Jorge M. Oviedo* and Ivan F. Julio**

*Instituto de Economía y Finanzas – Facultad de Ciencias Económicas - Universidad Nacional de Córdoba. Address: Bv. Enrique Barros s/n - Ciudad Universitaria X5000HRV Córdoba, Argentina – Email: jorgemoviedo@eco.uncor.edu

** Corresponding Author. Department of Administrative Sciences, Metropolitan College, BOSTON UNIVERSITY – Address: 1010 Commonwealth Av. Room 428, Boston, MA, 02215 – Email: julio@bu.edu

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Asymmetric effect of Argentina's fiscal deficit on the real exchange rate

Abstract

It is well documented that fiscal deficits generate deterioration in real exchange rates. However, the composition of the fiscal deficit, whether generated by an increase in expenditure or a tax reduction, may generate asymmetric effects. In this article, the differential impact on the real exchange rate, generated by an increase in public consumption expenditure, public investment and tax reduction, is analyzed and quantified. To this end, we develop a dynamic stochastic general equilibrium model (DSGE) with government and external sector, which we calibrate and simulate for Argentina. We find that the fiscal deficit originated in tax reduction can improve the real exchange rate, whereas the one generated by any increase in expenditure deteriorates it. Furthermore, the deterioration in the real exchange rate is greater when public expenditure is destined to public consumption than when it is used for public investment. Quantifying these different effects on the exchange rate within a dynamic stochastic general equilibrium framework is an important exercise of political economy for highly dollarized emerging economies that exhibit higher inflation pass-through.

Key Words: General Equilibrium, Public Spending, Tax Reduction, Real Exchange Rate

Classification JEL: E32; E61; H62

1. Introduction

The real exchange rate (*RER*) is a key variable for production decisions and for the microeconomic structure of emerging economies. In Argentina, its erratic behavior during the last 45 years is reflected in its chronic difficulty to follow a balanced growth path and the lack of incentives to generate enough investments to increase the competitiveness and productivity of its economy. The Argentine economy has been characterized in the last decades for incurring in strong processes of exchange rate overvaluation[1], unleashing substantive collapses on the value of its domestic currency and abrupt depressions in the economic activity, with its consequent effects on poverty and inequality. In this sense, knowing the determinants of the real exchange rate and the way in which each of these factors influence the real exchange rate is of vital importance for the Argentine economy. This is a key macroeconomic variable that affects the behavior of relevant nominal and real variables, including price stability, the balance of payments, output and employment levels and the economic growth rate. In this regard, the real exchange rate can have a decisive influence on strategic economic policy objectives.

In general, the theory establishes that the main fundamentals of the exchange rate are linked to the productivity of the tradable and non-tradable sectors, the terms of trade, the interest payments on the external debt, and public expenditure. For example, Balassa (1964), Devarajan et al (1991), Baldi and Mulder (2004), MacDonald and Ricci (2002), Calderon (2002) and Obstfeld and Rogoff (2004), affirm that the real exchange rate depends negatively on the productivity of the tradable goods sector, but positively on the productivity of the non-tradable sector, factor endowment and debt service.

The Balassa-Samuelson model (BS) was the first model that related sectorial productivity shocks to movements in the real exchange rate. In the BS framework, productivity in the tradable sector, given factor price equalization, determines the price of nontradables. This covers the well-known theory of the internal equilibrium of the determination of the real exchange rate. Calderon (2002) found evidence for the BS effects in Argentina; while Baldi and Mulder (2004) have found similar results for Argentina, Chile, Brazil and Mexico.

Another variable that the literature broadly recognizes as an important determinant of the exchange rate is government spending (Baldi and Mulder 2004, p.23-36). Government expending influences the real exchange rate through the effect of taking away resources from the private sector. Public spending increases the demand for tradable and non-tradable goods. In small economies, the additional demand for non-tradable goods cannot be satisfied at current non-tradable prices, so these prices would increase to clear the market. Following Carrera and Restout (2008, p.5), an increase in public spending exerts an upward pressure on the relative price of non-tradable goods and therefore reduces the value of the real exchange rate. The resulting appreciation reassigns resources and restructures the country's economy. However, not much attention has been paid to analyze the effects of other variables such as spending on public investment or various distorting taxes on the real exchange rate in emerging economies such as Argentina.

The objective of this article is to analyze the effects on the real exchange rate generated by various exogenous shocks to its determinants such as productivity of the exportable, importable and non-tradable sectors, interest rates on the external debt, the term of trade, public consumption, public investment, and tax rates imposed on employment, capital, exports and imports.

To this end, we build a Dynamic Stochastic General Equilibrium Model (DSGE) of flexible prices applied to a small open economy with a government sector subject to various productivity, fiscal, international interest rate and terms of trade shocks. Because of the agents' intertemporal optimizing behavior, equilibrium prices will be endogenously determined. A prominent role will be given to the price of tradable and non-tradable goods to construct the real exchange rate. The model is then parameterized and simulated to analyze the impacts on the equilibrium real exchange rate in the face of various exogenous shocks through impulse response functions.

The rest of the paper is organized as follows: Section 2 provides different definitions of real exchange rates, and explain in details which one is the most suitable for developing economies. Section 3 develops in detail the DSGE model. Section 4 analyze the results of the impulse response functions on the real exchange rate to draw conclusions in Section 5.

2. Real Exchange Rate Definitions

Real exchange rates (RER) are at the center of many heated discussions on economic policy. It is common to refer to the bilateral real exchange rate between two currencies (the multilateral one is an average of the bilateral ones) as the ratio between the product of the bilateral nominal exchange rate (E) and a price index that reflects the purchasing power of the foreign currency (P^*) and a price index that reflects the purchasing power of the domestic currency (P^d). In symbols,

$$RER = \frac{E \cdot P^*}{P^d}$$

Price indices P^d and P^* are typically consumer price indices, but a real exchange rate series can be constructed using other indices. To understand the determination of the real exchange rate, economists have found it useful to express the real exchange rate in terms of the relative price between domestic (or non-tradable) goods and tradable goods (or internationally tradable goods). The latter are those that are exported and imported such as manufactured products, raw materials, and agricultural products.; and the former are goods whose prices are not equalized across countries because, for various reasons, such as transportation costs and governmental trade restrictions, trading them across borders is economically inviable. Classical example of non-tradables are primarily services and the output of the construction industry.

So to understand the real exchange rate we have to understand the concept of this relative price that marks both the allocation of resources in the economy and their influence on economic policies. Hence, we define and explore below different definitions of real exchange rate and choose the one that is usually the most appropriate for the study of developing economies.

Different concepts of real exchange rate (*RER*)

The real exchange rate (*RER*) is traditionally defined as the nominal exchange rate adjusted for changes in external and domestic prices. However, this is just one of the possible definitions. Therefore, the real exchange rate is a relative price that can be measured in different ways:

- the purchasing power parity of the real exchange rate (PPP using purchasing power parity),

- the quotient between the wholesaler and the consumer price indexes as an approximation of the relatively tradable and non-tradable relative price, and,
- the relationship between the tradable and non-tradable price indices.

The Purchasing Power Parity (PPP) is a relative price that measures the value of national goods in terms of foreign goods, calculated as the quotient between the foreign and domestic good price indices, adjusted by the nominal exchange rate. The multilateral exchange rate is a real PPP exchange rate that reduces the entire external price index in an aggregate price index weighted by the trade quotas of the country analyzed with its main trading partners that could be consumer price indexes or wholesale. Formally:

$$PPP = \frac{NER \cdot P^*}{P^d}$$

where PPP is the real exchange rate, NER is the nominal exchange rate, P^* is an external price index, P^d the domestic prices. The real PPP exchange rate is also known as the external real exchange rate because it compares the relative price of a basket of goods produced (or consumed) in different countries (Hinkle and Nsengiyumva, 1999). If the level of domestic prices rises faster than the level of external prices, then the real price of the national currency rises (a real appreciation) and the domestic country's competitiveness falls (Pentecost, 1993, p.5).

The structural real exchange rate is measured as the quotient between wholesale and consumer price indices. Formally:

$$RER = \frac{NER \cdot PM}{P_c}$$

where RER is the real exchange rate, NER is the nominal exchange rate, PM the wholesale prices and P_c the consumer prices. Wholesale and consumer prices are usually measured by indexes. Bastourre, Carrera and Ibarlucia (2008) argue that the relationship between the wholesale price and the consumer price serves as a practical indicator of the structure of relative prices in an economy.

On the other hand, Edwards (1988) and Monacelli and Perotti (2010) present a similar decomposition of the equation, which implies that the real exchange rate depends on the relative price ratio of tradable and non-tradable goods. This exchange rate is called the structural real exchange rate and can be expressed as:

$$RER = \frac{PT}{PNT}$$

where RER is the real exchange rate, PT is the price of tradable goods, and PNT is the price of non-tradable goods.

The structural exchange rate and the real PPP exchange rate move in line when the law of one price is maintained and the foreign structural real exchange rate is constant. However, when the PPP does not work, the value of the real structural exchange rate is more useful than the value of the PPP, as is usually the case in developing economies.

The study of the relative price of non-tradable goods in the case of a small economy whose shocks do not affect the relative price of non-tradable goods in other countries is extremely important. For reason, we focus on this formulation. In other words for the small country, the *RER* is a decreasing function of the price of domestic goods in terms of tradable goods, that is to say, of the price of domestic goods in terms of soybeans for example.

In the case of small country, the local demand and supply do not influence the international price of the goods it trades: excess supply is exported and excess demand is imported at the international price. Therefore, we conclude that to understand the determination of the *RER* we have to understand the determination of the price of domestic goods. When these are cheap in dollars, the *RER* is depreciated and the economy gains competitiveness. When domestic goods are expensive in dollars we now say that the *RER* is appreciated and that economy loses competitiveness. In both cases, we can infer the impacts that will eventually occur on the economy.

3. The Model Economy

3.1 Overview

In this section, we introduce the theoretical framework used to model the Argentine economy, and then proceed to parameterize it. A basic dynamic stochastic general equilibrium (DSGE) model for small open economy with government sector subject to productivity, fiscal, international interest rate and terms of trade shocks is used. The present model fits within the real business cycle literature with perfectly competitive markets and flexible prices (Kydland and Zarazaga, 1997, 2002, and Kydland and Prescott 1982).

