente especificada no válida.**, the structural matrix $\mathbf{R}_{\mathrm{B}}$ of equation [III. 4] can be expressed as follows:

$$\begin{aligned}\mathbf{x} &= (\mathbf{I}_{B}-\mathbf{A}_{B}-\mathbf{F}_{B}\,(\mathbf{I}+\mathbf{T})\,\mathbf{PV})^{-1}\mathbf{f}^{*} \qquad \text{[III. 5]}\\ &= \left[\{\mathbf{I}_{B}-\mathbf{F}_{B}(\mathbf{I}+\mathbf{T})\,\mathbf{PV}(\mathbf{I}_{B}-\mathbf{A}_{B})^{-1}\}(\mathbf{I}_{B}-\mathbf{A}_{B})\right]^{-1}\mathbf{f}^{*}\\ &= (\mathbf{I}_{B}-\mathbf{A}_{B})^{-1}\left(\mathbf{I}_{B}-\mathbf{F}_{B}(\mathbf{I}+\mathbf{T})\,\mathbf{PV}(\mathbf{I}_{B}-\mathbf{A}_{B})^{-1}\right)^{-1}\mathbf{f}^{*}\\ &= \widetilde{\mathbf{R}}_{B}\left(\mathbf{I}_{B}-\mathbf{F}_{B}(\mathbf{I}+\mathbf{T})\,\mathbf{PV}\widetilde{\mathbf{R}}_{B}\right)^{-1}\mathbf{f}^{*}\end{aligned}$$

$$= \widetilde{\mathbf{R}}_B \mathbf{\Psi} \mathbf{f}^*$$

It implies that gross output can be decomposed into two matrices and one vector. Matrix $\widetilde{\mathbf{R}}_B$ represents the direct and indirect requirements of industry output per unit of aggregate final demand, it means the Leontief multiplier matrix.

Matrix $\mathbf{\Psi}$ is a subjoined inverse that shows the effect of the endogenous changes in final consumption by institutional sectors, considering the functional income distribution. Thus, in aggregate terms, the matrix $\mathbf{\Psi}$ represents the Keynesian multiplier of income (Keynes, 1936; Miyazawa, 1976), but it incorporates the direct and indirect effects of the inter-industrial system. Moreover, if the investment is endogenized in the EMM, it can be read as the accelerator of income multipliers.

Figure 3.3 *Structure of the Bi-regional Social Accounting Matrix Mexico-USA for 2017.*

		MX Goods and services	MX Production	MX Trade Margin	MX Primary Factors	MX Tax on products	MX Tax on incomes	MX Institutional Sector	MX Capital Account	USA Goods and services	U.S. Production	U.S. Trade Margin	U.S. Primary Factors	U.S. Tax on products	U.S. Tax on incomes	U.S. Institutional Sector	U.S. Capital Account	RoW Rest of the World
MX	Goods and services		$Z^{MX,MX}$					$F^{MX,MX}$	$K^{MX,MX}$		$F^{MX,U.S}$					$F^{MX,U.S}$	$K^{MX,U.S}$	$exp.^{MX,RoW}$
MX	Production	$X^{MX,MX}$																
MX	Trade Margin	$tm^{MX,MX}$																
MX	Primary Factors		$V^{MX,MX}$															1,973
MX	Tax on products	$t^{MX,MX}$	-															
MX	Tax on income							$t.inc.^{MX,MX}$										
MX	Institutional Sector				$H^{MX,MX}$	$t^{MX,MX}$	$t.inc.^{MX,MX}$	$T^{MX,MX}$								$T^{MX,U.S}$		$t.inc.^{MX,RoW}$
MX								$s^{MX,MX}$										$a^{MX,RoW}$
U.S.	Goods and services		$Z^{U.S.,MX}$					$F^{U.S.,MX}$	$K^{U.S.,MX}$		$Z^{U.S,U.S}$					$F^{U.S,U.S}$	$K^{U.S,U.S}$	$exp.^{U.S,RoW}$
U.S.	Production									$X^{U.S,U.S}$								
U.S.	Trade Margin									$tm^{U.S,U.S}$								
U.S.	Primary Factors										$V^{U.S,U.S}$							
U.S.	Tax on products									$t^{U.S,U.S}$								
U.S.	Tax on income															$t.inc.^{U.S,U.S}$		
U.S.	Institutional Sector							$T^{U.S,MX}$					$H^{U.S,U.S}$	$t^{U.S,U.S}$	$t.inc.^{U.S,U.S}$	$T^{U.S,U.S}$		$t.inc.^{U.S,RoW}$
U.S.																$s^{RoW,U.S}$		$a^{U.S,RoW}$
RoW	Rest of the World	$imp.^{RoW,MX}$			$h^{RoW,MX}$			$t^{RoW,MX}$		$imp.^{RoW,U.S.}$			$h^{RoW,U.S.}$		$t.inc.^{RoW,U.S}$	$t.^{RoW,U.S}$		

Source: Authors' elaboration.

3.2.1 The Macro-Multiplier Approach: the Singular Value Decomposition on a structural multiplier matrix

The classical approach to multipliers in Input-Output analysis (Chenery & Watanabe, 1958; Rasmussen, 1956) uses the sum of columns of structural matrices to analyze the multiplier effects in the multisectoral models. In this case, the analysis assumes that the exogenous final demand in each productive sector or product grows uniformly. However, neither the demand vector nor its changes will ever assume a structure of this type. Therefore, some authors conclude that multipliers should never be used (Skolka, 1986).

Thus, Ciaschini (1993) and Ciaschini & Socci (2007) suggest an alternative form to evaluate the multiplier effects of a structural matrix. This approach was called the Macro-Multipliers (MM), which uses the Singular Value Decomposition SVD (Lancaster & Tismenetsky, 1985). This methodology can be applied to positive or semi-positive definite matrices, the structural matrices $\mathbf{R}$, which are nonnegative matrices, so that it is possible to follow the propagation of induced effects from final demand to gross output or the income.

The SVD is a process that allows factorizing a nonnegative matrix into three matrices[15]. For example, the structural matrix $\mathbf{R}$ has a square matrix $\mathbf{W}$ defined by:

$$\mathbf{W} = \mathbf{R}'\mathbf{R}\,, \qquad \text{[III. 6]}$$

Where $\mathbf{W}$ has a positive definite or semidefinite square root $\mathbf{W}^{\frac{1}{2}}$: it implies that its eigenvalues are real and nonnegative (Lancaster & Tismenetsky, 1985). Simultaneously, the eigenvalues of $\mathbf{W}$ and $\mathbf{W}'$ coincide (Ciaschini & Socci, 2007). Therefore, it is possible to decompose a structural matrix from matrix $\mathbf{R}$ by

$$\mathbf{R} = \mathbf{USV}', \qquad \text{[III. 7]}$$

where $\mathbf{U} \in \mathbb{R}$ and $\mathbf{V} \in \mathbb{R}$ are orthogonal matrices; $\mathbf{U}$ contains the left singular vectors, which means the eigenvectors of the matrix $\mathbf{R}'\mathbf{R}$; while $\mathbf{V}$ contains the right singular vector, it means the eigenvectors of matrix $\mathbf{W}$ (Biswa-Nath, 2004).

The matrix $\mathbf{S} \in \mathbb{R}$ has essential properties. It is a diagonal matrix with nonnegative diagonal entries in decreasing order, called singular values $\{s_j \mid j = 1, \dots, n \rightarrow s_i > 0\}$ of $\mathbf{R}$, which are the square roots of the eigenvalues of matrix $\mathbf{W}$. At the same time, these singular values coincide with the $\mathbf{R}'$ (Ciaschini, 1993). Using the Perron-Frobenius theorem or Frobenius' version of the Perron Theorem, it is possible to state that the highest eigenvalue of the matrix $\mathbf{W}^{\frac{1}{2}}$, that is, the singular value s_1 of $\mathbf{R}$ has

[15] However, the SVD is not exclusive to the nonnegative square matrices. Stewart (1993) summarizes the development of this topic to the real matrices and the contributions of Beltrami (1873), Jordan in 1874, Sylvester in 1889 and Schmidt 1889. The SVD can be applied also to the Hermitian matrices and the non-Hermitian matrices (Eckart & Young, 1939).

associated a right an left eigenvector whose elements have a concordant sign (Hawkins, 2008; Nikaido, 1960). Therefore, $\mathbf{S} = \{\mathbf{s}_j\}$ contains the n elements which detect the effect on the input variable to obtain the output variable.

Thus, in economic terms, for the case of matrices $\mathbf{R}$, the respective matrix $\mathbf{V}'$ indicates the n reference structures for final demand, and $\mathbf{U}$ indicates the n reference structure of gross output, and it implies that the elements of the respective matrix $\mathbf{S}$ contain the macro multipliers of gross output.

Thus, using the jth column of matrices $\mathbf{S}$ and $\mathbf{U}$ and the ith row of matrix $\mathbf{V}'$ in equation 2.1, $\mathbf{R}$ can be defined by:

$$\mathbf{R} = \sum_{i,j=1}^{n} \mathrm{s}_j\, \mathbf{u}_j \mathbf{v}_i' \,, \tag{III. 8}$$

If the vectors and the scalar of equation 25 with $\boldsymbol{i}, \boldsymbol{j} = \mathbf{1}$ are taken, the first structure of the SVD is defined by:

$$\mathbf{R_1} = \mathrm{s}_1 \mathbf{u}_1 \mathbf{v}_1' \,, \tag{III. 9}$$

thus, $\mathbf{v}_1'$ and $\mathbf{u}_1$ represent the structure of the input variable (final demand) and the structure of the output variable (gross output) that are most sensible with respect to the specific macro multiplier s_1 (Socci, 2004). The matrix $\mathbf{R_1}$ is the first structural matrix of the bi-regional economy Mexico-USA, suggested by the MM approach. It incorporates the effects on the Mexican and the US systems, depending on the number of rows or columns. In the case of equation 2.4, when a unit of the exogenous final demand takes the structure of $\mathbf{v}_1'$, the ratio between the Euclidian module of the resultant vector of gross output $\|\mathbf{x}_1\|$ and the vector of the input variable $\|\mathrm{v}_1\|$ of structure $\boldsymbol{R_1}$ is equal to s_1. But, the observed exogenous final demand vector f^* may take the structure of v_1', resulting in a new vector $\bar{\mathrm{f}}_1$: final demand is expressed in terms of structures suggested by $\mathbf{v}_1'$. However, the ratio between the Euclidian module of the resultant output variable $\|\mathbf{x}_1\|$ and the Euclidian module of the input variable $\|\bar{\mathbf{f}}_1\|$is the same, that is, is equal to s_1.

