UNIVERSIDADE DE BRASÍLIA
FACULDADE DE ECONOMIA, ADMNISTRAÇÃO E CONTABILIDADE
PROGRAMA DE PÓS-GRADUAÇÃO EM ECONOMIA

Matheus Silva de Paiva

Essays on Structural Change and Economic Growth: An Approach to Public Taxation, International Trade and Endogenous Technical Progress

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Área de Concentração: Economia Política

Orientador(a): Dr. Ricardo Azevedo Araujo

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Dedico esta, bem como todas as minhas demais conquistas que porventura e bondade divina venham a acontecer, à Deus, à minha amada família e à minha amada namorada.

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1 Introduction

Structural change and economic growth are an importants researches schedules since the mid-1950s, because it is no surprise that poor countries have to catching up with advanced ones. Besides, the economic growth is related with structural changes. These changes, whose direction is unique, should be in order to mobilize labor and capital from the less advanced sectors towards the more advanced sectors. The directional uniqueness of structural change is due to the degrees of complexity and income elasticity of the economic sectors. In this sense, if all goods were equal, there would only be one sector and the wage rate would be unique. As the sectors differ, one must speak in a single direction, that is, from the primitive sectors towards the advanced sectors, generating a diversified productive structure, capable of reflecting the consumption basket of an average consumer. In other words, it means that structural change must promote the modernization of the economic structure, transferring labor and capital from more backward and less complex sectors (with lower income elasticity) to the more modern and more complex sectors (with higher income elasticity). In short, structural change plays a major role in the development, because "the most opulent nations, indeed, generally excel all their neighbours in agriculture as well in manufactures; but they are commonly more distinguished by their superiority in the latter than in the former" (SMITH, 2007, p. 10).

Although structural change is as important as economic growth for the full understanding of the economic development process, the study of the role of structural changes has not received the same attention as economic growth. And this is fundamental too, because this adequate and harmonious relationship between growth and structural change will increase several positive aspects of this society, for instance, reducing the illiteracy rate, reducing the poverty rate, increasing quality of life, improving education and health, and so on.

In this context, the main objective of this thesis is to show how a large number of issues related to the process of economic development can be addressed from a structural change dynamics approach. In this scenario, several entities can play decisive roles in this process, such as government, firms and families. Its central theme is the search for understanding the theory of economic development from an analytical framework in which changes in the sectoral composition coming from those agents, for instance, the government and the consumer's preferences, plays a central role. This approach is in line with the Structural Change Dynamics Analysis developed by Pasinetti in his books Economic Growth and Structural Change (1981) and Structural Economic Dynamics (1993). One of the ideas presented in this thesis is a view of a good government-designed economic policy can be the main driver of economic growth. In this case, the public sector plays such a major role in this generation of structural change and, therefore, economic growth. This idea was developed by Ram (1986), which empirically presented robust results showing that government size has a positive effect on economic performance and growth, that is, for the dozens of selected countries, government participation was able to pull economic growth. (RAM, 1986, p. 202).

From model extensions of the Thirlwall-Pasinetti growth literature to international trade and endogenous growth approach, we identify, from an unbalanced development perspective, which mechanisms are responsible for maintaining or increasing inequalities between developed and underdeveloped countries. In many cases, besides designing a correct tax policy, the government should not prevent market concentration when it occurs in a meritocratic way. This will increase the competitiveness of the sectors of higher income elasticity of exports, which will induce the export of these sectors, raising the rate of economic growth. This process will increase the diversification of the export agenda in the direction of the goods of greater income elasticity of exports, leading the economy along the path of development.

In this way, the aim is to develop an approach to economic growth and institutions relations that allows an analysis of the dynamics of structural change in the relations between distinct economic systems, an issue not yet satisfactorily addressed by endogenou growth theory. Faced with such an analytical framework, there is the possibility of formally analyzing the benefits of economic relations between countries, especially when they have some more relevant attributes, such as active government participation.In order to achieve these objectives of this thesis, it is necessary to formally address three essential points:

1. The relevance of proper taxation design in strengthening economic growth;
2. The identification of intermediate goods to lubricate international trade as an inhibitor of the growth process - the trade paradox;
3. The identification of how market structures can have effects on the creation of new sectors, the distribution of jobs and the production of technology.

One way of implementing the first two points is to extend the multisectoral balance-of-payments-constraint model by the Thirlwall-Pasinetti [Araujo and Lima (2007)], introducing the public sector and the possibility of importing intermediate goods. This approach requires an additional condition, which refers to the intertemporal balance of public accounts. Such a condition is formally stated and then analyzed in terms of its effects on trade gains.

For the treatment of the third topic, besides the Foellmi and Zweimüller model of structural change, the role of market concentration has been improved in an extended version of the Foellmi and Zweimüller model of structural change. This step was important since one of the pillars of development growth process is to understand the importance of this element as well as better use it. The point is that the proportion of firms in the economy that have market power was exogenous. This allowed for small advances in the understanding of the economic growth of the countries using comparative statics.

This analysis is then moving towards the construction of a model of endogenous structural changes capable of producing economic growth from the existence of economic profit and the assumption of Engel's Law. In this case, Engel's Law, reflected in the hierarchy of the consumption of goods, would be the mechanism on the demand side responsible for directing the opening of new sectors, while on the supply side, economic profit would be the mechanism responsible for conditioning the opening of new sectors. From this analysis, it is possible to compare strategies of economic growth that contemplate the mechanisms of interaction between technological progress and market concentration in an analytical scheme that simultaneously considers the sides of supply and demand.

Several of tries has been made by several countries and, in so many cases, unsuccessful. To see this, it is sufficient watch the unsuccessful attempts of Latin America, especially Brazil. In the last two decades, the brazilian governments made efforts to improve the distribution of income, increase the rate of growth, boost consumption and investment but managed Brazil into an unprecedented moral, economic, and political crisis. This is one of the reasons of why great researchers still studying this literature. Endless hard work is done among the countries and over the years by society and government and just a little advance was produced [see e.g. Ocampo (2005)]. In this vein, there is still a lot to be discovered through empirical and theoretical researches. This work is part of this theoretical framework, seeking to illuminate some questions in order to contribute to this journey.

Some countries, on the other hand, achieved great economic and social progress in the last decades, for instance, Luxemburg and South Korea. The European country used a strategy aimed at economic liberalization while the Asian focused on state intervention in the market [Roemer, 1995]. Both countries adopted different strategies and reached similar economic level. Regardless of which strategy is most appropriate for each country, it is of the utmost importance that we continue to research to find better and less costly ways of enabling people in each country to live better. In any case of economic development, we can find at least two satisfied requeriments for success which are economic growth and structural change. The first allows the country to have a larger amount of income and the second allows it to build more modern sectors, increasing profits and wages from first requeriment. If a country is underdeveloped this requeriments should constitute the main economic goal of society as a whole. Therefore, this objective should occupy a large part of policy discussions and guide reforms.

This thesis is structured in three articles. It aims to work with the themes structural change and economic growth from two different approaches. The first two articles, with heterodox roots, highlights the character of the type export-led-growth strategies. The first paper analyzes what the government can make to increase economic growth rate under general macroeconomic constraint. The second, analyzes what happen to a country when fed with intermediate goods imports of high-income elasticities. The third, more orthodox matrix, exposes how the concentration of markets can have effects on economic growth. In this sense, the first chapter deals with this issue involving import of intermediate goods and economic growth from a dynamic economy approach and the second with the government intervention, while the third chapter focuses on dynamic optimization and steady state.

Chapter 1: Fiscal Policy From a Structural Economic Dynamics Approach with General Macroeconomic Constraint

Abstract

The main aim of this paper is to consider the presence of government in macroeconomic aggregates using the Pasinettian framework, and to verify how sector taxation and public spending affect the domestic economic growth rate. The first result demonstrates that the balance of payments is not the only growth restriction that countries face, since public savings also play an important role in this regard. In addition, we demonstrate that the way the government implements taxation and spending across sectors may influence the economic growth rate over the long term. Finally, a computer simulation is presented to illustrate how much faster a country can develop when it is led by a government whose economic agenda is based on structural change. Several relevant empirical studies could be produced using this model of structural dynamics with general macroeconomic constraint.

Keywords: Structural Change; General Macroeconomic Constraint; Taxes; Government Spending; Economic Growth.

1. Introduction

Balance-of-payment-constraint growth models, henceforth BOPC, were initially formalized by Thirlwall (1979). One of his aims was to provide an alternative to the dominant theory [see Solow (1956) and Romer (1990)] to understand economic growth in developing countries. Briefly, this was because the theories which were unable to explain the growth process in underdeveloped countries, since their assumptions were not supported in countries deprived of mechanisms to improve the labor force. While the mainstream continued to orbit around the concept of Total Factor Productivity (TFP) in order to explain the growth phenomenon, Thirlwall's proposal (which took several elements from the structuralist tradition) was based on other fundamental concepts. Essentially, these concepts involve the ratio between the income elasticity of exports and the income elasticity of imports, which provides a parameter of sensitivity to growth in the rest of the world, in order to explain domestic growth. In the line with this notion, in order to achieve higher growth rates, a country should promote an increase in its income elasticity of exports or a reduction in its income elasticity of imports, or both, simultaneously. To this end, rather than increasing the productivity of production factors, the country should produce and start to export products with greater income elasticity of exports, and stop producing, and start to import, products with lower income elasticity of imports. In other words, the country must undergo structural change. In this sense, it should migrate from a quantitative point of view, represented by the mainstream framework (in which it was understood that in order to grow it was enough to produce more, using the same amount of resources), to a more qualitative point of view, represented by the BOPC agenda, which understands the phenomenon of growth from the point of view of structural change. Based on such a structural change approach, this article deals with the presence of government into the Pasinettian model, with a focus on how the public sector affects economic growth. The present article seeks to incorporate the work of Araujo and Teixeira (2004), which extended this model to an open economy, and added new elements into the structural change framework, in order to make the theory more robust and compatible with reality.

2. The Approach of Macroeconomic-constrained Growth

The balance-of-payments-constraint growth approach has contributed to a better understanding of long-term economic experiences in several countries, particularly in underdeveloped ones. According to this research agenda, a country's economic growth rate cannot be distinct from one which ensures that the balance of payments is stable and equal to zero over time. This theory, originally proposed by Thirlwall (1979), has been generalized in several ways. Among others, we note the incorporation of capital flows [Thirlwall and Hussain (1982)], the possibility of external debt [McCombie and Thirlwall (1997) and Moreno-Brid (1998-99)], interest payments [Moreno-Bridd (2003)], sector disaggregation [Araujo and Lima (2007)], commercial disaggregation [Nell (2003)] and, more recently, the conjunction of sector disaggregation and commercial disaggregation [Araujo, Paiva, Santos and Silva (2017)]. In this paper, we start with a multi-sectoral framework for this theory, known in the literature as the Multi-sectoral Thirlwall's Law (MSTL), as derived by Araujo and Lima (2007). Starting with the multi-sectoral Pasinetti model of sectoral changes (1981), these authors demonstrated that the income elasticity of demand for exports and imports should be considered as weighted averages of sectoral elasticity, which provides various commodities' participation in export and import structures. This result enabled the opening up of a new agenda of empirical research, now focused on demonstrating a better fit, as well as a forecast for the multi-sectoral version in relation to the aggregate one [see Gouvea and Lima (2009) and Romero and McCombie (2016)].

As presented by Araujo and Teixeira (2004), structural economic dynamics is a useful framework for analyzing the uneven development in a North-South set up. In their paper, Pasinetti's analysis was extended to an open economy, enabling a study of the effects of international economic relations on the dynamic pattern of production, technological progress and the evolution of preferences. As Araujo and Lima (2007) demonstrate, structural change was not properly incorporated into demand-oriented theories of economic growth. According to these authors, the exception is the Pasinettian structural dynamics approach, "whose main implication is that changes in the structure of production lead to changes in the growth rate, so that intercountry differences in the structure of production implies intercountry differences in the growth rate" (Araujo and Lima, 2007, p. 17). However, the authors did not include the government in their analysis, and their interesting results may be enhanced by taking government presence into account.

In this paper, we employ a version of that model which includes the presence of government in order to conduct a more general macroeconomic constraint growth analysis. As stated in Araujo and Lima (2007, p. 7),

> in a multi-sector economy in which productivity and demand vary over time at particular rates in each one of the sectors of two countries: let A denote the advanced country and U the underdeveloped one. Both countries are assumed to produce n−1 consumption goods: one in each vertically integrated sector but with different patterns of production and consumption. From the point of view of country U the physical and monetary flows of commodities can be summarized by three conditions, namely, the condition for full national income, the condition for disposition of national income and the general macroeconomic equilibrium, along with the solution for the system of physical and monetary quantities.

The full national income condition, considering the presence of government, may be stated as:

$$\sum_{i=1}^{n-1} \left(a_{in} + \xi a_{i\hat{n}} + g_{in}\right) a_{in} = 1 \tag{1.1}$$

where $i = 1, ..., n-1$ denotes this economy's final goods sectors, a_{in} denotes the domestic demand coefficient for commodity i produced domestically, $a_{i\hat{n}}$stands for the demand coefficients of the final commodity i, and g_{in} denotes the domestic government demand coefficient for commodity i. The production coefficients for consumption goods are given by a_{ni}. The family sector in country A is denoted by $\hat{n}$ and the size of population in each country is related to the other through the coefficient of proportionality ξ.

The condition for the full disposition of national income with government presence is given by:

$$\sum_{i=1}^{n-1} \left(a_{in} + a_{\hat{in}} + h_{in}\right) a_{in} = 1 \tag{1.2}$$

where $a_{\hat{in}}$ is the foreign demand coefficient for commodity i produced in country A and h_{in} is the domestic government revenue in the i-sector.

The government budget constraint, in terms of per capita physical quantities, is given by:

$$\sum_{i=1}^{n-1} h_{in} a_{in} = \sum_{i=1}^{n-1} g_{in} a_{in} \tag{1.3}$$

Note that by expression (3), total public income must be equal to total public spending. This guarantees intertemporal public budget constraint consistency and avoids the need to deal with public debts and potential Ponzi behavior. In the equilibrium, between full national income and the full disposition of national income, we have:

$$\sum_{i=1}^{n-1}\left(a_{in}+\xi a_{i\hat{n}}+g_{in}\right)a_{in}=\sum_{i=1}^{n-1}\left(a_{in}+a_{\hat{i}n}+h_{in}\right)a_{in} \tag{1.4}$$

We can rewrite equation (4) as follows:

$$\sum_{i=1}^{n-1}\left(\xi a_{i\hat{n}}-a_{\hat{i}n}\right)a_{in}+\sum_{i=1}^{n-1}\left(g_{in}-h_{in}\right)a_{in}=0 \tag{1.5}$$

Eq. (5) is well known in the literature if we consider just two sectors, that is, $n = 2$. In this case, it is easy to see that we have a macroeconomic identity.

In fact, equation (5) is the first important result of this extended Pasinettian model. This equilibrium condition, in terms of sectors, demonstrates that commercial balance finances the public deficit, and vice versa. This means that, in equilibrium, negative foreign savings imply public account surplus. Unlike the model presented by Araujo and Lima (2007), we note that is no longer necessarily any balance-of-payment constraint. Furthermore, balance-of-payment constraint is a particular case in our general macroeconomic constraint. In this sense, public sector presence may weaken external constraint. On the other hand, if the budget is not balanced, the public sector can direct foreign trade. If the government were to incur a deficit, there would be positive external savings to satisfy the general condition of macroeconomic equilibrium and, therefore, the country should import more than it exports. On the other hand, if there is a government surplus, then domestic exports are likely to exceed imports.

Assume that equation (5) holds for every single sector. Exports plus government spending are therefore equal to imports plus imports for each sector. Thus,

$$\xi a_{i\hat{n}}-a_{\hat{i}n}=g_{in}-h_{in}\quad \forall i=1,...,n-1 \tag{1.6}$$

As in the model developed by Araujo and Lima (2007), the macroeconomic equilibrium in our model can be written in terms of labor coefficients: labor coefficients weight both the export and the import demand coefficients for commodities i, as well government expenditure and tax coefficients for commodities i. This condition therefore requires that government expenditure and exported commodities, expressed in terms of labor quantities in country U, must be equal to government tax and imported commodities, also expressed in terms of labor quantities in U.

The work of Pasinetti (1981), and later that of Araujo and Teixeira (2004), have demonstrated that those goods for which productivity differences are smaller than tenfold must have a lower price in U than in A. Thus, even when the average productivity in Country A is higher than in country U, in sectors where U productivity is higher than its average productivity, there is a comparative advantage in producing these commodities.

Likewise, goods for which productivity differences are greater than tenfold must have a lower price in A than in U. In this way, if we allow for international trade, goods will be transacted between the two countries. People in country A will buy the first type of goods from U, if they are cheaper, and people in U will buy the second type of goods from A. Country U is induced to specialize, and then export, the first type of commodity, while country A is induced to specialize, and then export, the second type of commodity. Indeed, the results of these specialization patterns in the two countries provide an important economic reason for the per capita export supply and import demand functions that we adopt in the next section. Thus, like Pasinetti (1981, 1993), we can describe domestic price fluctuations in terms of changes in productivity as follows:

$$p_i = a_{ni} w^U \quad \forall i = 1, ..., n-1 \tag{1.7}$$

Equation (7) shows that the price for i-th goods is given by the domestic unitary labor requirement multiplied by the wage rate and the foreign price fluctuations, as follows:

$$p_{\hat{i}} = a_{n\hat{i}} w^A \quad \forall i = 1, ..., n-1 \tag{1.8}$$

For simplicity, assume that $w^A = w^U$ such that differences between prices is given by differences between productivity. The i-th domestic unitary labor requirement is given as:

$$a_{ni} = \frac{X_{ni}}{X_i} \quad \forall i = 1, ..., n-1 \tag{1.9}$$

where $X_n$is the labor force and X_i is the physical quantity produced in the i-th sector.

We shall now define X_i for all $n-1$ sectors. Following Pasinetti (1981, 1993), we can describe the production of the i-th sector as:

$$X_i = (a_{in} + \xi a_{i\hat{n}} + g_{in}) X_n \quad \forall i = 1, ..., n-1 \tag{1.10}$$

Equations (8) and (9) are very important for understanding the government mechanism of structural change. By substituting equation (10) for equation (9) we obtain:

$$a_{ni} = \frac{X_{ni}}{(a_{in} + \xi a_{i\hat{n}} + g_{in}) X_n} \quad \forall i = 1, ..., n-1 \tag{1.11}$$

By making a derivation in equation (11) in relation to time and assuming constant per capita consumption, we can obtain:

$$\dot{a}_{ni} = -(\xi \dot{a}_{i\hat{n}} + \dot{g}_{in}) \frac{a_{ni}}{X_i} \quad \forall i = 1, ..., n-1 \tag{1.12}$$

By equation (12) we note that exports and government spending can improve sectoral productivity and, as we will see, be used to make certain sectors internationally competitive, through the fall price effect.

3. Macroeconomic Constraint Growth Analysis in a Pasinettian Framework

Let us consider that foreign demand for commodity i is given by a standard export function, such as the one adopted by Thirlwall (1979). This condition can be summarized as follows:

$$x_{i\hat{n}} = \begin{cases} \left(\frac{p_i}{ep_{\hat{i}}}\right)^{\eta_i} Y_A^{\beta_i} & if \quad p_i < ep_{\hat{i}} \\ 0 & if \quad p_i \geq ep_{\hat{i}} \end{cases} \tag{1.13}$$

where $x_{i\hat{n}}$ is foreign demand for commodity i, η_i is the price elasticity of demand for the export of commodity i, with $\eta_i < 0$, while β_i is the income elasticity of demand for exports and $Y_A$is the national income of country A.

Dividing both sides of (13) by the population of country A, given by $X_{\hat{n}}$, we obtain the per capita coefficient for foreign demand of commodity i, that is:

$$a_{i\hat{n}} = \begin{cases} \left(\frac{p_i}{ep_{\hat{i}}}\right)^{\eta_i} y_A^{\beta_i} X_{\hat{n}}^{\beta_i - 1} & if \quad p_i < ep_{\hat{i}} \\ 0 & if \quad p_i \geq ep_{\hat{i}} \end{cases} \tag{1.14}$$

Consider that the import demand coefficients are given by a standard import demand function, which have the following functional form:

$$x_{\hat{i}n} = \begin{cases} \left(\frac{ep_{\hat{i}}}{p_i}\right)^{\psi_i} Y_U^{\varphi_i} & if \quad p_i > ep_{\hat{i}} \\ 0 & if \quad p_i \leq ep_{\hat{i}} \end{cases} \tag{1.15}$$

where ψ_i is the price elasticity of demand for imports of commodity i, with $\psi_i > 0$, φ_i is the income elasticity of demand for imports and Y_U is the real income of country U.

Dividing both sides of (15) by the population of country U, we obtain the per capita import coefficient for commodity i:

$$a_{\hat{i}n} = \begin{cases} \left(\frac{ep_{\hat{i}}}{p_i}\right)^{\psi_i} y_U^{\varphi_i} X_n^{\varphi_i - 1} & if \quad p_i > ep_{\hat{i}} \\ 0 & if \quad p_i \leq ep_{\hat{i}} \end{cases} \tag{1.16}$$

Let us consider that government sectoral expenditure can be described by the following equation:

$$G_{\hat{i}n} = \begin{cases} \left(\frac{p_i}{ep_{\hat{i}}}\right)^{\chi_i} H_U^{\kappa_i} & if \quad p_i > ep_{\hat{i}} \\ 0 & if \quad p_i \leq ep_{\hat{i}} \end{cases} \tag{1.17}$$

where χ_i is the price elasticity of government expenditure of commodity i, with $\chi_i > 0$, κ_i is the income elasticity of government expenditure, and H_U is the domestic total tax revenue.

Equation (17) shows that the government does not spend anything in sector i, if it is already internationally competitive, that is, if $p_i \leq ep_{\hat{i}}$; but may spend a non-negative value, if this sector is not competitive. Basically, the government here has the function of investing in sectors that are not yet competitive and which have a high-income elasticity of exports. This means that the sectoral income elasticity of government spending will be directly proportional to the sectoral income elasticity of exports.

