FISCAL POLICY IN A STRUCTURAL ECONOMIC DYNAMICS APPROACH UNDER GENERAL MACROECONOMIC CONSTRAINT

Matheus S. de Paiva (UNB)
Julio Fernando C. Santos (UFU)

Abstract

The main objective of this paper is to consider the government in the macroeconomic aggregates under the Pasinettian framework, as well as to verify how sectoral taxation and sectoral government spending affect the domestic economic growth rate. The first result shows that the balance of payments is not the only channel of growth restriction that countries face, but that public saving also plays an important role in this regard. In addition, it has been shown that the way the government conducts its taxation and its spending across sectors can influence the rate of economic growth in the long term. Finally, a computer simulation were presented to illustrate how much faster a country can develop when it has, in its command, a government whose economic agenda is based on structural change. Several relevant empirical studies can be produced in the future from this model of structural dynamics with general macroeconomic constraint and public sector.

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

Resumo

O objetivo deste trabalho é, principalmente, considerar o governo nos agregados macroeconômicos sob a abordagem Pasinettiana, bem como verificar como a tributação setorial e o gasto governamental setorial afetam a taxa de crescimento econômico doméstica. O primeiro resultado mostra que o balanço de pagamentos não é o único canal de restrição ao crescimento que os países enfrentam, mas que a poupança pública também desempenha um papel importante nesse aspecto. Além disso, mostrou-se que a forma como o governo realiza sua tributação e seus gastos, entre os setores, pode influenciar a taxa de crescimento da economia no longo prazo. Por fim, apresentou-se uma simulação computacional para ilustrar o quão mais rápido um país pode se desenvolver quando possui, em seu comando, um governo cuja agenda econômica se funde na mudança estrutural. Vários estudos empíricos relevantes podem ser produzidos no futuro a partir dessa modelagem de dinâmica estrutural com restrição macroeconômica geral.

Palavras-chave: Mudança Estrutural; Restrição Macroeconômica Geral; Tributos; Gasto do Governo; Crescimento Econômico.

Classificação JEL: E12; F43; O41

1. Introduction

The balance-of-payment-constraint growth models, henceforth BOPC, were initially formalized by Thirlwall (1979). One of the objectives was to provide an alternative theory to the dominant theory [see Solow (1956) and Romer (1990)] for understanding economic growth in developing countries. Briefly, this was because current theories were not able to explain the growth process of underdeveloped countries. This theories were not able to do this because their assumptions did not find support in countries deprived of mechanisms able to improve the labor force.

While the mainstream remained orbiting around the concept of Total Factor Productivity (TFP) to explain the growth phenomenon, Thirlwall's proposal (which considered several elements of the structuralist tradition) was based on other elementary concepts. These concepts are, basically, income elasticity of exports and income elasticity of imports that, from a ratio between them, provide a parameter of sensitivity to the growth of the rest of the world in explaining domestic growth.

In this wake, to achieve higher growth rates, a country should promote an increase in income elasticity of exports or a reduction in the income elasticity of imports or both simultaneously. To achieve this, the country should, instead of increasing the productivity of its factors of production, produce and begin to export products with greater income elasticity of exports, and stop producing and begin to import products with lower income elasticity of imports. In other words, it means that the country must realize the structural change. In this sense, it migrates from a quantitative view, represented by the mainstream framework, where it was understood that in order to grow, it was enough to produce more with the same amount of resources, for a more qualitative view, represented by the BOPC agenda, where understands the phenomenon of growth from the structural change.

Departing from a structural change approach, this article aims to incorporate the government in Pasinettian model, with focus on how public sector affects economic growth. In this sense, this article, as well as the work of Araujo and Teixeira (2004), which opened an economy of this model, seeks to incorporate new elements into structural change framework to make this theory more robust and compatible with reality.

2. The macroeconomic-constrained growth approach

The balance-of-payments-constraint growth approach has contributed to a better understanding about long-term economic experiences of several countries, especially underdevelopment ones. According to this theory, a country's economic growth rate cannot be recurrently distinct from that which makes the balance of payments stable and equal to zero over time.

This theory, originally proposed by Thirlwall (1979), was generalized in various dimensions. We can mention, among others, the incorporation of capital flows [Thirlwall and Hussain (1982)], the possibility of external debt [McCombie and Thirlwall (1997) and Moreno-Brid (1998-99)], the interest payments [Moreno-Bridd (2003)], the sectoral disaggregation [Araujo and Lima (2007)], the commercial disaggregation [Nell (2003)] and, more recently, the conjunction of sectoral disaggregation with the commercial disaggregation [Araujo, Paiva, Santos and Silva (2017)].

In this paper, we depart from a multi-sectoral framework of this theory, known as multi-sectoral Thirlwall's Law in literature, derived by Araujo and Lima (2007). These authors, starting from the multi-sectoral Pasinetti's model of sectoral changes (1981), showed that the income elasticities of demand for exports and imports should be considered as weighted averages of sectoral elasticities, being the weight given by the participation of the various commodities in the export and import structures. his result allowed the opening of a new agenda of empirical researches, Now focused on showing a better fit and forecast of the multi-sectoral version in relation to the aggregate version [see Gouvea and Lima (2009) and Romero and McCombie (2016)].