Considering the adequate number of structures to evaluate the multiplier effects under the MM approach is appropriate. Following Basilevsky (1983), Socci (2004) states that it is the cumulative percentage of singular values s_j. It is possible to argue that the macro multipliers can be read as the percentage of the degree of the association explained from the representation made through the relative eigenvectors. In summary, the MM approach allows individuating the interactions between the policy objective, total output, and the structure of the policy measure or policy control (Ahmed, et al., 2018), through Macro Multipliers (Ciaschini, et al., 2009).

3.2.2 The income multipliers of a convenient policy control for Mexico and the USA region

While there are still several controversies to be resolved in the T-MEC, one of the main interests of the two countries involved, Mexico and the United States, is to increase the region's exports and reduce imports. The above implies stimulating and promoting exports, mainly through investment, since stimulating a change in household consumption patterns cannot be seen as a short-term policy, i.e., encouraging household savings or modifying consumption patterns are policies that could require much more time.

Thus, using the EMM and the Macro-Multiplier approach, a first exercise on the evaluation of policy controls with convenient structures could be performed, that is, to analyze the target policy resulting from a policy control that follows an optimal final demand structure for the region. For example, the evaluation of the impact on the regional GDP of a stimulus equal to 5% of regional exports, taking the optimal structure of the $\boldsymbol{\Psi}$ matrix, which means the matrix of income multipliers by-product, was performed in the previous section.

Hence, given the matrix $\boldsymbol{\Psi}$ of the EMM for the Mexico-USA region, using a model where investment and net exports are exogenous for both countries, it is possible to take the first structure resulting from the calculation of Macro-Multipliers. Moreover, considering the equation [III. 10] we can express:

$$\Delta\mathbf{f} = s_1^{\Psi} u_1^{\Psi} \mathbf{f}^{o} = s_1^{\Psi} \mathbf{u}_1^{\Psi} \mathbf{v}_1^{\prime\Psi} \delta_{f^*} = s_1^{\Psi} \mathbf{u}_1^{\Psi} \Delta\mathbf{f}^* \,, \qquad \text{[III. 10]}$$

where $\Delta\mathbf{f}$ is the vector of change in the aggregate final demand; s_1^{Ψ} and u_1^{Ψ} are the first Macro-Multiplier of income and the first structure associated with the aggregate final demand of the income multipliers matrix, $\boldsymbol{\Psi}_1$, respectively; $\mathbf{v}_1^{\prime\Psi}$ is the first structure of the aggregate final demand; finally, $\mathbf{f}^{o}$ is the first structure associated with the exogenous final demand $\mathbf{v}_1^{\prime\Psi}$, the first structure of the control policies, multiplied by a scalar that corresponds to the amount of the policy control. In this case, the amount is equivalent to 5% of the regional exports; in other words, $\mathbf{f}^{o}$ represents the change in final demand caused by the amount of policy control with the optimal structure.

In Figure 3.4, it is possible to observe the results of the analysis of the first structure associated with the Macro Multiplier of income for matrix $\boldsymbol{\Psi}$ by the Mexico-United States region. Column 1 shows the gap observed between these two economies, where the US economy has a GDP of 16.79 times larger than that of Mexico. However, the gap reduces when an exogenous demand stimulus (policy control), equivalent to 5% of regional exports, is assumed to acquire the optimal exogenous final demand structure.

Figure 3.4 *Direct and indirect effects on the GDP of a policy control equal to 5% of exports from the Mexico-USA region under the optimal structure.*

	Share of regional PIB	**Share of Policy Control**	**Share of Policy Object**	**Share of policy control respect own GDP**	**Share of policy objective respect own GDP**
MX	5.62%	29.98%	14.84%	2.46%	6.35%
USA	94.38%	70.02%	85.16%	0.34%	2.17%
Total	100.00%	100.00%	100.00%		
Rapport USA/MX	16.79	2.34	5.74		

Source: Own elaboration.

By analyzing the participation of each country in the policy control, it can be observed that Mexico would receive or be responsible for 29.98% of the policy control, while it would receive 14.84% of the policy target. The above implies that policy control represents 2.46% of its GDP. However, this would result in a GDP growth of 6.35% (target policy). On the other hand, the United States would receive or be responsible for 70.02% of the policy control. Still, the US would receive 85.16% of the result on the policy objective, implicating that the policy control represents 0.34% of GDP for the United States, but the US GDP would grow by 2.17%. The above would represent, for Mexico, a multiplier effect of said policy control equal to 2.58; for the case of the United States, this would be 6.38. Finally, these results show that the target policy benefit ratio is 5.74; for every million-dollar growth of Mexico, the US GDP would grow by 5.74. However, this gap is almost three times smaller than the observed one, i.e., it confirms the optimality of the policy control that will seek to follow the optimal structure suggested by the MM approach.

Regarding the effort or stimulus that the suggested control policy outlines for each country, i.e., 2.46% of GDP for Mexico and 0.34% of GDP for the United States are possible amounts. Furthermore, if we consider that public spending on investment is 3% of GDP on average for the member countries of the Organization for Economic Cooperation and Development (OECD, 2021), Mexico has experienced a drop in this indicator in recent decades. In each country, investment represents more than 20% of the GDP.

Nevertheless, this heterogeneity is not only inter-country but also intra-country, as seen in Figure 3.5, which shows the distribution of the amounts and the percentage structure by-product of each country concerning the total of each policy variable. The heterogeneity between countries is immediately apparent, as the shares of the Mexican economy's products are barely perceptible concerning those of the US economy. As expected, given the difference in the size of each economy.

However, within each economy, there are also considerable asymmetries; for example, in the case of the United States, the top 10 products with the most significant participation in the policy control are *p.61Goverment*[16] *(1.61%), p.21 Apparel and leather and allied products (1.47%); p.63. Used (1.41%); p.42 Housing (1.30%); p.53 Hospitals (1.24%); p.19 Food and beverage and tobacco products (1.22%); p.52 Ambulatory health care services (1.22%); p.41 Federal Reserve banks, credit intermediation, and related activities (1.19%); p.59 Food services and drinking places; p.60 81 Other services, except government (1.19%); p.60 81 Other services, except government(1.16%).* Finally, it should be noted that none of the US products have less than 1% participation in policy control. The values for each industry can be seen in Table AIII-4 in appendix III.

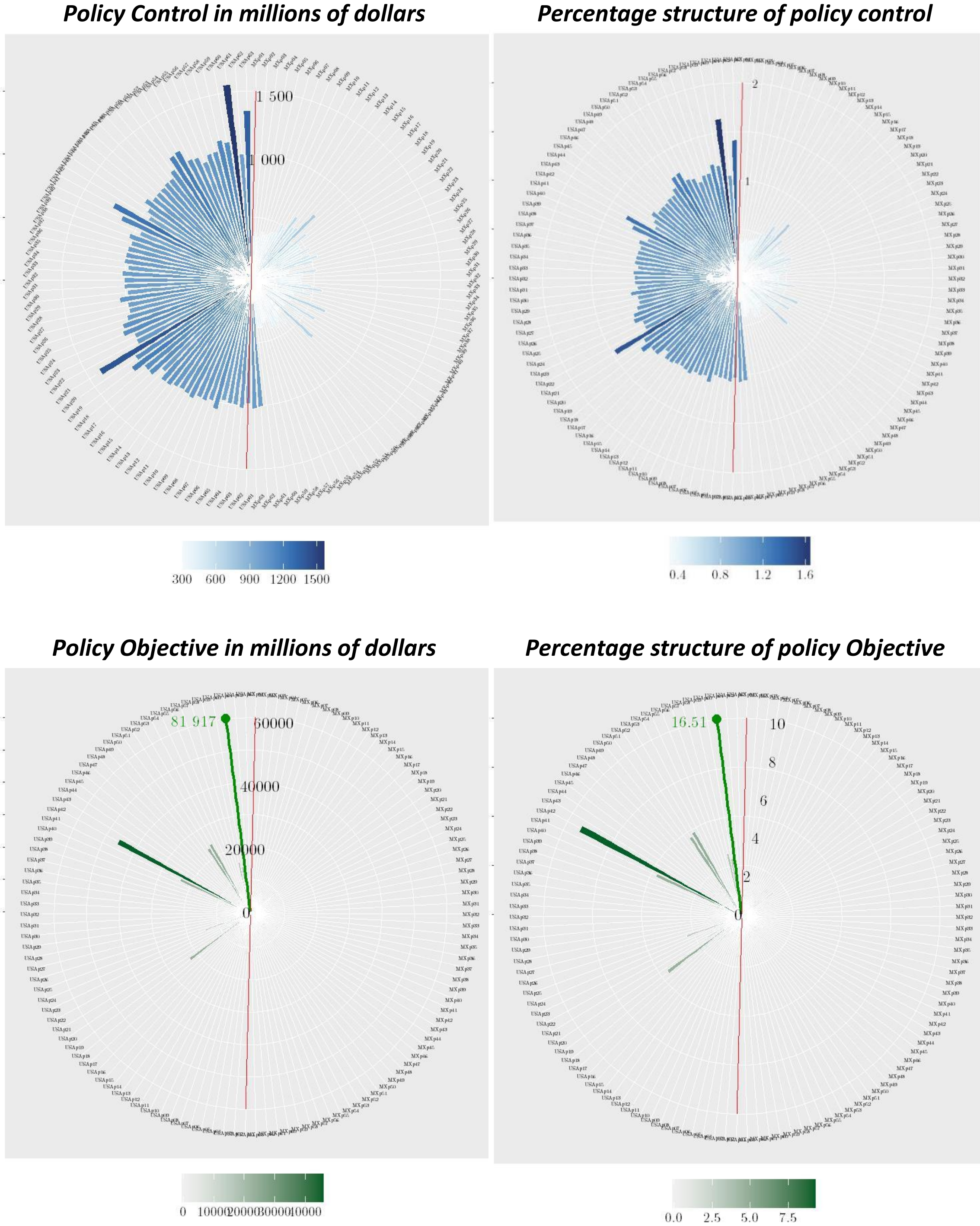
In the case of the total participation of the objective policy, the order and dimension changed slightly due to the rotation (output structure $\mathbf{u}_1^{\Psi}$) and the associated macro-multiplier (s_1^{Ψ}). Thus the top 10, in this case, are *p.61 Government (16.50%); p.42 Housing (9.23%); p.53 Hospitals (4.83%); p.41 Federal Reserve banks, credit intermediation, and related activities(4.72%); p.52 Ambulatory health care services (4.68%); p.19 Food and beverage and tobacco products(4.60%); p.59 Food services and drinking places(3.17%); p.25 Chemical products(2.88%); p.60 Other services, except government(2.85%) and, p.21 Apparel and leather and allied products(1.93%).* It can be observed that the government benefits from the magnitude of its multiplier. Contrary to the chemical industry, although it is not in the top ten in terms of participation in policy control, it does appear in the top ten in terms of participation in objective policy.