Dividing both sides of (17) by the population of country U, we obtain the per capita government expenditure coefficient for commodity i:

$$g_{in} = \begin{cases} \left(\frac{p_i}{ep_{\hat{i}}}\right)^{\chi_i} h_U^{\kappa_i} X_n^{\kappa_i - 1} & if \quad p_i > ep_{\hat{i}} \\ 0 & if \quad p_i \leq ep_{\hat{i}} \end{cases} \tag{1.18}$$

We now define the sectoral tax that will finance government expenditure, which can be described by the equation:

$$H_{in} = \begin{cases} 0 & if \quad p_i > ep_{\hat{i}} \\ H_U^{\tau_i} & if \quad p_i \leq ep_{\hat{i}} \end{cases} \tag{1.19}$$

where τ_i is the income elasticity of tax.

Equation (19) shows that, in order to finance the sectors that are not yet competitive, but which have high income elasticity of exports, the government imposes non-negative taxes on sectors that are competitive. Similar to public expenditure, taxation focuses on competitive sectors, but those which have lower income elasticity of exports, that is, the income elasticity of taxes is inversely proportional to the income elasticity of exports. The government equations for decision (17) and (19) express the government logic in this model: the government draws resources from the competitive sectors of lower income elasticity of exports and passes this on to the non-competitive sectors of great income elasticity of exports.

Dividing both sides of (19) by the population of country U, we obtain the per capita government tax coefficient for commodity i:

$$h_{in} = \begin{cases} 0 & if \quad p_i > ep_{\hat{i}} \\ h_U^{\tau_i} X_n^{\tau_i - 1} & if \quad p_i \leq ep_{\hat{i}} \end{cases} \tag{1.20}$$

We can take the natural logarithms on both sides of (14) and differentiate these with respect to time. By adopting the following notation: $\frac{\dot{p}_i}{p_i} = \sigma_i^U$, $\frac{\dot{p}_{\hat{i}}}{p_{\hat{i}}} = \sigma_i^A$, $\frac{\dot{e}}{e} = \varepsilon$, $\frac{\dot{y}_A}{y_A} = \sigma_y^A$, $\frac{\dot{y}_U}{y_U} = \sigma_y^U$, $\frac{\dot{X}_n}{X_n} = g$, $\frac{\dot{X}_{\hat{n}}}{X_{\hat{n}}} = \hat{g}$, this procedure yields the growth rate of the per capita export demand for commodity i:

$$\frac{\dot{a}_{i\hat{n}}}{a_{i\hat{n}}} = \begin{cases} \eta_i \left(\sigma_i^U - \sigma_i^A - \varepsilon\right) + \beta_i \sigma_y^A + \left(\beta_i - 1\right) \hat{g} & if \quad p_i < ep_{\hat{i}} \\ 0 & if \quad p_i \geq ep_{\hat{i}} \end{cases} \tag{1.21}$$

By adopting the same procedure with respect to expression (16), we obtain the following growth rate of per capita import demand coefficient for commodity i:

$$\frac{\dot{a}_{\hat{i}n}}{a_{\hat{i}n}} = \begin{cases} -\psi_i \left(\sigma_i^U - \sigma_i^A - \varepsilon\right) + \varphi_i \sigma_y^U + (\varphi_i - 1)\, g & if \quad p_i > e p_{\hat{i}} \\ 0 & if \quad p_i \leq e p_{\hat{i}} \end{cases} \tag{1.22}$$

Applying the same procedure with respect to expression (18) and adopting the notation that $\frac{\dot{h}_U}{h_U} = \sigma_h^U$, we obtain the growth rate of per capita government expenditure coefficient for commodity i:

$$\frac{\dot{g}_{in}}{g_{in}} = \begin{cases} \chi_i \left(\sigma_i^U - \sigma_i^A - \varepsilon\right) + \kappa_i \sigma_h^U + (\kappa_i - 1)\, g & if \quad p_i > e p_{\hat{i}} \\ 0 & if \quad p_i \leq e p_{\hat{i}} \end{cases} \tag{1.23}$$

By adopting the same procedure with respect to expression (20), we obtain the per capita growth rate from taxes collected from commodity i:

$$\frac{\dot{h}_{in}}{h_{in}} = \begin{cases} 0 & if \quad p_i > e p_{\hat{i}} \\ \tau_i \sigma_h^U + (\tau_i - 1)\, g & if \quad p_i \leq e p_{\hat{i}} \end{cases} \tag{1.24}$$

Let us assume that $g = \hat{g} = 0$ which means that the population in both countries remains constant. Suppose also that $\sigma_i^U - \sigma_i^A - \varepsilon = 0$, which means that the rate of change in the price of commodity i is equal in both countries. Given these conditions, expressions (21), (22), (23) and (24) can be respectively reduced to:

$$\dot{a}_{i\hat{n}} = a_{i\hat{n}} \beta_i \sigma_y^A \tag{1.25}$$

$$\dot{a}_{\hat{i}n} = a_{\hat{i}n} \varphi_i \sigma_y^U \tag{1.26}$$

$$\dot{g}_{in} = g_{in} \kappa_i \sigma_h^U \tag{1.27}$$

$$\dot{h}_{in} = h_{in} \tau_i \sigma_h^U \tag{1.28}$$

To continue this analysis, assume that the total collected taxes is a fraction of the aggregate output; that is, $T_U = cY_U$, with $0 \leq c \leq 1$. It follows that we have equality $\sigma_h^U = \sigma_y^U$. Considering the equilibrium condition given by equation (5), and for this equilibrium to be maintained, its rate of change must be equal to zero. Formally:

$$\sum_{i=1}^{n-1} \left(\xi \dot{a}_{ai\hat{n}} - \dot{a}_{\hat{i}n}\right) a_{in} + \sum_{i=1}^{n-1} \left(\dot{g}_{in} - \dot{h}_{in}\right) a_{in} + \sum_{i=1}^{n-1} \left(\xi a_{i\hat{n}} - a_{\hat{i}n}\right) \dot{a}_{in} + \sum_{i=1}^{n-1} \left(g_{in} - h_{in}\right) \dot{a}_{in} = 0 \tag{1.29}$$

Substituting (12), (25), (26), (27) and (28) into (29), after some algebraic manipulation, we obtain:

$$\sigma_y^U = \frac{\sum_{i=1}^{n-1} \xi a_{ni} a_{i\hat{n}} \beta_i}{\sum_{i=1}^{n-1} a_{ni} \left(a_{\hat{i}n} \varphi_i + h_{in} \tau_i - g_{in} \kappa_i \right)} \sigma_y^A \tag{1.30}$$

In fact, equation (30) is the second important result of this paper. It demonstrates the relationship between the growth rate of per capita income in countries U and A, as well as the way that this relationship might be influenced by economic policies. A major implication of equation (30), therefore, is that changes to the composition of government taxes and expenditure have an impact on the production structure. It is therefore very important for the process of economic growth. It is not difficult to see that, in most cases, it is easier to increase the domestic per capita growth rate through changes to the sector share of government spending than to let the companies themselves increase their relative share in exports. This is due to the more facility to do an internal political decision than it is to gain market share when there is serious external competition.

In this sense, efficient government expenditure should be organized according to the ratio of the income elasticity of exports and imports. In order to stimulate the growth rate the government should therefore follow the following rules: i) tax sectors in ascending order according to the ratio between the income elasticity of exports and imports and; ii) spend on sectors in descending order according to the ratio between the income elasticity of exports and imports. In this case, the government drains resources from the more backward sectors, which contribute the least to domestic growth (sectors with a low income elasticity ratio), and transfers them to the more modern sectors that can contribute more to growth (sectors with a high income elasticity ratio).

Efficient sectors, which nevertheless have a low income elasticity ratio, would therefore lose competitiveness, giving way to sectors which are less efficient but which have a high ratio of income elasticity. In practice, it would function as if the government were transferring resources from the primary sector (the lower ratio of income elasticity) to the industrial or services sector (the higher ratio of income elasticity).

4. Numerical Simulations

The model in this article has one characteristic that hinders econometric analysis[1]. For this reason, we preferred to use a numerical and stochastic simulation to evaluate the model's potential growth paths. Following the Pasinettian approach, this model includes the dynamic of structural changes.

The government aims to change the production structure through the dynamics of sectoral public spending and taxation. It sets out from the premise that when the government increases spending on a specific sector, this sector starts to manifest economies of scale and can therefore produce at a lower cost.

[1] The econometric estimation of this model is difficult because it works through structural change using sectors that already have structural parameters (income elasticity) but which do not export (or do not import). In this way, it is not possible to estimate a value using an econometric approach.

Moreover, since the analytical framework we are using considers goods in their physical quantities, public spending may be understood as a real increase in the supply of goods, while taxation, for its part, provides a real reduction in the supply of goods. Thus, when the government taxes any sector i, it reduces the real supply of i-th goods to a given demand, raising the price of those goods. On the other hand, when this resource is destined for any other sector j, there is an expansion of supply in the j-th sector and, therefore, a price reduction in any given demand. Consequently, if the government taxes and spends the same amount on the same sector, there will be no change in the actual supply of those goods, and therefore no price changes will occur. Producing goods at lower cost means that they can be traded on the international market, according to the import and export equations presented above. Note that income elasticity is a structural parameter. These are the parameters that will make the government change its spending behavior. A simple example can be seen in high-tech goods. These goods, in general, have high income elasticity[2], but if the country does not maintain a domestic price lower than the international one, they cannot be exported. The only way for this sector to become competitive is through falling prices. In this model, this is achieved by increasing productivity through sector spending.

The simulation was conducted as follows: we generated random values for the income elasticity of exports and imports[3]. In a similar way, we generated an initial Boolean variable for price competitiveness[4]. This defined the sectors that were initially importers and exporters. At a second point, we created a government reaction function, which is summarized in equation (31) and (32). The government selected Z, with $Z < N$, import sectors where there was a higher ratio of income elasticity, and Z export sectors for the lower ratios. In this way, the government taxed the lower ratio sectors (which already export) and spent in the higher ratio sectors (which do not export).

Thus, equation (31) states that the government spends on sector i if its income elasticity ratio is higher than the z sectors and its price is non-competitive. In turn, equation (32) states that the i-th sector is taxed if its elasticity ratio is lower than the z sectors and if the price is not competitive.

We did not impose budgetary constraints on the government, so it was able to fully intervene in the Z sectors. Following this, we evaluated the growth trajectories obtained in the government's presence and absence. Table 1 demonstrates the model's structure and the parameters of the simulated routine. Notice that the shares generated in this economy have the same weight in each sector, $\frac{1}{n-1}$[5].

[2] According to the econometric results of Romero and McCombie (2016), high-tech goods have higher income elasticity than simple goods.

[3] Structural elasticity was first extracted from Gouvêa and Lima's (2010) tables and the ranges for the maximum and minimum values were then analyzed. Based on this data, we used a function of random numbers with uniform distribution to simulate similar data.

[4] A Boolean variable was randomly generated to define each new simulation when the price of sector i was, or was not, competitive.

[5] Respecting the original structure of the Pasinetti models, share is the proportion of the sector according to the total number of sectors in the economy, rather than merely a proportion of the total for exports or imports.

$$g_{in}\kappa_i = \begin{cases} g_{in}k_i > 0 & if \quad \frac{\beta_i}{\varphi_i} > Top\ Z\ Sectors\ and\ ep_{\hat{i}} < p_i \\ 0 & if \quad \frac{\beta_i}{\varphi_i} < Top\ Z\ Sectors\ and\ ep_{\hat{i}} > p_i \end{cases} \tag{1.31}$$

$$h_{in}\tau_i = \begin{cases} h_{in}\tau_i > 0 & if \quad \frac{\beta_i}{\varphi_i} < Inf\ Z\ Sectors\ and\ ep_{\hat{i}} > p_i \\ 0 & if \quad \frac{\beta_i}{\varphi_i} > Top\ Z\ Sectors\ and\ ep_{\hat{i}} < p_i \end{cases} \tag{1.32}$$

Table 1 summarizes the data obtained in the simulation. The number of total sectors in the economy is , while the number of sectors where government intervention will occur is . Each sector's share is identical, and is $\frac{1}{n-1}$ for both importers and exporters. The β_i elasticity is randomly generated within a uniform range from 1 to 3, as well as φ_i elasticity. . The elasticity ratio is calculated for each sector, dividing β_i by φ_i and prices are competitive or not according to a random binary variable with equal probability.

Table 1: Numerical simulation of sectors - government present

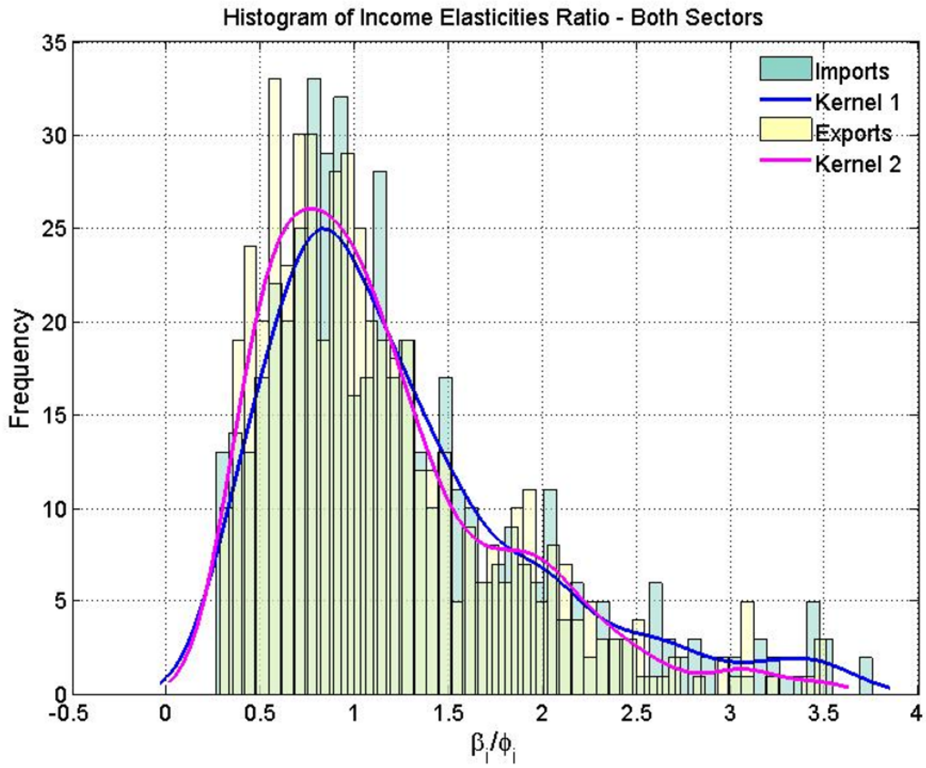
Sectors	Exports		Imports		$\frac{\beta_i}{\varphi_i}$	$ep_{\hat{i}} < p_i$
	Share	β_i	Share	φ_i		
1	$\frac{1}{n-1}$	$[1;3]$	$\frac{1}{n-1}$	$[1;3]$	$\frac{\beta_1}{\varphi_1}$	1
2	"	"	"	"	"	"
3	"	"	"	"	"	"
...	"	"	"	"	"	"
Z	"	"	"	"	"	1
...	...	...	...	...	...	...
n-1	$\frac{1}{n-1}$	$[1;3]$	$\frac{1}{n-1}$	$[1;3]$	$\frac{\beta_{n-1}}{\varphi_{n-1}}$	0 v 1

Source: Compiled by the authors.

Following this simulation, we separated the data in order to analyze the model's general behavior. To this end, we separated the import and export sectors and plotted a histogram for the elasticity ratio distribution, generated in simulation.

Figure 1 presents two histograms for the elasticity ratio of the sectors that were initially importers and exporters. The yellow columns represent the export sectors, while the green columns represent the import ones. For both data sets a non-parametric probability density function (PDF) was estimated (the Kernel line in the legend). We initially observed that the distributions were almost identical, meaning that in the final MSTL equation this economy should have a multiplier effect close to one.

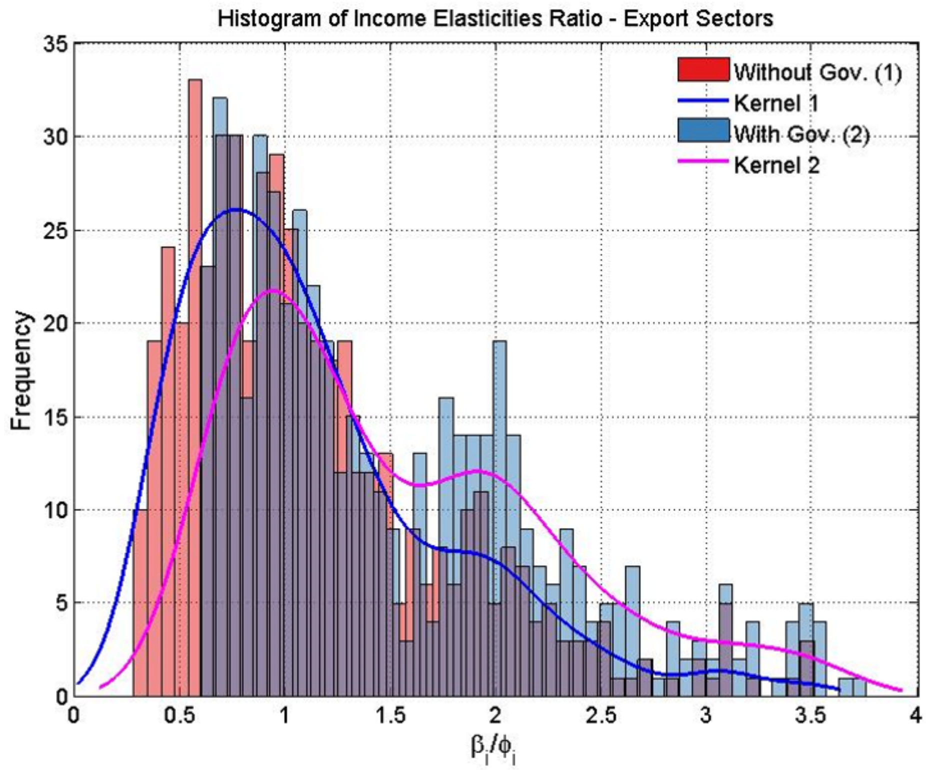
Figure 1: Numerical simulation of sectors - government present



Source: Compiled by the authors.

Figure 2 shows the export sectors in both the absence and presence of government. As stated previously, in the presence of government, taxation affects the sectors that both export and have a lower ratio of income elasticity. Public spending is aimed at the sectors that do not export, but have a higher ratio of income elasticity. This promotes structural change, so that the sectors that did not export (and only imported) begin exporting, while the sectors that used to export (and did not import) no longer do so. In the simulation carried out for this article, we arbitrarily determined that the government would effect a change of 10% of total sectors. Its intervention would therefore be to tax 10% of the worst exporters and spend on the top 10% importers (in terms of income elasticity ratio).

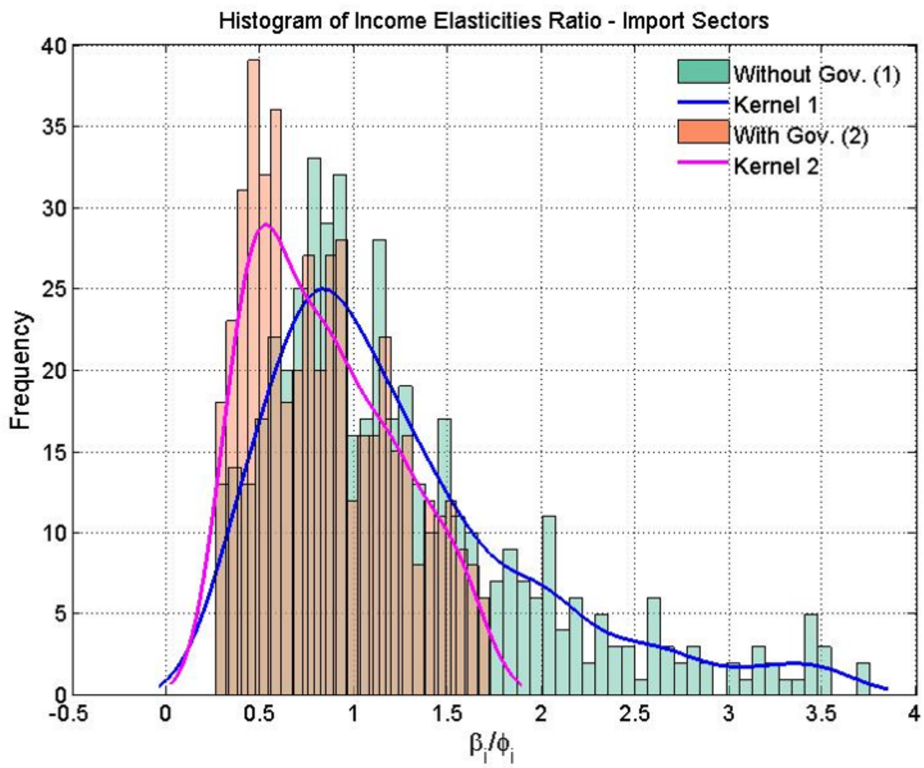
Figure 2: Histogram of the Income Elasticity Ratio - Export Sectors



Source: Compiled by the authors.

This change led to a structural change in the export sectors, which in turn changed the data distribution. Now we have a PDF that has shifted to the right, which indicates an average increase in the ratio of income elasticity that constitutes the exporting sectors. In Figure 2, the columns in red represent the export sectors in the absence of government, those in blue represent the export sectors in the presence of government, while purple represents the overlap between these two. The blue kernel line is the non-parametric PDF estimated in the absence of government, while the magenta is the PDF in the presence of government. An analysis of the graph allows us to confirm this shift.