From a theoretical point of view, other important developments followed the breakdown of the original version, Araujo (2012), for example, showed that even considering a validity of the Purchasing Power Parity between two currencies, as rather prolonged variations of the nominal exchange taxonomy has removed the average income elasticity of exports and imports of the variations produced in the weight of each sector in export and import tariffs. In this case, an explicit channel through a nominal foreign exchange taxon can affect a growth rate of the economy.

3. An Extended version of Pasinetti's model of structural change

As presented by Araujo and Teixeira (2004), the structural economic dynamics is quite a useful framework to make analysis about the uneven development in a North-South set up. In their paper, they have extended Pasinetti's analysis to the case of an open economy, which allows the study of the effects of the international economic relations on the dynamic pattern of production, technological progress and evolution of preferences.

As showed by Araujo and Lima (2007), the structural change was not incorporated in the proper way into demand-oriented theories of economic growth. According to them, 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, in such paper, the authors did not include the government in their analysis, reaching interesting results but that can be enhanced if considers the government's presence.

In this paper, it is employed a version of that model with the presence of government and without capital goods to carry on a 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:

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

where $i=1,...,n-1$ denotes the sectors of final goods of this economy, a_{in} denotes the domestic demand coefficient for commodity *i* produced domestically, $a_{i\hat{n}}$ stand for the demand coefficients of final commodity *i*, and g_{in} denotes the domestic government

demand coefficient for commodity *i*. The production coefficients of consumption goods are given by a_{ni}. The family sector in country *A* is denoted by $\hat{n}$ and the size of population in both countries is related to each other by the coefficient of proportionality ξ.

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

$$\sum_{i=1}^{n-1}\left(a_{in}+a_{\hat{i}n}+h_{in}\right)a_{ni}=1 \tag{2}$$

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

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

$$\sum_{i=1}^{n-1}h_{in}a_{ni}=\sum_{i=1}^{n-1}g_{in}a_{ni} \tag{3}$$

Note that by expression (3), the total public income must be equal to total public spending. This will guarantee the intertemporal public budget constraint consistency, avoiding us to deal with public debts and potential Ponzi behavior.

In equilibrium between full national income and full disposition of national income, we have:

$$\sum_{i=1}^{n-1}\left(a_{in}+\xi a_{i\hat{n}}+g_{in}\right)a_{ni}=\sum_{i=1}^{n-1}\left(a_{in}+a_{\hat{i}n}+h_{in}\right)a_{ni} \tag{4}$$

We can rewrite equation (4) as follow:

$$\sum_{i=1}^{n-1}\left(\xi a_{i\hat{n}}-a_{\hat{i}n}\right)a_{ni}+\sum_{i=1}^{n-1}\left(g_{in}-h_{in}\right)a_{ni}=0 \tag{5}$$

Eq. (5) is largely 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.

Eq. (5) is actually the first important result of this extended Pasinettian model. This equilibrium condition, in terms of sectors, shows that the commercial balance finances the public deficit and vice versa. It means that, in equilibrium, a negative

foreign savings implies surplus in public accounts. Differently of the model presented by Araujo and Lima (2007), note that there is no balance-of-payment constraint anymore, necessarily. Furthermore, the balance-of-payment constraint is a particular case of our general macroeconomic constraint. In this way, a public-sector presence can weaken the external constraint. On the other hand, the public sector can direct foreign trade if it does not have a balanced budget. In this respect, if the government were to incur a government deficit, then there would be a positive external saving to satisfy a general condition of macroeconomic equilibrium and, therefore, the country should import more than export. 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. So, exports plus government spending are equal to imports plus imports for each sector. Therefore,

$$\xi a_{i\hat{n}} + g_{in} = a_{\hat{i}n} + h_{in} \quad \forall i = 1...., n-1. \tag{6}$$

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

The work of Pasinetti (1981) and later Araujo and Teixeira (2004) showed that goods for which productivity differences are less than ten times must have a lower price in U than in A. Thus, even when the average productivity of Country A is higher than in country U, for sectors where U productivity is higher than its average productivity, it has a comparative advantage in the production of these commodities.

Likewise, goods for which differences in productivity are greater than tenfold must have a lower price in *A* than in *U*. In this way, if international trade is allowed for, goods will be transacted between the two countries. People in country A will buy goods of the first type in U, where they are cheaper, and people in U would buy goods of the second type in A. Country *U* would be induced to specialize, and then export, the first type of commodity, while country A would be induced to specialize, and then export,

the second type of commodity. Indeed, these results concerning patterns of specialization in the two countries provide an important economic reason for the per capita export and import demand functions that are adopted in the next section. Thus, as Pasinetti (1981, 1993), we can describe the domestic price fluctuations in terms of changes in productivity as following:

$$p_i = a_{ni} w^U \quad \forall i = 1,...,n-1 \tag{7}$$

The equation (7) shows that the price of i-th good is given by the domestic unitary labor requirement times the wage rate. And the foreign price fluctuations as following:

$$p_{\hat{i}} = a_{n\hat{i}} w^A \quad \forall i = 1,...,n-1 \tag{8}$$

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

$$a_{ni} = \frac{X_{ni}}{X_i} \quad \forall i = 1,...,n-1 \tag{9}$$

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

Now, we should define X_i for all *n-1* sectors. Following Pasinetti (1981, 1993), we can describe the production of i-th sector as:

$$X_i = \left(a_{in} + \xi a_{i\hat{n}} + g_{in}\right) X_n \quad \forall i = 1,...,n-1 \tag{10}$$