For the case of Mexico, the top 10 products with the most significant participation in the policy control are *p.63 Used(1.07%); p.62 Other(1.05%); p.16 Other transportation equipment(0.75%); p.47 Miscellaneous professional, scientific, and technical services(0.69%); p.40 Data processing, internet publishing, and other information services(0.67%); p.13 Computer and electronic products(0.64%); p.43 Other real estates (0.61%); p.35 Other transportation and support activities(0.59%); p.18 Miscellaneous manufacturing(0.59%); p.25 Chemical products(0.58%).* Only the first two products account for more than 1% of the share in policy control.

In the case of the total participation of the objective policy, the order to Mexico is *p.19 Food and beverage and tobacco products(1.87%); p.42 Housing(1.10%); p.61 Government(0.86%); p.15 Motor vehicles, bodies and trailers, and parts(0.74%); p.51 Educational services(0.63%); p.41 Federal Reserve banks, credit intermediation, and related activities(0.58%); p.24 Petroleum and coal products(0.39%); p.25 Chemical products(0.36%); p.33 Transit and ground passenger transportation(0.35%); p.1 Farms(0.34%).*

[16] The share of U.S. government products, which is relatively larger than the rest of the products, is replaced by a point range to specify the size of the product. Otherwise, its relative size is such that the rest of the products would have been barely noticeable in the Figure 3.5.

Figure 3.5 *Policy control and Policy Objective amounts and structure of a policy control equal to 5 % of the exports from the United States-Mexico under the optimal structure.*



Source: Own elaboration

In the case of Mexico, the structure of share in the policy control concerning the objective control share changes more than in the case of the United States. In this case, only the product p.25 Chemical products are present in both lists. The above is one of the advantages of the Macro Multiplier approach, which allows us to see optimal structures that could help guide a policy control to achieve various policy objectives, in this case, to increase GDP. This last is not observable when homogeneous final demand stimulus structures are assumed, which is avoided using the MM. Of course, the simulation presented in this paper assumes that optimal policy control is realized. It implicates a great political willingness for the institutional sectors and their members to coordinate a regional policy.

However, this exercise demonstrates that, at first glance, a policy control may seem inequitable across countries and sectors; however, the aggregate outcome of the economy may benefit each of the industries or institutional sectors involved in an economic system. In other words, the MM approach applied to the structural matrices, both the production and the induced effects, i.e., the income structure matrix, of an extended multisectoral model allows the analysis of several policies or even an optimal policy pull. Further exercises for this matrix, the analysis through the MM of this regional matrix could be: to analyze the combined effect of a pull of control policies, given the additivity of the structures associated to the MM, for example, the effects of control policies that optimize the value added in the automotive industry and the components, electrical and optical equipment industry in both countries.

3.1 Final Remarks

The Social Accounting matrices, by construction, incorporate the theory of the circular flow of income; that is, products and industries are connected to the institutional sectors through the generation, primary allocation, redistribution, and use of income. This use can go to final consumption or savings, which allows investment. Although in a national SAM, the Rest of the World is represented by the vector of imports and exports, tracing the entire circular flow of income caused by or stimulated by RoW becomes more complicated.

Therefore, constructing a multiregional SAM allows us to analyze the circular flow of income from the Rest of the World to the country or countries under analysis. For this chapter, a bi-regional SAM was constructed for the Mexico-United States region. For the analysis of the Mexican economy, this SAM is relevant because it extends the detail of the circular flow of income with the United States, the country to which 80% of Mexican exports are directed. In the case of the US economy analysis, although imports from Mexico represent only 15% of its total imports, this flow could increase, given the current interest of US policymakers in substituting Asian intermediate input suppliers. In addition, the spatial interest that the United States has in Mexico by sharing the southern border with that country also creates transfer flows such as remittances, which are an essential part of disposable income in Mexico (close to 4% of GDP).

If the Birregional SAM is modeled with the extended multisectoral EMM model, which recreates the circular flow of income, allowing us to identify the productive system's direct and indirect multiplier effects and the induced ones associated with income. Finally, if the analysis of Macro Multipliers is incorporated, various policy objectives associated with singular control policies or a combo can be evaluated.

Following the methodology described above, in addition to the construction of the bi-regional SAMs, a policy control was simulated to stimulate exogenous demand (hypothesized in the EMM) for an amount equal to 5% of regional exports. This policy control would take the optimal structure of final demand suggested by the Macro Multiplier approach. The results are as follows: the policy control is equivalent to 0.04% of the regional GDP following the optimal structure, and the bi-regional GDP would change by +2.4% (policy Objective); in the case of the United States, this country should receive or add 70.02% of the policy control, i.e., 0.34% of its GDP, and the result is a growth of 2.17% of GDP, that is, a multiplicative effect equal to 6.34. In the case of Mexico, this country should receive or add 29.98% of the policy control, that is, 2.46% of its GDP, and the result is a growth of 6.35% of GDP, that is, a multiplicative effect equal to 2.58. Although given the policy control assumed in the simulation, the United States benefits from 85.16% of the regional GDP growth and Mexico 14.84%, which represents a ratio of 5.74; this ratio is lower than the observed GDP growth, which is equal to 16.79.

The simulation carried out in this chapter shows the usefulness of the construction of bi-regional matrices; the use of models where consumption and, if possible, investment are endogenous (such as the EMM) to avoid under or over-estimation of the multipliers. In turn, if the analysis is complemented with the Multiplied Macro approach, it is possible to simulate, for the case of the Mexico-United States region, different optimal structures associated with products or the whole economic system or a combo of these, pursuing different policy objectives. The above provides an analysis of the combined effect of potential policy controls in the region; in an environment such as the current one, where the negotiations and controversies of the new T-MEC require the study of the potential effects of policy controls proposed by policymakers in the region.

Final Considerations and future research lines

The objective of this thesis was to carry out a structural analysis of the Mexican economy using multisectoral models. Given several events, these models have regained relevance as instruments for evaluating economic policies in recent years. For example, during the Covid-19 pandemic, several countries opted for a lockdown to avoid people's displacement and the virus's spread. Another example is the trade wars that have intensified in recent years, for example, the one between China and the United States over rare minerals or semiconductors, which has led to the intention to relocate production or change trading partners for both countries. As a last example, one could mention the blockade of oil or gas (generalized inputs and end-consumer products) that Russia has imposed on Europe following the start of the armed conflict with Ukraine in 2022.

In this context, multisectoral models based on Input-Output analysis have become relevant to assess the multiplicative effects of control policies focused on some industries or products. Although classical Input-Output models are the basis of multisectoral analysis, they have the limitation that they only partially capture the circular flow of income. Therefore, models based on Social Accounting Matrices (SAMs) are an alternative that allows for greater precision in multisectoral analysis. For SAMs, by construction, capture the circular flow of income of an economic system, i.e., they describe how the inter-industrial system relates to the institutional sectors (Corporations, Households, Government) and the rest of the world through the flow of income.

In other words, a SAM captures the generation of income in the productive process; its primary allocation among the institutional sectors; the redistribution of income through transfers and payments among the institutional sectors, resulting in disposable income, which is used for consumption or savings to finance investment, variables that activate the productive process again, reactivating the circular flow. Moreover, interactions with the rest of the world are also considered in an open economy.

For this reason, multisectoral models were selected, based on a framework of Social Accounting Matrices, to carry out a structural analysis of the Mexican economy, concentrating on the analysis of production multipliers, income, and international trade, particularly trade with the United States. Thus, the thesis has three chapters.

Thus, the first chapter aims to compare three multisectoral models for the evaluation of the production multipliers of the Mexican economy. The first model is the classic Leontief open model. The second is the Miyazawa model, which treats wages and final consumption as endogenous variables, modeling the Keynesian multiplier in a disaggregated form. However, in this thesis, we proposed a Miyazawa model based on a SAM, which allows us to capture the primary allocation of income and create a correction to the original model, which assumes that households do not participate in the allocation of gross operating surplus. Finally, the Extended Multisectoral Model (EMM) considers the primary and secondary distribution of income, allowing us to calculate the disposable income of each institutional sector and detailing the use of this income for savings or investment. By treating investment as an endogenous variable, the extended multisector model incorporates models of the "accelerator" of the Keynesian multiplier, or as Harrod would call the "ratio" in a static model.