3.1. The Household's Problem

The model economy is populated by a representative household with infinite life that derives utility from consumption and disutility from offering his labor services in various productive sectors. It is assumed that the functional specification of the instantaneous utility of each period, u_t, is a function of a quasilinear compound $\mathcal{X}$ between consumption $\mathcal{C}$ and effort $\mathcal{E}$ in each of the sectors. This quasi-linear specification responds to that used by Greenwood, Hercowitz, and Huffman (1988), commonly called preferences of the GHH type, which were widely popularized in the literature of real business cycles for open economies after the work of Mendoza (1991)[2].

$$u = f\big(\mathcal{C} - G(\mathcal{E})\big) \tag{1}$$

A specification for f of the type of constant elasticity of intertemporal substitution in $\mathcal{X}$ will be adopted, which is widely used in DSGE models is as follows:

$$f = \frac{\mathcal{X}^{1-\sigma}-1}{1-\sigma} \tag{2}$$

Following the specification used by Baxter and King (1993), the consumption compound includes private consumption, C_t, of a single final good that is produced in this economy and of the total level of public consumption determined by the government[3], g_t. The weighting of the consumption of the public good in the utility function, π, depends on the subjective valuation of the individual between private consumption

C_t, and public consumption, g_t. If $\pi = 1$, then private consumption and public consumption are perfect substitutes. If instead $\pi = 0$, then the consumption of public good does not affect the utility of the individual. In this way, since it is a variable not determined by the household, but by the government, an increase in the consumption of public good affects the marginal utility of consumption[4]. Formally:

$$\mathcal{C} = C_t + \pi g_t. \tag{3}$$

Regarding the disutility of the effort, this is derived from the offer of labor services to the market producing non-tradable goods, l_t^n, to the producing sector of exportable goods, l_t^x, and to the producing sector of importable goods, l_t^m. The functional specification of G that will be used will be the one used by Greenwood, Hercowitz, and Huffman (op.cit.). Formally:

$$G = \frac{(l_t^n)^{\gamma_n}}{\gamma_n} + \frac{(l_t^x)^{\gamma_x}}{\gamma_x} + \frac{(l_t^m)^{\gamma_m}}{\gamma_m} \tag{4}$$

where the parameters $\gamma_i, (i = n, x, m)$ are parameters associated with elasticity of the sector labor supply to their respective salaries[5].

The utility function of the representative agent with infinite life, $\mathcal{U}(\cdot)$, is assumed to be additively separable in his arguments and responds[6] to the following formulation:

$$\mathcal{U} = E_0 \sum_{t=0}^{\infty} \beta^t \frac{1}{1-\sigma} \left[\left(C_t + \pi g_t - \frac{(l_t^n)^{\gamma_n}}{\gamma_n} - \frac{(l_t^x)^{\gamma_x}}{\gamma_x} - \frac{(l_t^m)^{\gamma_m}}{\gamma_m} \right)^{1-\sigma} - 1 \right] \tag{5}$$

where $0 < \beta < 1$ is the subjective intertemporal discount factor and E_0 is the operator of conditional expectations to all the information available at time 0.

Families own productive factors such as labor l_t^i and capital k_t^i at each instant t and in each of the sectors i defined above. These factors are rented to companies that produce the non-tradable goods n, the exportable good x and importable good m. Thus, $(l_t^n, k_t^n), (l_t^x, k_t^x)$ and (l_t^m, k_t^m) represent the supply of labor and capital services allocated to the non-tradable sector, the exportable sector and the importable sector respectively. In exchange for these services, the household receives the retributions w_t^i and s_t^i, for $i = x, m, n$ respectively.

On the other hand, the government obtains part of its income by means of a proportional tax rate to the wage income, τ_t, and from tax to the capital income, τ_t^k so that only $(1 - \tau_t)$ and $(1 - \tau_t^k)$ are available to the household to cope with their expenses at time t. On the other hand, the household receives a lump sum transfer from the Government for the amount T_t.

Finally, the household can borrow from the rest of the world B_t denominated in units of the tradable good at an international interest rate of r_t from the period t to $t+1$. Here, we assume that B_t is the final amount, including the interest of the debt to be repaid in period t. Thus, the income in t from debt collection in the period will be $\frac{B_{t+1}}{1+r_t}$. The price of the tradable good in which the debt is denominated will be denoted by P_t^T. In short, we can write the income received by the representative agent as follows:

$$(1 - \tau_t)(w_t^n l_t^n + w_t^x l_t^x + w_t^m l_t^m) + (1 - \tau_t^k)(s_t^n k_t^n + s_t^x k_t^x + s_t^m k_t^m) + T_t + P_t^\tau \frac{B_{t+1}^P}{1+r_t} \qquad (6)$$

We suppose that there is a single final good Y_t which can be used for private consumption C_t, pubic consumption g_t or destined to investment in physical capital i_t^j in the productive sectors $j = n, x, m$. When investing in each sector, the household faces capital adjustments costs, $\phi(k_{t+1}^j - k_t^j)$, represented by the following function:

$$\phi(k_{t+1}^j - k_t^j) = \frac{\emptyset_j}{2}\left(k_{t+1}^j - k_t^j\right)^2, \qquad j = n, x, m \qquad (7)$$

where $\emptyset_j$ is a parameter that measures the magnitude of the convex costs in each sector $j = n, x, m$. This specification fits into the family of quadratic costs of capital adjustment widely used in the literature (see for example Mendoza (1991) and Schmitt Grohé, 1998 among many others). The capital adjustment costs penalize the magnitude of the investment at an increasing rate and vanish when the stock of capital is at the steady state level.

The income obtained in (6) is used to pay consumer goods C_t, investment goods i_t^j together with their respective capital adjustment costs in the sectors $j = n, x, m$ and to repay the capital and interest of the stock of accumulated debt from the previous period $p_t^{\tau} B_t^P$. Thus, the representative household budget restriction is given by:

$$C_t + \sum_j \left(i_t^j + \frac{\emptyset_j}{2} \left(k_{t+1}^j - k_t^j\right)^2 \right) + p_t^{\tau} B_t^P = (1 - \tau_t)(w_t^n l_t^n + w_t^x l_t^x + w_t^m l_t^m)$$

$$+\left(1 - \tau_t^k\right)(s_t^n k_t^n + s_t^x k_t^x + s_t^m k_t^m) + T_t + p_t^{\tau} \frac{B_{t+1}^P}{1+r_t}, \; j = n, x, m. \tag{8}$$

On the other hand, the sectoral capital stock evolves according to the following equation:

$$k_{t+1}^j = i_t^j + (1 - \delta) k_t^j, \qquad j = n, x, m, \tag{9}$$

where δ is the rate of depreciation of capital and i_t^j is the gross private investment of the period in the productive sector j.

In order to avoid consumer behaviors such as Ponzi scheme, it is assumed that they are subject to the following sequence of debt restrictions:

$$\lim_{j \to \infty} \frac{B_{t+j}^P}{(1+r)^j} \leq 0 \qquad t = 1, \dots, \infty. \tag{10}$$

This boundary condition affirms that the expectations of growth of the debt position of households must be lower than the interest rate r in the long term.

In this way, the problem of the agent consists of choosing the amount of consumption of final good C_t, the level of effort l_t^j, the level of investment in private sector capital i_t^j and the debt stock of B_t, in order to maximize its utility U subject to budget constraint (8), (9) and the no-Ponzi scheme condition given by (10). Thus, the representative household problem can be written as:

$$\max_{\left\{C_t, l_t^j, i_t^j, d_t^P\right\}_{t=0}^{\infty}} \mathcal{U} = E_0 \sum_{t=0}^{\infty} \beta^t \frac{1}{1-\sigma} \left[\left(C_t + \pi g_t - \frac{(l_t^n)^{\gamma_n}}{\gamma_n} - \frac{(l_t^x)^{\gamma_x}}{\gamma_x} - \frac{(l_t^m)^{\gamma_m}}{\gamma_m} \right)^{1-\sigma} - 1 \right], s.t. \tag{11}$$

$$C_t + \sum_j \left(i_t^j + \frac{\emptyset_j}{2} \left(k_{t+1}^j - k_t^j\right)^2 - (1 - \tau_t) w_t^j l_t^j + \left(1 - \tau_t^k\right) s_t^j k_t^j \right) = T_t + p_t^{\tau} \frac{B_{t+1}^P}{1+r_t} - p_t^{\tau} B_t^P$$

$$k_{t+1}^{j} = i_t^{j} + (1-\ \delta)k_t^{j}, \qquad t = 1, \dots \infty$$

$$\lim_{j\to\infty} \frac{B_{t+j}^{P}}{(1+r)^{j}} \leq 0 \qquad j = n, x, m;\ t = 1, \dots \infty$$

Like in any dynamic general equilibrium model for a small open economy, we face the problem that the agents' intertemporal solutions are non-stationary given that the parameters of the model can assume any arbitrary value. Consequently, this leads to agent's indebtedness or indefinitely grant loans according to the values of the parameters even without violating the transversality or the non-Ponzi schemes conditions giving rise to a non-stationary model. In order to avoid this type of situations and guarantee stationarity, following Schmitt-Grohé and Uribe (2003), we will close the open economy model in the following way. The international interest rate for this is considered elastic with respect to the accumulated stock of debt of the country and is following the structure given by:

$$r_t = \ r_t^{*} +\ \theta \left(e^{(B_t - \bar{B})} - 1\right),$$

where r_t^{*} is the international risk-free interest rate and $\theta\left(e^{(B_t - \bar{B})} - 1\right)$ is the risk premium of the country, which assumes a growing debt function.