Equations (8) and (9) will be very important to understand the government mechanism of structural change. By substituting equation (10) into equation (9) we obtain:

$$a_{ni} = \frac{X_{ni}}{\left(a_{in} + \xi a_{i\hat{n}} + g_{in}\right) X_n} \quad \forall i = 1,...,n-1 \tag{11}$$

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

$$\dot{a}_{ni} = -\left(\xi \dot{a}_{i\hat{n}} + \dot{g}_{in}\right) \frac{a_{ni}}{X_i} \quad \forall i = 1,...,n-1 \tag{12}$$

By equation (12) we can note that exports and government spending can improve the sectoral productivity and, as we'll see, it can be used to become some sectors internationally competitive through the fall price effect.

4. Macroeconomic constraint growth analysis in a Pasinettian framework

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

$$x_{i\hat{n}} = \begin{cases} \left(\frac{p_i}{ep_{\hat{i}}}\right)^{\eta_i} Y_A^{\beta_i} & \text{if } p_i < ep_{\hat{i}} \\ 0 & \text{if } p_i \geq ep_{\hat{i}} \end{cases} \tag{13}$$

where $x_{i\hat{n}}$ is foreign demand for commodity *i*, η_i is the price elasticity of demand for 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:

$$a_{i\hat{n}} = \begin{cases} \left(\frac{p_i}{ep_i}\right)^{\eta_i} y_A^{\beta_i} X_{\hat{n}}^{\beta_i - 1} & \text{if } ap_i < ep_{\hat{i}} \\ 0 & \text{if } p_i \geq ep_{\hat{i}} \end{cases} \tag{14}$$

Suppose that $p_i > ep_{\hat{i}}$ and consider that the import demand coefficients are given by a standard import demand function, which have the following functional form:

$$x_{\hat{i}n} = \begin{cases} \left(\frac{ep_{\hat{i}}}{p_i}\right)^{\psi_i} Y_U^{\varphi_i} & \text{if } p_i > ep_{\hat{i}} \\ 0 & \text{if } p_i \leq ep_{\hat{i}} \end{cases} \tag{15}$$

where ψ_i is the price elasticity of demand for imports of commodity *i*, with $\psi_i > 0$, and 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*:

$$a_{\hat{i}n} = \begin{cases} \left(\dfrac{ep_i^A}{p_i^U} \right)^{\psi_i} y_U^{\varphi_i} X_n^{\varphi_i - 1} & \text{if } p_i > ep_{\hat{i}} \\ 0 & \text{if } p_i \leq ep_{\hat{i}} \end{cases} \tag{16}$$

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

$$G_{in} = \begin{cases} \left(\dfrac{p_i}{ep_{\hat{i}}} \right)^{\chi_i} H_U^{\kappa_i} & \text{if } p_i > ep_{\hat{i}} \\ 0 & \text{if } p_i \leq ep_{\hat{i}} \end{cases} \tag{17}$$

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 can spend a non-negative value if this sector is not competitive. Basically, the government here conceived 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 elasticities 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*:

$$g_{in} = \begin{cases} \left(\dfrac{p_i}{ep_{\hat{i}}} \right)^{\chi_i} h_U^{\kappa_i} X_n^{\kappa_i - 1} & \text{if } p_i > ep_{\hat{i}} \\ 0 & \text{if } p_i \leq ep_{\hat{i}} \end{cases} \tag{18}$$

Now, we define the sectoral tax that will finance the government expenditure, which be describe by the equation:

$$H_{in} = \begin{cases} 0 & \text{if } p_i > ep_{\hat{i}} \\ H_U^{\tau_i} & \text{if } p_i \leq ep_{\hat{i}} \end{cases} \tag{19}$$

where τ_i is the income elasticity of government tax.

Equation (19) shows that the government, to finance the sectors that are not yet competitive but it's high-income elasticity of exports, taxes non-negatively the sectors that are competitive. Like public expenditures, taxation focuses on the competitive sectors, but with lower income elasticity of exports, that is, the income elasticity of taxes is inversely proportional to the income elasticity of exports. The government's equations of decision (17) and (19) state the logic to which the government is conceived in this model: government draws resources from the sectors of lower income elasticities of exports among the competitive ones and passes on to the non-competitive sectors of greater income elasticities of exports.