The analysis of the multipliers was done through the Macro Multiplier approach, based on singular value decomposition (SVD), which decomposes the inverse matrices of each model into the n possible structures that the respective exogenous demand can take, which are associated with the n output structures and each of them to a respective macro multiplier.

The results of this first chapter suggest that it is convenient, whenever the available databases allow it, to use the models that endogenize at least the primary allocation of income, i.e., the Miyazawa model and the Extended Multisectoral Model. Within the latter two, the EMM qualitatively corrects the multipliers of the Miyazawa model, which, by not considering income redistribution, can generate underestimates or overestimates in the multipliers. Finally, if the investment is endogenized, the EMM scales the multiplicative effects even more, i.e., it "accelerates" them.

Thus, in the second chapter, we decided to continue using the EMM, but this time to measure the impact of an adverse event that would create a supply shock in the Mexican economy, that is, to measure the impact of the adverse multiplicative effects of this kind of shock. The simulation chosen was the lockdown associated with Covid-19 in Mexico; the simulation aimed to estimate the "pure" impact of the lockdown', which should be the first estimate that a policymaker is interested in when a policy such as a lockdown is considered. The analysis focused on primary and secondary income distribution.

In turn, to evaluate the impacts of the lockdown on income distribution in Mexico, we used a variant of the Inoperability Input-Output model. In addition, we use a variant where the exogenous shock is created from the supply side, as it should occur in events that block production, which means we use an inoperability extended multisectoral model (IEM). At the same time, the inoperability models were re-read, admitting their usefulness when reinterpreted as a model of relative elasticities.

In the case of GDP, the IEM's estimation equals a change of -7.2%, while the observed data was -8.5% (INEGI, 2020a). Therefore, our estimate is very close to other estimates close to the observed data. For example, the IMF (2020) forecasted a drop in Mexican GDP between -7.54 and -10.5%. On the other hand, Esquivel (2020) estimated, calculating the arithmetic mean, a fall in the Mexican GDP between -8.5% and -10.5%. However, our estimation has desegregated results, so it is possible to identify the most affected industries or institutional sectors.

It is possible to argue that the IEM has replicated the trends of the lockdown's effect in Mexico, with an error of 1.3% on the GDP estimation. The results in primary and disposable income distribution correspond to the observed trends in the 'households' surveys, except for the phenomena, for example, the extraordinary transfers to households or the adjustment of the marginal propensity to consume of households given the fall in their disposable income, that corrected economic policies that are not considered in our simulation. However, as mentioned above, the chapter aimed to estimate the "pure" lockdown's impact, which should be the first estimate that a policymaker is interested in when a policy such as a lockdown is considered.

The Social Accounting matrices, by construction, incorporate the theory of the circular flow of income. Although in a national SAM, the Rest of the World is represented by the vector of imports and exports, tracing the entire circular flow of income caused by or stimulated by RoW becomes more complicated.

Therefore, a bi-regional Mexico-United States matrix was constructed in the third chapter. The above allows us to capture the entire circular flow of Mexico's income with its leading trading partner. The United States is the only country with which Mexico has a deficit; for its part, the US has a generalized trade deficit, particularly with China.

The recent negotiations of the United States-Mexico-Canada Agreement (USMCA) aim to reduce the region's trade deficit. Thus, using the bi-regional SAM of Mexico-United States and applying the extended multisectoral model, it was possible to decompose the matrix of the extended production multipliers into two matrices, the Leontief matrix and the matrix of the income multipliers.

Subsequently, the following data were obtained by simulating an optimal structure control policy, under the Macro Multiplier approach, for the region, equal to 5% of the region's exports: the policy control is equivalent to 0.04% of the regional GDP following the optimal structure, and the bi-regional GDP would change by +2.4% (policy Objective); in the case of the United States, this country should receive or add 70.02% of the policy control, i.e., 0.34% of its GDP, and the result is a growth of 2.17% of GDP, that is, a multiplicative effect equal to 6.34. In the case of Mexico, this country should receive or add 29.98% of the policy control, that is, 2.46% of its GDP, and the result is a growth of 6.35% of GDP, that is, a multiplicative effect equal to 2.58. Although given the policy control assumed in the simulation, the United States benefits from 85.16% of the regional GDP growth and Mexico 14.84%, which represents a ratio of 5.74; this ratio is lower than the observed GDP growth, which is equal to 16.79. The above implies that a coordinated policy can benefit both countries in the region and narrow the gaps between the economic systems.

The results obtained in this thesis are primitive results of potential future lines of research: for example, the dynamics within the multisectoral models; in the case of the extended multisectoral model, the incorporation of dynamic processes to the various parameters such as marginal propensity to consume or active savings. In the case of the bi-regional SAM, a more exhaustive study of specific control policies derived from the USMCA negotiations, which through the macro multiplier approach allows evaluation of the effects of optimal policies for an industry or product or by the optimal structure of the final demand of the system, even a pool of policies. Therefore, we reiterate that given the robustness of multi-sectoral models based on the SAM for the policy evaluation, the results presented in this thesis are primitive results of different lines of research

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Appendix I

Table AI-1 Industries for the Mexican SAM 2018

Industry	Industry
1. Agriculture	39. Other manufacturing industries
2. Animal Production and Aquaculture	40. Trade
3. Forestry and Logging	41. Air Transportation
4. Fishing, Hunting, and Trapping	42. Rail Transportation
5. Support Activities for Agriculture and Forestry	43. Water Transportation
6. Oil and Gas Extraction and Support Activities for Mining	44. Truck Transportation
7. Mining (except Oil and Gas)	45. Transit and Ground Passenger Transportation
8. Electric Power Generation, Transmission and Distribution	46. Support Activities for Transportation
9. Water supply and piped gas supply to the final consumer	47. Postal Service
10. Residential Building Construction	48. Warehousing and Storage
11. Nonresidential Building Construction	49. Publishing Industries (except Internet)
12. Heavy and Civil Engineering Construction	50. Motion Picture and Sound Recording Industries
13. Specialty Trade Contractors	51. Broadcasting (except Internet) and Other Information Services
14. Food Manufacturing	52. Telecommunications; Data Processing, Hosting, and Related ServicesT
15. Beverage and Tobacco Product Manufacturing	53. Central banking
16. Textile Mills	54. Credit Intermediation and Related Activities
17. Textile Product Mills	55. Securities, Commodity Contracts, and Other Financial Investments and Related Activities
18. Apparel Manufacturing	56. Insurance Carriers and Related Activities
19. Leather and Allied Product Manufacturing	57. Real Estate
20. Wood Product Manufacturing	58. Rental and Leasing Services

Industry	Industry
21. Paper Manufacturing	59. Lessors of Nonfinancial Intangible Assets & Management of Companies and Enterprises
22. Printing and Related Support Activities	60. Professional, Scientific, and Technical Services
23. Petroleum and Coal Products Manufacturing	61. Administrative, Support Services & Waste Management and Remediation Services
24. Chemical Manufacturing	62. Educational Services
25. Plastics and Rubber Products Manufacturing	63. Ambulatory Health Care Services
26. Nonmetallic Mineral Product Manufacturing	64. Hospitals
27. Primary Metal Manufacturing	65. Nursing and Residential Care Facilities
28. Fabricated Metal Product Manufacturing	66. Social Assistance
29. Machinery Manufacturing	67. Performing Arts, Spectator Sports, and Related Industries
30. Computer and Peripheral Equipment Manufacturing	68. Museums, Historical Sites, and Similar Institutions
31. Communications Equipment Manufacturing	69. Amusement, Gambling, and Recreation Industries
32. Audio and Video Equipment Manufacturing	70. Accommodation
33. Semiconductor and Other Electronic Component Manufacturing	71. Food Services and Drinking Places
34. Manufacture and reproduction of magnetic and optical media	72. Repair and Maintenance
35. Manufacturing and Reproducing Magnetic and Optical Media	73. Personal and Laundry Services
36. lectrical Equipment, Appliance, and Component Manufacturing	74. Social Advocacy Organizations
37. Transportation Equipment Manufacturing	75. Private Households
38. Manufacture of furniture, mattresses, and blinds	76. Public Administration

Appendix II

Table AII-1 Industries Declared indispensable activities by the Mexican Federal Government in the lockdown by COVID-19

76 industries of the Mexican Social Accounting Matrix harmonized whit 21 essential activities	alpha	Days
01. Financial sector		
no lockdown		
53. Central banking	0.00	75
partial lockdown		
54. Credit Intermediation and Related Activities	-0.70	75
55. Securities, Commodity Contracts, and Other Financial Investments and Related Activities	-0.75	75
56. Insurance Carriers and Related Activities	-0.76	75
02. Tax collection (the SAT and all its operations remain)		
partial lockdown		
76. Public Administration	-0.08	75
03. Distribution and sale of energy, gas stations and		
no lockdown		
06. Oil and Gas Extraction and Support Activities for Mining	0.00	75
08. Electric Power Generation, Transmission and Distribution	0.00	75
03. Distribution and sale of energy, gas stations, and gas		
no lockdown		
23. Petroleum and Coal Products Manufacturing	0.00	75
04. Generation and distribution of drinking water		
no lockdown		
09. Water supply and piped gas supply to the final consumer	0.00	75
05. Food and non-alcoholic beverages industry and Agroindustry		
no lockdown		
14. Food Manufacturing	0.00	75
partial lockdown		
15. Beverage and Tobacco Product Manufacturing	-0.75	75
06;07;08. Food markets; Groceries and prepared food sales; Supermarkets, Self-service stores, and Hardware stores		
partial lockdown		
40. Trade	-0.90	75
09. Passenger and cargo transportation services		
partial lockdown		
45. Transit and Ground Passenger Transportation	-0.60	120
10. Agricultural, fisheries, and livestock production		
no lockdown		
01. Agriculture	0.00	75
02. Animal Production and Aquaculture	0.00	75
05. Support Activities for Agriculture and Forestry	0.00	75
partial lockdown		
04. Fishing, Hunting, and Trapping	-0.50	75
11. Chemical industry and Cleaning products		
partial lockdown		
16. Textile Mills	-0.86	75