Defining the Lagrange multipliers for each time period by λ_t, the Lagrangean of the problem is given by:

$$\max_{\left\{C_t, l_t^{j}, k_t^{j}, B_t^{P}\right\}_{t=0}^{\infty}} \mathcal{L} = E_0 \sum_{t=0}^{\infty} \beta^{t}\ \frac{1}{1-\ \sigma}\left[\left(C_t + \pi g_t - \frac{(l_t^{n})^{\gamma_n}}{\gamma_n} - \frac{(l_t^{x})^{\gamma_x}}{\gamma_x} - \frac{(l_t^{m})^{\gamma_m}}{\gamma_m}\right)^{1-\ \sigma} - 1\right]$$

$$-\lambda_t B^{t}\left\{C_t + \sum_{j=x,m,n}\left[k_{t+1}^{j} - (1-\ \delta)k_t^{j} + \frac{\emptyset_j}{2}\left(k_{t+1}^{j} -\ k_t^{j}\right)^{2} - (1-\ \tau_t)w_t^{j} l_t^{j} + \left(1-\ \tau_t^{k}\right)s_t^{j} k_t^{j}\right] - T_t \right.$$

$$\left. - P_t^{T}\frac{B_t^{P}+1}{1+\ r_t} - P_t^{T} B_t^{P}\right\}$$

In every period t, the consumer chooses the value of C_t, l_t^{j}, K_{t+1}, and B_{t+1}.Therefore, the optimality conditions are:

$$\beta^t \left(C_t + \pi g_t - \frac{(l_t^n)^{y_n}}{y_n} - \frac{(l_t^x)^{y_x}}{y_x} - \frac{(l_t^m)^{y_m}}{y_m} \right)^{-\sigma} = \lambda_t \tag{11.1}$$

$$-\beta^t \left(l_t^j\right)^{Y_j - 1} \left(C_t + \pi g_t - \frac{(l_t^n)^{y_n}}{y_n} - \frac{(l_t^x)^{y_x}}{y_x} - \frac{(l_t^m)^{y_m}}{y_m} \right)^{-\sigma} = w_t^j (1 - \tau_t) \lambda_t, \ j = n, x, m \tag{11.2}$$

$$E_t \lambda_{t+1} \beta \left((1 - \delta) + \left(1 - \tau_t^k\right) s_{t+1} + \phi_j \left(k_{t+2}^j - k_{t+1}^j\right) \right) = \lambda_t \left(1 + \phi_j \left(k_{t+1}^j - k_t^j\right) \right), j = n, x, m \tag{11.3}$$

$$\frac{\beta(1 + r_t)}{p_t^\tau} E_t \lambda_{t+1} p_{t+1}^\tau = \lambda_t \tag{11.4}$$

The dynamic lagrange multiplier λ_t in equation (11.1) should be interpreted as the marginal utility of wealth, i.e. λ_t is the increase in utility as a result of having an extra unit of wealth. In this sense, expression (11.1) displays that the household is at her optimum in relation to her consumption when the marginal utility of consumption of an extra unit of c is exactly equal to the usefulness of an additional unit of wealth. Similarly, equation (11.2) shows that the consumer is at his best in relation to the amount of time he is willing to work, when the marginal disutility of providing an extra unit of work l^j is exactly equal to the marginal utility that generates the increase in wealth, net of taxes, by allocating one more unit of labor in sector j. Expression (11.3) states that the optimal level of k is such that the marginal utility of consumption currently being sacrificed by the household at time t is exactly equal to the expected value of the marginal profit of the higher income that will come from the investment in k, discounted and net of taxes, depreciation and the effects of adjustment costs. Finally, expression (11.4) shows that taking an extra unit of debt at t increases the current income. The marginal utility derived from that higher current income is measured by λ_t. In the future, that debt plus its interest $(1 + r_{t+1})$ should be repaid, resulting in loss of utility measured by $\lambda_{t+1}(1 + r_{t+1})$. The latter value is discounted and corrected by the price variation of the tradable good and must be equalized in expected value with the greatest current utility for optimal debt taking.

Working with these first order conditions, we derive the tradeoff between current and future consumption as:

$$u_{C_t} = \frac{\beta E_t u_{C_{t+1}}\left(1+\left(1-\tau_t^k\right)s_{t+1}-\delta+\phi_j\left(k_{t+2}^j-k_{t+1}^j\right)\right)}{1+\phi_j\left(k_{t+1}^j-k_t^j\right)} \tag{11.5}$$

where $u_{C_t} = \left(C_t + \pi g_t - \frac{(l_t^n)^{y_n}}{y_n} - \frac{(l_t^x)^{y_x}}{y_x} - \frac{(l_t^m)^{y_m}}{y_m}\right)^{-\sigma}$ for all t, is the marginal utility of consumption to simplify notation. Equation (11.5) states that sacrificing a unit of consumption at t in order to invest and obtain greater wealth in the following period, $t+1$, has a cost in terms of utility measured by u_{C_t}. That unit of consumption is invested in sector j to produce in $t+1$ a return net of depreciation and taxes equal to $1+\left(1-\tau_t^k\right)s_{t+1}-\delta$, which multiplied by $u_{C_{t+1}}$, and taking into account capital adjustment costs, generates expected marginal utility from the extra units of future consumption obtained by the new investment. At best, the trade-off between current and future consumption implies that these marginal utilities must be balanced as indicated by equation (11.5).

Similarly, from the first order conditions, we can analyze the tradeoff between current labor hours and future leisure:

$$\frac{u_{l_t^j}}{(1-\tau_t)w_t^j} = \beta E_t\left[\frac{u_{l_{t+1}}\left(1+\left(1-\tau_t^k\right)s_{t+1}-\delta+\phi_j\left(k_{t+1}^j-k_t^j\right)\right)}{\phi_j\left(k_{t+2}^j-k_{t+1}^j\right)(1-\tau_t)w_{t+1}^j}\right], \quad j=n,x,m \tag{11.6}$$

where $u_{l_t^j} = \left(l_t^j\right)^{Y_{j-1}}\left(C_t + \pi g_t - \frac{(l_t^n)^{y_n}}{y_n} - \frac{(l_t^x)^{y_x}}{y_x} - \frac{(l_t^m)^{y_m}}{y_m}\right)^{-\sigma}, \quad j=n,x,m$ is the marginal utility of labor (leisure) to simplify notation. Supplying one extra unit of work in period t generates income by the value of $(1-\tau_t)w_t$, which may eventually be invested, obtaining in $t+1$ a compensation net of taxes and depreciation equal to $\left(1+(1-\tau_t)s_{t+1}^j-\delta\right)w_{t+1}^j$. This net remuneration minus capital adjustment costs should be equal to the value of offering a unit of work today. At the optimum, the consumer adjusts their decisions between present and future working hours so that the marginal rate of substitution between working today and working tomorrow is equal to the relative net income.

Another important relationship derived from the first order conditions states that the agent must select the optimal amount of consumption and labor in the sector in such a way that the marginal rate of substitution between leisure and consumption is equal to the after tax salary of the sector as expressed by equation (11.7) below.

$$-\left(l_t^j\right)^{y_j-1} = (1-\tau_t)w_t^j, \quad j = n, x, m \tag{11.7}$$

Finally, equation (11.8) below shows that the expected marginal utility derived from the return on investing k^j in sector j net of depreciation, adjustment cost, and taxes must be exactly equal to the marginal utility of the return in external assets.

$$\frac{E_t u_{C_{t+1}}\left(1+(1-tau_t^k)s_{t+1}^j-\delta+\phi_j\left(k_{t+2}^j-k_{t+1}^j\right)\right)}{1+\phi_j\left(k_{t+1}^j-k_t^j\right)} = \frac{\beta(1+r_t)}{P_t^\tau} E_t \lambda_{t+1} P_{t+1}^\tau, \quad j = n, x, m \tag{11.8}$$

Moreover, and as a corollary to the relationship above, it follows that the discounted net returns of all sectors must be equalized and equal to the return of the external assets.

3.2. The Government Sector

In this model, following the formulation of Baxter and King (1993), we consider the existence of a government sector that obtains resources through the application of distorting taxes to the household's income, by means of an aliquot τ_t to salary income and τ_t^k to capital income, as described in the previous section. Likewise, the government obtains income through the application of aliquots to foreign trade, with τ_t^x applied to exports X_t and τ_t^m applied to imports M_t. We also assume that the government has access to international capital markets in case it needs to finance its public deficit. For this we assume that it can take loans from the rest of the world at an international interest rate of r_t increasing the stock of Public Debt B_t^g measured in units of tradable good.

The resources thus obtained are used by the government in public consumption g_t, in public investment i_t^g, in net transfers to families for the amount T_t and to repay the interest of the stock of accumulated debt of the previous period $r_t B_t^g$.

In this way, the government budget constraint is given by:

$$g_t + i_t^g + T_t + P_t^T B_t^g = \tau_t(w_t^n l_t^n + w_t^x l_t^x + w_t^m l_t^m) + \tau_t^k(s_t^n k_t^n + s_t^x k_t^x + s_t^m k_t^m) + \tau_t^x X_t$$

$$+\tau_t^m M_t + P_t^T \frac{B_{t+1}^g}{1+r_t}. \tag{12}$$

Throughout this model we will assume that the government plays a passive and exogenous role in the economy in the sense that it will not act by selecting the relevant variables of political decision: g_t, i_t^g, T_t, B_t^g, τ_t, τ_t^k, τ_t^x,and τ_t^m, in order to maximize the welfare of a Social Utility function. These variables are determined arbitrarily and exogenously. This assumption is reasonable when trying to model the Argentine economy since the economic history of this country is characterized by economic policy applications that do not follow any consistent rule over time in order to maximize social welfare or that fits a rule with explicit objectives that can be known by economic agents in the short and long term. In this sense, the option of modeling fiscal policy as exogenous is appropriate. Specifically, the fiscal variables will be characterized by the following stochastic processes described below.

Public spending evolves according to:

$$g_t = (1-\rho_g)\bar{g} + \rho_g\, g_{t-1} + \xi_t^g. \tag{13}$$

The public investment shock is given by:

$$i_t^g = (1-\rho_{ig})\overline{\imath^g} + \rho_{ig} i_{t-1}^g + \xi_t^{ig}. \tag{14}$$

The tax rate shock to salary income is:

$$\tau_t = (1-\rho_\tau)\bar{\tau} + \rho_\tau\, \tau_{t-1} + \xi_t^\tau. \tag{15}$$

The aliquot shock to income by sector is:

$$\tau_t^i = (1-\rho_{\tau_i})\overline{\tau^\imath} + \rho_{\tau_i}\tau_{t-1}^i + \xi_t^{\tau_i},\ i = k, x, m. \tag{16}$$

And the rest of aliquots:

$$T_t = (1-\rho_T)\bar{T} + \rho_T T_{t-1} + \xi_t^{\mathrm{T}}. \tag{17}$$

with:

$$\xi_t^j \sim N(0, \psi_j), \quad j = g, ig, \tau, T. \tag{18}$$

The variables denoted by an upper bar represent values of steady state in expected value and the coefficients $|\rho_j| < 1$ for $j = g, ig, \tau_h, T$ refer to the persistence parameters of the shocks which are assumed to be stationary.

In turn, these policy decisions must be consistent with their budget constraint (19) below so the stock of debt is adjusted to be consistent with it, that is:

$$P_t^T \frac{B_{t+1}^g}{1+r_t} = g_t + i_t^g + T_t + P_t^T B_t^g - \tau_t (w_t^n l_t^n + w_t^x l_t^x + w_t^m l_t^m) - \tau_t^k (s_t^n k_t^n + s_t^x k_t^x + s_t^m k_t^m)$$

$$-\tau_t^x X_t - \tau_t^m M_t. \tag{19}$$

In order to prevent the stock of public debt from growing indefinitely and uncontrolled, the condition of steady state fiscal balanced is added. So:

$$\bar{T} = \bar{g} + \bar{\iota}^{g} + \bar{\tau}(w^n l^n + w^x l^x + w^m l^m) - \overline{\tau^k}(s^n k^n + s^x k^x + s^m k^m). \tag{20}$$

Where each of the variables represent values in steady state. Consequently, the Government presents a balanced budget in terms of expected value in the long term, leaving public debt issuance as a transitory phenomenon to cope with short-term parameter shocks.