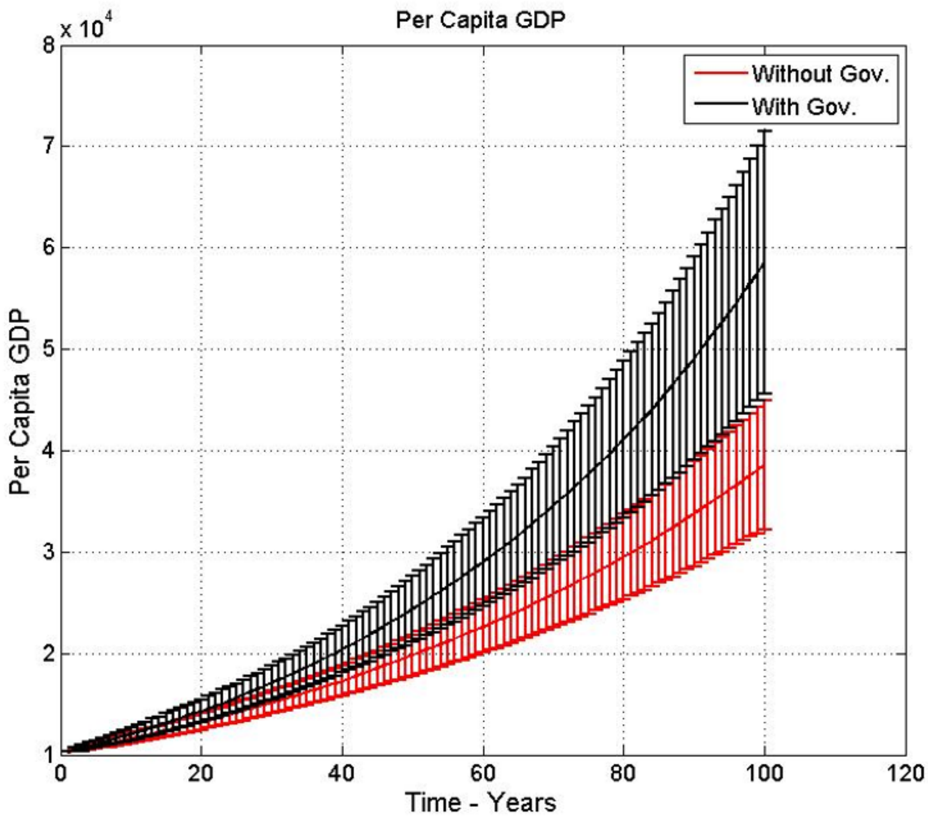
Figure 3: Histogram of the Income Elasticity Ratio - Import Sectors



Source: Compiled by the authors.

Figure 3 shows the histogram for the import sectors in both the presence and absence of government. We can see that, through the action of public intervention, the PDF is displaced to the left, compared to the original obtained in the economy without government. By identifying the shift in PDF exports to the right and the shift in PDF imports to the left, we conclude that the presence of government leads to a long-term growth trajectory higher than that originally obtained through the MSTL. In order to confirm this conclusion, it is necessary to numerically simulate the net impact on the denominator in the presence of spending and taxation.

Figure 4: Long-term GDP per capita growth



Source: Compiled by the authors.

In order to investigate all the possible trajectories for per capita GDP over the long term, we performed exhaustive simulations (10,000), calculating standard deviations and average behavior. To calculate each GDP per capita pathway, we used the following equation:

$$y_{U_t} = y_{U_1}\left[\prod_{t=1}^{T}\left(1+\sigma_{y_t}^{U}\right)-1\right] \tag{1.33}$$

where Y_{U_t} is the per capita GDP at the end of the period, y_{U_1}, is the per capita GDP at the outset and $\sigma_{y_t}^{U}$ is the income growth rate in period t. We used 10,000 US Dollars for the initial per capita value and the world growth rate was randomly (normal distribution) generated with a mean of 1.3376% and a standard deviation of 1.3225% (these values were taken from the historical average obtained from the WDI database - 1960 to 2013).

Figure 4 presents these trajectories. The black lines represent the average GDP per capita behavior with error bars demonstrating the confidence interval obtained from the simulation in the presence of government. In red, we have the same average behavior and error bars for the absence of government. In all these simulations, the presence of government generated more robust growth rates and had an impact on the economy's long-term trajectory. This result also demonstrates that, numerically, government intervention enables higher growth rates for a given degree of intervention (in the simulations, 10% of total economic sectors).

Although not presented here, we also found that the greater the degree of intervention (the number of sectors in which there was intervention over the total number of sectors), the greater the distance between accumulated growth in the presence of government, compared to economic growth when there is no government.

5. Concluding Remarks

The aim of this work was, principally, to consider the presence of government in the macroeconomic aggregates using the Pasinettian approach, as well as to verify how sectoral taxation and governmental sectoral spending affect the domestic economic growth rate. In addition, we aimed to demonstrate that the growth constraint generally faced by economies is not limited to the external sector, but that restrictions from the public budget should also be considered. In this sense, we have shown that the public budget and the balance of payments together provide constraints to economic growth. Our conclusion suggests that the per capita income growth rate is directly proportional to the growth rate of exports, and that this proportionality is inversely (directly) related to sectoral income elasticity of imports (exports). Elasticity is weighted by the share of each sector in aggregate imports and exports respectively, as well as by the difference between what the government collects and spends in each sector. In addition, we note that taxation and public spending can influence the economic growth rate. In this sense, based on knowledge of the ratio of sectoral income elasticity, it is possible for the government to choose the best way to tax and spend among sectors, in order to accelerate the development process. Finally, several relevant empirical results for both municipal and federal government applications may be generated from this model.

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Chapter 2: The Role of Intermediate Inputs in a Multisectoral Balance-of-Payments-Constrained Growth Model: The case of Mexico

Abstract

In this paper we focus on the effects of the imports of intermediate inputs over the growth performance. Such analysis is important insofar as some countries import large amounts of intermediate inputs to be used in the production of final goods to export. Then it arises the question whether such strategy is harmful to the growth performance in a balance-of-payments-constrained growth set up. In order to address this point the paper blends the multisectoral balance-of-payments-constrained growth model incorporating structural change (MSTL), originally developed by Araujo and Lima (2007), with the balance-of-payments-constrained growth model including intermediate goods developed by Blecker and Ibarra (2013), and applies the resulting framework to the Mexican economy from 1962 to 2014 – which has a very strong reliance on exports of goods that embody large amounts of intermediate goods (with limited domestic value added in many export products). The most important result is that the MSTL growth rate in the presence intermediate goods is lower than the 'standard' MSTL growth rate calculated in the usual fashion (ignoring intermediate imports). This shows the importance of taking imports of intermediate goods into account in a balance-of-payments-constrained growth (BPCG) model, at least for the Mexican case. It especially helps to explain why Mexico's apparently strong export performance since it liberalized its trade (1986) and joined NAFTA (1994) has not produced better results in terms of long-term growth. The results show that a strategy based on the imports of intermediate inputs with high elasticity with respect to exports may dampen the growth performance of countries that adopt it.

1. Introduction

The role of imports of intermediate inputs as one of the elements of a sound growth strategy is a contentious issue. For some authors, see e.g.Amit and Konings (2007) and Goldberg et al. (2010), the access to imported intermediate goods allows for quality improvement in manufacturing products and for a larger participation of a country in international trade. Their viewpoint rests on the arguments that the increased availability of imported inputs may facilitate product diversification and trigger pro-competition effects, inducing cost reductions and quality improvements in the final product. But for other authors such as Blecker and Ibarra (2013), Moreno-Brid (1999, 2002) and Pacheco-López and Thirlwall (2004) the reliance on a strategy based on imported intermediate goods may be harmful to growth. While for Moreno-Brid (1999, 2002) and Pacheco-López and Thirlwall (2004) such an strategy may result in an increase in the income elasticity of demand for imports without a compensating effect on the income elasticity of exports, Blecker and Ibarra (2013) have argued that it may led to a shift in the composition of imports (i.e., structural change) toward a greater share of intermediate goods. If this is the case, then a country that relies on imports of intermediate input may experience lower growth rates consistent with balance-of-payments constrained growth. This kind of reasoning follows straight from the balance-of-payments constrained growth hypothesis, which considers that a country long run growth rate can be approximated by the ratio of the export and import income elasticities multiplied by the growth rate of international income [see Thirlwall (1979) and Perraton (2003)].[1]

In order to assess the outcome of an strategy based on imports of intermediate goods on growth, we follow two contributions to the disagreggated view of the balance-of-payment constrained growth hypothesis. The first is the multisectoral Thirlwall's law - MSTL hereafter - advanced by Araujo and Lima (2007). According to this view, the export and import elasticities may be considered as averaged means of sectoral export and import elasticities respectively, being the weight of each sectoral elasticity the share of each sector in trade. With such derivation, the authors have shown that even if sectoral elasticities and world income growth are constant, a country can grow faster by either increasing the share in exports of sectors with a high-income elasticity for exports or decreasing the share of import of sectors with a high-income elasticity for imports. Such range of view, which points to the connections between economic growth and structural change, has been confirmed by studies showing that countries that relied upon strategies based on export-led structural changes such as the east Asian countries succeeded in terms of growth performance [see e.g. McMillan and Rodrik (2011)].[2]The second approach is due to Blecker and Ibarra (2013) whose contribution aims to give more realism to the balance-of-payments growth rate hypothesis by considering explicitly the imports of intermediate goods that are used in the production of final goods for exports, and is related to the fact that a strategy based on the imports of intermediate inputs could potentially allow a country to increase its exports of manufactures with higher income elasticity of demand. A common thread of these two contributions is the acknowledgement that any strategy that affects the structure of the economy may have impact on the growth performance.In this vein, the principal aim of this paper it to deliver a multi-sectoral version of the Thirlwall law that takes into account the imports of intermediate goods. By merging the contributions by Araujo and Lima (2007) and Blecker and Ibarra (2013) we are able to present a fully multi-sectoral version of the balance-of-payments constrained growth model in

[1] The Thirlwall law [Thirlwall (1979)], as this hypothesis is known, is an empirical regularity that has been confirmed for a number of countries [see e.g. Thirlwall (2012), Razmi (2005), Jeon (2009), McGregor and Swales (1985), Atesoglu (1993) and Halicioglu (2012)].

[2] Following the derivation of the MSTL number of empirical studies aiming at testing it have found support to the disaggregate version [see e.g. Gouvea and Lima (2009), Gouvea and Lima (2013), Tharnpanich and McCombie (2013) and Romero and McCombie (2016)]. These papers highlight the fact that higher levels of disaggregation allow us to better understand the factors that can spur growth mainly in underdeveloped and in emerging countries. In all cases the authors have found that export and import composition play an important role in explaining growth experiences, with high and sustained growth rates being related to a larger share of high-tech products in exports. Countries that increase the share of high tech goods in their exports benefit more from international trade than those that specialize in the production and exports of goods with low income elasticity.

the presence of intermediate inputs.[3]

Such derivation becomes important insofar as over the last two decades, the production pattern has shifted towards the split of production stages amongst several producers accompanied by an increased trade in intermediaries. But if on one hand, such strategy allows manufacturers benefit from having access to varied and good quality intermediate inputs, on the other hand, it lessens the gains from increased exports, potentially leading to a tightening rather than a loosening of the BP constraint, mainly if the intermediate inputs present high elasticity with respect to exports. The final outcome, namely if such strategy is beneficial or harmful to growth, is a question addressed in this paper analitically and empirically with respect to the Mexican economy.

In order to illustrate the working of this extended version, we test it to the case of the Mexican economy in the last decades by using data from COMTRADE. In order to estimate sectoral elasticities we have adopted the estimates by using log versions of the series in level. But in that case, we needed to employ the Johansen methodology that allows us to consider cointegration of I(1) series.

But in order to precisely determine the effect of this strategy on growth, we have run numerical simulations by using the estimated elasticities to compare the performance of the economy. The results show that, by considering two categories of imports, namely final and intermediate, the economic performance is worst than if all imports are considered as final imports. With this result we show that a growth strategy based on imports of intermediate goods may be misleading. But it is important to bear in mind that we are not against such strategy since it may allow a country to increase the income elasticity of exports. What we are advocating is that countries that adopt such strategy should try to diminish their dependence on intermedia te imports, mainly if they present a high elasticity with respect to exports.

Besides this introductory section, this article comprises three more sections. The next one advances a derivation of a MSTL with intermediate inputs and section 3 presents the econometric and numerical simulation exercises comparing the original MSTL [Araujo e Lima (2007)] and the one derived here. Section 4 concludes.

2. Derivation of the Multi-sectoral Thirwall Law with Intermediate Inputs

The fact that Mexican exports are highly dependent on imports of intermediate goods has been highlighted by some authors as Moreno-Brid et al. (2005) and

[3] We follow Blecker and Ibarra (2013) by assuming that the growth rate of intermediate inputs is a function of the growth rate of exports. But here we intend to proceed to a higher level of disaggregation. While Blecker and Ibarra (2013) have considered just four sectors, namely two exporters and two importers, the version presented here is advanced in a fully multi-sectoral scheme, which takes into account an arbitrary number of sectors. Such development is in accordance with the structural economic dynamic approach advanced by Pasinetti (1993) and used by Araujo and Lima (2007) in deriving the MSTL.

Ibarra and Blecker (2016). One of the striking aspects of this arrangement is that the exports of final goods require massive imports of intermediate goods, giving rise to the question of whether such a strategy is harmful to growth under a balance-of-payments constraint. In order to address this question, we believe that the most appropriate analytical framework is a disaggregated version of the Thirwall law such as the one advanced by Araujo and Lima (2007) since it focuses on multi-sectoral assessment of the balance-of-payments constrained growth hypothesis. But although such framework is carried out under some level of disaggregation, it was not originally designed for analyzing the impacts of a strategy based on imports of intermediate goods since it takes into account only the exports and imports of final goods. Hence, such as the original Thirlwall's law, the MSTL cannot take into fully account the imports of intermediate goods in the growth performance.

Conscious of such limitation, Blecker and Ibarra (2013) have explicitly introduced the possibility of importing intermediate goods in a balance of payment framework with four sectors, two exporters, namely manufactured exports and primary commodities, and two importers, namely intermediate and final goods. By considering the growth rate of imports of intermediate goods as a function of the growth rate of exports of manufactures, the authors have concluded analytically that there is a reduction in the balance of payments equilibrium growth rate. More specifically, they have found that the income elasticity of exports of final goods undergoes a proportional decrease to the income elasticity of imports of intermediate goods. Such result was obtained under the hypothesis that "all imports have the same prices and all import-competing domestic goods have the same prices, regardless of whether they are intermediate or final goods" and that both physical quantities and prices of primary commodities grow at an exogenously given rate.

In what follows we intend to derive a multi-sectoral version of the MSTL in the same spirit of the one advanced by Blecker and Ibarra (2013) but now with an arbitrary number of sectors. In order to accomplish that, we consider the existence of two countries namely D (domestic) and F (foreign) [see Nishi (2014)] and carry out the analysis from the viewpoint of domestic country. We specify sectoral export functions that depend on the imports of intermediate inputs [see Blecker and Ibarra (2013)] according to:

$$m_{k_i} = \bar{m}_{k_i} \left(\frac{ep_{Fk_i}}{p_{k_i}} \right)^{-\varepsilon_{Dk_i}} Y_D^{\eta_{Dk_i}} x_i^{\gamma_{Dk_i}} \tag{1}$$

where e stands for the nominal exchange rate, p_{Fk_i} is the foreign price of the i-th intermediate input, k_i, used to produce the final i-th consumption good, p_{k_i} is the domestic price of the i-th intermediate output and ε_{Dk_i} it the price elasticity of the intermediate output. According to this specification, the production of the i-th consumption good requires only one kind of intermediate output, let us say k_i. The demand for intermediate inputs in terms of one unit of final output of the i-th good for exports, namely m_{k_i}, is a function of the income of the domestic country Y_D, weighted by the income elasticity of demand $\eta_{Dk_i} \geq 0$, and export demand for good i, x_i, weighted by the export demand income elasticity of good i, $\gamma_{Dk_i} \geq 0$. We also consider usual export and import functions for the final goods respectively as:

$$x_i = \bar{x}_i \left(\frac{p_i}{ep_{Fi}} \right)^{-\varepsilon_{Fi}} Y_F^{\eta_{Fi}} \tag{2}$$

$$m_i = \bar{m}_i \left(\frac{ep_{Fi}}{p_i} \right)^{-\varepsilon_{Di}} Y_D^{\eta_{Di}} \tag{3}$$

where $\bar{x}_i$ and $\bar{m}_i$ are a constant terms, x_i is the export demand function for consumption good i, m_i is the import demand function for consumption good i, Y_F is the income of foreign country F, p_i is the domestic price of the i-th good, p_{Fi} is the foreign price of the i-th good, $\eta_{Fi} \geq 0$ and $\eta_{Di} \geq 0$ are the income elasticities of demand for the i-th good exports and imports respectively and $\varepsilon_{Fi} \in (0,1)$ and $\varepsilon_{Di} \in (0,1)$ are the price elasticities of demand for the i-th good exports and imports respectively. By differentiating expressions (1), (2) and (3) we obtain:

$$\hat{m}_{k_i} = \varepsilon_{Dk_i} \left(\hat{p}_{k_i} - \hat{e} - \hat{p}_{Fk_i} \right) + \eta_{Dk_i} \hat{Y}_D + \gamma_{Dk_i} \hat{x}_i \tag{4}$$

$$\hat{x}_i = -\varepsilon_{Fi} \left(\hat{p}_i - \hat{e} - \hat{p}_{Fi} \right) + \eta_{Fi} \hat{Y}_F \tag{5}$$

$$\hat{m}_i = \varepsilon_{Di} \left(\hat{p}_i - \hat{e} - \hat{p}_{Fi} \right) + \eta_{Di} \hat{Y}_D \tag{6}$$

where $\hat{Y}_D$ is the domestic growth rate, $\hat{Y}_F$ is the foreign country growth rate, $\hat{p}_{Fi}$ is the growth rate of price of the i-th good in foreign country, $\hat{p}_i$ is the domestic growth rate of price of the i-th good, $\hat{p}_{Fk_i}$ is the growth rate of price of the k_i-th intermediate good in foreign country, $\hat{p}_{k_i}$ is the domestic growth rate of price of the k_i-th intermedia–te good and $\hat{e}$ is the growth rate of the nominal exchange rate. Following Araujo and Lima (2007) an Nishi (2014), due to inexistence of technical change, let us assume that $\hat{p}_{k_i} = \hat{p}_{Fk_i} = \hat{p}_i = \hat{p}_{Fi} = 0$, $\forall i = 1, .., n-1$ which also means zero inflation rate in both countries for all goods. Besides, let us consider that $\hat{e} = 0$, meaning that neither continuous devaluations nor continuos overvaluations are allowed. By substituting (5) in (4), allows us to obtain:

$$\hat{m}_{k_i} = \eta_{Dk_i} \hat{Y}_D + \gamma_{Dk_i} \eta_{Fi} \hat{Y}_F \tag{7}$$

$$\hat{x}_i = \eta_{Fi} \hat{Y}_F \tag{8}$$

$$\hat{m}_i = \eta_{Di} \hat{Y}_D \tag{9}$$

From Araujo and Teixeira (2003) and Nishi (2014) the balance-of-payments equilibrium in the presence of intermediate inputs may be written as:

$$\sum_{i=1}^{n-1} p_i x_i = \sum_{i=1}^{n-1} \left(e p_{Fi} m_i + e p_{Fk_i} m_{k_i} \right) \tag{10}$$

Expression (10) considers that in equilibrium the imports of final and intermediate has to be totally financed by exports since we do not take into account the possbility of capital inflows, external debt etc. Then the main change in relation to Araujo and Lima (2007) is that now the domestic country imports two different goods, namely final goods and intermediate goods. But, unlike to Blecker and Ibarra (2013) we do not assume that the prices of such goods are the same. By differentiating expression (10) with respect to time it yields after some algebraic manipulation the following expression:

$$\sum_{i=1}^{n-1} \left[\frac{p_i x_i \left(\hat{p}_i + \hat{x}_i \right)}{\sum_{i=1}^{n-1} p_i x_i} - \frac{e p_{Fi} m_i \left(\hat{e} + \hat{p}_{Fi} + \hat{m}_i \right) + e p_{Fk_i} m_{k_i} \left(\hat{e} + \hat{p}_{Fk_i} + \hat{m}_{k_i} \right)}{\sum_{i=1}^{n-1} e \left(p_{Fi} m_i + p_{Fk_i} m_{k_i} \right)} \right] = 0 \tag{11}$$

Following Nishi (2014), we define $v_i \equiv \frac{p_i x_i}{\sum_{i=1}^{n-1} p_i x_i}$ as denoting the market share of the i-th industry in a domestic country's total exports, $\mu_i \equiv \frac{e p_{Fi} m_i}{\sum_{i=1}^{n-1} e \left(p_{Fi} m_i + p_{Fk_i} m_{k_i} \right)}$ as denoting the market share of the i-th industry in the domestic country's total imports and $\omega_{k_i} \equiv \frac{e p_{Fk_i} m_{k_i}}{\sum_{i=1}^{n-1} e \left(p_{Fi} m_i + p_{Fk_i} m_{k_i} \right)}$ as denoting the market share of the intermediate k_i-th industry in the domestic country's total imports, with $v_i, \mu_i, \omega_{k_i} \in [0,1]$. It should also be noted that $\sum_{i=1}^{n-1} v_i = 1$ and $\sum_{i=1}^{n-1} \mu_i + \sum_{i=1}^{n-1} \omega_{k_i} = 1$. We assume that these terms are exogenous and constant. Taking into account that $\hat{p}_{k_i} - \hat{e} - \hat{p}_{Fk_i} = 0$ and $\hat{p}_i - \hat{e} - \hat{p}_{Fi} = 0$ and replacing these expressions in (11) we obtain:

$$\sum_{i=1}^{n-1} v_i \hat{x}_i = \sum_{i=1}^{n-1} \mu_i \hat{m}_i + \sum_{i=1}^{n-1} \omega_{k_i} \hat{m}_{k_i} \tag{12}$$

By substituting (7), (8) and (9) in (12) it yields after some algebraic manipulation, the growth rate consistent with the balance of payments equilibrium:

$$\hat{Y}_D = \frac{\sum_{i=1}^{n-1} \left(v_i - \omega_{k_i} \gamma_{Dk_i} \right) \eta_{Fi}}{\sum_{i=1}^{n-1} \left(\mu_i \eta_{Di} + \omega_{k_i} \eta_{Dk_i} \right)} \hat{Y}_F \tag{13}$$

Expression (13) is a generalization of the MSTL law since if $\omega_{k_i} = 0 \ \forall i = 1, ..., n-1$ we obtain the result derived by Araujo and Lima (2007) without intermediate inputs. Note that both the numerator and denominator now incorporates the presence of intermediate goods to the imports. In the denominator, it is just a matter of decomposition of the imports between final and intermediate goods that were not taken into consideration in the original MSTL. However, the most important difference is in the numerator, where the income elasticity of exports are decreasing in those sectors where intermediate inputs are imported. The additional message that accrue from expression (13) is that the growth rate consistent with intertemporal equilibrium in the balance-of-payments is lower in the presence of intermediate goods being imported to master final goods to export.