24. Chemical Manufacturing	-0.75	75
25. Plastics and Rubber Products Manufacturing	-0.82	75
11. Nurseries, Shelters, and care centers for women victims of violence, their sons and daughters		
partial lockdown		
74. Social Advocacy Organizations	0.50	75
12. Courier services		
no lockdown		
47. Postal Service	0.00	75
13. Private security guards and tasks		
partial lockdown		
61. Administrative, Support Services & Waste Management and Remediation Services	-0.88	75
14. Nurseries, Shelters, and care centers for women victims of violence, their sons and daughters		
no lockdown		
66. Social Assistance	0.00	75
15. Instances for the elderly		
no lockdown		
65. Nursing and Residential Care Facilities	0.00	75
16. Sanitary services		
no lockdown		
63. Ambulatory Health Care Services	0.00	75
64. Hospitals	0.00	75
17. Telecommunications and information media		
no lockdown		
51. Broadcasting (except Internet) and Other Information Services	0.00	75
52. Telecommunications; Data Processing, Hosting, and Related ServicesT	0.00	75
18. Private emergency services, funeral and burial services		
partial lockdown		
73. Personal and Laundry Services	-0.90	75
19. Storage and cooling chain of essential supplies		
no lockdown		
48. Warehousing and Storage	0.00	75
20. Logistics (airports, ports, and railways).		
partial lockdown		
41. Air Transportation	-0.91	75
44. Truck Transportation	-0.80	75
21. As well as activities whose suspension may have irreversible effects for its continuation.		
partial lockdown		
27. Primary Metal Manufacturing	-0.71	75
33. Semiconductor and Other Electronic Component Manufacturing	-0.50	75
34. Manufacture and reproduction of magnetic and optical media	-0.50	75
59. Lessors of Nonfinancial Intangible Assets & Management of Companies and Enterprises	-0.80	75
60. Professional, Scientific, and Technical Services	-0.80	75
62. Educational Services	-0.50	75
Nonessential activity		
lockdown		
03. Forestry and Logging	-1.00	75

07. Mining (except Oil and Gas)	-1.00	75
10. Residential Building Construction	-1.00	75
11. Nonresidential Building Construction	-1.00	75
12. Heavy and Civil Engineering Construction	-1.00	75
13. Specialty Trade Contractors	-1.00	75
17. Textile Product Mills	-1.00	75
18. Apparel Manufacturing	-1.00	75
19. Leather and Allied Product Manufacturing	-1.00	75
20. Wood Product Manufacturing	-1.00	75
21. Paper Manufacturing	-1.00	75
22. Printing and Related Support Activities	-1.00	75
26. Nonmetallic Mineral Product Manufacturing	-1.00	75
28. Fabricated Metal Product Manufacturing	-1.00	75
29. Machinery Manufacturing	-1.00	75
30. Computer and Peripheral Equipment Manufacturing	-1.00	75
31. Communications Equipment Manufacturing	-1.00	75
32. Audio and Video Equipment Manufacturing	-1.00	75
35. Manufacturing and Reproducing Magnetic and Optical Media	-1.00	75
36. Electrical Equipment, Appliance, and Component Manufacturing	-1.00	75
37. Transportation Equipment Manufacturing	-1.00	95
38. Manufacture of furniture, mattresses, and blinds	-1.00	75
39. Other manufacturing industries	-1.00	75
42. Rail Transportation	-1.00	75
43. Water Transportation	-1.00	75
46. Support Activities for Transportation	-1.00	75
49. Publishing Industries (except Internet)	-1.00	75
50. Motion Picture and Sound Recording Industries	-1.00	75
57. Real Estate Services	-1.00	75
58. Rental and Leasing Services	-1.00	75
67. Performing Arts, Spectator Sports, and Related Industries	-1.00	120
68. Museums, Historical Sites, and Similar Institutions	-1.00	120
69. Amusement, Gambling, and Recreation Industries	-1.00	120
70. Accommodation	-1.00	120
71. Food Services and Drinking Places	-1.00	120
72. Repair and Maintenance	-1.00	75
75. Private Households	-1.00	75

Source: Own elaboration

Appendix III

Table AIII-1 Products of the Bi-regional Social Accounting Matrix Mexico-U.S..

	Name with code NAICS	No.	Name with code NAICS
p.1	111CA Farms	***p.33***	485 Transit and ground passenger transportation
p.2	113FF Forestry, fishing, and related activities	***p.34***	486 Pipeline Transportation
p.3	211 Oil and gas extraction	***p.35***	487OS Other transportation and support activities
p.4	212 Mining, except oil and gas	***p.36***	493 Warehousing and storage
p.5	213 Support activities for Mining	***p.37***	511 Publishing industries, except internet (includes software)
p.6	22 Utilities	***p.38***	512 Motion picture and sound recording industries
p.7	23 Construction	***p.39***	513 Broadcasting and telecommunications
p.8	321 Wood products	***p.40***	514 Data processing, internet publishing, and other information services
p.9	327 Nonmetallic mineral products	***p.41***	521CI-525 Federal Reserve banks, credit intermediation, and related activities
p.10	331 Primary metals	***p.42***	H.S. Housing
p.11	332 Fabricated metal products	***p.43***	ORE Other real estates
p.12	333 Machinery	***p.44***	532RL Rental and leasing services and lessors of intangible assets
p.13	334 Computer and electronic products	***p.45***	5411 Legal services
p.14	335 Electrical equipment, appliances, and components	***p.46***	5415 Computer systems design and related services
p.15	3361MV Motor vehicles, bodies and trailers, and parts	***p.47***	5412OP Miscellaneous professional, scientific, and technical services
p.16	3364OT Other transportation equipment	***p.48***	55 Management of companies and enterprises
p.17	337 Furniture and related products	***p.49***	561 Administrative and support services
p.18	339 Miscellaneous manufacturing	***p.50***	562 Waste management and remediation services
p.19	311FT Food and beverage and tobacco products	***p.51***	61 Educational services
p.20	313TT Textile mills and textile product mills	***p.52***	621 Ambulatory health care services
p.21	315AL Apparel and leather and allied products	***p.53***	622 Hospitals
p.22	322 Paper products	***p.54***	623 Nursing and residential care facilities
p.23	323 Printing and related support activities	***p.55***	624 Social assistance
p.24	324 Petroleum and coal products	***p.56***	711AS Performing arts, spectator sports, museums, and related activities
p.25	325 Chemical products	***p.57***	713 Amusements, gambling, and recreation industries
p.26	326 Plastics and rubber products	***p.58***	721 Accommodation
p.27	42 Wholesale trade	***p.59***	722 Food services and drinking places
p.28	44-4A0 Retail Sale	***p.60***	81 Other services, except government
p.29	481 Air transportation	***p.61***	Government
p.30	482 Rail Transportation	***p.62***	Other
p.31	483 Water transportation	***p.63***	Used
p.32	484 Truck transportation		

Source: Own elaboration

A.III.1 Construction of a Bi-regional Social Accounting Matrix Mexico-U.S. for 2017

The Construction of the Bi-regional Social Accounting Matrix Mexico-U.S. from Mexico and the U.S. in 2017 implicated a series of steps described as follows:

1) With information on the Bureau of Economic Analysis (BEA, 2020), a Social Accounting Matrix was constructed using its Make and Use Tables (before redefinition) and the institutional accounts. The SAM from the U.S. uses the North American Industry Classification System 2017 -NAICS 2017- (United Census Bureau, 2020). However, the same United Census Bureau reports the NAICS Codes tab, which compares the I-O codes to the 2012 NAICS codes.

   The U.S. SAM has a framework Make and Use with 53 industries and 63 products; four components of the Gross Value Added (wages, gross operating surplus, taxes on production, and products). Also, this SAM incorporates five institutional sectors (non-financial corporations, Financial Corporations, Households, Federal Government, and local governments) and the account of the Rest of the World (RoW).

2) In the case of the SAM from Mexico, this was constructed using the correspondence of macroaggregates and institutional accounts for the Mexican economy reported by INEGI (INEGI, 2021b), and finally was used the SAM structure reported by INEGI (INEGI, 2021). The industrial code used in this SAM is the NAICS 2013 (INEGI, 2021c).

   Thus, the preliminary result was a SAM from Mexico with a framework Make and Use with 76 industries and 171 products; four components of the Gross Value Added (wages, gross operating surplus, taxes on production, and products). Also, this SAM incorporates five institutional sectors (non-financial corporations, Financial Corporations, Households, Federal Government, and local governments) and the account of the Rest of the World (RoW).

3) Even if it is possible to use the bi-regional extended model with SAMs that are not harmonized, we preferred to homogenize both SAMs, which means both Make and Use have 53 industries and 63 products like in the original Make and Use tables from the U.S.. The harmonization was possible by the closeness of the code NAICS used by the SAM of each country and the report of the NAICS Codes tab that presents a concordance of the I-O codes to the associated 2012 NAICS codes.

Tables Table AIII-2 and Table AIII-3 present the concordance between products and industries in Mexican and U.S. SAMs.

