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Intertemporal Adjustment and Fiscal Policy under a Fixed Exchange Rate Regime

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Abstract

The paper presents a dynamic model for small to medium open economies operating under a fixed exchange rate regime. The model provides a partial explanation of the channels through which fiscal and monetary policy affects the real exchange rate. An empirical investigation is conducted for the case of Argentina during the currency board period of 1991–2001.

Empirical estimates show that fiscal policy may indeed be an efficient instrument for promoting macroeconomic stability insofar as it encourages convergence toward long-run equilibrium and alters the long-term balance between exports and consumption, both private and public.

The simulation applied to Argentina shows that if the share of public spending in the economy is higher than the share of imports, an increase in the tax rate will stimulate capital stock slightly, at least in the short term, and depreciate the real effective exchange rate.

In the long run, the fiscal policy affects the value of the real exchange rate and consequently external competitiveness.

Intertemporal Adjustment and Fiscal Policy under a Fixed Exchange Rate Regime

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Introduction

In the debate over the choice of exchange rate regimes in the 1990s, it became fashionable to favor the extremes of fixed and free floating regimes, while eschewing intermediate regimes as macroeconomically inconsistent.[1] The proponents of fixed exchange rates cite the credibility that monetary authorities can obtain by committing to macroeconomic stability, the "disciplining effect" on price setters, and the anchoring impact on price expectations.[2]

Unfortunately, recent exchange rate crises have shown that, perhaps owing to external shocks or inappropriate monetary and fiscal policies, some emergent economies with a hard peg regime, most notoriously Argentina in 2001, have lost control of their current accounts and fallen into acute financial crisis and recession. In other cases, such as Korea and Thailand, currency crises have occurred even though monetary and fiscal policies were perceived as fully consistent with the exchange rate regime; in those cases, an excess of confidence in nominal anchors has led to indiscriminate short-term capital inflows that masked failures in the domestic banking system and misled investors.

Since then, research in the field of financial crisis has found that fixing exchange rates, while refraining from seignorage and adjusting the domestic credit supply to the rate of long-run output growth, is indeed conducive to macroeconomic stability, though it does not guarantee it.[3]

Since the first currency board was set up in Mauritius in 1849 to enforce a fixed exchange rate, up to the most recent one in Bosnia, about 80 currency boards have operated in small and medium-size countries.[4] The monetary discipline implicit in these arrangements is often seen as a means of preventing the depletion of foreign exchange reserves in the face of expanding domestic credit. Moreover, history seems to support the idea that currency boards are an efficient way of achieving short-term price stability. With a fixed exchange rate, after all, the money supply is endogenous, and both interest rates and inflation rates must converge toward international levels.

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[1] Frenkel, Fajnzylber, Schmukler, Serven (2001)
[2] See for instance Corbo (2002), Fisher (1996), and Quirk (1996).
[3] These points are discussed in Alberola and Molinas (2000).
[4] See for instance the excellent review provided in Ghosh et al (2000).

Most recent studies of dynamic macroeconomic adjustment in a fixed exchange rate regime have emphasized the influence of the relative prices of traded and nontraded goods on changes in the real exchange rate, ignoring the money supply constraint to which all small open economies operating under a fixed exchange rate regime are subject. This is a curious omission, given that a key role of a hard peg system is to maintain equilibrium in the balance of payments. For that reason, the money supply must be considered as part of the macroeconomic framework.

Only few studies have analyzed the problem of balance-of-payments equilibrium in the context of monetary optimal intertemporal models in a pure fixed exchange rate regime.[5] Furthermore, to our knowledge, no one has yet attempted a macrodynamic analysis of a strict fixed exchange rate regime focusing on the interaction between the real exchange rate, monetary determination, and the impact of fiscal policy. That is precisely what we undertake here. Given an endogenous money supply, we ask how fiscal policy might influence both the real exchange rate and the macroeconomic dynamics in the transition toward long run equilibrium , as well as in the long run.