Although this result is akin to the one obtained by Blecker and Ibarra (2013) it is worthy to highlight an important difference. Those authors have considered a particular structure for the economy assuming that the export sectors, for instance, are manufactured and other goods, the latter comprising primary commodities, chiefly oil and agricultural products. The authors then reasonably assume that both the growth rate of exports of the primary goods and their price grow at an exogenously given rate, presuming that their quantities and prices are determined by conditions in global commodity markets. Here we do not make these assumptions since our first aim was just to obtain a generalization of the MSTL. Although we do not assume a particular structure *ex-ante* for the economy, the model can accommodate such sectoral arrangements with minor changes in the final outcome.

3. Econometric Analysis and Numerical Simulations

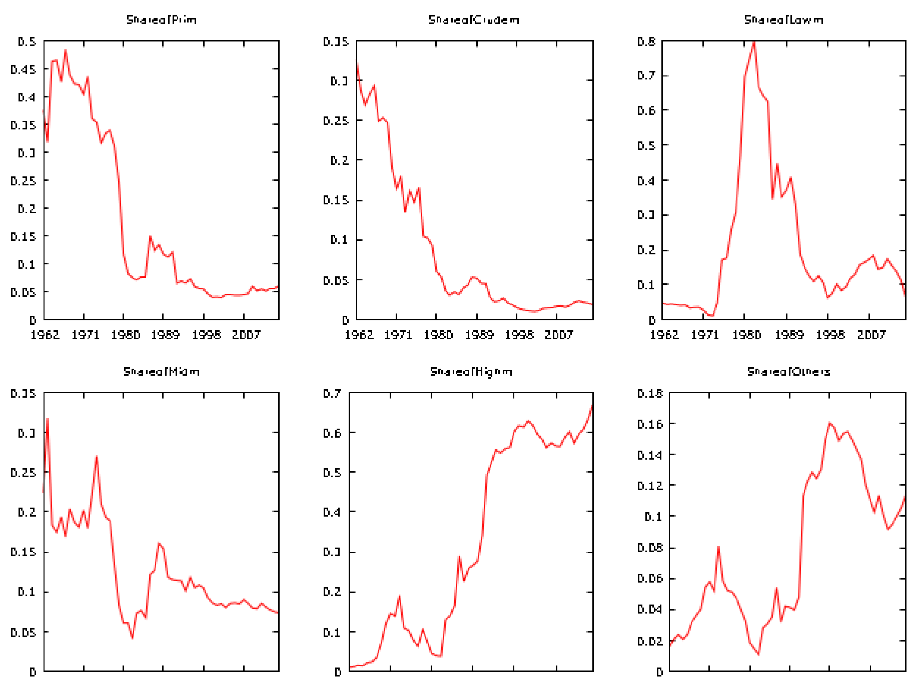
As previously stated, one of the aims of this paper consists in comparing the predictive power of the original MSTL and the version presented here with intermediate inputs. In order to reckon the balance-of-payments-constrained growth rate, we have estimated two different versions of the multisectoral Thirlwall's law. The first one being that derived by Araujo and Lima (2007) and the second one that derived here in the presence of intermediate goods. In the first case, according to the methodology adopted by Araujo and Lima (2007), we consider that all imported goods are just final goods not taking into account the existence of intermediate goods. For the second estimate, we have split imports into two categories, namely final goods and intermediate goods. In this regard, we intend to evaluate which of these approaches is best suited to explain the economic growth in Mexico from 1962 to 2014.

In order to proceed to this empirical exercise, due to the high complexity of the economic structure of Mexico, we have focused only on the six major sectors in the Mexican trade in 2014 according to the United Nations Commodity Trade Statistics Database (COMTRADE). The nomenclature of these sectors and their abbreviations are: i) food and live animals (prim), (ii) crude materials, inedible, except fuels (crudem), (iii) mineral fuels, lubricants and related materials (lowm), iv) manufactured goods classified chiefly by material (midm), v) machinery and transport equipment (highm), and vi) miscellaneous manufactured articles (others). All these sectors are organized according to the catalog of the Standard International Trade Classification Revision 1 (SITC-Rev. 1). From this information, we have reckoned the sectoral trade as well as the relative share of exports and imports in the trade sector. The other variables used, namely the economic growth rate of Mexico (gdpmex), the growth rate of the world economy (gdpwld) and the growth rate of the bilateral real exchange rate (exch) were drawn from the World Development Indicators (WDI).

Although the relevant equations of the theoretical model were derived in terms of growth rates, we have decided to follow Gouvea and Lima (2010) and Blecker and Ibarra (2013) who estimated the model by using data in logarithm by using the Johansen (1991).

Figure 1 shows the evolution of the relative share of sectors in the export of Mexico over the past decades. As can be seen, the more technology-intensive products, namely, the machinery and transport products hold a stake of approximately 65% in the exports against 2% which they had in 1962. On the other hand, primary products, that once held 37.5% share in the exports, now have only 5.5%. This shows that there has been, to some extent, a structural shift in favor of higher income elasticity of demand sectors as pointed out by Gouvea and Lima (2009), implying a better growth performance. This range of view is supported by Blecker and Ibarra (2013, p. 2): "Mexico's exports shifted toward more technologically advanced products with higher income elasticities in a way that more resembles the East Asian countries rather than other Latin American nations in their sample". However, such changes in the composition of exports were not sustained across years and do not reflect their heavy dependency on imported intermediate goods.

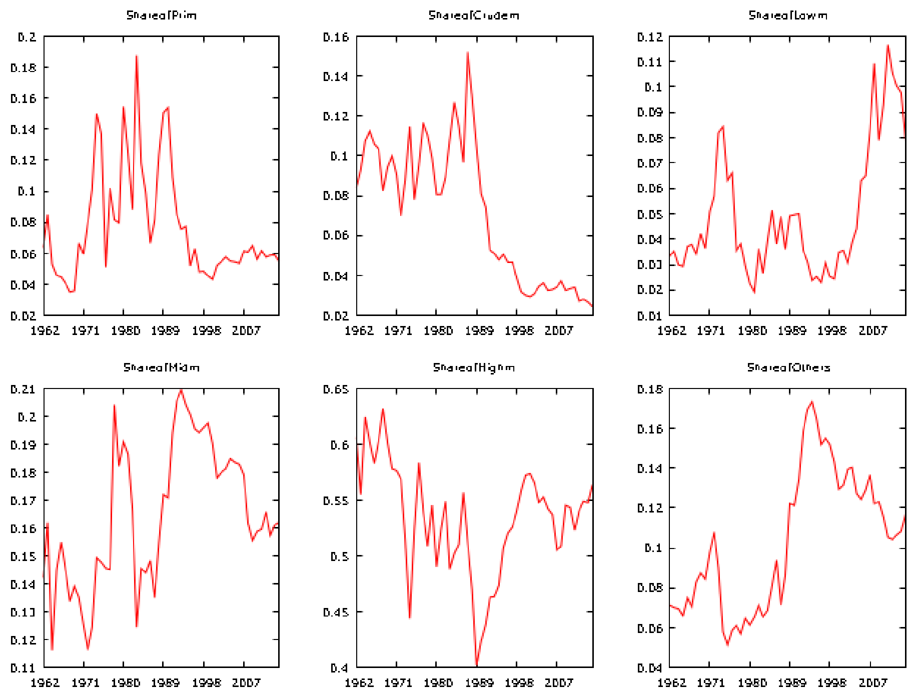
Figure 1: Evolution of Relative Participation of Exports of Mexico Between 1962 and 2015.



Source: COMTRADE.

Figure 2 illustrates the evolution of the relative share of each sector in imports from 1962 to 2015. Imports of hi-tech products (highm) decreased by 4 percentage points or so. In addition, Mexico has also increased the share of intermediate goods (midm) in the imports by approximately 4 percentage points between 1964 and 2015. Insofar as these products have a high-income elasticity of demand, this contributed to the fact that the income elasticity of imports has raised after Nafta as reported by Moreno-Brid (1999, 2002) and Pacheco-López and Thirlwall (2004). In this sense, in the light of the structural change theory [see Blecker (2009) and Thirlwall (2013)], it can be said that structural changes implemented on the export front was somewhat offset by the deterioration in the imports schedule, slowing the pace of economic growth in Mexico after deepening of trade liberalization.

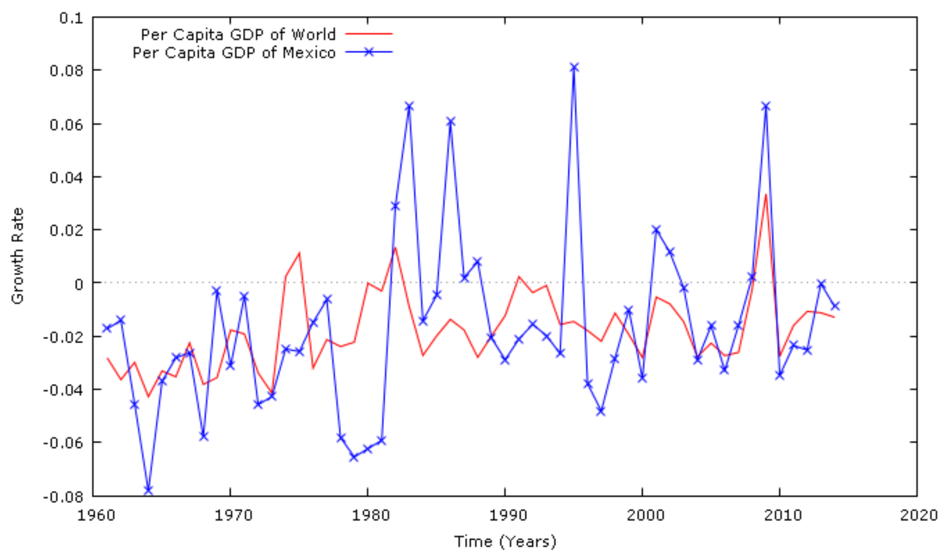
Figure 2: Evolution of Relative Participation of Imports of Mexico Between 1962 and 2015.



Source: COMTRADE.

The reflection of that on the dynamics of trade of the Mexican economy can be seen in Figure 3, which shows the trend observed in the growth rate of GDP of Mexico and of the world growth rate since 1962. Note that the Mexico average per capita economic growth in the first 25 years (2.86% a.p.) was very higher than the average of the last 30 years (0.88% a.p.). Moreover, the annual Mexico average per capita economic growth (1.78% a.p.) was close to the growth rate of the world per capita income (1.79%). Other factors such as the fierce competition of the Chinese producers in the U.S. market after China entry in the WTO in 2001 and repeated economic crisis may help to explain such performance, leading Blecker and Ibarra (2013) to conclude that the external constraint was not binding through the whole period. This shows evidence that had Mexico succeeded in performing a complete structural change, then it would keep growth rates consistent with those in the first years.

Figure 3: Mexico and World GDP Economic Growth Between 1960-2014.



Source: WDI.

Table 1 shows the result of the unit root tests. Among the available tests we used are the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS), whose results are shown below. Although all series but the real exchange rate one were found to be integrated of the first order, all of the series in first difference are stationary at 1% regardless of the test adopted. Hence, the Johansen (1991) test was used to determine if the I(1) series are cointegrated. Then, whenever it is not possible to reject the null hypothesis of the existence of at least one cointegration vector, we estimate the equations by the Johansen method. The advantage of such approach is that there is no loss of information since all variables are considered in levels.

Table 1: Results of Unit Roots Tests.

Series\Tests	ADF		PP		KPSS		Concl.	
	Level	Diff.	Level	Diff.	Level	Diff.	Level	Diff.
LN(realexch)	-3.13**	-7.28***	-3.12**	-9.85***	0.12	0.18	I(0)	I(0)
LN(xprim)	-0.49	-7.86***	-0.41	-9.24***	0.87△△△	0.11	I(1)	I(0)
LN(xcrudem)	-0.13	-7.40***	-3.29*	-7.74***	0.85△△△	0.11	I(1)	I(0)
LN(xlowm)	-1.49	-4.42***	-1.45	-4.45***	0.71△△	0.17	I(1)	I(0)
LN(xmidm)	-1.00	-7.37***	-0.76	-9.22***	0.86△△△	0.12	I(1)	I(0)
LN(xhighm)	-2.10	-7.09***	-2.15	-7.09***	0.86△△△	0.37△	I(1)	I(0)
LN(xotherm)	-1.37	-7.30***	-1.38	-7.30***	0.85△△△	0.18	I(1)	I(0)
LN(mprim)	-1.24	-7.54***	-1.31	-8.19***	0.17△△	0.09	I(1)	I(0)
LN(mcrudem)	-2.01	-8.08***	-3.31**	-7.83***	0.22△△△	0.38△	I(1)	I(0)
LN(mlowm)	-0.71	-7.76***	-0.63	-8.42***	0.86△△△	0.07	I(1)	I(0)
LN(mmidm)	-1.02	-6.06***	-1.10	-6.39***	0.85△△△	0.15	I(1)	I(0)
LN(mhighm)	-0.77	-6.46***	-0.80	-6.97***	0.86△△△	0.12	I(1)	I(0)
LN(motherm)	-1.01	-5.92***	-1.04	-5.83***	0.86△△△	0.14	I(1)	I(0)
LN(gdpmex)	-1.64	-6.61***	-2.22	-5.91***	0.96△△△	0.25	I(1)	I(0)
LN(gdpwld)	-2.05	-3.90***	-2.35	-3.84***	0.96△△△	0.44△	I(1)	I(0)

Source: Elaborated by the author.
(1) * Stationary at 10%; ** stationary at 5%; *** stationary at 1%.
(2) △ Non stationary at 10%; △△ non stationary at 5%; △△△ non stationary at 1%.

Due to the lack of data available for the sectoral prices in the period considered, we used the rate of the effective bilateral real exchange rate (US-Mexico) as a proxy for the real exchange growth rate sector, which corresponds to the growth rate of the effective bilateral real exchange rate. Besides, we have taken into account that sector 'prim', 'midm' and 'crudem' import intermediate goods that are used to produce the final goods of the 'highm' sector. This choice rested on the fact that the 'highm' sector is essentially a final good sector. Also, according to World Input Output Data (WIOD), goods from 'prim', 'mid' and 'crudem' sectors are common used as intermediate in economy. Although there is no perfect match between the COMTRADE database and the input-output matrix of Mexico available in the WIOD, we have that the 'prim', 'midm' and crudm' sectors have high participation as intermediate goods in other sectors, like 'highm', as can be seen in Table 7 presented in Appendix A. Besides, this observation is consistent with our econometric results, which we will be shown in Table 3.
[4]

[4] The elasticities extracted through Johansen method (1991) allow us to prescind of realization of structural break test, because the cointegration ensures a long term stable relationship between the variables and the short term deviation are corrected by the Vector Error Correction (VEC).

Table 2 presents the results of the econometrically estimated parameters by Johansen methods. Firstly, it may be noted that practically all parameters concerning to real exchange rate are statistically significant. It might be concluded that changes in the terms of trade play a role [Ibarra and Blecker (2016)], that is, effects from real exchange rate affected substantially the Mexican trade performance in recent decades. This is especially true for the 'prim', 'lowm' and 'others'. Furthermore, as expected, all sectoral parameters related to the growth rate of both domestic and foreign income were statistically significant at 1%. In the one hand, the results highlight 'others' and 'highm' as the most important for growth in Mexico during the period analyzed in terms of the ratio of the income elasticities. On the other hand, the intermediate import sectors have shown to been playing a negative effect both on the elasticity ratio and on the growth performance.

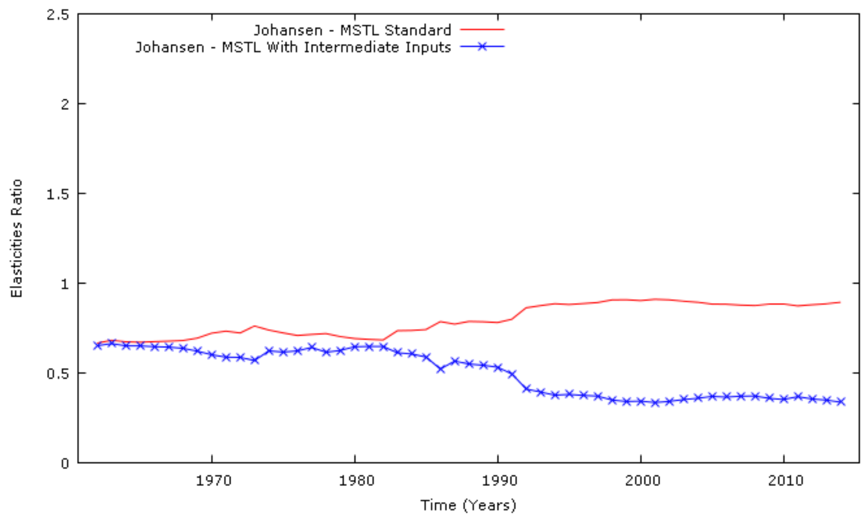
Table 2: Estimated Parameters for the Mexican Economy (1962-2014).

Sectors/Param.	η_{Fi}	ε_{Fi}	ε_{Di}	η_{Di}	ε_{Dki}	η_{Dki}	γ_{Dk_i}
	J.	J.	J.	J.	J.	J.	J.
prim	0.82***	1.18**	3.46***	1.15***	1.66**	0.37**	0.72***
	(0.03)	(0.38)	(0.94)	(0.09)	(0.72)	(0.18)	(0.17)
crudem	0.75***	0.74	1.36***	0.94***	0.55*	0.59***	0.32***
	(0.04)	(0.51)	(0.39)	(0.03)	(0.28)	(0.07)	(0.06)
lowm	0.83***	1.14	5.43***	1.32***	-	-	-
	(0.24)	(2.94)	(1.30)	(0.12)	-	-	-
midm	0.93***	2.49**	4.67***	1.29***	2.08**	0.59***	0.49***
	(0.09)	(1.15)	(1.05)	(0.10)	(0.90)	(0.13)	(0.09)
highm	1.25***	6.06*	4.18***	1.29***	-	-	-
	(0.29)	(3.56)	(0.89)	(0.08)	-	-	-
others	1.21***	6.04**	5.00***	1.31***	-	-	-
	(0.21)	(2.59)	(1.37)	(0.13)	-	-	-

Source: Elaborated by the authors.
(1) * Statistically significant at 10%; ** Statistically significant at 5%; *** Statistically significant at 1%.
(2) Standard error in parentheses.

Figure 4 shows the evolution of the ratio of the income elasticities weighted by the sector share in the Mexico trade by using parameters estimated by the two methods. Note that for both methods, the ratio of the elasticities in the model with intermediate inputs is lower than the ratio of the elasticities in the traditional MSTL. However, until 1982, the difference between the ratios of elasticities is almost negligible, while from 1982 on, that difference increased substantially and passed to amount to a significant difference between the two versions. This fact indicates that the imports of intermediate inputs did not matter significantly to explain the Mexican growth performance in the first twenty years of the series. In the mid-eighties, however, such cathegory of imports acquired a central importance due to the government stimulus to the maquilas. Therefore, we conclude that the imports of intermediate goods due to the maquilas is of key importance to understanding the reduction both in the ratio of the income elasticities and the growth rate of the Mexican economy. Therefore, Figure 4 is important because it helps us to see that the version of the MSTL with intermediate goods is able to explain the decay in the growth rate of Mexico economy after 1982.

Figure 4: Evolution of The Mexican Ratio of Income-Elasticities Between 1962 and 2014.



Source: Elaborated by the authors.

Table 3 reports the actual Mexican growth rate and the Mexican growth rate estimated by the two models as well as the absolute error between the actual and estimated models. The elasticities that fed the numerical simulations were estimated by using the Johansen method. We have found that the average absolute error of the forecast made by the traditional model was 3.90% while the model with intermediate goods, 3.00% p.p. Therefore, there is a difference of approximately 30% between the predictions of both models. Moreover, the results show that the intermediate goods version of the MSTL generates better forecast results for Mexico's growth rate in the observed period.

Table 3: Observed and Foreseen Economic Growth Rates of The Mexico Between 1962 and 2013.

Years/Variables	$\hat{Y}_D(1)$	$\hat{Y}_D^S(2)$	Absolute Error (2) - (1)	$\hat{Y}_D^I(3)$	Absolute Error (3) - (1)
1962	0.081	0.032	0.049	0.032	0.050
1965	0.061	0.043	0.018	0.042	0.019
1967	0.094	0.035	0.060	0.032	0.062
1970	0.038	0.034	0.004	0.029	0.008
1972	0.079	0.073	0.006	0.065	0.013
1975	0.044	-0.021	0.065	-0.022	0.066
1977	0.090	0.066	0.023	0.063	0.026
1980	0.088	0.045	0.043	0.042	0.046
1982	-0.042	-0.007	0.035	-0.009	0.033
1985	-0.038	-0.097	0.060	-0.099	0.062
1987	0.012	0.191	0.179	0.179	0.166
1990	0.042	0.079	0.036	0.068	0.026
1992	0.041	0.070	0.030	0.063	0.022
1995	0.059	0.129	0.071	0.119	0.060
1997	0.047	0.012	0.035	-0.002	0.049
2000	-0.006	0.065	0.072	0.059	0.065
2002	0.014	-0.064	0.078	-0.087	0.101
2005	0.049	0.040	0.010	0.019	0.031
2007	0.014	0.007	0.007	-0.001	0.014
2010	0.039	0.045	0.006	0.030	0.009
2012	0.014	0.077	0.063	0.063	0.049
2013	0.022	0.005	0.017	-0.008	0.030
Mean	0.038	0.039	0.043	0.030	0.045

Source: Elaborated by the authors.