Table AIII-2 Concordance between products in Mexican and U.S. SAMs

Mexican products with code NAICS harmonized to 63 products	**total of products**
p01.Farms	8
1111 - Growing of oil seeds, pulses, and cereals	1
1112 - Growing of vegetables	1
1113 - Growing of fruit and nut crops	1
1114 - Growing of crops in greenhouses and nurseries and floriculture	1
1119,1151 - Other cultivation of crops and services related to agriculture	1
1121,1122 - Raising of cattle and pigs	1
1123 - Poultry farming	1
1124,1125,1129 - Raising of sheep and goats, aquaculture, and other animals	1
p02.Forestry, fishing, and related activities	6
1131 - Forestry	1
1132 - Tree nurseries and harvesting of forest products	1
1133 - Felling of trees	1
114 - Fishing, hunting, and trapping	1
1152 - Services incidental to animal breeding and farming	1
1153 - Services incidental to logging	1
p03.Oil and gas extraction	1
2111 - Extraction of oil and gas	1
p04.Mining, except oil and gas	3
2121 - Mining of coal	1
2122 - Mining of metalliferous minerals	1
2123 - Mining of nonmetallic minerals	1
p05.Support activities for Mining	1
2131 - Mining and related services	1
p06.Utilities	3
2211 - Electric power generation, transmission, and distribution	1
2221 - Water collection, treatment, and supply	1
2222 - Supply of gas through pipelines to final consumers	1
p07.Construction	10
2361 - Residential building	1
2362 - Non-residential building	1
2371 - Construction of works for the supply of water, oil, gas, electricity, and telecommunications	1
2372 - Land division and Construction of urban development works	1
2373 - Construction of roads	1
2379 - Other civil engineering constructions	1
2381 - Foundations, erection of prefabricated structures and outdoor works	1
2382 - Building installation and equipment work	1
2383 - Finishing work on buildings	1
2389 - Other specialized construction work	1
p08.Wood products	3

Mexican products with code NAICS harmonized to 63 products	total of products
3211 - Sawing and preserving of wood	1
3212 - Manufacture of wood laminates and binders	1
3219 - Manufacture of other wood products	1
p09.Nonmetallic mineral products	1
327 - Manufacture of nonmetallic mineral products	1
p10.Primary metals	2
3311 - Basic iron and steel manufacturing	1
3312-15,3321-23 - Manufacture of iron, steel, and non-ferrous metal products	1
p11.Fabricated metal products	1
3324-3329 - Manufacture of other fabricated metal products	1
p12.Machinery	6
3331 - Manufacture of agricultural, Construction, and Mining machinery and equipment	1
3332,3339 - Manufacture of machinery and equipment for the manufacturing industry and gene	1
3333 - Manufacture of machinery and equipment for commerce and services	1
3334 - Manufacture of air conditioning, heating, industrial and commercial refrigeration	1
3335 - Manufacture of machinery and equipment for the metalworking industry	1
3336 - Manufacture internal combustion engines, turbines, and transmissions	1
p13.Computer and electronic products	5
3341 - Manufacture of computers and peripheral equipment	1
3342 - Manufacture of communication equipment	1
3343,3344 - Manufacture audio and video equipment and electronic components	1
3345 - Manufacture of measuring, control, navigational, and electronic medical instruments	1
3346 - Manufacture and reproduction of magnetic and optical media	1
p14.Electrical equipment, appliances, and components	4
3351 - Manufacture of lighting fittings	1
3352 - Manufacture of electrical household appliances	1
3353 - Manufacture of electrical power generation and distribution equipment	1
3359 - Manufacture of other electrical equipment and accessories	1
p15.Motor vehicles, bodies and trailers, and parts	2
3361 - Manufacture of motor cars and trucks	1
3363 - Manufacture of parts for motor vehicles	1
p16.Other transportation equipment	3
3362,3366,3369 - Manufacture of bodies and trailers, boats, and other transport equipment	1
3364 - Manufacture of aerospace equipment	1
3365 - Manufacture of railway equipment	1
p17.Furniture and related products	2
3371,3372 - Manufacture of furniture	1
3379 - Manufacture mattresses, blinds, curtains, and curtain blinds	1
p18.Miscellaneous Manufacturing	2
3391 - Manufacture of non-electronic equipment and disposable medical, dental, and laboratories	1
3399 - Other manufacturing	1
p19.Food and beverage and tobacco products	12
3111 - Processing of animal feeding pieces of stuff	1

Mexican products with code NAICS harmonized to 63 products	total of products
3112 - Milling of grains and seeds and production of oils and fats	1
3113 - Manufacture of sugars, chocolates, sweets, and similar products	1
3114 - Preserving fruit, vegetables, stews, and other prepared foods	1
3115 - Processing of dairy products	1
3116 - Slaughtering, packing, and processing of meat of livestock, poultry, and other ed	1
3117 - Preparation and packaging of fish and shellfish	1
3118 - Manufacture of bakery products and tortillas	1
3119 - Other food industries	1
3121 - Manufacture of beverages	1
3122 - Manufacture of tobacco products	1
p20.Textile mills and textile product mills	4
3131 - Preparation and spinning of textile fibers and manufacture of yarns	1
3132,3133 - Manufacture of textile fabrics and textile finishing	1
3141 - Manufacture of carpets, rugs, and similar furnishing materials	1
3149 - Manufacture of other textile products, except garments	1
p21.Apparel and leather, and allied products	3
315 - Manufacture of wearing apparel	1
3161,3162 - Tanning and dressing of leather and leather products	1
3169 - Manufacture of other products of leather and leather substitutes	1
p22.Paper products	2
3221 - Manufacture of pulp, paper, and paperboard	1
3222 - Manufacture of paper, paperboard, and paper products	1
p23.Printing and related support activities	1
3231,5111 - Printing and publishing of newspapers, periodicals, magazines, books, and t	1
p24.Petroleum and coal products	1
3241,3251 - Manufacture petroleum and coal products and basic chemical products	1
p25.Chemical products	5
3252 - Manufacture of synthetic resins and rubber and chemical fibers	1
3253 - Manufacture of fertilizers, pesticides, and other agrochemical products	1
3254 - Manufacture of pharmaceuticals	1
3255,3259 - Manufacture paints, coatings, adhesives, and other chemical products	1
3256 - Manufacture of soaps, cleansers, and toilet preparations	1
p26.Plastics and rubber products	2
3261 - Manufacture of plastic products	1
3262 - Manufacture of rubber products	1
p27.Wholesale trade	1
4300 - Wholesale trade	1
p28.Retail Sale	1
4600 - Retail trade	1
p29.Air transportation	1
481 - Air transport	1
p30.Rail transportation	1
4821 - Rail transport	1
p31.Water transportation	1
483 - Water transport	1

Mexican products with code NAICS harmonized to 63 products	total of products
p32.Truck transportation	1
484,4851 -Cargo transportation and urban and suburban fixed-route passenger bus transportation	1
p33.Transit and ground passenger transportation	3
4852 - Foreign fixed-route collective passenger transport	1
4853 - Taxi and limousine services	1
4854,4855,4859 - School and staff transport, chauffeur-driven bus hire, and other passe	1
p34.Pipeline transportation	2
4861,4862 - Transportation of crude petroleum and natural gas by pipeline	1
4869 - Transport of other products by pipeline	1
p35.Other transportation and support activities	1
487,488 - Tourist transport and other transport-related services	1
p36.Warehousing and storage	2
491,492 - Postal, courier, and parcel services	1
4931 - Warehousing services	1
p37.Publishing industries, except the internet (includes software)	1
5112 - Publishing of software and publishing of software integrated with reproduction	1
p38.Motion picture and sound recording industries	2
512 - Motion picture and video industry and sound industry	1
515,5171 - Radio and television broadcasting and operators of wired telecommunications	1
p39.Broadcasting and telecommunications	1
5172 - Operators of wireless telecommunications services	1
p40.Data processing, internet publishing, and other information services	1
5174,5179,5182,5191 - Operators of satellite telecommunications services, other telecommunications	1
p41.Federal Reserve banks, credit intermediation, and related activities	2
521 - Central banking	1
522,523,524 - Financial and insurance services, except central banking	1
p42.Housing	3
5311 - Renting of real estate without real estate intermediation	1
5312 - Real estate agencies and real estate brokers	1
5313 - Services related to real estate services	1
p43.Other real estates	1
5321 - Renting of automobiles, lorries, and other land transport equipment	1
p44.Rental and leasing services and lessors of intangible assets	2
5322,5323,5324 - Rental and leasing services of movable property, except transport ser	1
5331 - Rental and leasing services of trademarks, patents, and franchises	1
p45.Legal services	1
5411,5412,5413,5414 - Legal, accounting, architectural, engineering, specialized design	1
p46.Computer systems design and related services	1
5415 - Computer systems design and related services	1
p47.Miscellaneous professional, scientific, and technical services	4
5416 - Management, scientific, and technical consultancy services	1
5417 - Scientific research and development services	1
5418 - Advertising services and related activities	1

Mexican products with code NAICS harmonized to 63 products	**total of products**
5419 - Other professionals, scientific and technical services	1
p48.Management of companies and enterprises	1
5511 - Corporate services	1
p49.Administrative and support services	7
5611 - Business management services	1
5612 - Combined facility support services	1
5613,5614 - Employment, secretarial support, photocopying, collection, credit investing	1
5615 - Travel agencies and reservation services	1
5616 - Investigation, security, and security services	1
5617 - Cleaning services	1
5619 - Other business support services	1
p50.Waste management and remediation services	1
5621 - Waste management and remediation services p 5621 - Waste management and remedial	1
p51.Educational services	1
61 - Educational services	1
p52.Ambulatory health care services	5
6211 - Medical practice	1
6212 - Dental offices	1
6213,6214 - Other health care offices and non-hospital inpatient care centers	1
6215 - Medical and diagnostic laboratories	1
6216,6219 - Home nursing services and ambulance services, organ banks, and other ancillaries	1
p53.Hospitals	1
622 - Hospitals	1
p54.Nursing and residential care facilities	2
6231,6232,6233 - Social work and health care homes	1
6239 - Orphanages and other social work homes	1
p55.Social assistance	1
624 - Other social work services	1
p56.Performing arts, spectator sports, museums, and related activities	2
711 - Artistic, cultural, sporting, and other related services	1
7121 - Museums, historical sites, zoos, and the like	1
p57.Amusements, gambling, and recreation industries	1
713 - Amusement and recreation services in recreational facilities and other recreation	1
p58.Accommodation	1
721 - Temporary accommodation services	1
p59.Food services and drinking places	3
7223 - Food preparation services on a fee or contract basis	1
7224 - Nightclubs, bars, pubs, canteens, and the like	1
7225 - Food preparation services and preparation services of alcoholic and non-alcohol	1
p60.Other services, except government	12
8111 - Repair and maintenance of automobiles and truck	1
8112 - Repair and maintenance of electronic and precision equipment	1
8113 - Repair and maintenance of agricultural, industrial, commercial, and service machinery	1