The paper presents a simple dynamic model for small to medium open economies operating under a fixed exchange rate regime.[6] The model provides a partial explanation of the channels through which fiscal and monetary policy affects the real exchange rate. An empirical investigation is implemented for the case of Argentina during the currency board period of 1991–2001.

The paper is organized as follows. The first section provides background on Argentina. The second section describes an optimal monetary intertemporal model for an open economy under a currency board, emphasizing the links between fiscal policy, monetary constraints, and the real exchange rate. The third section applies the model to the currency board experience in Argentina, simulating the dynamic effects of changes in the tax rate and foreign interest rates on the paths of capital accumulation and the real exchange rate.

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[5] Chang and Tsai (1998) have offered an optimizing monetary model of an open economy operating under purchasing power parity, assuming capital immobility and equilibrium in the government budget balance. More recently, Daniel (2001) suggests an analysis of an open economy in a fixed exchange rate regime under the restrictive hypothesis of an exogenous income endowment. Other papers, such as Turnovsky (1996) and Normandin (1999), deal with fiscal policy issues in a small open economy without money.

[6] "Small to medium" denotes economies that are not big enough to influence international prices or interest rates.

1. Argentina's currency board experience

Argentina's experience with a currency board is an attractive subject of study because of the dramatic macroeconomic events that occurred during and after the decade during which the board was in place, and because of the lessons that Argentina's experience holds for other open economies that may be considering a fixed exchange rate regime.

Argentina's central bank failed with its currency board because of an explosive combination of factors—chief among them the impossibility of conducting monetary policy (by definition endogenous), foreign currency developments in the leading country to which the currency was pegged (the United States), difficulties in designing and implementing fiscal policy to compensate for imbalances in other sectors (monetary, financial, labor), institutional rigidities, and issues of political economy issues (Carrera 2002). [7]

For some time, the results of the currency board were considered impressive for their stabilizing effect. Hyperinflation was reduced to almost zero, and growth rates increased until the verge of the crisis (figure 1.1).

Figure 1.1   Argentina's GDP at constant prices, 1991–2001

Millions of pesos
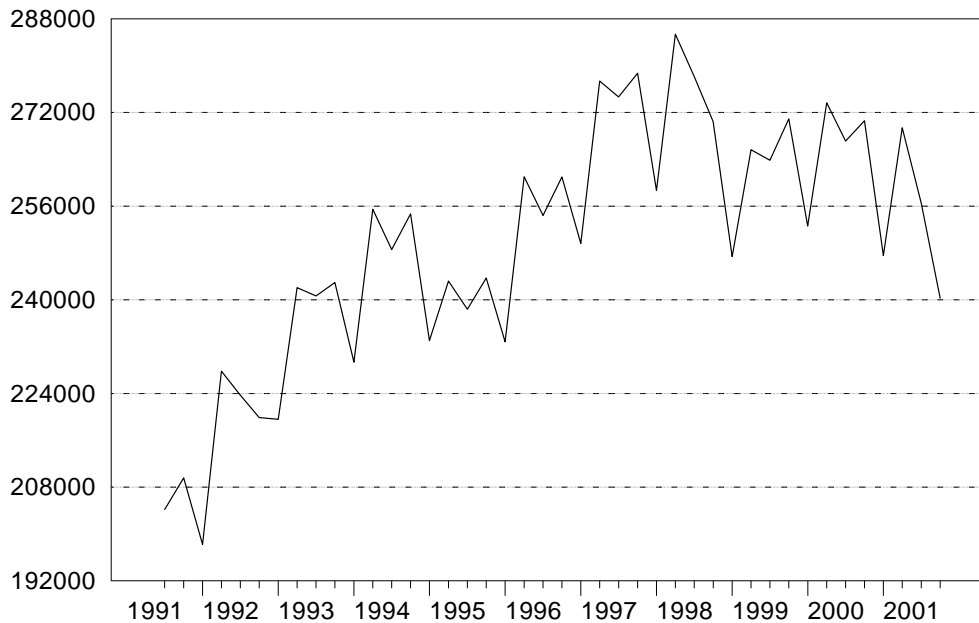
Source: IFS-FMI.