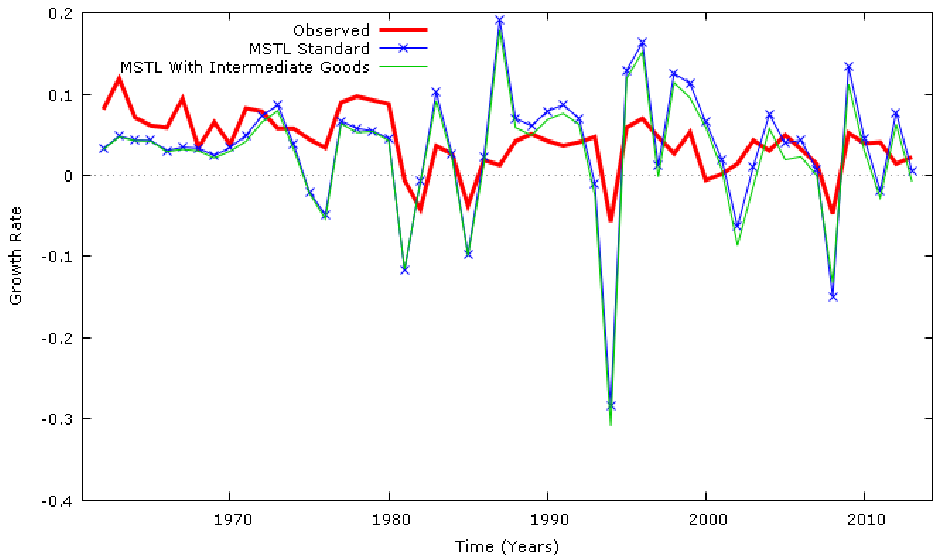
Notes: (1) represents the true Mexican growth rate;

(2) the Mexican growth rate foreseen by the LTMS standard and

(3) the Mexican growth rate foreseen by the LTMS with intermediate goods.

Figure 5 shows the intuition of what is presented in Table 5, focusing on the evolution of the tree series: observed growth rate, and growth rate predicted by the traditional model [Araujo and Lima (2007)] and by the extended version presented here. Note that, for some periods, the observed growth rate is higher than the predicted one by the two methods but, for others, the predicted growth rate is lower than the observed ones. In the first ten years, the observed growth rates were, consistently, higher than the predicted growth rate by both methods. The results also show that by considering the original MSTL the Mexican growth experience after Nafta is not balance-of-payments constrained, a result that is tantamount to the one obtained by Ibarra and Blecker (2016). According to them, other factors than the balance-of-payments constraint should be taken into account to explain Mexican growth performance since 1962.

Figure 5: Comparison Between the Mexican Economic Growth Rate Observed and Foreseen.



Source: Elaborated by the authors.

In order to decide which model best fit the data, a regression of the rate observed with the rates set by the two cases was performed. Table 4 shows the degree of growth rate adjustment (R-squared). As can be seen, the results show that MSTL with intermediate goods have a better predictive power than the data than the original MSTL in the period under consideration.

Table 4: Comparison Between the Adjusted Level of Both Forecasts.

$\hat{Y}_D$	LTMS Standard	LTMS with Intermediate Goods
Coefficient	0.2645 ***	0.2739 ***
	(0.0564)	(0.0563)
Intercept	0.0316 ***	0.0336 ***
	(0.0047)	(0.0044)
R-squared	0.3054	0.3209
Adjusted R-squared	0.2915	0.3073

Source: Elaborated by the authors.
(1) * Statistically significant at 10%; ** Statistically significant at 5%; *** Statistically significant at 1%.
(2) Standard error in parentheses.

These results show that at least for the case of the Mexican economy since 1962, the version with intermediate goods is better to explain the mexican economic growth than the original MSTL. A possible interpretation of such result is that the imports of intermediate goods did play a decisive role in explaining the Mexican growth experience mainly after 1982. In order to further investigate this issue, the econometric results for the Mexican economy were used to feed a numerical routine. To this end, we have obtained via Monte Carlo simulation results from equation (14) with and without disaggregation in terms of intermediate inputs to determine the Mexico growth rate. The sectoral income elasticities adopted in the simulations were drawn from table 3, and the share of each sector in exports and imports were obtained from COMTRADE. These parameters were used to compare the performance of the Mexican economy under two scenarios, namely with and without disaggregating the imports in terms of intermediate goods. With respect to the share of each sector in imports and exports, we have chosen to made them constant through time thus keeping the composition of exports and imports according to the values observed in 2014. With respect to the growth rate of world income, we have used expression (14) below to reckon it in each period:

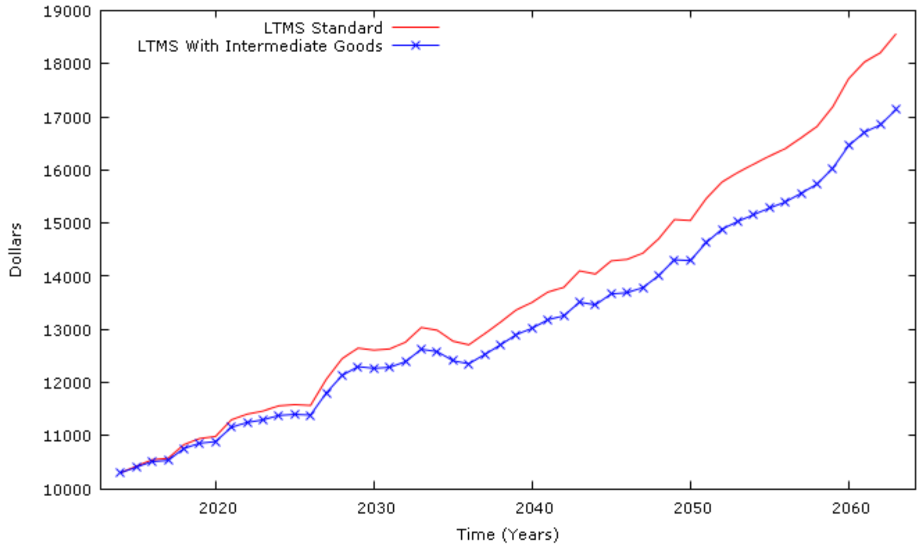
$$X_t = \mu + \sigma \epsilon_t \tag{14}$$

where X_t is a stochastic process with mean μ and standard error σ. The term ϵ_t is a white noise. Then by considering the time span from 1962 to 2014 we have obtained $\mu = 0.0133$ and $\sigma = 0.0132$. With such information, and by using the parameters estimated econometrically it was possible to generate the growth rate of the Mexico economy under the two scenarios, namely with and without intermediate goods by using the following expression:

$$Y_{D_T} = Y_{D_1} \left[\prod_{t=1}^{T} (1 + g_t) - 1 \right] \tag{15}$$

where Y_{D_t} is the per capita income at the end of the period and $Y_{D_1}$is the per capita income at time one. g_t is the growth rate of income in the period t. Figure 6 shows the trajectory of per capita income in Mexico for the two simulated cases. In the scenario that ignores the import of intermediate goods, from the current amount of US$ 10,300.00, a per capita income of US$ 18,565.46 is reached after 50 periods. In the alternative scenario, which considers the imports of intermediate goods, an income per capita of US$ 17,135.86 was reached after the same period.

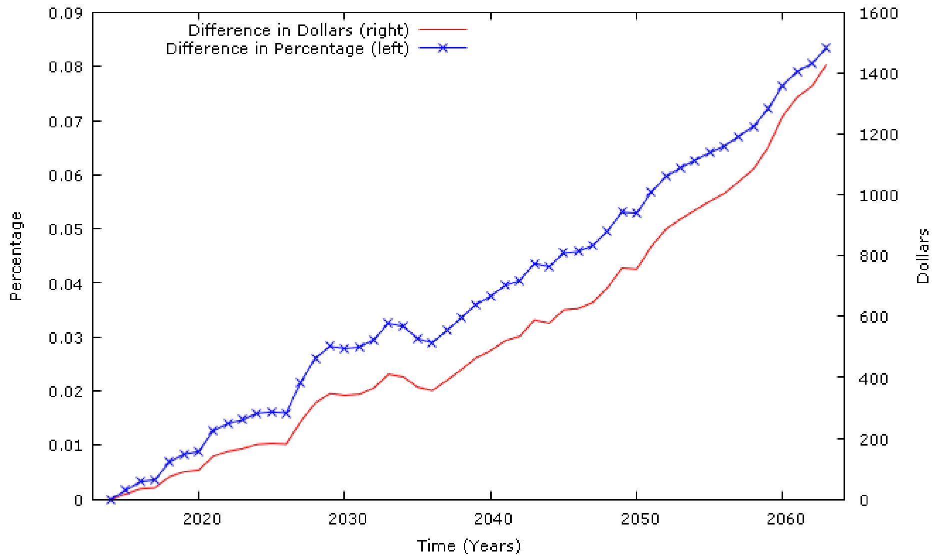
Figure 6: Mexico PNB per capita Evolution Foreseen in Both Versions of LTMS (US$).



Source: Elaborated by the authors.

Note that for each year the difference between the simulated economic growth rates is increasing - see Figure 6 - resulting in a not negligible difference in the values of per capita incomes in the end of the period - see Figure 7. In the long run, the value of the difference in dollars corresponds to approximately to US$ 1,400.00, and in percentage it amounts to 8.50%.

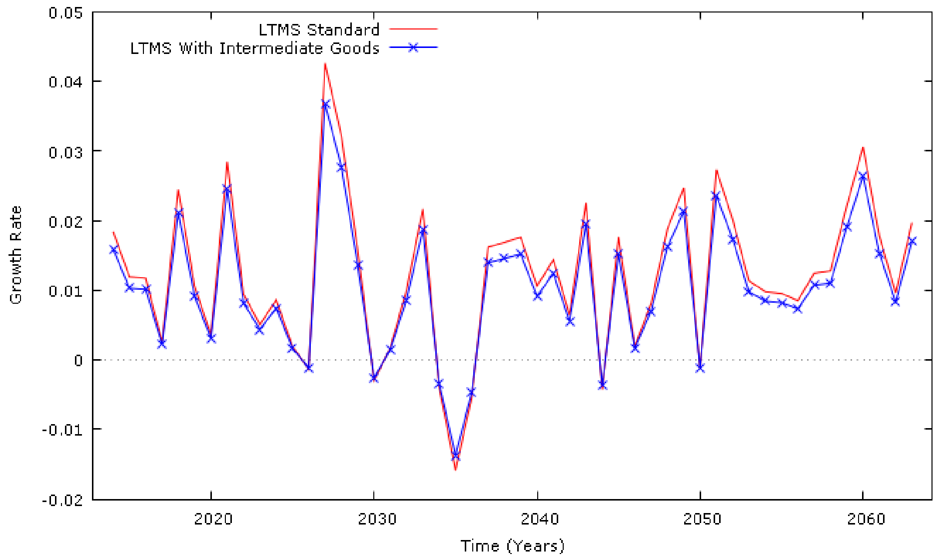
Figure 7: Difference Between Accumulated Mexico Foreseen PNB per capita in Dollars and Percentage.



Source: Elaborated by the authors.

Finally, Figure 8 decisively shows that a growth strategy based on imports of intermediate inputs with high-elasticity with respect to exports may give rise to a worse growth performance than that without intermediate inputs. This result allows us to conclude that, although Mexico has obtained a certain success in terms of growth performance, the strategy of relying on massive imports of intermediate inputs seems to be flawed since it reduces the chance of catching-up with advanced economies in the long run. In this vein, such results suggest that it is important to Mexico to reduce its dependence on imports of intermediate goods with high income elasticity with respect to exports.

Figure 8: Annual Growth Rates of the Mexico In Both Scenarios.



Source: Elaborated by the authors.

So we conclude that a growth strategy driven by the absence of imports of intermediate high income elasticity goods is superior in terms of growth performance than an strategies based on imports of such goods. In this case, if on the one hand a strategy based on the imports of intermediate inputs would allow the country to export manufactured goods with higher income elasticity of demand by enhacing the average income elasticity of exports, on the other hand, it also increases the average income elasticity of imports, mainly if the intermediate inputs present high elasticity with respect to exports.

4. Concluding Remarks

In this paper we study the effects of the imports of intermediate inputs on the growth performance. With such analysis we aimed at determining whether the presence of those goods in the imports of a country would imply a significant reduction in the balance-of-payments-constrained growth rate. To that end, we have adopted a procedure similar to Blecker and Ibarra (2013) who included exports of manufactured goods in the demand function for imports of intermediate goods. By using this strategy within the structural economic dynamic model [Pasinetti (1993) and Araujo and Teixeira (2003)] it was possible to establish an extended version of the MSTL taking into account imports of intermediate goods, which shows that the presence of intermediate goods in the imports can indeed lead to a reduction in the growth rate compatible with the intertemporal equilibrium in the balance-of-payments.

This result was econometrically tested for the Mexican economy by comparing the balance-of- payments-constrained growth rate by using the traditional

MSTL and the one derived here with intermediate inputs. From 1962 to 1982, we have found that the estimates from the two versions are close but from 1982 on, when a strategy based on imports of intermediate inputs was adopted, the growth rate reckoned by Johansen method present a significant difference, with the performance with intermediate goods being closer to the actual growth experience. By using the parameters from the two versions of the MSTL we ran numerical simulations that showed that the imports of intermediate inputs can dampen the growth performance of the economy in the long run, confirming the econometric findings. From these results we can infer that had Mexico not relied so much on the imports of intermediate inputs it could have experienced higher growth rates. Therefore these findings reassert the central message of the MSTL, namely that, in the end, the growth rate of a country will depend on its structure, which is strongly reflected in the weighted export and import elasticities.

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Appendix A

Table 5: Technological Classification

Classification	Examples
Food and live animals	Meat, fish, cereals, fruits, cofee, tea, spices.
Crude materials, inedible, except fuels	Hides, skins, some animals skins, oil seeds.
Mineral fuels, lubricants and related materials	Coal, coke, lignite, petroleum, distillate fuels.
Manufact goods classified chiefly by material	Leather, rubber manufactures, paper, cork manufactures.
Machinery and transport equipment	Nuclear reactors, water turbines, walking tractors.
Miscellaneous manufactured	Sanitary, plumbing, travel goods, handbags, umbrellas.

Source: Authors' calculations according to the Standard International Trade Classification, Rev. 1.

Table 6: Final Share Destination of Sectoral Production: Average between 2000-11.

Sectors	Input to other sectors
Crop and animal production, hunting and related service activities	68.31%
Forestry and logging	92.43%
Fishing and aquaculture	18.81%
Mining and quarrying	48.00%
Manufacture of textiles, wearing apparel and leather products	27.63%
Manufacture of wood and of products of wood and cork, except furniture	82.25%
Manufacture of paper and paper products	71.09%
Printing and reproduction of recorded media	62.58%
Manufacture of coke and refined petroleum products	64.84%
Manufacture of chemicals and chemical products	64.79%
Manufacture of basic pharmaceutical products and pharmaceutical preparations	28.14%
Manufacture of rubber and plastic products	65.56%
Manufacture of other non-metallic mineral products	65.00%
Manufacture of basic metals	74.43%
Manufacture of fabricated metal products, except machinery and equipment	46.94%
Manufacture of computer, electronic and optical products	18.85%
Manufacture of machinery and equipment n.e.c.	34.22%
Manufacture of furniture; other manufacturing	31.39%
Repair and installation of machinery and equipment	80.00%
Electricity, gas, steam and air conditioning supply	67.78%
Water collection, treatment and supply	80.92%
Sewerage; waste collection, treatment and disposal activities; materials recovery	24.41%
Wholesale and retail trade and repair of motor vehicles and motorcycles	35.85%
Wholesale trade, except of motor vehicles and motorcycles	35.25%
Retail trade, except of motor vehicles and motorcycles	35.18%
Water transport	24.88%
Warehousing and support activities for transportation	53.42%
Postal and courier activities	70.47%
Publishing activities	72.75%
Telecommunications	34.87%
Computer programming, consultancy and related activities	49.81%
Financial service activities, except insurance and pension funding	40.34%
Activities auxiliary to financial services and insurance activities	58.50%
Legal and accounting activities; activities of head offices	73.49%
Architectural and engineering activities; technical testing and analysis	83.20%
Scientific research and development	90.87%
Other professional, scientific and technical activities; veterinary activities	89.50%
Administrative and support service activities	38.68%

Source: Authors' calculations according to the WOID.

Endogenous Technological Progress and Structural Change

Abstract

This article aims to reconcile two economic growth theories, which are the Endogenous Growth and the Structural Change. To accomplish this, we model a multisectoral economy endowed with variety in final goods under imperfect markets. The analytical results shows that economic growth at steady state is subject to the degree of economic concentration, to intertemporal and intersectoral preferences and to the functional income distribution. Besides, we show that consumer may faced up a trade-off between consumption and sectoral complexity. Furthermore, we show that degree of economic concentration can decrease the economic growth rate, as well a non equitative income distribution.

1. Introduction

Although the process of long-run economic growth might seem stable in the aggregate, the reallocation of resources across sectors accompanying growth, namely structural change, has been reported by some authors such as Chenery (1960), Kuznets (1973) and Pasinetti (1981, 1993). Structural change refers to variations in the structure of an economy, and should be understood as the outcome to the existence of particular rates of technological progress and also growth of demand levels for final consumption goods. Despite being an intrinsic phenomenon of the development process, just recently it has been fully integrated into the mainstream research agenda on growth.[1] To understand the neglect of this phenomenon by the growth theory, one should bear in mind that a great deal of growth theory developed in the last half of the 20th century was carried out in terms of aggregated models such as the Solow growth model. Implicit in this representation of growth is a well-known definition of balanced growth, which precludes an analysis of the relationship between growth and structural change. The so-called new growth theory that unfolds in the eighties and nineties, namely the New Growth Theory, focused on some specific determinants of growth such as the optimal allocation of human capital [Lucas (1988)],

[1] For Krüger (2008, p. 331) "[t]he topic of structural change is frequently neglected in economic research, despite its relevance for growth theory, business cycle theory and labour market as well as for economic policy".

horizontal innovation and product variety [Romer (1990)] and, vertical Innovation in Schumpeterian Models [Aghion and Howitt (1992)], etc. Such models are also ill equiped to deal with structural change because they have only one final good.[2]

According to Arena and Porta (2012), when it comes to establishing a reference regarding renewed interest in studying structural change, it is necessary to take Echevarria's article (1997) into account. In this paper, the author departs from Solow's one sector framework and considers the existence of different types of consumer goods that are demanded based on intertemporal non-homothetic preferences. Notwithstanding there are particular rates of productivity growth for each of the sectors, the source of unbalanced growth is in the demand side insofar as the main result may be obtained even with similar TFP growth in all sectors. However, in the long term, although all sectors expand in absolute terms, one of them grows faster than the others, generating the asymptotic result of an economy with one sector only. In fact, such outcome is found in some models in the burgeoning literature that unfolded [see Arena (2017)], which led some authors to reassert the relevance and appropriateness of the Solow's growth model even in the presence of structural change. According to this rationale, unbalanced growth is compatible with the Kaldor's stylized facts. However, most of these models strive to explain how unbalanced growth can be consistent the Kaldor's growth facts, insofar as this result depends critically on a widely criticized knife-edge assumption, which ties preference and technology parameters and implies constant relative prices [see, e.g., Ngai and Pissarides (2007)].

Another article that is also considered an essential reference in the emergence of the neoclassical literature of structural change is by Ngai and Pissarides (2007), who focused on the source of structural change in the supply side. In the presence of particular TFP growth for each of the sectors, the authors show that it is possible to obtain a dynamic of structural change. They further consider the superiority of their framework over Echevarria's (1997) analytical scheme, in that they use a CES utility function, which avoids mapping preference and technology parameters as it happens with the Stone-Geary utility function. As a consequence, notwithstanding structural changes in Ngaï and Pissarides arise from the interaction between the intertemporal substitution elasticity of the utility function, and particular rates of TFP for each of the sectors, the supply side is the source of the structural change [see Arena and Porta (2012)].

The distinction between the sources of structural change being either in demand or the supply side is so evident in the literature that led Acemoglu (2009) to classify the models among those where structural changes originate on either the demand side or supply side. That is somewhat awkward insofar as

[2] This point is raised by Aghion and Howitt (1998, p. 65) who considers that endogenous growth models "[...] miss the stages of development in which resources are gradually reallocated from agriculture to manufacturing and then to services, all with different factor requirements and different technological dynamics. The economy is always a scaled up version of what it was years ago, and no matter how far it has developed already prospects for future development are always a scaled up version of what they were years ago".

we have seen unbalanced growth is only correctly understood when considered through a simultaneous supply and demand approach. The major problem, however, is associated with the fact that, in such studies, structural change is seen only as the effect of the process of economic growth. Most of them assume exogenous TFP growth, with no feedbacks between demand composition and technological change.

An exception is the work by Foellmi and Zweimüller (2008), who developed a model in which an important two-way causality between growth and structural change arises. In their formulation, growth is sustained by the continuous introduction of new goods in the economy but the speed of structural change is itself determined by aggregate growth. According to their view, consumption evolves along a hierarchy of wants and consumers get increasingly satiated with existing products, and new goods have to be continuously introduced to ensure that demand keeps pace with technological progress. The central idea is that the dynamic patterns of human needs and preferences give rise to entirely different compositions of consumer demand, and therefore different structures of production and employment. What is behind this phenomenon is the empirical regularity first described by Ernst Engel (1857), a German statistician of the nineteenth century, that the share of income spent on any particular consumption good is never constant as personal income increases, but tends to reach saturation. Non-homothetic preferences in growth model yields results that contrast with the standard growth models, which implicitly assume homothetic preferences.