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

$$h_{in} = \begin{cases} h_U^{\tau_i} X_n^{\tau_i - 1} & \text{if } p_i > ep_{\hat{i}} \\ 0 & \text{if } p_i \leq ep_{\hat{i}} \end{cases} \tag{20}$$

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

$$\frac{\dot{a}_{i\hat{n}}}{a_{i\hat{n}}} = \begin{cases} \eta_i \left(\sigma_i^U - \sigma_i^A - \varepsilon \right) + \beta_i \sigma_y^A + (\beta_i - 1)\, \hat{g} & \text{if } p_i \geq ep_{\hat{i}} \\ 0 & \text{if } p_i < ep_{\hat{i}} \end{cases} \tag{21}$$

By adopting the same procedure with respect to expression (16) and by defining $\frac{\dot{y}_U}{y_U} = \sigma_y^U$ and $\frac{\dot{X}_n}{X_n} = g$, we obtain the following growth rate of per capita import demand coefficient for commodity *i*:

$$\frac{\dot{a}_{\hat{i}n}}{a_{\hat{i}n}} = \begin{cases} \psi_i \left(\sigma_i^A + \varepsilon - \sigma_i^U \right) + \varphi_i \sigma_y^U + (\varphi_i - 1) g & \text{if } ep_{\hat{i}} > p_i \\ 0 & \text{if } ep_{\hat{i}} \leq p_i \end{cases} \tag{22}$$

Applying the same procedure with respect to expression (18) and by 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*:

$$\frac{\dot{g}_{in}}{g_{in}} = \begin{cases} \chi_i\left(\sigma_i^U - \sigma_i^A - \varepsilon\right) + \kappa_i\sigma_h^U + (\kappa_i - 1)g & \text{if } p_i > ep_{\hat{i}} \\ 0 & \text{if } p_i \le ep_{\hat{i}} \end{cases} \tag{23}$$

By adopting the same procedure with respect to expression (20), we obtain the growth rate of per capita public funds collect coefficient for commodity *i*:

$$\frac{\dot{h}_{in}}{h_{in}} = \begin{cases} \tau_i\sigma_h^U + (\tau_i - 1)g & \text{if } a_{ni} > ea_{n\hat{i}} \\ 0 & \text{if } a_{ni} \le ea_{n\hat{i}} \end{cases} \tag{24}$$

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

$$\dot{a}_{i\hat{n}} = a_{i\hat{n}}\beta_i\sigma_y^A \tag{25}$$

$$\dot{a}_{\hat{i}n} = a_{\hat{i}n}\varphi_i\sigma_y^U \tag{26}$$

$$\dot{g}_{in} = g_{in}\kappa_i\sigma_h^U \tag{27}$$

$$\dot{h}_{in} = h_{in}\tau_i\sigma_h^U \tag{28}$$

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

$$\sum_{i=1}^{n-1}\left(\xi\dot{a}_{i\hat{n}} - \dot{a}_{\hat{i}n}\right)a_{ni} + \sum_{i=1}^{n-1}\left(\dot{g}_{in} - \dot{h}_{in}\right)a_{ni} + \sum_{i=1}^{n-1}\left(\xi a_{i\hat{n}} - a_{\hat{i}n}\right)\dot{a}_{ni} + \sum_{i=1}^{n-1}\left(g_{in} - h_{in}\right)\dot{a}_{ni} = 0 \tag{29}$$

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

$$\sigma_y^U = \frac{\sum_{i=1}^{n-1} \xi a_{ni} a_{i\hat{n}} \beta_i}{\sum_{i=1}^{n-1} a_{ni} \left(a_{\hat{i}n} \varphi_i + h_{in} \tau_i - g_{in} \kappa_i \right)} \sigma_y^A \tag{30}$$

Actually, equation (31) is the second important result of this paper. It shows the relationship between the growth rate of per capita income in countries *U* and *A*, as well as the way that such relationship can be influenced by economic policies. A major implication of equation (30) is therefore that changes in the composition of government taxes and its expenditure reflects on the structure of production. Therefore, it matters significantly in the process of economic growth. It is not difficult to see that, in most cases, is easier to improve the national per capita growth rate by changes in government expenditure than share of specific sector on trade agenda. It happens because is less difficult to make an internal political decision than to gain market with hard external competition.

In this sense, the expenditures of an efficient government should be directed according to the ratio of income elasticities of exports and imports. Thus, to stimulate the growth rate, the government should follow the following rules: i) to tax the sectors according to an increasing order of the ratio of income elasticities of exports over imports and; ii) to expend in sectors according to a decreasing order of the ratio of income elasticities of exports over imports. If this is done, the government would drain resources from the more backward sectors that contribute least to domestic growth (sectors of low income elasticities ratio) and transfer them to the more modern sectors e that could contribute more to the growth (sectors of high income elasticities ratio).

Therefore, the efficient sectors, but with a low ratio of income elasticities, would lose competitiveness and give way to less efficient sectors, but a high ratio of income elasticities. In practice, it is as if the government transfers resources from the primary sector (from lower ratio of income elasticities) to the industrial or services sector (the higher the ratio of income elasticities).

5. Numerical simulation

The model of this article has a characteristic that hinders an econometric analysis[1]. Because of this, we prefer to use a numerical and stochastic simulation to evaluate the possible growth paths of the model. Following the Pasinettian approach, this model covers the dynamic of structural changes.