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[7] We do not analyze the political economy or institutional failures in this paper.

Over the period of our analysis, inflation in Argentina dropped dramatically, falling below the U.S. rate by 1996 (figure 1.2). And, during the entire currency board period, Argentina's economy was spared a liquidity shortage because of increases in net foreign assets (figure 1.3).

Nevertheless, over the period, Argentina's external competitiveness worsened because fiscal policy was unable to offset deterioration in the current account by a voluntary increase in the tax rate or a slowdown in public expenditures (figure 1.4).

In 1991, when the currency board was adopted, the real exchange rate stood higher its long-run equilibrium (Carrera 2002), so competitiveness was already a problem. Subsequently, the peso continued to rise further in real terms, boosting imports and discouraging exports, which served to increase current account deficits (figures 1.5 and 1.6).

Figure 1.2   Inflation in Argentina (solid line) and United States, 1990–2001

Percent

Source: IFS- IMF.

5
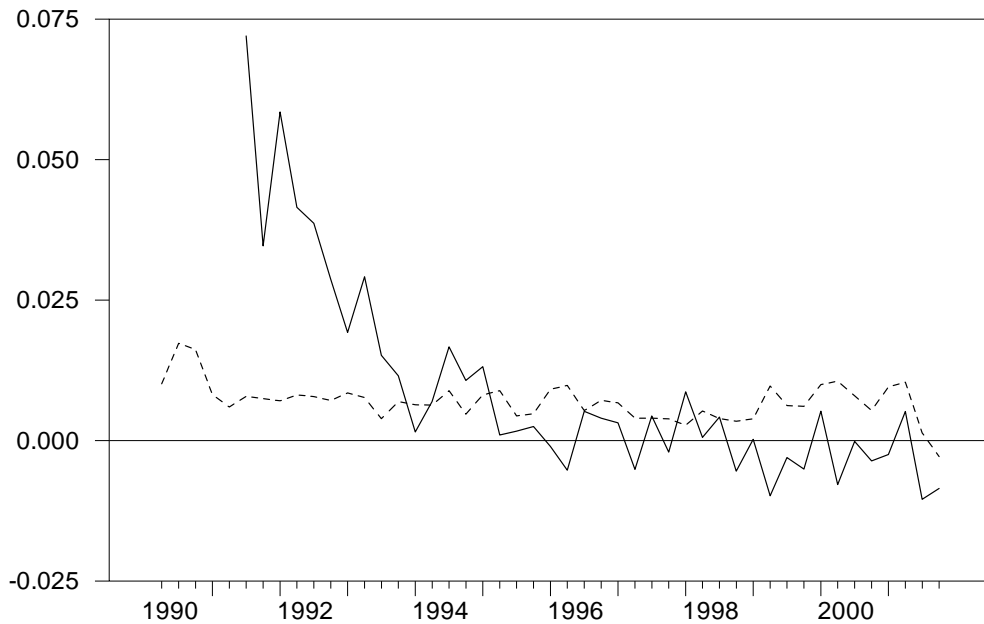
Figure 1.3   Net foreign assets in Argentina, 1991–2001