3.3. The Firm's Problem

The productive scheme of this economy is described by means of a system of nested production functions, as will be explained below. There are five types of firms. Firms that produce a single final good Y, which use as inputs tradable goods Y^τ and non-tradable goods Y^n; firms that produce non-tradable goods using productive factors l^n and k^n, owned by households, and the stock of public capital k^g; firms that produce a tradable good using importable goods a^m and exportable goods a^x as inputs; firms that produce importable good, Y^m and firms producing the exportable good Y^x. These last two carry out their production using labor and capital factors that families contribute to public capital.

Note that the production of the exportable good Y^x can be used as an input in the production of tradable goods, a^x, and the rest is destined to the rest of the world as exports. Similarly, the demand for inputs of importable good by the companies producing tradable good, a^m, is supplied with the production of importable good Y^m and with purchases to the rest of the world as imports.

3.3.1. The final-goods sector

There is a single representative firm that produces a single final good Y_t for which it uses non-tradable goods a_t^n and a compound of tradable goods a_t^t as intermediate inputs. The final good Y_t is used by households for their own consumption C_t or sectoral investment i_t^j and by the government public consumption g_t or public investment i_t^g. The production function that describes the technology of the sector is one of constant replacement elasticity type with constant returns to scale and is formulated as follows:

$$Y_t = \left(\chi(a_t^n)^{1-\frac{1}{\mu}} + (1-\chi)(a_t^\tau)^{1-\frac{1}{\mu}}\right)^{\frac{1}{1-\frac{1}{\mu}}}. \tag{21}$$

Where χ is the parameter of participation of the non-tradable good and μ the elasticity of substitution. The firm sells its product at a normalized price of one and pays p_t^n for each unit of non-tradable good that it uses in its production process and p_t^t for each unit of the tradable good. In this manner, the firm faces the following optimization problem:

$$\max_{a_t^n, a_t^t} BT = \left(\chi(a_t^n)^{1-\frac{1}{\mu}} + (1-\chi)(a_t^\tau)^{1-\frac{1}{\mu}}\right)^{\frac{1}{1-\frac{1}{\mu}}} - p_t^n a_t^n - p_t^t a_t^t \tag{22}$$

The optimality conditions for this problem are:

$$P_t^n = \chi\left(\chi(a_t^n)^{1-\frac{1}{\mu}} + (1-\chi)(a_t^\tau)^{1-\frac{1}{\mu}}\right)^{\frac{\frac{1}{\mu}}{1-\frac{1}{\mu}}} (a_t^n)^{-\frac{1}{\mu}} \tag{22.1}$$

$$P_t^\tau = (1-\chi)\left(\chi(a_t^n)^{1-\frac{1}{\mu}} + (1-\chi)(a_t^\tau)^{1-\frac{1}{\mu}}\right)^{\frac{\frac{1}{\mu}}{1-\frac{1}{\mu}}} (a_t^n)^{-\frac{1}{\mu}} \tag{22.2}$$

3.3.2. The non-tradable-goods sector

In the non-tradable goods sector, there is a single, perfectly competitive representative firm in all the markets in which Y_t^n produces. For this purpose, it hires N_t^n workers and rents K_t^n units of capital and is subject to a stochastic technological shock A_t^n. The technology of the non-tradable sector is characterized by a Cobb Douglas function type with constant returns to scale in the private productive factors and is formulated as follows:

$$Y_t^n = A_t^n (N_t^n)^{\alpha_n} (K_t^n)^{1-\alpha_n} \left(K_t^{g}\right)^{\phi}, \tag{23}$$

where K_t^g is the stock of public capital. The company paid w_t^n and s_t^n to the productive factors N_t^n and K_t^n respectively, and sells its product a_t^n at the price p_t^n. Thus, the problem of the company is the following:

$$\max_{N_t^n, K_t^n} BT = p_t^n A_t^n (N_t^n)^{\alpha_n} (K_t^n)^{1-\alpha_n} \left(K_t^{g}\right)^{\phi} - w_t^n N_t^n - s_t^n K_t^n, \tag{24}$$

where p_t^n is the price of the non-tradable good in terms of final good. The optimality conditions for this problem are:

$$w_t^n = P_t^n \alpha_n A_t^n \left(\frac{K_t^n}{N_t^n}\right)^{1-\alpha_n} \left(K_t^g\right)^{\phi} \tag{24.1}$$

$$s_t^n = P_t^n (1-\alpha_n) A_t^n \left(\frac{K_t^n}{N_t^n}\right)^{-\alpha_n} \left(K_t^g\right)^{\phi} \tag{24.2}$$

3.3.3. The tradable-goods sector

The compounded tradable good Y_t^τ is produced using exportable and importable goods through the following technology:

$$Y_t^\tau = \left(\chi_\tau \left(a_t^\chi\right)^{1-\frac{1}{\mu_\tau}} + (1-\chi_\tau)(a_t^m)^{1-\frac{1}{\mu_\tau}}\right)^{\frac{1}{1-\frac{1}{\mu_\tau}}}, \tag{25}$$

where a_t^χ y a_t^m represent the internal absorption of exportable goods and importable goods respectively. We assume that the firm behaves in a perfectly competitive manner in the final and intermediate goods markets, being able to sell its product at a price p_t^τ and pay p_t^x for each unit of exportable good and p_t^m for each unit of the importable that is used as inputs. In this way, the firm faces the following optimization problem:

$$\max_{a_t^x, a_t^m} BT = p_t^\tau \left(\chi_\tau \left(a_t^\chi\right)^{1-\frac{1}{\mu_\tau}} + (1-\chi_\tau)(a_t^m)^{1-\frac{1}{\mu_\tau}} \right)^{\frac{1}{1-\frac{1}{\mu_\tau}}} - p_t^x\left(1-\tau_t^\chi\right)a_t^\chi - p_t^m(1+\tau_t^m)a_t^m, \quad (26)$$

The optimality conditions for this problem are:

$$(1-\tau_t^x)P_t^x = P_t^\tau \chi_\tau \left(\chi_\tau \left(a_t^\chi\right)^{1-\frac{1}{\mu_\tau}} + (1-\chi_\tau)(a_t^m)^{1-\frac{1}{\mu_\tau}} \right)^{\frac{\frac{1}{\mu_t}}{1-\frac{1}{\mu_\tau}}} \left(a_t^\chi\right)^{1-\frac{1}{\mu_\tau}} \quad (26.1)$$

$$(1-\tau_t^m)P_t^m = P_t^\tau (1-\chi_\tau) \left(\chi_\tau \left(a_t^\chi\right)^{1-\frac{1}{\mu_\tau}} + (1-\chi_\tau)(a_t^m)^{1-\frac{1}{\mu_\tau}} \right)^{\frac{\frac{1}{\mu_t}}{1-\frac{1}{\mu_\tau}}} (a_t^m)^{1-\frac{1}{\mu_\tau}} \quad (26.2)$$

The exportable-goods sector:

In the exportable sector there is a single representative firm that is perfectly competitive in all the markets where Y_t^m participates. To do so, it hires N_t^m workers and K_t^m units of capital and is subject to a stochastic technological shock A_t^m. The production function that describes the technology of the exportable sector is of the Cobb Douglas type with constant returns to scale in private factors and is formulated as follows:

$$Y_t^x = A_t^x (N_t^x)^{a_x} (K_t^x)^{1-a_x} \left(K_t^g\right)^\phi, \quad (27)$$

The company compensates labor N_t^m and capital K_t^m with w_t^x and s_t^x respectively and sells its product a_t^m at the after-tax price of $\left(1-\tau_t^\chi\right)\rho_t^m$. Thus, the problem of the company is the following:

$$\max_{N_t^x, K_t^X} BT = \left(1-\tau_t^\chi\right)\rho_t^X A_t^X (N_t^x)^{a_x} (K_t^x)^{1-a_x} \left(K_t^g\right)^\phi - w_t^x N_t^x - s_t^x K_t^x, \quad (28)$$

where ρ_t^X is the price of the exportable good in terms of the final good. The optimality conditions for this problem are:

$$w_t^x = (1-\tau_t^x)\rho_t^x \alpha_x A_t^x \left(\frac{K_t^x}{N_t^x}\right)^{1-a_x} \left(K_t^g\right)^\phi \quad (28.1)$$

$$s_t^x = (1-\tau_t^x)\rho_t^x(1-\alpha_x)A_t^x\left(\frac{K_t^X}{N_t^X}\right)^{-a_x}\left(K_t^g\right)^{\phi} \tag{28.2}$$

The importable-good sector

There is a single perfectly competitive representative firm in the importable sector that produces Y_t^m. To do so, it contracts N_t^m workers and K_t^m units of capital and is subject to a stochastic technological shock A_t^m. The production function that describes the technology of the importable sector is of the Cobb Douglas type with constant returns to scale in private factors and is formulated as follows:

$$Y_t^m = A_t^m(N_t^m)^{a_m}(K_t^m)^{1-a_m}\left(K_t^{\mathrm{g}}\right)^{\phi}, \tag{29}$$

The company compensates the productive factors N_t^m and K_t^m with the values w_t^m and s_t^m respectively per unit of factor and sells its product a_t^m to the price $(1-\tau_t^m)\rho_t^m$ after the deductions tax. Thus, the problem of the company is the following:

$$\max_{N_t^m, K_t^m} BT = (1-\tau_t^m)\rho_t^m A_t^m(N_t^m)^{a_m}(K_t^m)^{1-a_m}\left(K_t^{\mathrm{g}}\right)^{\phi} - w_t^m N_t^m - s_t^m K_t^m, \tag{30}$$

where ρ_t^m is the price of the importable good in terms of the final good. The optimality conditions for this problem are:

$$w_t^m = (1-\tau_t^m)\rho_t^m \alpha_m A_t^m\left(\frac{N_t^m}{K_t^m}\right)^{1-a_m}\left(K_t^g\right)^{\phi} \tag{30.1}$$

$$s_t^m = (1-\tau_t^m)\rho_t^m(1-\alpha_m)A_t^m\left(\frac{K_t^m}{N_t^m}\right)^{-a_m}\left(K_t^g\right)^{\phi} \tag{30.2}$$

External Sector

We define imports M_t as the value of the difference between domestic absorption a_t^m and domestic production of the importable good:

$$M_t = \rho_t^m(a_t^m - Y_t^m), \tag{31}$$

and exports X_t as the value of the difference between the domestic production of the exportable good and the internal absorption of the exportable good a_t^x:

$$X_t = \rho_t^x (Y_t^x - a_t^x). \tag{32}$$

The commercial balance BC_t and the current account CC_t can be defined as:

$$BC_t = X_t - M_t \tag{33}$$

and

$$CC_t = X_t - M_t - r_t \rho_t^\tau \frac{B_t}{1+r_t}, \tag{34}$$

respectively.