For Foellmi and Zweimuller (2008) the source of structural change is in the demand side but the authors try to present the model in the context of a standard endogenous growth framework a la Romer (1990) and Grossman and Helpman (1991). In the present paper, we intend to provide a more inclusive role for the supply side. By following the contributions of horizontal innovation and product variety [Romer (1990)] and, vertical Innovation in Schumpeterian Models [Aghion and Howitt (1992)], we show that the supply side of the model can be further developed. With this approach we are able to show a number of interesting facts: (i) structural change pulls economic growth; (ii) the saturation of the consumption of some products opens space for the emergence of new markets; (iii) firms react to sector competition by innovating in final goods, which provides profits above the perfect competition sector; and (iv) depending on the resulting degree of monopoly, consumers can reduce per capita consumption when there is economic growth.

This paper is organized as follows. After this short introduction, the next section presents a brief review of the benchmark model that we will use to inspire our model built in chapter three. In chapter four we provide a numerical analysis used to help in understanding the impacts of the degree of competition on economic growth. In the end, some considerations are made.

2. The Foellmi and Zweimüller Model

In this section, we synthesize the main ideas presented in Foellmi and Zweimüller (2005), especially those that will be used later in the construction of the model that connects both approaches. They consider an economy endowed with an agent representative of the consumers, with infinite goods classified by an index i. They study the consumption structure that is generated by preferences of the following form:

$$u(c[i]) = \int_0^\infty \xi(i)\, v(c(i))\, di \tag{1}$$

where $v(c(i))$ is an index for the utility derived from consuming the good i in the amount c. The utility function $v(c(i))$ satisfies the usual assumptions $v'(c(i)) > 0$ and $v''(c(i)) < 0$; and the hierarchy function, $\xi(i)$, is monotonically decreasing in i, $\xi'(i) < 0$. Therefore, goods whose subscript i is lower obtain a greater weight than those of subscript i higher in the generation of utility for the representative agent. For the construction of the hierarchy function, two factors were taken into account. Firstly, some goods can not be consumed because the consumer can not buy them. This implies that the preferences must be such that the non-equality constraints are not met and the Engel curves for the various goods are not linear. If the marginal utility of consuming the good i in the zero amount was infinitely large, it would be great to consume a (small) positive amount even when prices are very high and/or the budget is very low. Second, Engel's law implies that the additional income is spent mainly on high-income elastic goods. This characteristic is captured by the formulation that the utility of the consumption of distinct goods differs only in the factor $\xi(i)$. As the hierarchy function, $\xi(i)$, is decreasing in i, the marginal utility of a high priority (i low) good falls fast. Optimized consumer behavior implies that the additional income is spent primarily on low priority (high i) goods with marginal utilities falling slowly.

To keep the analysis mathematically treatable and satisfy Engel's law, the authors made two assumptions about the functional forms of the hierarchy function, $\xi(i)$, and the utility function, $v(c(i))$. Firstly, they assumed that the function hierarchy is a function-power $\xi(i) = i^{-\gamma}$ with $\gamma \in (0, 1)$. Secondly, they assumed that the utility function is quadratic, $v(c(i)) = \frac{1}{2}\left[(s - c(i))^2 - s^2\right]$. Besides that, assume that only goods with high priority $i \in [0, A]$ are available on the market, while all $i > A$ were not developmented yet. In this case an objective function of the representative consumer is:

$$u(c[i]) = \int_0^A i^{-\gamma} \frac{1}{2}\left[(s - c(i))^2 - s^2\right] di \tag{2}$$

Equation (2) shows the utility of the representative consumer when consuming each of the$A$ high priority goods available in the economy. Given this, the problem of the representative consumer is to maximize the instant utility subject to its budgetary constraint, E,

$$\max_{c(i),A} \int_{0}^{A} i^{-\gamma} \frac{1}{2} \left[(s - c(i))^2 - s^2 \right] di \quad s.t \quad \int_0^A p(i)\, c(i)\, di = E$$

Therefore, the representative consumer must choose the quantity that will consume from each available good, $c(i) \quad \forall i$. Going beyond what was done by the authors, we can impose that the representative consumer choose which will be the last good that will consume, A. Thus, the first order conditions (F.O.C.) for this problem are related not only to the amount of the i-th good consumed but also to the number of goods consumed. Hence, the F.O.C. with respect to the amount of the i-th consumed goods is:

$$i^{-\gamma} (s - c(i)) - \lambda p(i) = 0 \quad \forall i \tag{3}$$

Besides, unlike Foellmi and Zweimüller (2005), we also take another F.O.C. with respect to the last good that is consumed, namely A, which yields:

$$\frac{A^{-\gamma} \left[s^2 - (s - c(A))^2 \right]}{2} - \lambda p(A)\, c(A) = 0 \tag{4}$$

From (3), we have, in particular:

$$A^{-\gamma} (s - c(A)) - \lambda p(A) = 0 \tag{5}$$

Using expressions (3) and (4), we conclude that:

$$c(A) = 0 \tag{6}$$

From (3), we can obtain the inverse demand curve for the good i:

$$p(i) = \frac{i^{-\gamma} (s - c(i))}{\lambda} \quad \forall i \tag{7}$$

Assume, just as Foellmi and Zweimüller (2008, p. 8), that the production marginal costs are the same for all goods and are normalized to one. In addition, goods $i \in [0, aA]$ are supplied in perfectly competitive markets and the goods $i \in (aA, A]$ supplied in monopolistic competitive market. The prices of goods in the range $i \in [0, aA]$ are equal to the marginal costs which are equal to the unit. The determination of the prices of goods in the $i \in (aA, A]$ may be obtained from the problem of the monopolistic firm as follows:

$$\max_{c(i)} \pi [c(i)] = \max_{c(i)} \left[\frac{i^{-\gamma} [s - c(i)]}{\lambda} - 1 \right] c(i)$$

The first-order condition (F. O. C) of the problem of firms in monopolistic competition provides us with:

$$c\left(i\right)=\frac{s-i^{\gamma}\lambda}{2}\quad\forall i\in\left(aA,A\right]\tag{8}$$

From (8), by considering $i=A$ we obtain:

$$c\left(A\right)=\frac{s-A^{\gamma}\lambda}{2}\tag{9}$$

From (6) we know that$c(A)=0$, so then it is possible to determine the λ from (9):

$$\lambda=sA^{-\gamma}\tag{10}$$

From (7) and (10), we can conclude that:

$$p\left(A\right)=1\tag{11}$$

Expression (11) shows that the price of last sector in monopolistic competition is the same as the price of the firms in perfect competition. Thus, we can rewrite the problem of the monopolistic firm in terms of prices as follows:

$$\max_{p(i)}\pi\left[p\left(i\right)\right]=\max_{p(i)}\left[p\left(i\right)-1\right]\left[s-i^{\gamma}p\left(i\right)\lambda\right]$$

The F.O.C. with respect $p(i)$ provides us:

$$p\left(i\right)=\frac{s+i^{\gamma}\lambda}{2i^{\gamma}\lambda}\quad\forall i\in\left(aA,A\right]\tag{12}$$

As we know, from (10), the value ofλ then the value of $p\left(i\right)$ will be:

$$p\left(i\right)=\frac{1}{2}\left[1+\left(\frac{A}{i}\right)^{\gamma}\right]\quad\forall i\in\left(aA,A\right]\tag{13}$$

Substituting (13) into (7), we find:

$$c\left(i\right)=\frac{s}{2}\left[1-\left(\frac{i}{A}\right)^{\gamma}\right]\quad\forall i\in\left(aA,A\right]\tag{14}$$

To obtain the consumption of the i-th good in competitive markets, let us replace $\lambda=sA^{-\gamma}$ into equation (7), which yields:

$$c\left(i\right)=s\left[1-\left(\frac{i}{A}\right)^{\gamma}\right]\quad\forall i\in\left[0,aA\right]\tag{15}$$

Therefore, we can summarize consumption as follows:

$$c\left(i\right)=\begin{cases}s\left[1-\left(\frac{i}{A}\right)^{\gamma}\right] & \forall i\in\left[0,aA\right]\\ \frac{s}{2}\left[1-\left(\frac{i}{A}\right)^{\gamma}\right] & \forall i\in\left(aA,A\right]\end{cases}\tag{16}$$

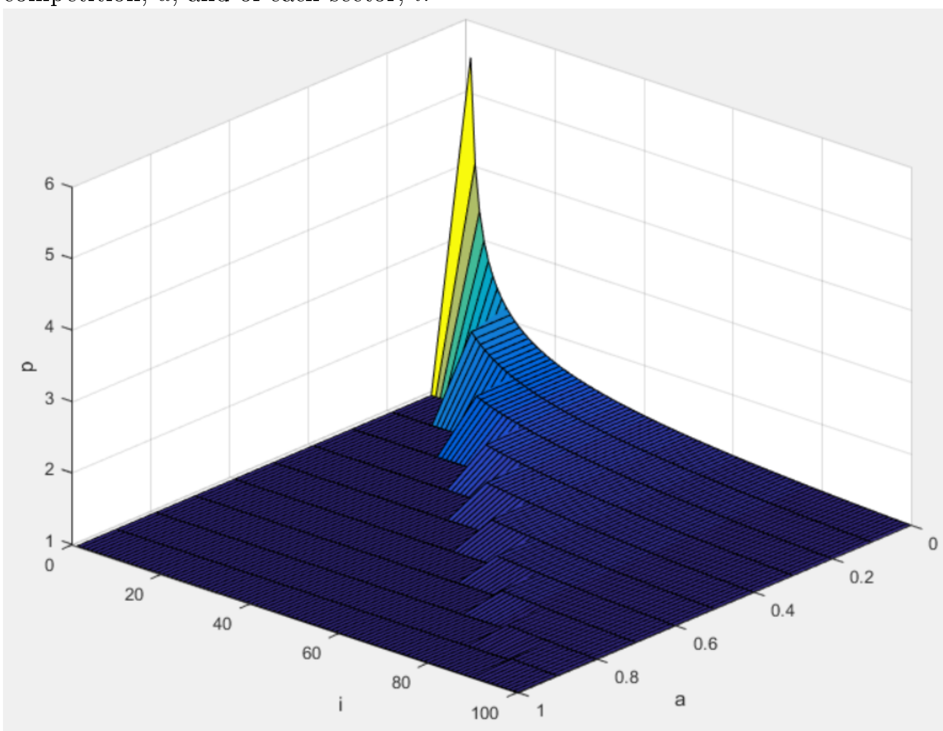
It is easy to see that, for a given number of sectors, the quantity consumed is smaller the higher the index i. Thus, essential goods (smaller i indices) are consumed in larger amounts than nonessential goods (larger indices i). We can also summarize the prices as follows:

$$p(i) = \begin{cases} 1 & \forall i \in [0, aA] \\ \frac{1}{2}\left[1 + \left(\frac{A}{i}\right)^{\gamma}\right] & \forall i \in (aA, A] \end{cases} \tag{17}$$

The prices are unitary for the goods produced by firms in perfect competition and, under monopolistic competition, they decrease until reaching an unit in the last sector, namely A. In this scenario, the economic profit is maximum in the sector subsequent to the last sector in perfect competition. In other words, firms that produce essential goods will have lower profits than those producing nonessential goods insofar as the latter are produced and selled in non-competitive markets, where the firms have some market power, which yields higher prices and profit margins.

Graph 1 describes the price behavior of an increasingly diversified and imperfectly competitive economy. Note that the proportion of sectors in perfect competition is fixed and given by $a > 0$, then for the first aA sectors, the price is equal to one. For the remainder sectors, namely $(aA, A]$, the price is a decreasing function of i, with $p(A) = 1$ being the lower bound for the price of firms in monopolist competition. Thus, the first sector in imperfect competition will be the one with the highest price of the economy, given the level of concentration of the economy, a. Note that, if $a = 0$, this is, if all sectors are under imperfect competition, so we have to $p(i) > p(A) = 1$ for all sectors $i \neq A$. Conversely, if all sectors are perfectly competitive, $a = 1$, then $p(i) = p(A) = 1$ for all sectors $i = 1, ..., A$.

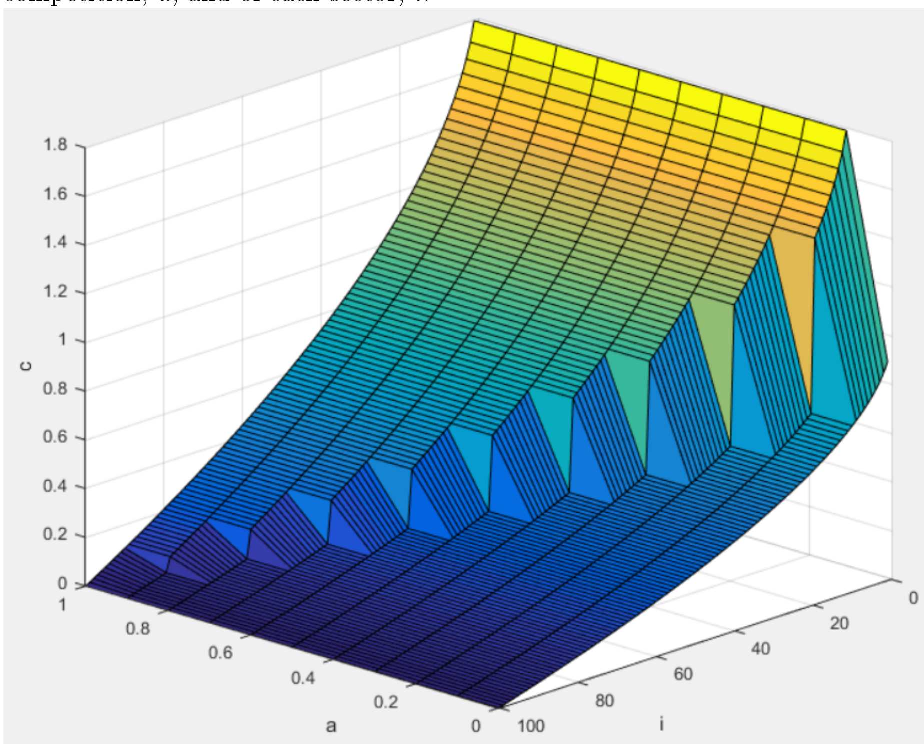
Graph 1: The behaviour of $p(i)$ according to the proportion of sectors in perfect competition, a, and of each sector, i.



Source: Elaborated by the authors.

Graph 2 shows the consumption of each sector i in relation to the proportion of sectors in perfect competition. Note that the consumption of goods under perfect competition is higher than the consumption of sector under imperfect competition but the consumption is a decreasing function of $i \in [0, A]$, with a dicontinuity in $i = aA$. Thus, in this perspective, it is important to avoid increasing the number of sectors under imperfect competition to increase total per capita consumption.

Graph 2: The behaviour of $c\,(i)$ according to the proportion of sectors in perfect competition, a, and of each sector, i.



Source: Elaborated by the authors.

This session briefly highlighted some important points raised by Foellmi and Zweimüller (2005), which will be necessary for the introduction of structural change in the endogenous growth model. As we have seen, according to equations (16) and (17), what matters for prices and quantities is the relative position in the hierarchy of needs, i/A. We have also seen that the higher the hierarchy (the higher γ), the more important is the relative position of the good under consideration. Finally, as we can see from graphs 1 and 2, the higher the degree of economic concentration (the lower a), the higher the prices and the lower the quantities which are consumed in each of the sectors.

3. The Supply Side and the Intertemporal Model

Let us assume that there are a finite number of sectors and firms in a given economy. In this economy, the sectors are vertically integrated, so that the firm producing the i-th final good uses a fraction of the available labor, as well as an intermediate input that comes from sector i itself. Therefore, we will have the following production function for an arbitrary firm i:

$$Y(i) = [L]^{1-\alpha} x(i)^{\alpha} \qquad \forall i \in [0, A] \tag{18}$$

where L denotes labor and $x(i)$ denotes the i-th intermediate good used in the production of the final good i. Let $A \in \mathbb{R}_+$ the number of sectors of this economy. Following Aghion and Howitt (1990), we add up all the sectoral production and aggregate them as follows:

$$Y = \int_0^A Y(i)\, di = L^{1-\alpha} \int_0^A x(i)^{\alpha}\, di \tag{19}$$

The profit maximazation problem of the final firms will depend on whether they sell in a competitive market or in monopolistic competitive markets. Following the convention of the previous section, goods $i \in [0, aA]$ are supplied in perfectly competitive markets and the goods $i \in (aA, A]$ supplied in monopolistic competition market. Then the problem to be solved to by each firm is given by the following expression:

$$\begin{cases} \max_{x(i),L} [L]^{1-\alpha} x(i)^{\alpha} - wL - x(i) & \forall i \in [0, aA) \\ \max_{x(i),L} p(i) [L]^{1-\alpha} x(i)^{\alpha} - wL - x(i) & \forall i \in [aA, A] \end{cases} \tag{20}$$

where w is the wage. We assume that the cost of the intermediate input $x(i)$ is constant and normalized to 1. From expression (17) $p(i) = \frac{1}{2}\left[1 + \left(\frac{A}{i}\right)^{\gamma}\right]$ is the price that the i-th final firm establishes for its final product while the price of the firm in competitive equilibrium is 1. The F. O. C. for the final firm is given by the following equation:

$$x(i) = \begin{cases} \alpha^{\frac{1}{1-\alpha}} L & \forall i \in [0, aA) \\ \left[\frac{\alpha}{2}\left[1 + \left(\frac{A}{i}\right)^{\gamma}\right]\right]^{\frac{1}{1-\alpha}} L & \forall i \in [aA, A] \end{cases} \tag{21}$$

Equation (21) shows that optimal quantity of intermediate good demanded by the final firms. If the marginal product is greater than its price, then the firm producing the final good i will use more input $x(i)$. Equation (21) shows that optimal quantity of intermediate good demanded by the final firms. If the marginal product is greater than its price, then the firm producing the final good i will use more input $x(i)$. Replacing equations (21) into (19) we obtain:

$$Y = AL\left\{\alpha^{\frac{\alpha}{1-\alpha}} a + \left(\frac{\alpha}{2}\right)^{\frac{\alpha}{1-\alpha}} (1-a)\left[\theta + (1-\theta)\left(1 + a^{-\gamma}\right)^{\frac{\alpha}{1-\alpha}}\right]\right\} \tag{22}$$

Following Romer (1990), the aggregate stock of capital of the economy is giben by$K = \eta \int_0^A x(i)\, di$. In order to solver the integral for it is important to bear in mind that the integral should be split in two insofar as some firms operate in competitive equilibrium while other operate in competitive mopoly.

$$K = \eta \int_{0}^{aA} x(i)\, di + \eta \int_{aA}^{A} x(i)\, di \tag{23}$$

After some algebraic manipulation it is possible to show that by solving the integrals it yields:[3].

$$K = \eta AL\alpha^{\frac{1}{1-\alpha}} \left\{ a + (1-a) \left[\theta + (1-\theta)\left(1 + a^{-\gamma}\right)^{\frac{1}{1-\alpha}} \right] \right\} \tag{24}$$

Equation (24) shows shows the aggregate capital stock of the economy, K. Basically, as we can see, it depends on the number of sectors, A, the number of workers, L, and the level of competition in the economy, a. Let is isolate AL to replace it in equation (22), as following:

$$AL = \frac{K}{\eta \left\{ \alpha^{\frac{1}{1-\alpha}} a + \alpha^{\frac{1}{1-\alpha}} (1-a) \left[\theta + (1-\theta)\left(1 + a^{-\gamma}\right)^{\frac{1}{1-\alpha}} \right] \right\}} \tag{25}$$

Defining $B = \frac{\left\{ \alpha^{\frac{\alpha}{1-\alpha}} a + \left(\frac{\alpha}{2}\right)^{\frac{\alpha}{1-\alpha}} (1-a) \left[\theta + (1-\theta)\left(1+a^{-\gamma}\right)^{\frac{\alpha}{1-\alpha}} \right] \right\}}{\eta \left\{ \alpha^{\frac{1}{1-\alpha}} a + \alpha^{\frac{1}{1-\alpha}} (1-a) \left[\theta + (1-\theta)(1+a^{-\gamma})^{\frac{1}{1-\alpha}} \right] \right\}}$ and replacing expression (25) into (22), we find the aggregate production function of this economy with variety in the final goods.

$$Y = BK \tag{26}$$

Equation (26) shows the aggregate production function, where B is a positive and rigid term, reflecting the aggregate technological level of the economy. Besides, the marginal and average products of the aggregate capital stock are represented by $B > 0$. In this case, the product is not reduced when a unit of capital is added during the production process.

Although the number of firms producing final goods is finite, A is endogenous. To determine this number it is necessary that we replace the equations (16) and (17) in the budget constraint ($\int_0^A p(i)\, c(i)\, di = E$), therefore, we can determine the number of sectors of the economy from per capita income, E, and the degree of economic concentration in the sectors, a:

$$A = \frac{E}{s \left[a - \frac{a^{1+\gamma}}{1+\gamma} + \frac{1-a^{1-\gamma}}{4(1-\gamma)} + \frac{a^{1+\gamma}-1}{4(1+\gamma)} \right]} \tag{27}$$

Equation (27) shows how per capita income,E, the saturation level, s, and the degree of economic concentration, a, affect the number of sectors of a given economy. Note that, of course, the relationship between per capita income and the number of firms is positive. This means that, if there is an increase in per capita income, there will be an increase in the number of sectors, *coeteris*

[3] The authors wish to thank Wilfredo Sosa for this demonstration, which can be found in Appendix A

paribus. The opposite effect occurs between the saturation level and the number of sectors. This is due to the functional form of the utility function that we use (Foellmi and Zweimüller, 2005). This utility function is based on the difference between what is consumed in i-th sector, $c(i)$, and the saturation level, s. As $c(i)$ is decreasing in i (F. O. C. result), then sectors whose index i is higher (sectors of less essential goods) generate less utility when compared to sectors whose index i is lower (sectors of essential goods). Thus, if s increases, so does the opportunity cost of consuming the goods of less essential sectors. Thus, the sectors closest to A generate even less utility to the consumer, which induces him to change the sectoral composition of demand towards the most essential goods, which generates a retraction in the number of sectors in the economy.