The government aims to change the productive structure through the dynamics of sectoral public spending and sectoral taxation. It starts from the premise that when the government increases the spending in a specific sector, this sector starts to have economies of scale and thus it can produce at a lower cost. Moreover, since the analytical framework we are using considers the goods in their physical quantities, public spending can be understood as a real increase in the supply of goods and taxation, in turn, as a real reduction in the supply of goods. Thus, when the government taxes any sector *i*, it reduces the real supply of the *i*-th good to a given demand, raising the price of that good. On the other hand, when this resource is destined for any other sector *j*, there is an expansion of the supply of the *j*-th sector and, therefore, for a given demand, its price reduction. Consequently, if the government taxes and spends the same amount on the same sector, there will be no change in the actual supply of that good, and therefore no price changes will occur. Therefore, producing goods at lower cost, these can be traded in the international market, according to the import and export equations previously presented. Note that income elasticities are structural parameters. It will be these parameters that will make the government change its spending behavior. A simple example can be given through a high-tech good. This good, in general, has high income elasticity[2], but if the country does not have the domestic price lower than the international price, it cannot be exported. The only way for this sector become competitive is through falling prices. In this model, this is achieved by increasing productivity through sector spending.

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

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

The simulation was done as follows: we generated randomly 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 are initially importers and exporters. In a second moment, we created the government reaction function, which is summarized in equation (31) and (32). Government selected the Z, with $Z < N$, import sectors where there was a larger ratio of income elasticities and Z export sectors with the lower ratios. In this way, the government taxed the sectors of lower ratio (that already export) and expended in the sectors with greater ratio (that doesn't export).

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

We did not put budgetary constraints on the government, so that it has full chance to intervene in the Z sectors. After that, we evaluated the growth trajectories obtained in the presence of the government and in the absence of it. Table 1 shows the structure of the model and the parameters of the simulated routine. Notice that the shares generated in this economy have the same weight for each sector, $\frac{1}{(n-1)}$[5].

$$g_{in}k_i = \begin{cases} g_{in}k_i > 0 \; if \; \dfrac{\beta_i}{\phi_i} > Top\ Z\ \text{Sectors and } ep_{\hat{i}} < p_i \\ 0 \; if \; \dfrac{\beta_i}{\phi_i} < Top\ Z\ \text{Sectors or } ep_{\hat{i}} > p_i \end{cases} \tag{31}$$

$$h_{in}\tau_i = \begin{cases} h_{in}\tau_i > 0 \; if \; \dfrac{\beta_i}{\phi_i} < Inf\ Z\ \text{Sectors and } ep_{\hat{i}} > p_i \\ 0 \; if \; \dfrac{\beta_i}{\phi_i} > Inf\ Z\ \text{Sectors or } ep_{\hat{i}} < p_i \end{cases} \tag{32}$$

[3] The structural elasticities were first extracted from the tables of Gouvêa and Lima (2010) and analyzed the ranges of maximum and minimum values. From these data, a function of random numbers with uniform distribution was used to simulate similar new data.

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

[5] Respecting the original structure of the Pasinetti models, share is the sector over the total sectors of the economy and not just over the exporting or importing sectors.

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

Table 1: Numerical simulation of sectors with Government.

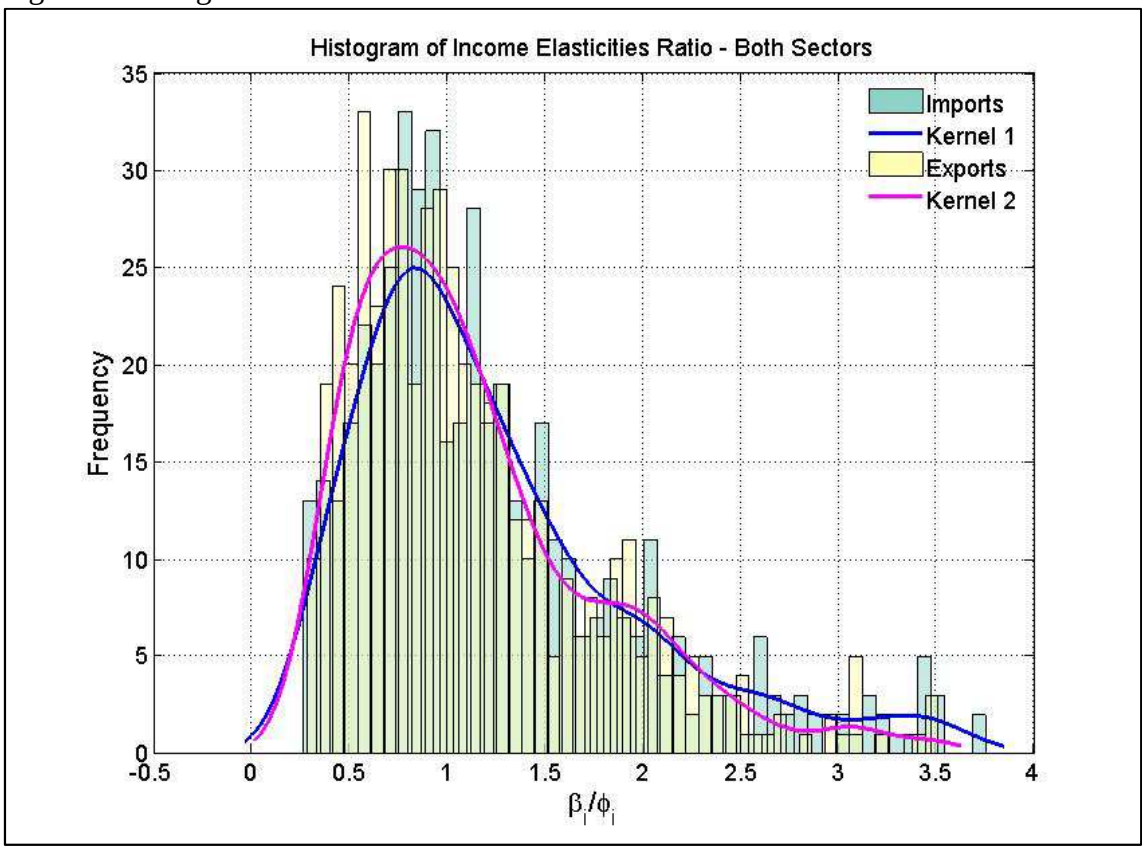
Sectors	*Exports*		*Imports*		β_i/ϕ_i	$p_i < e.p_{\hat{i}}$
	Share	β_i	Share	ϕ_i		
1	*1/(n-1)*	[1; 3]	*1/(n-1)*	[1; 3]	β_1/ϕ_1	1
2	"	"	"	"	"	"
3	"	"	"	"	"	"
...	"	"	"	"	"	"
Z	"	"	"	"	"	1
...	...	...	...	...	...	...
n-1	*1/(n-1)*	[1; 3]	*1/(n-1)*	[1; 3]	β_{n-1}/ϕ_{n-1}	0 v 1