Mexican products with code NAICS harmonized to 63 products	total of products
8114 - Repair and maintenance of household and personal goods	1
8121 - Beauty parlors and beauty clinics, public baths, and bowling alleys	1
8122 - Laundries and dry-cleaning establishments	1
8123 - Funeral services and cemetery administration	1
8124 - Parking and boarding houses for motor vehicles	1
8129 - Photograph developing and printing services and other personal services	1
8131 - Trade, labor, professional and recreational associations and organizations	1
8132 - Religious, political, and civic associations and organizations	1
8141 - Households with domestic servants	1
p61.Government	8
9311 - Legislative bodies	1
9312 - Public administration in general	1
9313 - Regulation and promotion of economic development	1
9314 - Administration of justice and maintenance of public order and safety	1
9315 - Regulation and promotion of activities for the improvement and preservation of	1
9316,9321 - Administrative activities of social welfare institutions and international	1
9317 - External relations	1
9318 - National security activities	1
p62.Other	1
It was added	1
p63.Used	1
It was added	1
Total general	173

Source: Own elaboration

Table AIII-3 Concordance between industries in Mexican and U.S. SAMs

Mexican industries with code NAICS harmonized to 53 industries	total industries
i01.Farms	2
111---Agriculture	1
112---Breeding and animal husbandry	1
i02.Forestry, fishing, and related activities	3
113---Forestry	1
114---Fishing, hunting, and trapping	1
115---Agriculture and forestry-related services	1
i03.Oil and gas extraction; Support activities for Mining; Pipeline Transportation	1
211-213-486---Petroleum and gas extraction, Mining related services, Pipeline transport	1
i04.Mining, except oil and gas	1
212---Mining of metallic and nonmetallic minerals, except oil and gas	1
i05.Utilities	2

Mexican industries with code NAICS harmonized to 53 industries	**total industries**
221---Generation, transmission, and distribution of electrical energy	1
222---Water supply and piped gas supply to the final consumer	1
i06.Construction	4
2361---Residential building	1
2362---Non-residential building	1
237---Construction of civil engineering works	1
238---Specialized construction work	1
i07.Food and beverage and tobacco products	2
311---Food industry	1
312---Beverages and tobacco industry	1
i08.Textile mills and textile product mills	2
313---Manufacture of textile inputs and finishing of textiles	1
314---Manufacture of textile products, except garments	1
i09.Apparel and leather, and allied products	2
315---Manufacture of garments	1
316---Tanning and finishing of leather and fur, and manufacture of products of leather, fur, and substitute materials	1
i10.Wood products	1
321---Woodworking industry	1
i11.Paper products	1
322---Paper industry	1
i12.Printing and related support activities	1
323---Printing and allied industries	1
i13.Petroleum and coal products	1
324---Manufacture of petroleum and coal products	1
i14.Chemical products	1
325---Chemical industry	1
i15.Plastics and rubber products	1
326---Plastics and rubber industry	1
i16.Nonmetallic mineral products	1
327---Manufacture of nonmetallic mineral products	1
i17.Primary metals	1
331---Basic metal industries	1

Mexican industries with code NAICS harmonized to 53 industries	**total industries**
i18.Fabricated metal products	1
332---Manufacture of metal products	1
i19.Machinery	1
333---Manufacture of machinery and equipment	1
i20.Computer and electronic products	6
3341---Manufacture of computers and peripheral equipment	1
3342---Manufacture of communication equipment	1
3343---Manufacture of audio and video equipment	1
3344---Manufacture of electronic components	1
3345---Manufacture of measuring, control, navigation, and medical electronic instruments and equipment	1
3346---Manufacture and reproduction of magnetic and optical media	1
i21.Electrical equipment, appliances, and components	1
335---Manufacture of electrical accessories, apparatus, and equipment for generating electrical energy	1
i22.Manufacture of transport equipment	1
336---Manufacture of transport equipment	1
i23.Furniture and related products	1
337---Manufacture of furniture, mattresses, and blinds	1
i24.Miscellaneous Manufacturing	1
339---Other manufacturing industries	1
i25.Trade	1
43-46---Trade	1
i26.Air transportation	1
481---Air transport	1
i27.Rail transportation	1
482---Transport by rail	1
i28.Water transportation	1
483---Water transport	1
i29.Truck transportation	1
484---Automotive freight transport	1
i30.Passenger Transportation	1
485---487---Passenger land transport, except by rail, Tourist transport	1
i31.Warehousing and storage	2

Mexican industries with code NAICS harmonized to 53 industries	**total industries**
488---Transport-related services	1
493---Warehousing services	1
i32.Publishing industries, except the internet (includes software)	2
491-492---Postal services. Courier and parcel services	1
511---Publishing of newspapers, periodicals, magazines, books, software, and other materials, and publishing of such publications integrated with printing	1
i33.Motion picture and sound recording industries	1
512---Film and video industry and sound industry	1
i34.Broadcasting and telecommunications	1
515-519---Radio and television, other information services	1
i35.Data processing, internet publishing, and other information services	1
517-518---Telecommunications, Electronic information processing, hosting, and other related services	1
i36.Federal Reserve banks, credit intermediation, and related activities	2
521---Central banking	1
522---Credit and non-market financial intermediation institutions	1
i37.Securities, commodity contracts, and investments	1
523---Stock exchange, foreign exchange, and financial investment activities	1
i38.Insurance carriers and related activities	1
524---Bonding, insurance, and pension companies	1
i39.Real estate	1
531---Real estate services	1
i40.Rental and leasing services and lessors of intangible assets	2
532---Rental of movable property services	1
533---551---Trademark, patent, and franchise rental services, Corporate	1
i41.Professional, scientific and technical services	1
541---Professional, scientific and technical services	1
i42.Waste management and remediation services	1
561-562---Business support services, Waste and refuse management, and remediation services	1
i43.Educational services	1
611---Educational services	1
i44.Ambulatory health care services	1
621---Outpatient medical and related services	1
i45.Hospitals	1

Mexican industries with code NAICS harmonized to 53 industries	total industries
622---Hospitals	1
i46.Nursing and residential care facilities	1
623---Health care and social work residences	1
i47.Social assistance	1
624---Other social work services	1
i48.Performing arts, spectator sports, museums, and related activities	2
711---Artistic, cultural, sporting, and other related services	1
712---Museums, historical sites, zoos, and the like	1
i49.Amusements, gambling, and recreation industries	1
713---Entertainment services in recreational facilities and other recreational services	1
i50.Accommodation	1
721---Temporary accommodation services	1
i51.Food services and drinking places	1
722---Food and beverage preparation services	1
i52.Other services, except government	4
811---Repair and maintenance services	1
812---Personal services	1
813---Associations and organizations	1
814---Households with domestic servants	1
i53.Government	1
931---Legislative, governmental, and law enforcement activities	1
Total general	76

Source:Own elaboration

4) The before harmonization is helpful because it allows us to compare the industrial systems of Mexico and the U.S.. It is also helpful to the construction of intercountry flows in the industrial system of both countries.

   The construction of the intercountry flows used four two matrices and three vectors described as follows. The Bureau of Economic Analysis (BEA, 2020) reports the Use table of the imports to the U.S. $\mathbf{U}^{\text{RoW,U.S.}}$ conformable with the total Use table of the U.S. $\mathbf{U}^{\text{U.S.}}$**;** in the case of Mexico, the INEGI (2021) also reports a Use table of the imports to Mexico $\mathbf{U}^{\text{RoW,MX}}$ however these matrix are reported to 256 products and are not conformable with the total Use table of Mexico $\mathbf{U}^{\text{MX}}$**.**

   The United Census Bureau, through the project *U.S. trade online* (2022), reports the vectors of the 63 products with the NAICS classification of the imports $\mathbf{m}^{\text{MX,U.S.}}$ and exports $\mathbf{m}^{\text{U.S.,MX}}$ from and to Mexico, respectively. Using the last two vectors can be constructed two dichotomic vectors; the vector that its entries are equal to 1 if the imports from Mexico to the U.S. are different from 0 to the respective product $\mu^{\text{MX,U.S.}}$ in analogic form was constructed the dichotomic vector of export from the U.S. to Mexico $\mu^{\text{U.S.,MX}}$.

It was possible to calculate the intercountry flows of goods and services using the above tables, matrices, and vectors. To estimate the Use table of goods and services exported from MX to the U.S. $\mathbf{U}^{\text{MX,U.S.}}$The following steps were done

First to the Use table of the imports to the U.S. $\mathbf{U}^{\text{RoW,U.S.}}$ is transformed into a Use Table $\widetilde{\mathbf{U}}^{\text{MX,U.S.}}$with rows equal to 0 if Mexico does not export the product to the U.S., by following:

$$\widetilde{\mathbf{U}}^{\text{MX,U.S.}} = \hat{\mu}^{\text{MX,U.S.}}\ \mathbf{U}^{\text{RoW,U.S.}}, \qquad \text{[a.1]}$$

where $\hat{\mu}^{\text{MX,U.S.}}$ is the diagonalized vector $\mu^{\text{MX,U.S.}}$. The matrix $\widetilde{\mathbf{U}}^{\text{MX,U.S.}}$ only "clear" the row of products Mexico does not export to the U.S.. Thus, assuming that the U.S. imports from Mexico have the same structure as the U.S. imports from RoW by product, it is possible to estimate the structure of the U.S. imports from Mexico $\breve{\mathbf{U}}^{\text{MX,U.S.}}$ by product.