3.4. The Shocks to the economy

The stochastic nature of the economy is given by the random shocks that fall on the technology parameters of the non-tradable, exportable and importable sectors, the terms of trade, the international interest rate and the fiscal parameters. Following Neumeyer and Perry (2001) and Uribe (2010), we assume that the shocks follow first order autoregressive stationary processes as described below:

$$A_t^n = (1 - \rho_n)\overline{A^n} + \rho_n A_{t-1}^n + \xi_t^n, \tag{35}$$

$$A_t^x = (1 - \rho_x)\overline{A^x} + \rho_x A_{t-1}^x + \xi_t^x, \tag{36}$$

$$A_t^m = (1 - \rho_m)\overline{A^m} + \rho_m A_{t-1}^m + \xi_t^m, \tag{37}$$

The terms of exchange ρ_t is given by:

$$\rho_t = \frac{\rho_t^x}{\rho_t^m}$$

The shock to the terms of trade is determined by:

$$\rho_t = \left(1 - \rho_p\right)\bar{P} + \rho_p \rho_{t-1} + \xi_t^P, \tag{38}$$

On the other hand, the shock that affects the international interest rate is defined by:

$$r_t^* = (1-\rho_r)\bar{r} + \rho_r r_{t-1}^* + \xi_t^r, \tag{39}$$

where

$$\xi_t^j \sim N(0, \Psi_j), \quad j = n, x, m, r, p, g, ig, \tau, \tau^k, \tau^x, \tau^m, T. \tag{40}$$

Regarding the fiscal parameters, the shocks to public consumption, g_t, public investment, i_t^g and aliquot τ_t follow the definitions given in (13) to (17), respectively.

The variables denoted by an upper bar represent values of steady state in expected value and the coefficients $|\rho_J| < 1$ for all $j = n, x, m, r, p, g, ig, \tau, \tau^k, \tau^x, \tau^m, T$ refer to the persistence parameters of the shocks which were assume stationary.

3.5. The Equilibrium

The competitive general equilibrium for this economy is the following set of decision functions; $\{C_t, l_t^n, l_t^x, l_t^m, i_t^n, i_t^x, i_t^m, k_t^n, k_t^x, k_t^m, B_t^p\}$ for the representative agent, $\{Y_t, a_t^\tau, a_t^x\}$ for the firm producing the final good, $\{Y_t^n, N_t^n, K_t^n\}$ for the firm producing the non-tradable good, $\{Y_t^\tau, a_t^x, a_t^m\}$ for the firm producing the tradable good, $\{Y_t^x, N_t^x, K_t^x\}$ for the firm producing the exportable good, $\{Y_t^m, N_t^m, K_t^m\}$ for the firm producing the importable good and a set of functions $\{P_t^n, P_t^\tau, P_t^x, P_t^m, w_t^n, w_t^x, w_t^m, s_t^n, s_t^x, s_t^m\}$ describing the evolution of prices such that:

1. The household's decision functions are optimal given the factor prices' functions, the law of movement for capital stock, the fiscal parameters and the international interest rate.
2. The firm's decision-making functions are optimal given the product and inputs' price functions, the relative price of the exportable goods in terms of internationally determined imports and the fiscal parameters.
3. The markets for all goods (except imported goods, exported goods and foreign assets) and all factors are cleared in each market in each period.

4. The expectations are rational, that's to say: $k_{t+1}^{j} = (1 - \delta)k_{t}^{j} + i_{t}^{j}, \quad j = n, x, m.$

In addition to the optimality conditions for the families, the firms, the government's budget constraint and the random shocks, we impose a set of market clearing conditions detailed below.

The production of final good Y_t must be equal to the demand for private consumption C_t, plus the demand for private investment i_t^j with their respective capital adjustment costs $\frac{\phi}{2}\left(k_{t+1}^{j} - k_{t}^{j}\right)$ in each of the sectors $j = n, x, m$, plus public investment i_t^{g} and government spending g_t:

$$Y_t = C_t + \sum_j \left[i_t^j + \frac{\emptyset}{2}\left(k_{t+1}^{j} - k_{t}^{j}\right)^2\right] + i_t^{g} + g_t, \;\; j = n, x, m. \tag{41}$$

The total labor supply by the family to sector j must be equal to the demand for labor in sector j:

$$l_t^j = N_t^j, \qquad j = n, x, m, \tag{42}$$

The total stock of capital held by the families in each sector must be equal to the sectoral demand for capital by the non-tradable sector, K_t^n, the exportable sector, K_t^x, and the importable sector, K_t^m.

$$K_t^j = K_t^j, \qquad j = n, x, m. \tag{43}$$

The demand for inputs generated by the firms that produce the final good a_t^n must be equal to the production of nontradable good Y_t^n

$$Y_t^n = a_t^n. \tag{44}$$

The demand for inputs generated by the firms that produce the final good a_t^τ must be equal to the production of tradable good Y_t^τ

$$Y_t^\tau = a_t^\tau. \tag{45}$$

Regarding the markets for the exportable and importable goods, equilibrium conditions are not established because, by definition, the imbalances in them will generate exports and imports respectively.

The gross domestic product Y^* is equal to the value of the total production of the final good Y minus the value of the imports M used to manufacture it, plus the value of the goods that were produced locally but not used in the production of the final good, i.e. the value of the exports X. Since the production functions of all sectors are homogeneous of degree one, the value of the production is also equal to the remuneration to the productive factors. Formally:

$$Y_t^* = Y_t + X_t - M_t = w_t^n l_t^n + s_t^n k_t^n + w_t^x l_t^x + s_t^x k_t^x + w_t^m l_t^m + s_t^m k_t^m. \qquad (46)$$

Relationship between Current Account and External Debt Accumulation

Defining the total debt of the economy as $B_t = B_t^p + B_t^{\mathrm{g}}$ and combining the household's budget constraint (8) and the government's budget constraint (19) we have:

$$C_t + \sum_j \left[i_t^j + \frac{\emptyset}{2}\left(k_{t+1}^j - k_t^j\right)^2 \right] + i_t^{\mathrm{g}} + \mathrm{g}_t + P_t^\tau B_t^{\mathrm{p}} = w_t^n l_t^n + s_t^n k_t^n + w_t^x l_t^x + s_t^x k_t^x + w_t^m l_t^m + s_t^m k_t^m$$

$$+ s_t^m k_t^m + P_t^\tau \frac{B_{t+1}^P}{1+r_t} \qquad (47)$$

Using the definitions of exports (32) and imports (31), plus the definition of gross domestic product next to condition (41), the expression (47) above can be written as:

$$M_t - X_t + P_t^\tau B_t^{\mathrm{p}} = P_t^\tau \frac{B_{t+1}^P}{1+r_t}. \qquad (48)$$

Price of Tradable Goods and the Equilibrium Real Exchange Rate

From the conditions of optimality of the firm producing the tradable good and, by clearing a^x from one of them and substituting them in the other, it is possible to clear the equilibrium price of the tradable good, as follows:

$$P_t^t = P_t^x (1-\tau_x) \left[1 + \left(\frac{1-\alpha}{\alpha}\right)^{\mu_\tau} \left(P_\tau \frac{(1-\tau_t^x)}{(1-\tau_t^m)} \right)^{\mu_\tau - 1} \right] \left\{ \alpha \left[1 + \left(\frac{1-\alpha}{\alpha}\right)^{\mu_\tau} \left(P_\tau \frac{(1-\tau_t^x)}{(1-\tau_t^m)} \right)^{\mu_\tau - 1} \right] \right\}^{\frac{1}{1-\mu_\tau}} \qquad (49)$$

This establishes that the price of the tradable good in terms of the final good is a function of the terms of trade P_t, the tariffs to the external sector, τ_x and τ_m, and the price of the exportable good in relation to the final good. Note that P_t, τ_x and τ_m are exogenously determined while P_t^x arises endogenously from the conditions of optimality and equilibrium.

On the other hand, the equilibrium real exchange rate can be defined as the quotient between the equilibrium values of the prices of tradable goods and non-tradable goods. Formally:

$$RER_t = \frac{P_t^{\tau}}{P_t^{n}}, \tag{50}$$

where P_t^{τ} depends as indicated previously while P_t^{n} depends on all the parameters of the own economy.

This equation is very useful to find the equilibrium real exchange rate and compare it with the current and past values of it for the Argentine economy. Thus, it is possible to determine whether currency deficit exists, a macroeconomic phenomenon that turns out to be one of the main problems in Argentine economic history.

4. Model Simulation and Evaluation

Due to the analytical complexity of the model, closed-form solutions cannot be obtained, and therefore the dynamics is solved and analyzed numerically. To carry out a quantitative analysis, we must first parameterized the model of the previous section for the Argentine economy. The calibration technique will be used here, which involves assigning values to the parameters of the theoretical model so that it can replicate certain dimensions of the data observed, especially those associated with their long-term evolution. In this sense, as the model is built, it will be abstracted from the growth of the economy; that is, the economic fluctuations of the model variables will occur around a constant level in the long term (steady state).

Once the model has been parameterized, the optimality conditions of the described agents must be resolved. This implies finding the value of the stationary state of the model first and then solving the dynamic stochastic general equilibrium by finding explicit numerical expressions of each one of the decision variables of the agents involved.

The resolution of the model will then allow to carry out the simulation of the model variables and their respective comparison with reality. For this purpose, in the following sections we will continue to analyze the properties of synthetic series such as correlation between variables, volatility and relative volatility.

Additionally, impulse-response and decomposition of variance analysis will be carried out to have a better understanding of how each of the variables react to the occurrence of various shocks. The reaction of the variables will tell us the way in which the agents adapt, maximizing their interests in a consistent way before the realization of the different shocks.

4.1. Parameterization of the Model: Calibration

The parameterization of the model is possible through the process of calibration or econometric estimation. The need to directly calibrate some of the parameters responds to its simplicity and to the identification problems that SDGE models usually present, which make estimation difficult. However, the advantages that methods such as GMM (generalized method of moments), matching with response impulse functions, ML (maximum likelihood) or Bayesian estimation have in relation to calibration are not unknown[7]. Almost always, studies of the economic cycle employ a combination of calibration and econometric estimation.

The parameters related to preferences and investment possibilities were calibrated as detailed below. In some cases, they were selected in a way that coincides with certain first and/or second moments of the variables generated by the model with the moments of reality.

β: The intertemporal discount rate of the utility of consumption was calibrated as $1/(1+\bar{r})$, that is, the reciprocal of one plus the long-term international interest rate.

σ: This parameter, which determines the curvature of the utility function, is set following Uribe (1997) and Reinhart and Vegh (1995).