Source: Elaborated by the authors.

After performing the simulation, we separate the data to analyze the general behavior of the model. To do this, we separate the import and export sectors and plot the histogram of the distribution of the ratio of the elasticities generated to a simulation.

Figure 1 presents two histograms of the elasticities ratio for the sectors that are initially importers and exporters. In yellow we have the histogram of the export sectors and in green the histogram of the import sectors. For both data sets a non-parametric probability density function (PDF) was estimated (Kernel line in legend). What is observed initially is that the distributions are almost identical so that this economy should have in the final equation of the MTSL the multiplier effect near one.

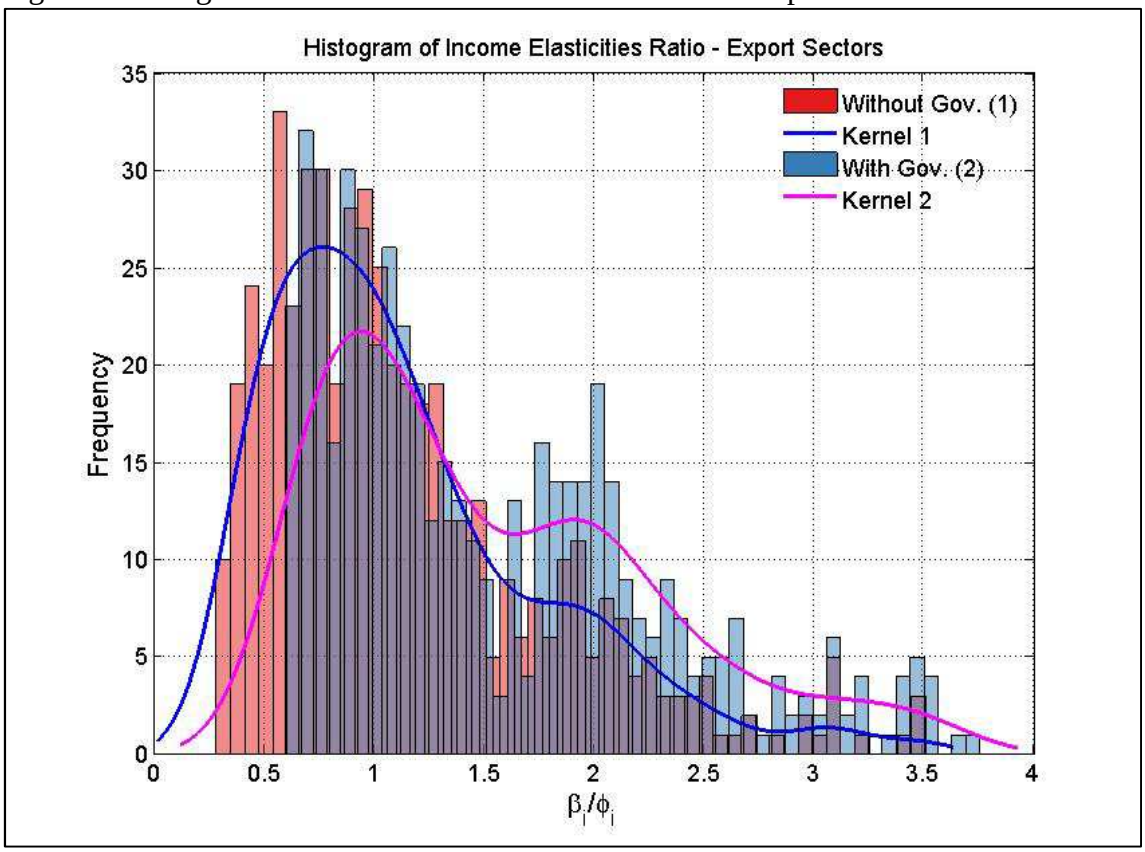
Figure 1: Histogram of the Income Elasticities Ratio from both Sectors.



Source: Elaborated by the authors.