Millions of pesos at current prices
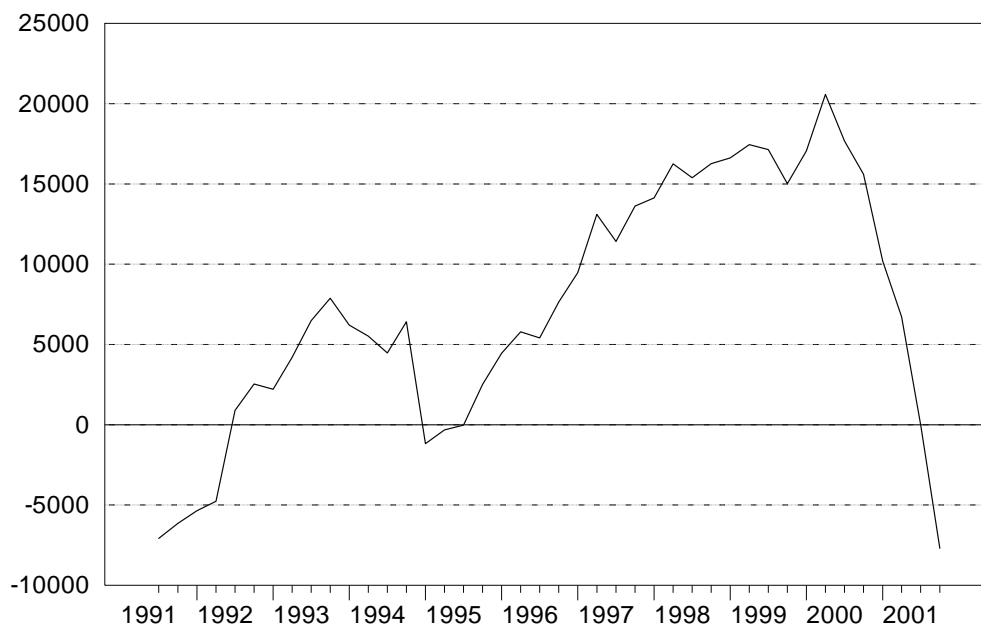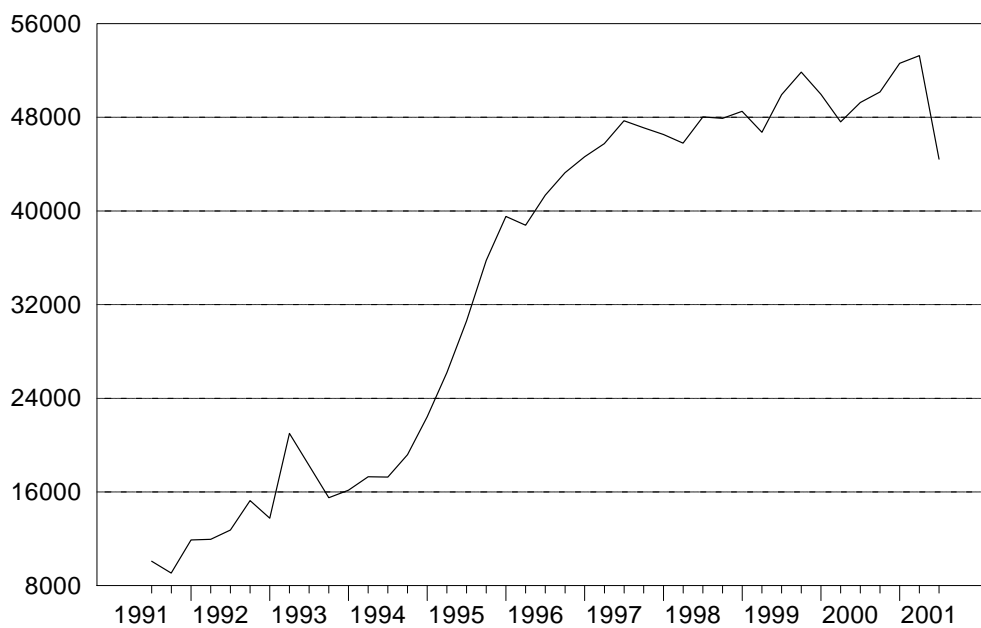

Source: IFS-FMI.