First was calculate the sum by rows of the Matrix $\widetilde{\mathbf{U}}^{\text{MX,U.S.}}$ it means the vector $\widetilde{\mathbf{u}}^{\text{MX,U.S.}}$

$$\widetilde{\mathbf{u}}^{\text{MX,U.S.}} = \widetilde{\mathbf{U}}^{\text{MX,U.S.}}\mathbf{i}\,, \qquad \text{[a.2]}$$

where $\mathbf{i}$ is a unitary vector that allows the conformability of scalar product in the equation a.2, it means the vector $\widetilde{\mathbf{u}}^{\text{MX,U.S.}}$ is to order 63×1. It allows estimating

$$\breve{\mathbf{U}}^{\text{MX,U.S.}} = \hat{\widetilde{\mathbf{u}}}^{\text{MX,U.S.}^{-1}}\widetilde{\mathbf{U}}^{\text{MX,U.S.}}\,, \qquad \text{[a.3]}$$

Where $\hat{\widetilde{\mathbf{u}}}^{\text{MX,U.S.}^{-1}}$ is the inverse of the diagonalized vector $\widetilde{\mathbf{u}}^{\text{MX,U.S.}}$. Finally, it is possible to estimate the matrix $\mathbf{U}^{\text{MX,U.S.}}$ By following:

$$\mathbf{U}^{\text{MX,U.S.}} = \mathbf{m}^{\text{MX,U.S.}}\ \breve{\mathbf{U}}^{\text{MX,U.S.}}\,, \qquad \text{[a.4]}$$

It is important to remember that $\mathbf{U}^{\mathrm{MX,U.S.}}$ contains the matrix to intermediate consumption imported to the U.S. from Mexico $\mathbf{Z}^{\mathbf{MX,USA}}$, also the vector of final consumption demand $\mathbf{f}^{\mathbf{MX,USA}}$ imported to the U.S. from Mexico, and the vector $\mathbf{k}^{\mathbf{MX,USA}}$. Thus, to estimate the matrices $\mathbf{F}^{\mathbf{MX,USA}}$ and $\mathbf{K}^{\mathbf{MX,USA}}$, the structures of $\mathbf{f}^{\mathbf{MX,USA}}$ and $\mathbf{k}^{\mathbf{MX,USA}}$ were used, **but their** entries were redistributed using the institutional sector share concerning the total of each variable, according to institutional accounts.

An analogic process was used to calculate the U.S.'s exports to Mexico. However, in this case, it was used the matrix $\mathbf{U}^{\mathrm{MX}}$ and not the matrix $\mathbf{U}^{\mathrm{RoW,MX}}$ to estimate the structure of Mexican imports. The rest of the process is analogic to the case of the U.S..

Table AIII-4 Policy Control and Policy Objective resulted for the Bi-regional SAM Mexico-U.S.

ID	Policy control in millions of dollars	Policy objective millions of dollar	Share concerning the total Policy Control	Share concerning the total Policy Objective	ID	Policy control in millions of dollars	Policy objective millions of dollar	Share concerning the total Policy Control	Share concerning the total Policy Objective
MX p01	376	1 712	0.39	0.34	**U.S. p01**	979	3 836	1.03	0.77
MX p02	382	483	0.40	0.10	**U.S. p02**	1 017	1 189	1.07	0.24
MX p04	347	347	0.36	0.07	**U.S. p04**	994	999	1.04	0.20
MX p05	388	388	0.41	0.08	**U.S. p05**	977	977	1.03	0.20
MX p06	365	756	0.38	0.15	**U.S. p06**	1 059	6 675	1.11	1.34
MX p07	376	419	0.39	0.08	**U.S. p07**	1 004	1 004	1.05	0.20
MX p08	392	423	0.41	0.09	**U.S. p08**	1 023	1 252	1.07	0.25
MX p09	413	541	0.43	0.11	**U.S. p09**	1 014	1 527	1.07	0.31
MX p10	422	556	0.44	0.11	**U.S. p10**	1 045	1 085	1.10	0.22
MX p11	505	712	0.53	0.14	**U.S. p11**	1 031	1 953	1.08	0.39
MX p12	477	523	0.50	0.11	**U.S. p12**	1 021	1 431	1.07	0.29
MX p13	618	1 668	0.65	0.34	**U.S. p13**	1 033	4 575	1.09	0.92
MX p14	533	1 085	0.56	0.22	**U.S. p14**	1 053	2 866	1.11	0.58
MX p15	548	3 711	0.58	0.75	**U.S. p15**	1 055	7 933	1.11	1.60
MX p16	719	765	0.76	0.15	**U.S. p16**	995	1 786	1.05	0.36
MX p17	435	722	0.46	0.15	**U.S. p17**	1 085	3 508	1.14	0.71
MX p18	563	1 024	0.59	0.21	**U.S. p18**	1 085	6 322	1.14	1.27
MX p19	457	9 327	0.48	1.88	**U.S. p19**	1 171	22 871	1.23	4.61

ID	Policy control in millions of dollars	Policy objective millions of dollar	Share concerning the total Policy Control	Share concerning the total Policy Objective	ID	Policy control in millions of dollars	Policy objective millions of dollar	Share concerning the total Policy Control	Share concerning the total Policy Objective
MX p20	464	626	0.49	0.13	**U.S. p20**	1 098	2 724	1.15	0.55
MX p21	464	1 533	0.49	0.31	**U.S. p21**	1 397	9 616	1.47	1.94
MX p22	527	808	0.55	0.16	**U.S. p22**	1 023	2 025	1.08	0.41
MX p23	444	572	0.47	0.12	**U.S. p23**	1 019	1 256	1.07	0.25
MX p24	505	1 983	0.53	0.40	**U.S. p24**	1 097	7 556	1.15	1.52
MX p25	556	1 814	0.58	0.37	**U.S. p25**	1 078	14 323	1.13	2.89
MX p26	506	1 013	0.53	0.20	**U.S. p26**	1 026	2 462	1.08	0.50
MX p27	308	308	0.32	0.06	**U.S. p27**	993	993	1.04	0.20
MX p28	300	300	0.32	0.06	**U.S. p28**	994	1 094	1.04	0.22
MX p29	522	860	0.55	0.17	**U.S. p29**	1 054	2 933	1.11	0.59
MX p30	411	425	0.43	0.09	**U.S. p30**	985	1 014	1.03	0.20
MX p31	381	398	0.40	0.08	**U.S. p31**	1 006	1 441	1.06	0.29
MX p32	394	775	0.41	0.16	**U.S. p32**	1 008	1 259	1.06	0.25
MX p33	398	1 765	0.42	0.36	**U.S. p33**	1 022	1 913	1.07	0.39
MX p34	481	481	0.51	0.10	**U.S. p34**	979	979	1.03	0.20
MX p35	568	698	0.60	0.14	**U.S. p35**	1 014	1 487	1.07	0.30
MX p36	421	470	0.44	0.09	**U.S. p36**	1 011	1 014	1.06	0.20
MX p37	483	483	0.51	0.10	**U.S. p37**	1 005	3 669	1.06	0.74
MX p38	345	921	0.36	0.19	**U.S. p38**	994	1 736	1.04	0.35
MX p39	353	698	0.37	0.14	**U.S. p39**	1 025	8 178	1.08	1.65
MX p40	640	651	0.67	0.13	**U.S. p40**	953	2 163	1.00	0.44
MX p41	351	2 924	0.37	0.59	**U.S. p41**	1 136	23 455	1.19	4.73
MX p42	312	5 502	0.33	1.11	**U.S. p42**	1 237	45 849	1.30	9.24
MX p43	588	596	0.62	0.12	**U.S. p43**	945	1 069	0.99	0.22
MX p44	461	481	0.48	0.10	**U.S. p44**	984	3 166	1.03	0.64
MX p45	322	479	0.34	0.10	**U.S. p45**	1 045	3 257	1.10	0.66
MX p46	463	463	0.49	0.09	**U.S. p46**	1 005	1 005	1.06	0.20
MX p47	663	771	0.70	0.16	**U.S. p47**	1 008	2 545	1.06	0.51
MX p48	309	309	0.33	0.06	**U.S. p48**	1 007	1 007	1.06	0.20
MX p49	342	491	0.36	0.10	**U.S. p49**	1 019	2 317	1.07	0.47
MX	434	451	0.46	0.09	**U.S.**	1 019	1 561	1.07	0.31

ID	Policy control in millions of dollars	Policy objective millions of dollar	Share concerning the total Policy Control	Share concerning the total Policy Objective	ID	Policy control in millions of dollars	Policy objective millions of dollar	Share concerning the total Policy Control	Share concerning the total Policy Objective
p50					**p50**				
MX p51	359	3 173	0.38	0.64	**U.S. p51**	1 068	8 508	1.12	1.71
MX p52	389	1 303	0.41	0.26	**U.S. p52**	1 164	23 272	1.22	4.69
MX p53	433	1 679	0.45	0.34	**U.S. p53**	1 176	23 989	1.24	4.83
MX p54	393	403	0.41	0.08	**U.S. p54**	1 072	6 286	1.13	1.27
MX p55	412	490	0.43	0.10	**U.S. p55**	1 059	5 482	1.11	1.10
MX p56	315	476	0.33	0.10	**U.S. p56**	1 005	2 567	1.06	0.52
MX p57	336	557	0.35	0.11	**U.S. p57**	1 052	4 899	1.11	0.99
MX p58	352	1 202	0.37	0.24	**U.S. p58**	1 056	3 371	1.11	0.68
MX p59	384	1 333	0.40	0.27	**U.S. p59**	1 135	15 753	1.19	3.17
MX p60	381	1 544	0.40	0.31	**U.S. p60**	1 111	14 159	1.17	2.85
MX p61	378	4 280	0.40	0.86	**U.S. p61**	1 560	81 917	1.64	16.51
MX p62	1 008	734	1.06	0.15	**U.S. p62**	1 003	- 521	1.05	-0.10
MX p63	1 021	922	1.07	0.19	**U.S. p63**	1 345	5 126	1.41	1.03

Source: Own elaboration