Figure 2 shows the export sectors in the absence of government and in its presence. As stated previously, in the presence of the government, the current taxpayer passes the sectors of lower ratio of income elasticities that export and starts to spend in sectors of greater ratio of income elasticities. This promotes structural change so that sectors that did not export and export, and sectors that were exporting stopped exporting and start importing. In the simulation carried out in this article, we arbitrarily define that the government would change in 10% of the total sectors. Thus, its intervention is to tax the 10% of the worst exporters and spend on the top 10% of importers (in terms of income elasticity ratio).

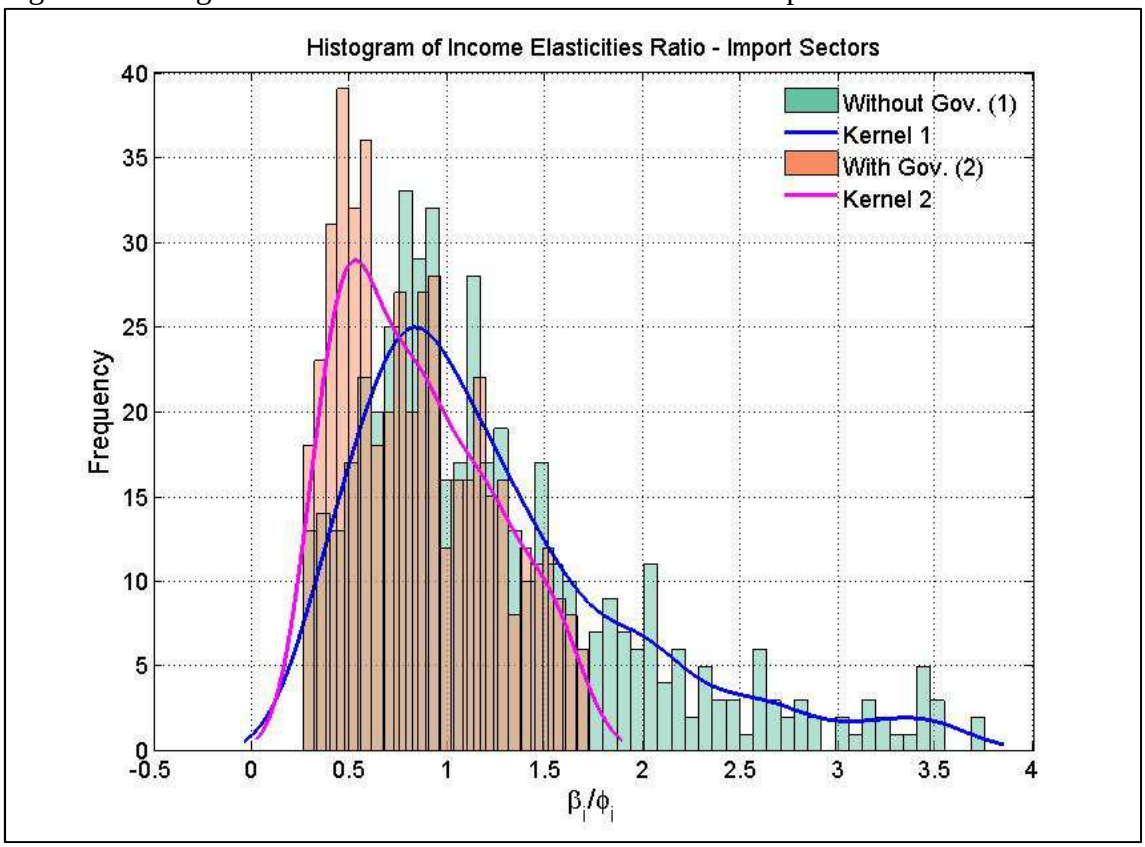
Figure 2: Histogram of the Income Elasticities Ratio from Export Sectors.



Source: Elaborated by the authors.

This change led to a structural change in the export sectors that changed the distribution of data. We now have a PDF shifted to the right which indicates an average increase in the ratio of the income elasticities that make up the exporting sectors. In figure 2 we have in red the histogram of the export sectors in the absence of the government, in blue the histogram of the export sectors in the presence of the government and in purple the overlap of the two cases. The blue kernel line is the non-parametric PDF estimated in the absence of government and the magenta is the PDF in the presence of government. The graphical analysis allows us to confirm this shift.