π: The representative parameter of the degree of complementarity between spending on private and public consumption goods was determined via GMM so that the data observed during the period 1993-2019 are consistent with the optimality conditions of the proposed model.

δ: The depreciation rate was calibrated considering a quarterly value of 3 percent, following the international standards that place this parameter between 10 and 12 percent per year

$\bar{b}$: This parameter was calibrated so that the synthetic series generated by the model reflect a steady state debt/GDP ratio matching the observed value in reality.

The other parameters, $\gamma, \phi_x, \phi_m, \phi_n$ y θ, were calibrated in such a way that the second centered moments of the GDP, consumption, trade balance and total and sectorial investment series were close to the values of reality. The calibrated parameters are summarized in the following table:

[Table 4.1 Here]

Parameters related to Technology:

In order to calibrate the parameters related to the technology, structural characteristics of the Argentine economy are taken into account. Thus, for example, following the estimates of Uribe (1997), who obtains the labor participation in the tradable sector in Argentina of 62 percent and 48 percent for the non-tradable sector, and assuming as Uribe that the size of the importable sector is equal to the exportable sector, the parameters α_x, α_m and α_n were set at 0.48, 0.48 and 0.62 respectively.

Regarding the parameter linked to the elasticity of substitution between traded and nontraded goods, we adopt the estimated value of 0.5, as in Akinci (2011).

On the other hand, there is a broad literature on estimating the elasticity of substitution between exportable and importable goods, μ_τ. One branch of this literature uses data aggregated at a quarterly frequency and estimates μ_τ in a dynamic stochastic general equilibrium model (DSGE) adapted for open economies. This body of work typically estimates this value below the unit. For example, Corsetti, Dedola, and Leduc (2008), Gust, Leduc, and Sheets (2009), and Justinian and Preston (2010), all get an estimate of μ_τ between 0.8 and 0.86. In the same lines, we set a value of 0.8 for this parameter.

Because the trade balance-to-GDP ratio is near 1% and the exports-to-GDP ratio is close to 12% in Argentina, we decided to set values for parameter χ and χ_τ in a way such that the relationships on the simulated data approach those values.

The parameter related to the elasticity of public capital is generally a variable that is difficult to estimate. However, it is common to approximate it by using the average public investment-to-GDP ratio, i^g/Y, as in

Baxter and Kind (opt. cit). The rationale behind this choice is that if public investment as a percentage of GDP is determined in such a way as to maximize the level of consumption in steady state, taking into account the tradeoff between higher investment-production and less resources available for consumption, it should be exactly equal to the elasticity of public capital. In any case, we later perform a sensitivity analysis modifying the value of ϕ.

Finally, the parameters linked to the long-term values of technological changes, A_x, A_m y A_n, are simply scale parameters, thus, without loss of generality, we set them equal to one.

Table 4.2 summarizes the calibrated parameters related to technology.

[Table 4.2 Here]

Parameters linked to Exogenous Shocks:

Regarding the computation of the parameters linked to sectoral technological shocks, we used ordinary least squares regressions applied to sectoral Solow residuals.

Based on the residuals of the regressions, the variance and covariance matrix of the shocks is obtained. The results of these are shown Table 4.3 and Table 4.4 respectively.

[Table 4.3 Here]

[Table 4.4 Here]

Finally, in the parameters of the shocks linked to the values of the same in the long term were calibrated as detailed following:

$\bar{r}$: This value was adjusted for the model to reflect the international interest rate on average loans for Argentina in the period under analysis, 1993-2014.

$\bar{\rho}$: A steady state value equal to 1 was used.

$\bar{g}$: It is calibrated such that the model reflects the average percentage share of public consumption in Argentina's GDP, which accounts for 13% of the GDP.

$\overline{\iota g}$: Similar to the previous one, a value was set in such a way as to represent the average public investment in Argentina during the period under review.

$\bar{\tau}$: Finally, this parameter is calibrate so that the steady state of the model represents the average of the Tax Revenue/GPD ratio during the period under analysis, which is above 27 percent of the GDP. The same for capital and external taxes.

[Table 4.5 Here]

4.2. Computation of the Stationary State, Optimal Policy Functions and Simulation of the Model

The stationary state occurs when the variables are stable over time, i.e. $\psi_t = \psi_{t+1} = \psi$, where ψ_t is each of the variables under analysis treated in the model and ψ its value in steady state. To find the steady state, the system of equations generated by the first order conditions must be solved.

The solution of the model consist in finding the steady state and the policy functions compatible with the previously determined parameterization. It is important to note the importance of obtaining the policy functions since, given certain initial conditions, these will allow to find the optimal trajectories of the variables of the system and, later, to contrast them with the observed data.

For this purpose, recursive numerical methods of dynamic programming must be used, using a Taylor approximation of the second order around the steady state. Matlab Software was used together with the Dynare complement. The solution algorithm can be expressed in recursive terms in the following way:

$$X_{t+1} = f_1(\Theta)X_t + f_2(\Theta)\varepsilon_{t+1}, \tag{51}$$

$$M_{t+1} = f_3(\Theta)X_{t+1}. \tag{52}$$

Where $f_1(\Theta)$ is a vector of stable coefficients generated by the recursive algorithm that depends on the parameters of the model Θ that is, each of the previously calibrated parameters, X_t represents the state variables of the problem $\left(K_t^n, K_t^x, K_t^m, B_t, p_t, r_{t,} A_t^x, A_t^m, A_t^n, \mathrm{g}_t, \tau_t, i\mathrm{g}_t\right)$ and M_t represent the control variables:

$$\begin{pmatrix} C_t, l_t^n, l_t^x, l_t^m, i_t^n, i_t^x, i_t^m, Y_t, a_t^\tau, a_t^n, Y_t^n, N_t^n, K_t^n, Y_t^\tau, a_t^x, a_t^m, \\ Y_t^x, N_t^x, K_t^x, Y_t^m, N_t^m, K_t^m, p_t^n, p_t^\tau, w_t^n, w_t^x, w_t^m, s_t^n, s_t^x, s_t^m \end{pmatrix}$$

In line with what is stated, it is possible to express the control variables through the policy functions as variables dependent on the state variables; which, in turn, are a function of the values that they themselves assume in the immediately preceding period and of the value assumed by contemporary shocks.

Once the model for the Argentine economy has been calibrated, next step is to perform simulations on certain elements of empirical interest of the model and compare their outputs with the data observed in reality[8]. Another type of experiment is to use the calibrated model to predict the trajectory of the main variables before the initial realization of a certain type of shock. In this study, we will use it to analyze the response of the real exchange rate to various shocks.

5. Response of the Real Exchange Rate to various Fiscal Deficit Shocks

After we verified that the proposed parametrized model adequately replicates the main stylized facts of the Argentine economic cycle, we can use it to conduct artificial economic policy experiments and analyze the impact on the macroeconomic variables relevant to the case.

This section will analyze the effects on the exchange rate in the face of various exogenous shocks in the determinants such public consumption, in public investment, in aliquots that burden employment, capital, exports and imports. For this purpose, the impulse response functions of the model linked to the real exchange rate will be used.

Various simulation scenarios will be proposed in which the Fiscal Deficit will increase by one percent in relation to GDP and in all cases the financing will come from loans from the rest of the world.

5.1. Fiscal Deficit Generated by Increase in Public Expenditure: The Public Consumption vs Public Investment Case

Figure 5.1 shows the percentage effect on the real exchange rate in the face of a one percent increase in the fiscal deficit generated by an increase in public consumption spending. In the same, it is deduced that an increase of 1% in this type of deficit produces a fall of 11% in the real exchange rate. Then throughout the 12 periods or three years the effects vanish by 80 percent in relation to its initial magnitude.

[Figure 5.1 Here]

On the other hand, in Figure 5.2, the percentage effects on the real exchange rate can be seen in the face of an increase in the Fiscal Deficit of one percent due to increases in public investment. Unlike the previous case, the initial impact of the shock generates a fall in the real exchange rate of only 2.5%, that is, less than a quarter of the magnitude of the impact of public consumption. This is so, since although an increase in public investment detracts resources from the rest of the sectors generating upward pressures in prices of non-tradable goods that deteriorate the real exchange rate, the resulting increase in the stock of public capital positively impacts in the production of all sectors, partially offsetting the initial rise in non-tradable prices. Consequently, the harmful effects on the real exchange rate will be moderated when the increase in public spending is applied to investment to the detriment of the state's consumption.

In turn, the duration of the deterioration in the real exchange rate fades completely after 10 quarters and even generates a slight improvement in the variable in question, a situation that would accentuate the preference for this type of component in public spending.

Given that the results of the simulations shown obey the values of the pubic capital productivity parameter, φ, set at 0.04, we will proceed to analyze how robust the conclusions are when they are sensitized.

[Figure 5.2 Here]

[Figure 5.3 Here]

Thus, in Figure 5.3, various values of ϕ ranging from 0.03 to 0.15 can be observed. In all cases, an increase in spending on public investment impacts the real exchange rate deteriorating in a percentage always lower than that would generate a public expenditure shock.

In addition, in some cases, those associated with values of ϕ equal to or greater than 0.08, even show a rapid recovery so that after 4 quarters, positive effects on the real exchange rate can be seen.

In this way, the preference for a Public Expenditure policy applied to Public Investment is robust to different values in the calibrations of parameter ϕ.

5.2. Fiscal Deficit Generated by Tax Reduction

Figure 5.4 shows the impact on the real exchange rate that causes an increase in the fiscal deficit of one percent in relation to the GDP originated by a tax reduction.

Thus, for example, a reduction in tax rates on labor income reduces the wage cost in all sectors, but this reduction is only transferred to the price of non-tradable goods, since importables and exportables are given internationally. In this way, the fall in the price of the Non-Tradable reduces the Real Exchange Rate.

This result is important since it is generally believed that the fiscal deficit deteriorates the exchange rate regardless of the nature of the same, when our results indicate that it is key to determine whether it is due to increases in Expenses or Tax Reduction.

[Figure 5.4 Here]

6. Conclusions

In this paper, the differential impact generated by increases in public consumption expenses, public investment and tax reduction on the real exchange rate is analyzed and quantified. To this end, we developed a dynamic stochastic general equilibrium model with government and external sector, which is then calibrated and simulated for Argentina. We carefully adapt the model using micro-fundamentals specifically designed for Argentina to analyze the behavior of the Equilibrium Real Exchange Rate (RER) before various fiscal disturbances related to different fiscal deficit composition alternatives.

The theoretical framework adopted here belongs to the family of real business cycles models with competitive markets and flexible prices including a final good, a tradable good, a non-tradable good, an exportable good and an importable good. In this article we model a small open economy with government sector subject to sectoral productivity, fiscal, international interest rate and terms of trade shocks. Agents were allowed to take debt and grant loans to the rest of the world.