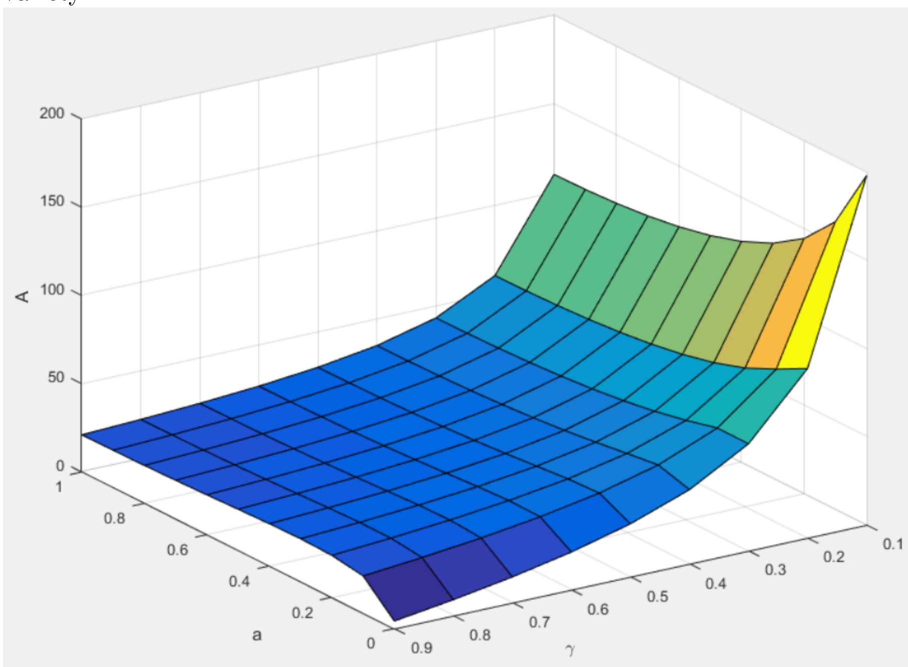
To check the effect of the degree of concentration of the economy on the number of sectors it is necessary to verify the first derivative. Let us derive the expression (26) in relation to the degree of concentration of the economy, a, and verify the conditions that the latter affects the first:

$$\frac{1}{a^{\gamma}} + 3a^{\gamma} - 4 > 0 \tag{28}$$

If condition (28) is verified, then increasing the degree of concentration of the economy contributes to increasing the variety of sectors.

Graph 3 illustrates the degrees of concentration and γ that satisfy inequality (28). Combinations of few sectors in perfect competition, $a < 40\%$, and high γ, are effective in engendering the creation of new industries. Therefore, for the opening of new sectors it is desirable that there be few sectors in perfect competition and, therefore, with barriers to entry and exit of firms, prices higher than the marginal cost, conjugated with values for γ that are less than 0.5.

Graph 3: The degrees of economic concentration and its impacts on the sectorial variety.



Source: Elaborated by the authors.

For simplicity define$\Theta\left(a\right)=a-\frac{a^{1+\gamma}}{1+\gamma}+\frac{1-a^{1-\gamma}}{4(1-\gamma)}+\frac{a^{1+\gamma}-1}{4(1+\gamma)}$ as the function that measures the sensitivity of the variety of sectors, A, to the degree of economic concentration, a. Therefore, equation (27) can be described in a condensed way as follows:

$$A=\frac{E}{s\Theta\left(a\right)} \tag{29}$$

Therefore, the number of sectors of the economy, A, depends on the budget constraint of an average or representative consumer, E, and on the level of satiety of the representative consumer, s, and on a function of the relative participation of monopolistic-type market structures among sectors. $\Theta\left(a\right)$.

Assuming the percentage of monopoly sectors in the economy, a, and the saturation level, s, we can derive equation (29) with respecto to time, to find:

$$\frac{\dot{A}}{A}=\frac{\dot{E}}{E}=g \tag{30}$$

where g is the growth rate of the representative individual's budget, which is equivalent to the per capita economic growth rate. Equation (30) shows, *coeteris paribus*, that the number of sectors of an economy grows as per capita income increases. Basically, this is because individuals seek to vary the consumption budget in order to escape the limits of saturation imposed on utility.

Let us integrate the sectoral instantaneous per capita consumption of a representative agent, $c(i)$, between 0 and A with respect to i to obtain per capita consumption of the representative individual:

$$c = sA\left[a + \frac{(1-a)}{2} - \frac{a^{\gamma+1}}{\gamma+1} + \frac{1}{2}\left(\frac{a^{\gamma+1}-1}{\gamma+1}\right)\right] \tag{31}$$

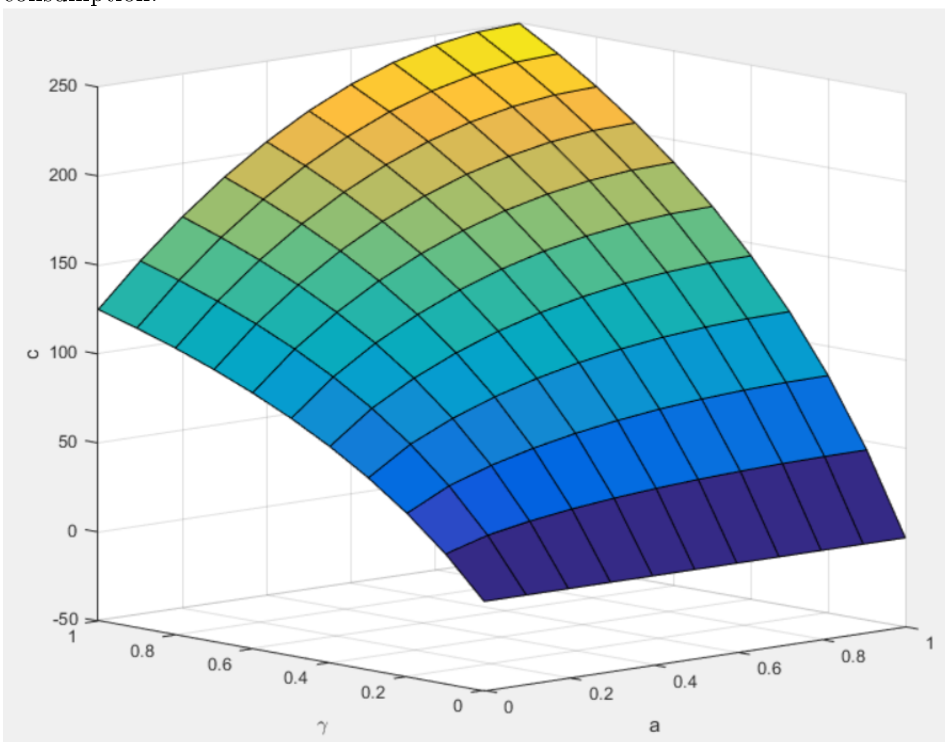
Equation (31) shows the per capita consumption of a representative individual among all sectors. Note that the higher the saturation level, s, and the greater amount of sectors, A, he higher the per capita consumption. In order to know the effect of the degree of concentration of the economy on per capita consumption it is necessary to derive the expression (31) in relation to the a and verify which conditions should be checked so that changes in a have an effect on c. Therefore:

$$\frac{dc}{da} = \frac{sA}{2}\left[1 - a^{\gamma}\right] \geqslant 0 \tag{32}$$

since $a^{\gamma} < 1$ due to the fact that $0 < a < 1$ and $0 < \gamma < 1$. Thus, increasing the number of sectors under perfect competition increases per capita consumption of the representative agent. Since a andγ are elements of the range $[0, 1]$ so whatever your values this condition will be satisfied. Therefore, consumption tends to increase as more firms cease to operate in the monopolistic competition market and become active in the perfect competition market. This is because it reduces the price of goods, allowing greater consumption of the representative agent.

Graph 4 shows the behavior of per capita consumption, given a per capita income,y, and given a level of satiety, s, due to the proportion of firms in the economy in perfect competition. It is clear, therefore, that as the economic structures of the sectors become the perfect competition, the per capita consumption of the individuals will increase.

Graph 4: The degrees of economic concentration and its impacts on per capita consumption.



Source: Elaborated by the authors.

Defining $\Omega(a) = a + \frac{(1-a)}{2} - \frac{a^{\gamma+1}}{\gamma+1} + \frac{1}{2}\left(\frac{a^{\gamma+1}-1}{\gamma+1}\right)$ as the function of the competitive structure of the economy that affects per capita consumption. It follows that,

$$c = sA\Omega(a) \tag{33}$$

But we also know from equation (29) that $As = \frac{E}{\Theta(a)}$. Substituting (29) into (33) we have:

$$c = E\frac{\Omega(a)}{\Theta(a)}$$

Since E represents per capita income, y, then:

$$c = y\frac{\Omega(a)}{\Theta(a)} \tag{34}$$

Equation (34) shows that per capita consumption depends on the level of income weighted by the degree of concentration of the economy. Thus, depending on the proportion of firms in monopolistic competition, per capita income may not be entirely allocated to consumption, making room for savings. We can find the rate of change of the capital stock, which will give us the restriction of capital accumulation per capita. Therefore, let us join the restriction of per capita capital into an intertemporal maximization problem of the utility of the representative individual. The problem can be presented as follows:

$$\max_{c_t} \int_0^\infty u\left(c_t\right) e^{-(\rho+n)t} dt \quad s.t.$$

$$\dot{k_t} = \dot{k}_t = B_t k_t - c_t - n k_t \tag{35}$$

The problem Hamiltonian can be written as:

$$\mathcal{H} = u\left(c_t\right) + \lambda_t \left[B_t k_t - c_t - n k_t\right] \tag{36}$$

The F. O. C. for control variable, c_t, is:

$$u'\left(c_t\right) = \lambda_t \tag{37}$$

From equation (37), it can be concluded that:

$$\frac{u''\left(c_t\right)}{u'\left(c_t\right)} \dot{c}_t = \frac{\dot{\lambda}_t}{\lambda_t} \tag{38}$$

The Euler condition with respect to the state variable k_t is:

$$\frac{\dot{\lambda}_t}{\lambda_t} = \rho + n - B_t \tag{39}$$

At steady state, it must happen $\frac{\dot{k}_t}{k_t} = \frac{\dot{y}_t}{y_t} = \frac{\dot{c}_t}{c_t} = g$. Assume that $u\left(c_t\right) = \frac{c_t^{1-\sigma} - 1}{1-\sigma}$. From equation (38), we have:

$$-\sigma \frac{\dot{c}_t}{c_t} = \frac{\dot{\lambda}_t}{\lambda_t} \tag{40}$$

Substituting (39) into equation (40) and $\frac{\dot{c}_t}{c_t} = g$, we have $-\sigma g = \rho + n - B_t$, which yields:

$$g = \frac{B_t - \rho - n}{\sigma} \tag{41}$$

Substituting the value of B into equation (41):

$$g\left(a\right) = \frac{\left\{\alpha^{\frac{\alpha}{1-\alpha}} a + \left(\frac{\alpha}{2}\right)^{\frac{\alpha}{1-\alpha}} \left(1-\alpha\right) \left[\theta + \left(1-\theta\right)\left(1 + a^{-\gamma}\right)^{\frac{\alpha}{1-\alpha}}\right]\right\}}{\sigma \eta \left\{\alpha^{\frac{1}{1-\alpha}} a + \alpha^{\frac{1}{1-\alpha}} \left(1-\alpha\right) \left[\theta + \left(1-\theta\right)\left(1 + a^{-\gamma}\right)^{\frac{1}{1-\alpha}}\right]\right\}} - \left(\frac{\rho + n}{\sigma}\right) \tag{42}$$

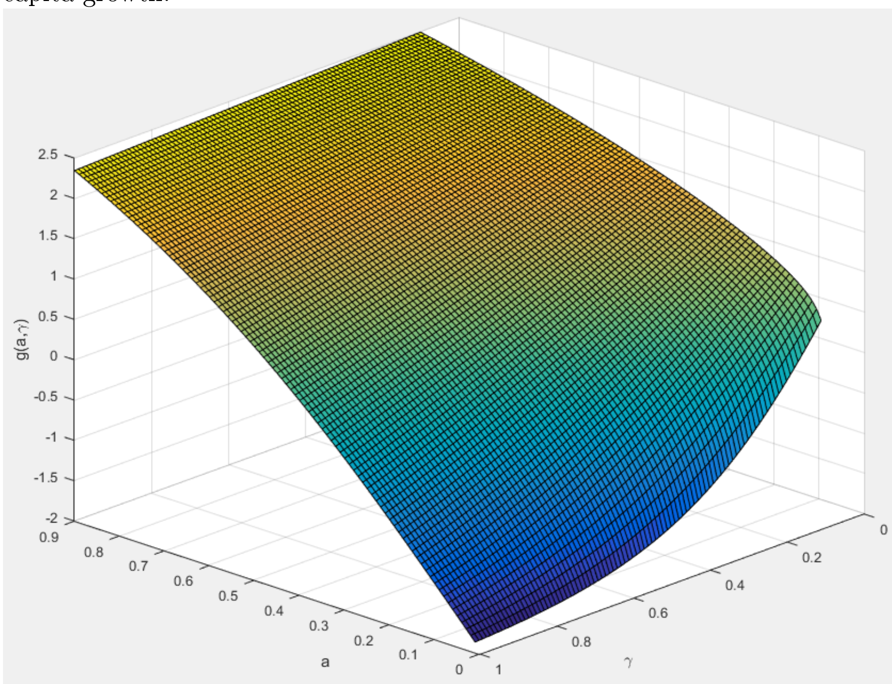
Equation (42) shows which are the determining variables for per capita economic growth, given the hypotheses of this model. As we can see, the key variable for growth is the degree of economic concentration, a. In addition, the lower the proportion of profit in income, α, the greater the growth tends to be. Therefore, the model presented in this section shows how the economic structure can affect the rate of economic growth. Moreover, it shows how demand, with its parameters related to the preferences of the representative consumer, γ, can influence the growth of new sectors and, therefore, the economic growth itself. In this sense, the rate of economic growth was endogenized, becoming dependent not only on factors related to supply, but also on how the sectoral economic structure is organized and the preferences of consumers. Thus, it is clear that economic growth is a phenomenon not restricted to the supply side, and the demand side is of great importance.

4. Numerical Analysis

In this section we will present a numerical analysis of the model delivered in the previous sections.

We focus on equation (42) to show how economic growth rate responds to changes in market concentration. As we shall see below, increasing the number of sectors in imperfect competition reduces the rate of economic growth.The Graph 5 shows the effects of economic concentration and sector preference on per capita growth. Given a markets concentration degree, a, note that the more the consumer prefers the essential goods (the higher the gamma) the lower the growth rate. The reduction in economic growth rate comes from an unwillingness of representative consumer to buy new products, because the new j sectors that could potentially arise will produce goods with low consumer valuation. Therefore, because this preference makes it more unfeasible for firms to create new products because they face difficulties in selling them. As the incentives to open new sectors are reduced, then economic growth will be lower.

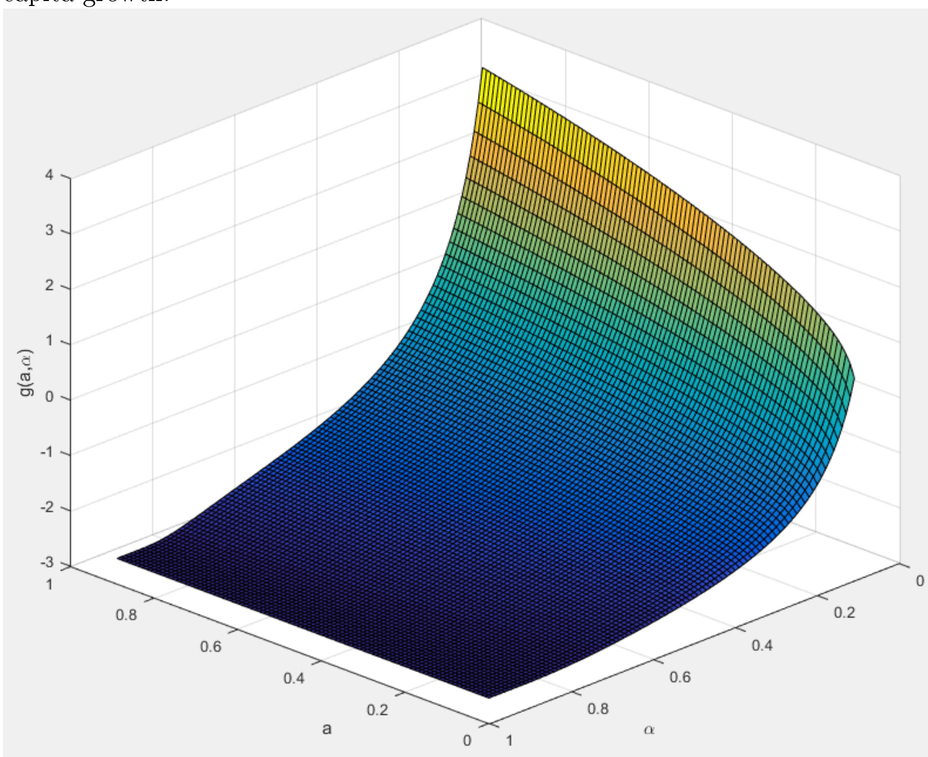
Graph 5: The effects of economic concentration and sector preference on per capita growth.



Source: Elaborated by the authors.

From the Graph 6, we conclude that there is a region with specific values of income distribution and economic concentration favorable to economic growth. In this region, the triple $(\alpha, \gamma, g) \in \mathbb{R}_3^+$ is associated with a higher proportion of wages in income (wage share bigger then 0.6) and with a higher number of sectors operating under perfect competition. Thus, it can be inferred that in the presence of a better income distribution, the higher the number of sectors under perfect competitions the higher the per capita growth rate (coeteris paribus). This result is intuitive because it means higher wages to be spent on goods, which clearly favors the viability of producing new goods which boosting the opening up of new sectors and leads to economic growth.

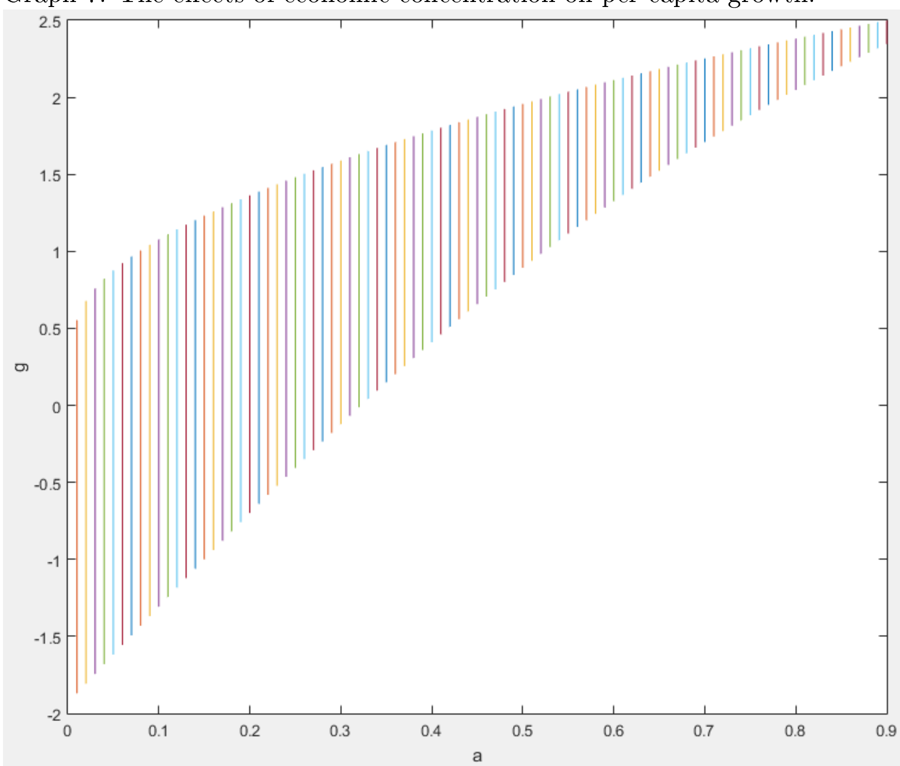
Graph 6: The effects of economic concentration and income distribution on per capita growth.



Source: Elaborated by the authors.

From Graph 7 we can infer that how economic concentration affects per capita income growth. The most important result is to recognize that, regardless of the parameters, [increasing the number of sectors under perfect competition (increase of a) increases the rate of per capita economic growth. This phenomenon occurs because the higher the a, the higher the number of sectors under perfect competition, which for a given income of the consumer, allows him to buy the same basket of consumption spending less resources. By the Engel's Law and the saturation of consumption of available goods, to capture these saved resources the firms need to develop new products and services. This process of innovation will occur for two reasons: first, in the attempt to get the extra income from the consumer; and second, in an attempt to escape from a perfect competition environment, where price equals marginal cost. The opening up of new sectors as well as the production of new goods will lead to processes of structural change and economic growth. From another point of view, the increase in the competition among the firms, will force them to elaborate new products to achieve positive economic profits. Driven by the pursuit of monopoly economic profit, in the process of developing new products and services, by a series of market issues, some firms will succeed in the market and others will fail. Those that are successful will open new markets, hire new workers, boost job creation and production, which leads to an increase in the rate of economic growth. In this sense, a situation that leads firms to innovate can create space to increase the opportunities and the number of sectors operate under imperfect competition which yields positive economic profit, what can allow the creation of new sectors, pulling the economic growth.

Graph 7: The effects of economic concentration on per capita growth.



Source: Elaborated by the authors.

Therefore, it is important to avoid the dominance of the imperfect competition structure between sectors in order to achieve higher rates of economic growth. It is fundamental to understand that growth stems from the reaction of firms to the process of imitation engendered by competitors. Thus, at first, markets can become less concentrated, which allows the consumer to obtain the same satisfaction by spending less resources. This result will generate savings that can be used to buy new goods and services, because those that are already available have already reached saturation in consumption. Then, some firms will reposition themselves in the market by launching new products and reaching markets where they can operate as monopolists and capture the resources saved by the consumer, which increases the concentration of markets. If the new level of market concentration is lower than the old, which means more firms in imperfect markets than before, then the average price of the economy may increase. Thus, a trade-off arises between the variety of final goods and the quantity of goods consumed, that is, it is worth consuming a lot of few goods or consuming little of several goods. However, resolving it is not a simple task because it will depend on how the agents' preferences are about each of the options.