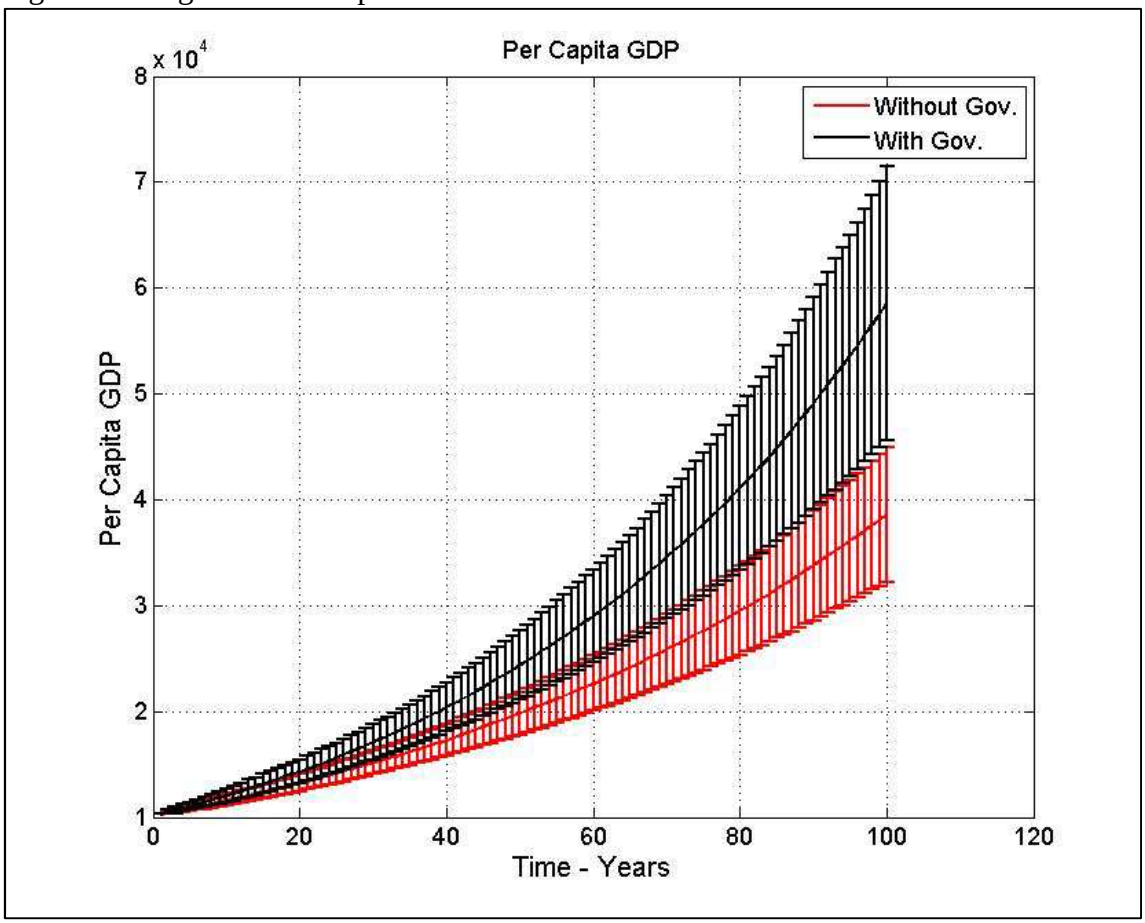
Figure 3: Histogram of the Income Elasticities Ratio from Import Sectors.



Source: Elaborated by the authors.

Figure 3 shows the histogram of the import sectors in the presence of the government and in its absence. What we can notice is that with the action of the public intervention, there is a displacement of the PDF to the left when compared with the one originally obtained in the economy without government. Thus, by identifying the shift to the right of the PDF of exports and to the left of the PDF of imports, we must that the presence of the government will lead the long-term growth to a trajectory of growth higher than originally obtained for MSTL. For this affirmation, it is necessary to simulate numerically the net impact that will be in the denominator of the presence of expenses and taxation.

Figure 4: Long-term Per Capita GDP Growth.



Source: Elaborated by the authors.

In order to investigate all the possible trajectories for GDP per capita in the long run, we performed exhaustive simulations (10,000), calculated the standard deviations and the average behaviors.

To calculate each GDP per capita path, we used the following equation:

$$Y_{L_T} = Y_{L_1}\left[\prod_{t=1}^{T}(1+g_t)-1\right] \tag{33}$$

were Y_{L_T} is the per capita GDP at the end of the period, Y_{L_1} is the per capita GDP at initial time, g_t is the growth rate of income 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 mean 1.3376% and standard deviation of 1.3225% (the values was taken from the historical average obtained in the WDI database - 1960 to 2013).

Figure 4 presents these trajectories. We have in the black figure the average behavior of GDP per capita and its error bars that show the confidence interval obtained

with the simulation in the presence of government. In red we have the same average behavior and error bars in the absence of the government. In all the simulations generated, the presence of the government generated more robust growth rates impacting the economy's long-term trajectory. This result also shows that, numerically, government intervention allows higher growth rates for a given degree of intervention (in the simulations, 10% of the total sectors of the economy).

Although not presented, it was 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 the accumulated growth in the presence of the government compared to the growth of the economy without government.

6. Conclusion

The objective of this work was, mainly, to consider the government in the macroeconomic aggregates under the Pasinettian approach, as well as to verify how the sectoral taxation and the governmental sectoral expenditure affect the domestic economic growth rate. In addition, the aim was to show that the growth constraint that the economies in general are facing is not limited to the external sector, but the restriction from the public budget should be considered. In this sense, it has been shown that the public budget and the balance of payments together offer constraints to the process of economic growth. The conclusion of this work showed that the per capita income growth rate is directly proportional to the growth rate of exports, such proportionality being inversely (directly) related to sectoral income elasticities of imports (exports). Elasticities are 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 what it spends in each sector.

In addition, it has been noted that taxation and public spending can influence the rate of economic growth. In this sense, based on the knowledge of the ratio of sectoral income elasticities, it is possible for the government to choose the best way to tax and spend among sectors, with the aim of speeding up the development process. Finally, several relevant empirical results can be produced from this modeling, both in municipal and federal government applications.

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