Various scenarios were proposed to increase the fiscal deficit corresponding to one percentage point in relation to GDP. In the first scenario, the fiscal deficit originated by an increase in expenditures destined to public consumption, deteriorated the real exchange rate.

In another scenario, the increase in public spending was applied to public investment, which also resulted in a deterioration in the exchange rate, but with a magnitude and intensity significantly lower than that caused by public consumption. In addition, in some cases, those associated with values of ϕ equal to or greater than 0.08, even show a rapid recovery so that after about 4 quarters the harmful effects disappear, even improving the real exchange rate. In all cases, the deficit is financed by loans from the rest of the world. These results were robust to several calibrations of the parameters in question.

Finally, a third scenario shows an increase in the fiscal deficit corresponding to one percentage point in relation to GDP, but this time caused by a reduction in taxes. The result is that this fiscal deficit generates an improvement in the equilibrium real exchange rate, a result that differs from other paper such as Baldi and Mulder [2004], Carrera y Restout [2008].

In summary, the fiscal deficit originated in tax reduction can improve the Real Exchange Rate (RER) while the one generated by any increase in expenditure deteriorates it. Furthermore, the deterioration in the Real Exchange Rate is greater when public expenditure is applied to public consumption than when it is used for public investment.

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Table 4.1

β	γ	σ	π	θ	B	δ	ϕ_χ	ϕ_m	ϕ_n
0.970	1.455	5	0.1	0.00003	14530	0.03	0.01	0.01	0.0001

Table 4.2

α_x	α_m	α_n	χ_τ	χ	μ_τ	μ	ϕ	A_x	A_m	A_n
0.48	0.48	0.62	0.09	0.70640	0.8	0.5	0.05	1	1	1

Table 4.3: Matrix of Variances and Covariances of Stochastic Shocks

	ξ_t^χ	ξ_t^m	ξ_t^n	ξ_t^p	ξ_t^r	ξ_t^g	ξ_t^{ig}	ξ_t^τ
ξ_t^χ	3.74781	3.74781	0.57910	-0.72589	-1.93043	0.65784	0.62455	0.68022
ξ_t^m	3.74781	3.74781	0.57910	-0.72589	-1.93043	0.65784	0.62455	0.68022
ξ_t^n	0.57910	0.57910	1.09629	0.99646	-1.71222	0.21723	0.11751	0.35775
ξ_t^p	-0.72589	-0.72589	0.99646	6.15618	-1.53606	-0.31840	0.23896	0.43608
ξ_t^r	-1.93043	-1.93043	-1.71222	-1.53606	17.93207	-1.50639	-0.80514	-1.54852
ξ_t^g	0.65784	0.65784	0.21723	-0.31840	-1.50639	0.91640	0.19988	0.22712
ξ_t^{ig}	0.62455	0.62455	0.11751	0.23896	-0.80514	0.19988	5.24220	0.53085
ξ_t^τ	0.68022	0.68022	0.35775	0.43608	-1.54852	0.22712	0.53085	1.16147

Note: Values expressed in 10^{-5}

Table 4.4

$\bar{r}$	$\bar{p}$	$\bar{g}$	$\overline{ig}$	$\bar{\tau}$
0.03	1	5300	800	0.27

Table 4.5: Coefficients of Autocorrelation of Stochastic Shocks

ρ_x	ρ_m	ρ_n	ρ_p	ρ_r	ρ_g	ρ_{ig}	ρ_τ
0.834927	0.834927	0.907082	0.823089	0.969298	0.880292	0.853949	0.932502

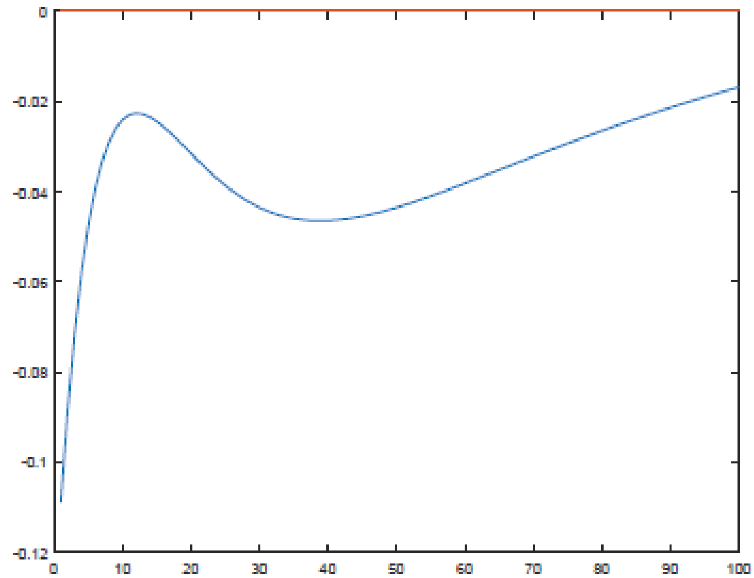

Figure 5.1: Effects on the Exchange Rate in the face of an increase in fiscal deficit as a result of an increase in Public Consumption.

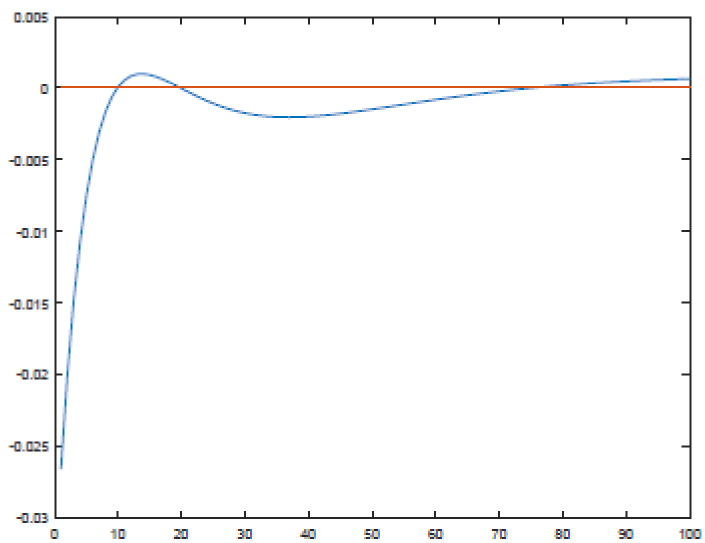

Figure 5.2: Effects on the Exchange Rate in the face of an increase in the fiscal deficit resulting from an increase in Public Investment.

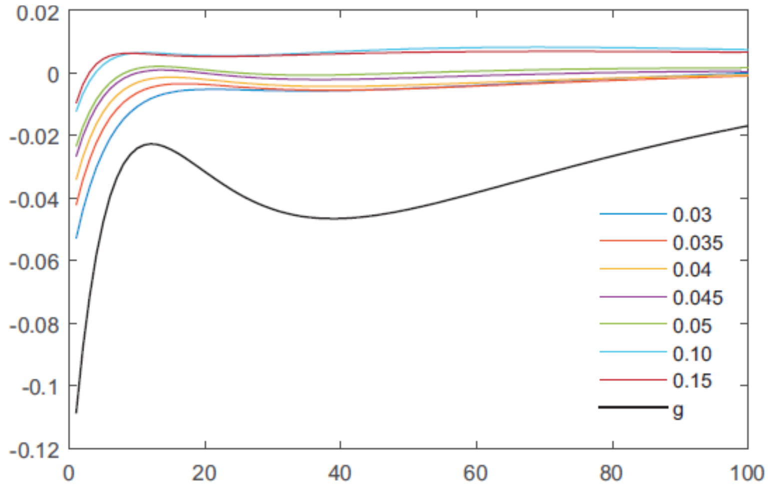

Figure 5.3: Effects on the Exchange Rate in the face of an increase in the fiscal deficit as a result of an increase in Public Investment due to various values of ϕ.

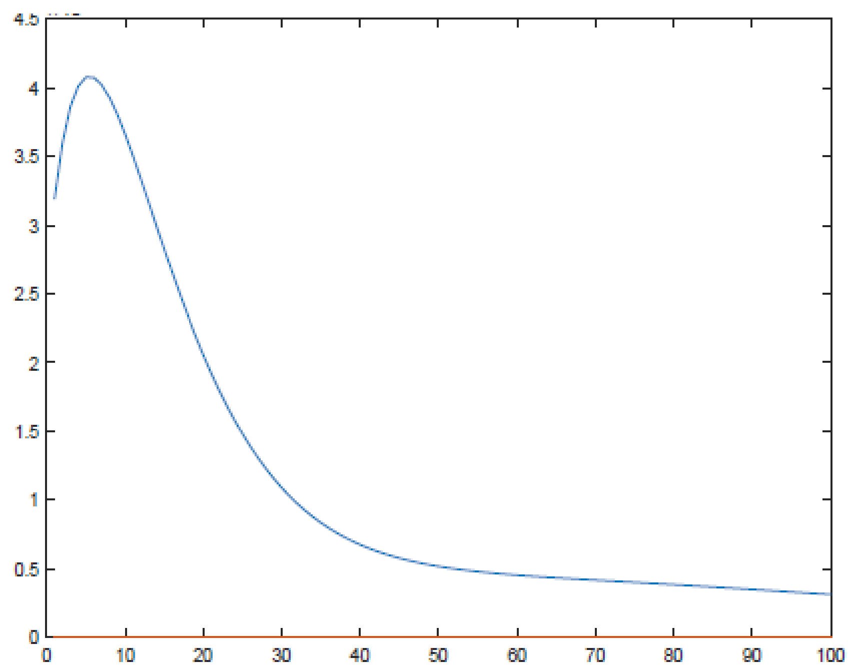

Figure 5.4: Effects on the Exchange Rate in the face of an increase in the fiscal deficit resulting from a reduction in taxes

APPENDIX

A.1 Correlation with GDP

Once the model for the Argentine economy has been calibrated, simulations are carried out on certain elements of empirical interest from the model and compare to the data observed in reality. Another type of experiment is to use the calibrated model to predict the trajectory of the main variables before the initial realization of a certain type of shock.

In order for the outcomes from the model to be comparable with the results shown in the main text, they were log-linearized around the steady state. Thus, the simulated series should be interpreted as percentage deviations from their steady state. Such an interpretation is then comparable to the actual data transformed into logarithms and filtered by Hodrick-Prescott as they represent percentage deviations from its trend.