The major result was to show, first, that the degree of market monopoly has effects on economic growth and, second, what are the channels of transmission of these impacts. In this sense, it is argued that it is possible to stimulate the process of structural change through the increasing competition among firms. This is because firms, in pursuit of new business opportunities and higher profits, in many cases, prefer to invest in research and development and create a new product, rather than competing with other companies in perfectly competitive markets. The first situation may lead to a positive expected economic profit, while in the second, economic profit is zero. Therefore, the existence of saved resources means to the firms the existence of opportunities to achieve positive economic profits, which creates spaces for new firms to create new products, expanding the number of sectors of the economy and triggering the process of structural change, either by the mobilization of employment and its impacts on the wage mass, or by the change in the production of the economic structure.

5. Concluding Remarks

This article aimed to reconcile two economic growth theories, which are the Endogenous Growth Theory and the Structural Change Theory, and find out how concilitation can yield new insights to understand the economic growth process. To accomplish this, we model a multisectoral economy endowed with variety in final goods under imperfect markets. Basically, we present a model that shows how much economic concentration can be lethal to economic growth because it does not allow the formation of savings to finance new sectors. If there is no change in the concentration of markets, the consumer does not save and the companies in monopoly contexts do not invest in product innovation (unless they feel threatened by new entrants). In this sense, these firms have no incentive to persuit positive economic profit (because they are already getting) and, therefore, to create a new product and increase the number of sectors in the economy.

Besides, we showed a potential trade-off between consumption amount and the sectoral complexity. This trade-off arises when the consumer experience per capita income growth. This growth leads it to a path where he must choose what will do with his additional income. It occurs because income growth is conditioned to a creation of new sectors at higher prices. In this sense, new sectors will not be created in competitive markets. If the new income is less than the increase in prices, in percentage terms, he faces two simple options: i) buy a released good and gave up buying a known good; or ii) gave up buying a released good and buy another known good. The latter option may hinders economic growth process, because occurs the saturation of consumption of goods that already exist, through Engels Law. In addition, the trend is the consumer to want new goods instead of consuming larger quantities of existing goods.

In short, the natural process of growth can be described in this way: first, some goods are copied by other firms, causing a reduction in the degree of market economic concentration; second, this pressure firms to innovate in product in the search for positive economic profit; when they find a viable project and implement it, this presses the prices up and then then new industries are created and this push up the economic growth. At this point, consumption may increase or decrease. It can decreases when the increase in per capita income is lower than the increase in prices. If it decreases, so the consumer face up the trade-off.

Lastly, we show that the more the markets are under perfect competition, the greater the economic growth rate. This is because high prices are attractors of new companies, which are seeking to maximize your profits. So if we want economic growth and structural change, we must accept higher prices at least in the short term, even though this may sacrifice consumption.

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Appendix A

Optimal amount of firms:

$$E = \int_0^A p(i)\, c(i)\, di = \int_0^{aA} p(i)\, c(i)\, di + \int_{aA}^A p(i)\, c(i)\, di$$

$$\int_0^{aA} p(i)\,c(i)\,di+\int_{aA}^{A} p(i)\,c(i)\,di = \int_0^{aA} s\left[1-\left(\frac{i}{A}\right)^{\gamma}\right]di+\int_{aA}^{A}\frac{1}{2}\left[1+\left(\frac{A}{i}\right)^{\gamma}\right]\frac{s}{2}\left[1-\left(\frac{i}{A}\right)^{\gamma}\right]di$$

$$E = s\int_0^{aA}\left[1-\left(\frac{i}{A}\right)^{\gamma}\right]di+\frac{s}{4}\int_{aA}^{A}\left[1+\left(\frac{A}{i}\right)^{\gamma}\right]\left[1-\left(\frac{i}{A}\right)^{\gamma}\right]di$$

$$E = s\int_0^{aA}di-\frac{s}{A^{\gamma}}\int_0^{aA}i^{\gamma}di+\frac{s}{4}\int_{aA}^{A}\left[1+\left(\frac{A}{i}\right)^{\gamma}\right]\left[1-\left(\frac{i}{A}\right)^{\gamma}\right]di$$

$$E = saA-\frac{s}{A^{\gamma}}\left[\frac{i^{\gamma+1}}{\gamma+1}\right]_0^{aA}-\frac{s}{4A^{\gamma}}\left[\frac{i^{\gamma+1}}{\gamma+1}\right]_{aA}^{A}+\frac{sA^{\gamma}}{4}\left[\frac{i^{1-\gamma}}{1-\gamma}\right]_{aA}^{A}$$

$$E = saA-\frac{s}{A^{\gamma}}\left[\frac{(aA)^{\gamma+1}}{\gamma+1}\right]-\frac{s}{4A^{\gamma}}\left[\frac{A^{\gamma+1}-(aA)^{\gamma+1}}{\gamma+1}\right]+\frac{sA^{\gamma}}{4}\left[\frac{A^{1-\gamma}-(aA)^{1-\gamma}}{1-\gamma}\right]$$

$$E = Asa-A\left[\frac{sa^{\gamma+1}}{\gamma+1}\right]-A\left[\frac{s\left(1-a^{\gamma+1}\right)}{4(\gamma+1)}\right]+A\left[\frac{s\left(1-a^{1-\gamma}\right)}{4(1-\gamma)}\right]$$

$$E = Asa-As\left[\frac{a^{\gamma+1}}{\gamma+1}\right]-As\left[\frac{\left(1-a^{\gamma+1}\right)}{4(\gamma+1)}\right]+As\left[\frac{\left(1-a^{1-\gamma}\right)}{4(1-\gamma)}\right]$$

$$E = As\left[a+\frac{\left(1-a^{1-\gamma}\right)}{4(1-\gamma)}-\frac{a^{\gamma+1}}{\gamma+1}-\frac{\left(1-a^{\gamma+1}\right)}{4(\gamma+1)}\right]$$

$$E = As\left[\frac{a(1+\gamma)-a^{1+\gamma}}{1+\gamma}+\frac{\left(1-a^{1-\gamma}\right)(1+\gamma)-\left(1-a^{1+\gamma}\right)(1-\gamma)}{4(1-\gamma)(1+\gamma)}\right]$$

$$E = As\left[a-\frac{a^{1+\gamma}}{1+\gamma}+\frac{1-a^{1-\gamma}}{4(1-\gamma)}+\frac{a^{1+\gamma}-1}{4(1+\gamma)}\right]$$

$$A = \frac{E}{s\left[a-\frac{a^{1+\gamma}}{1+\gamma}+\frac{1-a^{1-\gamma}}{4(1-\gamma)}+\frac{a^{1+\gamma}-1}{4(1+\gamma)}\right]}$$

Derived from the number of firms in relation to the degree of economic concentration.

$$\frac{dA}{da} = \frac{E}{s}\left[a - \frac{a^{1+\gamma}}{1+\gamma} + \frac{1-a^{1-\gamma}}{4(1-\gamma)} + \frac{a^{1+\gamma}-1}{4(1+\gamma)}\right]^{-1}$$

$$\frac{dA}{da} = -\frac{E}{s}\left[a - \frac{a^{1+\gamma}}{1+\gamma} + \frac{1-a^{1-\gamma}}{4(1-\gamma)} + \frac{a^{1+\gamma}-1}{4(1+\gamma)}\right]^{-2}\left[1 - \frac{a^{-\gamma}}{4} - \frac{3a^{\gamma}}{4}\right]$$

$$\frac{dA}{da} = \frac{-E\left[1 - \frac{a^{-\gamma}}{4} - \frac{3a^{\gamma}}{4}\right]}{s\left[a - \frac{a^{1+\gamma}}{1+\gamma} + \frac{1-a^{1-\gamma}}{4(1-\gamma)} + \frac{a^{1+\gamma}-1}{4(1+\gamma)}\right]^{2}}$$

$$\frac{dA}{da} = \frac{E\left[\frac{a^{-\gamma}}{4} + \frac{3a^{\gamma}}{4} - 1\right]}{s\left[a - \frac{a^{1+\gamma}}{1+\gamma} + \frac{1-a^{1-\gamma}}{4(1-\gamma)} + \frac{a^{1+\gamma}-1}{4(1+\gamma)}\right]^{2}}$$

$$a^{-\gamma} + 3a^{\gamma} > 4$$

Integration of $c(i)$ with respect to i:

$$\int_0^A c(i)\,di = \int_0^{aA} s\left[1 - \left(\frac{i}{A}\right)^{\gamma}\right]di + \int_{aA}^{A} \frac{s}{2}\left[1 - \left(\frac{i}{A}\right)^{\gamma}\right]di$$

$$\int_0^A c(i)\,di = s\int_0^{aA} \left[1 - \left(\frac{i}{A}\right)^{\gamma}\right]di + \frac{s}{2}\int_{aA}^{A} \left[1 - \left(\frac{i}{A}\right)^{\gamma}\right]di$$

$$\int_0^A c(i)\,di = s\int_0^{aA} di - s\int_0^{aA} \left(\frac{i}{A}\right)^{\gamma} di + \frac{s}{2}\int_{aA}^{A} di - \frac{s}{2}\int_{aA}^{A} \left(\frac{i}{A}\right)^{\gamma} di$$

$$\int_0^A c(i)\,di = s\int_0^{aA} di - sA^{-\gamma}\int_0^{aA} i^{\gamma} di + \frac{s}{2}\int_{aA}^{A} di - \frac{sA^{-\gamma}}{2}\int_{aA}^{A} i^{\gamma} di$$

$$c = saA - sA^{-\gamma}\frac{(aA)^{\gamma+1}}{\gamma+1} + \frac{s}{2}[A - aA] - \frac{sA^{-\gamma}}{2}\left[\frac{A^{\gamma+1} - (aA)^{\gamma+1}}{\gamma+1}\right]$$

$$c = saA - \frac{sA^{-\gamma}(aA)^{\gamma+1}}{\gamma+1} + \frac{sA}{2}[1 - a] - \frac{sA^{-\gamma}}{2}\left[\frac{A^{\gamma+1} - (aA)^{\gamma+1}}{\gamma+1}\right]$$

$$c = saA - \frac{sAa^{\gamma+1}}{\gamma+1} + \frac{sA}{2}[1 - a] - \frac{sA}{2}\left[\frac{1 - a^{\gamma+1}}{\gamma+1}\right]$$

$$c = sAa - sA\frac{a^{\gamma+1}}{\gamma+1} + sA\frac{(1-a)}{2} - \frac{sA}{2}\left[\frac{1 - a^{\gamma+1}}{\gamma+1}\right]$$

$$c = sA\left[a + \frac{(1-a)}{2} - \frac{a^{\gamma+1}}{\gamma+1} - \frac{1}{2}\left(\frac{1-a^{\gamma+1}}{\gamma+1}\right)\right]$$

Integration of $x(i)$:

Let be $x(i) = L\left[\frac{\alpha}{2}\left[1+\left(\frac{A}{i}\right)^{\gamma}\right]\right]^{\frac{1}{1-\alpha}}$. Note that:

$$L\left[\frac{\alpha}{2}\left[1+\left(\frac{A}{i}\right)^{\gamma}\right]\right]^{\frac{1}{1-\alpha}} = L\left(\frac{\alpha}{2}\right)^{\frac{1}{1-\alpha}} A^{\frac{\gamma}{1-\alpha}}\left(A^{-\gamma}+i^{-\gamma}\right)^{\frac{1}{1-\alpha}}$$

We have that $aA \leq i \leq A$ then $A^{-\gamma} \leq i^{-\gamma} \leq (aA)^{-\gamma}$. Therefore,

$$2A^{-\gamma} \leq A^{-\gamma} + i^{-\gamma} \leq A^{-\gamma}\left(1+a^{-\gamma}\right)$$

$$\left(2A^{-\gamma}\right)^{\frac{1}{1-\alpha}} \leq \left(A^{-\gamma}+i^{-\gamma}\right)^{\frac{1}{1-\alpha}} \leq \left[A^{-\gamma}\left(1+a^{-\gamma}\right)\right]^{\frac{1}{1-\alpha}}$$

$$2^{\frac{1}{1-\alpha}} = A^{\frac{\gamma}{1-\alpha}}\left(2A^{-\gamma}\right)^{\frac{1}{1-\alpha}} \leq A^{\frac{\gamma}{1-\alpha}}\left(A^{-\gamma}+i^{-\gamma}\right)^{\frac{1}{1-\alpha}} \leq \left(2A^{-\gamma}\right)^{\frac{1}{1-\alpha}} \leq \left(A^{-\gamma}+i^{-\gamma}\right)^{\frac{1}{1-\alpha}} \leq A^{\frac{\gamma}{1-\alpha}}\left[A^{-\gamma}\left(1+a^{-\gamma}\right)\right]$$

$$L\left(\frac{\alpha}{2}\right)^{\frac{1}{1-\alpha}} 2^{\frac{1}{1-\alpha}} \leq x\left(i\right) \leq L\left(\frac{\alpha}{2}\right)^{\frac{1}{1-\alpha}}\left(1+a^{-\gamma}\right)^{\frac{1}{1-\alpha}}$$

$$L\alpha^{\frac{1}{1-\alpha}} \leq x\left(i\right) \leq L\left[\frac{2\left(1+a^{-\gamma}\right)}{2}\right]^{\frac{1}{1-\alpha}} = L\alpha^{\frac{1}{1-\alpha}}\left(1+a^{-\gamma}\right)^{\frac{1}{1-\alpha}}$$

$$L\alpha^{\frac{1}{1-\alpha}} A\left(1-a\right) \leq \int_{aA}^{A} x\left(i\right) di \leq L\alpha^{\frac{1}{1-\alpha}}\left(1+a^{-\gamma}\right)^{\frac{1}{1-\alpha}} A\left(1-a\right)$$

$$\int_{aA}^{A} x\left(i\right) di = L\alpha^{\frac{1}{1-\alpha}} A\left(1-a\right)\left[\theta + \left(1-\theta\right)\left(1+a^{-\gamma}\right)^{\frac{1}{1-\alpha}}\right] \ for\ \theta \in [0,1]$$

Conclusion remarks

There is some consensus among economists that the challenge to develop a country economically is to implement the appropriate structural changes [See Ocampo (2005)]. In this sense, variables such as consumer preferences and production technologies have a very important role in this process. Because they constitute the mechanism that marks the evolution of the sectoral composition of the economy. This is the central message of this thesis. In it, the implications of the analysis of structural change in the theory and practice of economic development were studied, with a main focus on the understanding of the mechanisms responsible for maintaining and increasing the technological and per capita income gaps between advanced and underdeveloped countries. More specifically, we sought to understand how structural changes affect and are affected by government and the creation of new technologies.

One of the contributions presented in this thesis is that the approaches to structural change dynamics and balance-of-payments constrained growth approaches can be enriched when extended by other relevant economic aspects, such as the introduction of government and tax policy, as well as import of intermediate goods. The approaches to structural change dynamics and balance of payments constrained growth, which share the view that demand plays an important role in the process of economic growth, reach other levels of understanding of an economic phenomenon when extended in order to be some more relevant phenomena. While the first extension looks at how sectoral taxation and spending can lead to structural changes, while the second extension throws light on the impacts of importing intermediate goods with high income elasticity on the growth rate. Both extensions help to understand the difference in growth between countries in the light of public sector action and the import of intermediate goods.

Based on the study of these interactions, the balance-of-payments-constraint multisectoral model of growth in its pure working version and exclusive trade of final goods was extended to consider the public sector as well as the importation of intermediate goods. The conditions for full employment, full national income expenditure, the intertemporal balance of public accounts and the intertemporal balance of the economy, as well as the rates of economic growth resulting from these conditions were established.

Two were the starting points for dealing with the studied problems of the thesis. The first was the structural change dynamics approach, proposed by Pasinetti (1993) and Araujo and Lima (2007), to study the interaction between (i) the role of government, (ii) the use of intermediate goods in international trade, on the process of change structural and growth. The first approach (i), we shown that the government can accelerate the gains of prosperity arising from international trade if it designs its tax policy correctly. However, the government may also delay or even prevent the country from producing structural change if it incorrectly designs its tax policy. It was possible to verify that the effect of tax policy on the rate of economic growth may be due to a channel: that of transferring resources from one sector to another. This process occurs when the government imposes the transfer of real flows (goods) from one sector to another through taxation and expenditures. Therefore, if one wants to help a sector to become competitive, that is, that has a price lower than the international price, it must increase the supply of goods in this sector through tax policy.

In chapter one, it was found that a tax policy that favors the more complex sectors, the prudent use of intermediary goods with high income elasticity and the permission for there to be market power in the firms are sources of benefits, but always conditional to the physical, economic and policies that economies face. In other words, allowing a greater participation of the public sector in the economy can be a possibility of increasing exports, and therefore, a possible source of gains from the flourishing of a more solid competitive environment. In the first two chapters, the analysis was conducted in an economic system in which values could be measured in terms of labour quantities. In the latter, the analysis was carried out in an economic system measured in prices. It was then verified under what conditions a theory of labor value would apply to the study of the role of government in structural change.

Therefore, we can conclude from chapter one that a country can still increase its growth rate, even if it faces low rates of world income growth, if the government is able, through a correct design of its tax policy, to change the sectoral composition of exports and / or imports. This result may contradict the idea that fiscal and tax policies have no effect on long-term economic growth. In this sense the heterodox view that the process of economic growth in developing countries can be induced by growth strategies is confirmed [see Thirlwall (1997)].

From the second approach (ii), the use of intermediate goods with high income elasticity brings increases in income per capita, due to the increase in the quality of the final product to be exported, which translates into increased exports of final goods. However, we discovered that the use of sophisticated intermediate goods may obscure a deeper problem, the result of which is usually felt in the long run when per capita income falls short of its desired value. Thus, the productive structure of the economy reflects in the long run the dynamic patterns of demand evolution and the basic needs of consumers.

In chapter two, it is shown that an increase in the use of intermediate goods of high income elasticity affect the benefits in the long term. At first, they can be used to fill a structural bottleneck of the economy, widening the scope of the international market for a particular country. However, this bottleneck in the productive chain that is supplied by the imports of intermediate goods, destroys the country's incentives to develop a more diversified production structure, creating a dependency on these imports, which, in the second place, reduces its capacity to develop. Following this reasoning, and considering a multi-sectorial version of the Thirlwall Law, it is possible to show that the growth rate of a country can be strongly affected by movements by the imports of these intermediate goods of high income elasticity, so that the more one country uses them, but further constrains their ability to achieve sustainable economic development.

The second reason put forward in this thesis is that there are a number of technological barriers that make it difficult for developing countries to become involved in international trade. This often leads them to adopt inadequate strategies, but faster to produce effects, as in cases where high value-added products are imported to be used as final good inputs, adding little value to this transformation. In this perspective, although international trade is a possible source of gains for the countries involved, these gains are conditioned by the productive structure as well as by the export strategies adopted by the economies involved. In some cases analyzed in this thesis, a greater insertion of a country in the international trade through the use of intermediate goods of high complexity caused deterioration in its productive structure, leading to the specialization in products with low elasticity demand income, which reflected on its rate of economic growth and per capita income.

In chapter three, it has been shown that the increase in the number and complexity of the sectors is favored when the level of competition in the economy increases and there is predominance of sectors in perfect competition in detriment of sectors in monopolistic competition. This in itself can cause economic development, since more complex sectors require more specialized labor, which raises the average wage of the economy. New sectors generate new income, also driving economic growth.

It was also possible to perceive that the effect of the economic concentration (increase of the market power of the firms) in the economic growth rate can be due to two channels. The first is due to the existence of competition decrease. Reducing competition among firms reduces the incentive to innovate, which decreases the production and, therefore, slow growth. The second is due to the extra profit lost by firms that were in monopolistic competition and are now in perfect competition. With less money in cash, less investments are possible to make and, therefore, smaller production and growth.

There is a general perception about the urgency of promoting structural change and accelerate the process of economic development. This feeling is shared by a lot of governments, several multilateral agencies, great economists and mainly by the populations. Then, to know how to implement adequate policies to the process of structural change is one of today's great challenges. To achieve this end, there are some core variables, as consumer tastes and technology uses, that need to be well understood and some instruments, as exchange rate and interest rate, that need to be well used. So, for a country to develop, the effort of all individuals is fundamental, as well as the policies adopted by the public sector in the design of the correct institutional environment. This is the central message of this thesis: structural change is something extremely complex and necessary.

Let us summarize: first, we started from a multisector Thirlwall's law approach with public sector, trying to show how the government can boost the process of economic growth in a context of external constraint. For this, we shown that fiscal policy is the toolbox where the public agent can choise what are the best devices, which he has at his disposal, to increase economic growth and strucutral change. We presented there is a better combination of incentives and taxes between the sectors of an economy that provides greater economic growth, as well a numerical example of this. So, fiscal policies can be great allies of the society in the battle against poverty and economic backwardness. This result can be understood as a warning to voters to choose politicians whose agenda for policy implementation is in line with the agenda of structural change and economic development. If there are no candidates to support these reforms, it is vital that voters show strong dissatisfaction with their political options. Second, we then show to what extent the importation of intermediate goods of high aggregate value can disturb the process of economic growth. We take the Mexico's case as example. This country did well in the last decades. However, more could be made in the same time with other commercial strategies. The maquilas succeeded in printing a good economic performance, but with the sacrifice of the ratio of income elasticities. In the long run the effects of this sacrifice were felt on Mexico's per capita income level and, therefore, suffered by the entire population. As before, politicians should have an interest in encouraging a favorable change in the ratio of income elasticities and should have this as one of their main economic guidelines. By results of chapters one and two, it is very recommended for the government to commune with trade policies and fiscal policies. Lastly, in the chapter three, we presented a connection between supply and demand in the process of economic growth. In this process, new sectors are being created, where each new good is designed to answer consumer's tastes. The new sectors will only be sustained if the utility of the new goods exceeds the market price. This shows how important is the role of consumers in the innovation process and sectoral expansion.

Thus, multiple departments of society must mobilize together to achieve development goals. The public sector have a special function to improve and guide society during the transition. Political candidates engaged with the economic development and structural change policies are sine qua non condition. In addition, it is necessary to avoid the use of intermediate goods of high income elasticity of imports and the sectors of monopolistic competition.