The correlation between the GDP and the rest of the most important series in the model are shown in Table A.1 below. We also show the outcomes produced by models applied to Argentina by other authors. In particular, column 2 replicate the classic real business cycle model of Kydland and Prescot calibrated for Argentina. Colum 3 shows a model of real business cycles that includes government but without external sector. Column 3 and 4 display models with external sector, which is only accessible for to take debt since there is only one good, and finally, our proposed model in column 6. It is worth clarifying that the results yielded by the first two models were extracted from Capello-Grion (op. cit.) and while the third and fourth of Neumeyer and Perry (op. cit) and Uribe (op. cit.).

If we look at the performance of the models to replicate the correlation of Argentine Consumption with its GDP we observe that both the basic models of RBC and the version with government sector of Capello-Grion fail to replicate it properly, although the latter improve slightly the approximation. Indeed, they obtain values of 0.57 and 0.59 for basic and governance models respectively. Thus underestimating the true correlation of 0.98. On the other hand, Uribe and Neumeyer and Perry obtain by incorporating the external financial sector improve the correlation between consumption and GDP by reaching values of 0.79 and 0.85 respectively. However, these improvements are different from the real value.

Table A.1: Correlation of macro variables with GDP

	(1) Reality[a]	(2) RBC	(3) RBC with gov.	(4) Neumeyer y Perry	(5) Uribe	(6) Proposed Model
Consumption	0.98 (0.03)	0.57	0.59	0.85	0.79	0.97
Private Inv.	0.72 (0.004)	0.99	0.97	0.50	0.35	0.94
Interest Rate[b]	−0.36 (0.03)	0.98	0.97	-0.26		-0.55
Public Inv.	0.43 (0.09)	-	-	-		0.08
Exports	0.50 (0.08)	-	-	-		0.57
Trade Balance	0.00 (0.11)	-	-	-	-	0.18
Exchange Rate	0.06 (0.10)	-	-	-		0.01

[a] Values in parenthesis represent the standard error of the analyzed statistic.
[b] Interest rate correlation with the GDP was calculated with a 4-period lag as the maximum impact on GDP was achieved there.

In contrast, the proposed model obtains a result of 0.97 for the consumption-GDP correlation, which is consistent with what is shown by reality. Regarding the investment-GDP correlation, the basic RBC models without and with government yield results that are too high when compared to actual data. These show not very dissimilar values between 0.99 and 0.97 overestimating the true value of 0.72. Models incorporating external financial sector, on the contrary, underestimate the correlation by obtaining results of 0.35 in the case of the Uribe model and 0.50 for Nuemeyer and Perry. The model presented in this work also departs from the values thrown by reality reaching results of 0.94 which is slightly higher in performance than the first three models shown and in similar disparity, albeit in the opposite direction, as the one shown by Uribe. As for the performance of the proposed model in replicating the correlation of investment with GDP we can conclude notably that it is slightly higher than most existing models.

When we compare the correlation between exports and GDP we see that the proposed model generates a correlation of 0.57 when in reality the value is 0.50. The model significantly approximates the correlation with exports significantly well. As for the other models, as they do not include actual external sector as they are single-good models, there are no values available to compare, so the proposed model contributes in this regard.

The correlation between public investment and GDP is not covered by the Basic model and is not available in the model with government. The other models with external financial sector also do not consider the variable public investment whereas in the model presented here the correlation public investment-GDP reaches a value of 0.08. This result is below the true correlation of 0.42 but shows a positive correlation as in reality. The proposed model therefore makes an important contribution in the area of public investment and its correlation with the GDP.

With respect to the interest rate, the basic model and the one with government - both closed economy models - obtain positive correlations of 0.98 and 0.97 respectively while reality yielded negative values of -0.36. The proposed model here hits the direction of correlation but moves slightly away from the true value by obtaining a result of -0.56, which is similar to the value obtained by Neumeyer and Perry.

The trade balance shows no correlation with GDP in the actual data while in the proposed model it shows some positive but very slight correlation, only of 0.18. All other models do not allow you to extract information about this variable.

As for the terms of exchange rate, the actual data showed a low correlation with GDP, of only about 0.06 while the proposed model shows a correlation of 0.33. The other models presented here do not include in their treatment the exchange rate, thus comparisons cannot be made and the proposed model also contributes to this variable.

Thus, we can conclude that in terms of correlation with GDP the proposed model adequately replicates the properties of the Argentine reality macroeconomic variable showing in almost all the cases better performance than other models introduced for Argentina.

A.2 Volatility Analysis

Absolute Volatility

Table A.2 below shows the volatility generated by the series compared to the reality and results from other models. For the period under analysis, GDP has a volatility of 3.74 percent with respect to its trend. This value of reality is approximated by the result of the simpler RBC model that generates a volatility of 3.94 percent, which is slightly overestimate the real one. The RBC model with government distances itself a little further from the real one by overestimating it. Similarly, external financial sector models overestimate and more intensely, GDP volatility by yielding values of 4.24 and 6.3 percent. Finally, the model proposed here reproduces a product volatility with a better approximation to reality than the basic RBC models by obtaining 3.83 percent.

Table A.2: Absolute Volatility

Variable	(1) Reality[a]	(2) RBC	(3) RBC with gov.	(4) Neumeyer y Perry	(5) Uribe	(6) Proposed Model
Y	3.74 (0.56)	3.94	4.28	4.24	6.3	3.83
c	4.36 (0.66)	0.65	0.96	4.96	8.4	4.53
g	1.98 (0.20)	-	-	-	-	1.79
i_p	6.54 (1.01)	11.55	13.87	12.72	17.7	6.58
i_g	4.40 (0.25)	-	-	-	-	4.80
M	15.71 (2.38)	-	-	-	-	8.31
bc	196.89 (29.7)	-	-	-	-	30.65
p	4.07 (0.61)	-	-	-	-	3.06

[a] Values in parenthesis represent the standard error of the analyzed statistic.

On the contrary, external financial sector models achieve consumption volatility of 4.96 and 8.4 values that significantly overestimate real values. The proposed model, on the other hand, predicts a volatility of 4.53 percent, a value that is not significantly far from reality.

Concerning investment, the basic RBC model and the RBC model with government overestimate its volatility by attaining 11.55 and 13.87% respectively; when in reality the volatility of investment is close to 6.54%. A similar overestimation error shows in models with external financial sector, with investment volatility values close to 12.72 and 17.7 for Neumeyer and Uribe respectively. The proposed model, on the other hand, produces a volatility of 6.54%, a value that fits reality better than the rest of the models.

With regard to public consumption, it achieves an almost perfect fit by achieving a value of 1.96 being 1.97 the reality value. The other models do not include this variable in their results.

With reference to the imports and the trade balance the model underestimates the values of reality, however the values are adequate by generating a volatility far higher than that of GDP.

The terms of exchange show in reality a volatility of 4.07 while the proposed model provides a value of 3.06% thus yielding an approximation that is not significantly very different from reality.

As for absolute volatility, we observe that the proposed model achieves substantial improvements in its ability to reproduce certain aspects of economic reality in comparison to that of other existing models.

Relative Volatility

Table A.3 below shows the volatility of selected model's variable measured in relation to the GDP volatility. We show that while for some variables the model outcomes were slightly different from reality, when we measured it in relative terms these differences are further reduced, and in other cases eliminate them. For example, private consumption is 1.17 more volatile than the GDP, a situation that is not captured by the basic RBC model and the RBC model with government. Both show that consumption volatility is only 0.16 and 0.22 of the GDP volatility. Our model instead replicates a private consumption that is 1.18 more volatile than GDP, thus achieving a very good approximation as do models with external financial sector, mainly that of Neumeyer and Perry.

Table A.3: *Relative Volatility*

Variable	(1) Reality[a]	(2) RBC	(3) RBC with gov.	(4) Neumeyer y Perry	(5) Uribe	(6) Proposed Model
Y	1.00	1.00	1.00	1.00	1.00	1.00
c	1.17	0.16	0.22	1.17	1.33	1.18
g	0.53	-	-	-	-	0.61
i_p	1.75	2.93	3.24	3.00	2.80	1.72
i_g	1.17	-	-	-	-	1.25
M	4.20	-	-	-	-	3.21
bc	52.69	-	-	-	-	8.33
p	1.09	-	-	-	-	1.37

Similarly the volatility of private investment that was slightly overestimated before by our model is virtually identical to reality when measure in relative terms generating a value of 1.72 versus 1.75 of reality. Note that the rest of the models overestimate it in a range that goes from 2.8 to 3.23 times of GDP.

The trade balance is much more volatile than the GDP, specifically 52 times more volatile. The proposed model produces a trade balance 8.33 times more volatile than GDP, which captures the stylized fact of enormous volatility of the trade balance while underestimating it.

As for the terms of exchange, the model states that it is 1.37 times more volatile than GDP while the reality shows only 1.09. The model slightly overestimates the relative volatility of the terms of exchange but captures the stylized fact of being slightly more volatile than GDP.

We can conclude so far that in terms of volatility the proposed model properly adjusts its results to reality. It gets better performances over other models by being able to replicate more volatile consumption and investment than GDP. It stresses the importance of considering an open economy model, with the possibility of lending and borrowing to the rest of the world, the incorporation of a multisector economy and the impact of the various structural technological shocks, terms of interest rate and tax variables.

[1] Bello, Heresi y Pineda (2010) estimate the real exchange rate for 17 Latin American countries from 1970 to 2005 and demonstrate the existence of recurrent processes of exchange rate overvaluation for several of these countries.

[2] Consequently, the marginal rate of substitution between consumption and employment will depend only on the latter, making employment independent of the dynamics of consumption. This simplification facilitates the numerical simulations and the computation of the steady state, a computation that is still very complex, while allowing to focus on the inter-sectorial interactions and the various shocks that will be defined later. The cost of these advantages will result in the loss of wealth effects in the labor supply linked to public or private consumption.

[3] It is common in economic literature to model preferences that include patterns of habit formation in consumption. Such inclusion in general is motivated to generate extra channels that reduce the volatility of consumption, especially in times of economic crisis. However, the stylized facts for the Argentine case denote a consumption with greater volatility than the GDP, which is why including habits in the preferences would not be an appropriate assumption when constructing a model that seeks to explain this particularity of the economy under study.

[4] Using a non-linear specification, for example multiplicative, between C_t and g_t would generate the same qualitative effects, so the linear specification used here is not restrictive.

[5] So the same is equal to $\varepsilon_{l_i}^{w_i} = \frac{1}{\gamma_i - 1}, i: n, x, m.$

[6] In this way the past decisions of consumption and effort do not directly generate utility in the current or future period, without prejudice to the indirect effects through the state variables influence the present decisions (Barro and King, 1982)

[7] Kydland y Prescott (1982) calibrate the parameters in such a way as to minimize the difference between theoretical and empirical moments.

[8] See Appendix for a detailed exposition of the comparison of the statistical properties of the artificial series generated by the model with those of reality. There it is concluded that the model correctly replicates the main macroeconomic variables of Argentina.