Figure 1.4   Public expenditures in Argentina, 1991–2001
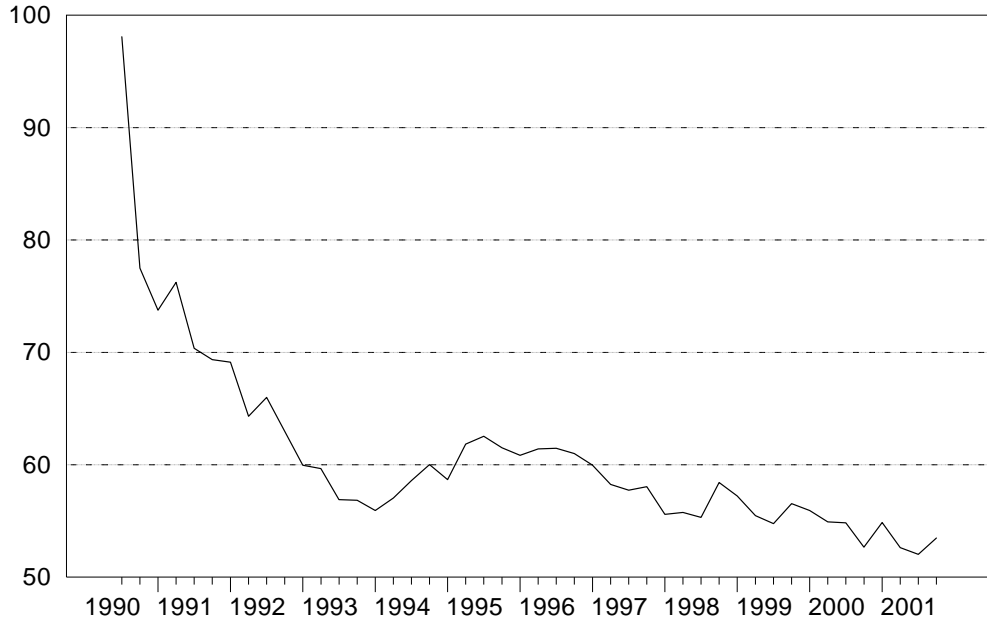
Millions of pesos, current prices

Based on data from IMF.

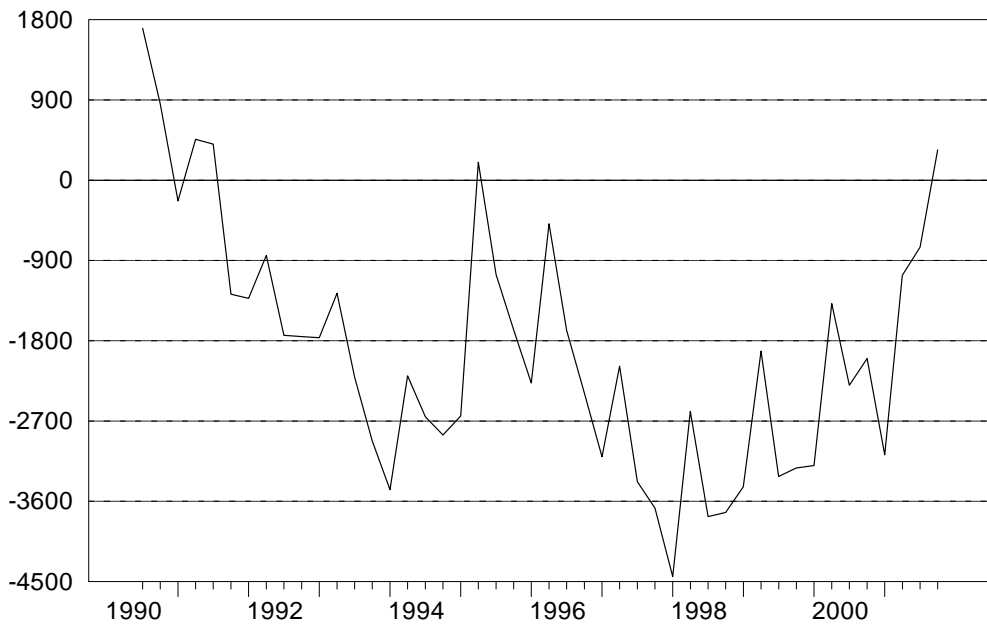**Figure 1.5   The real exchange rate in Argentina, 1990–2001**

Real Exchange Rate Index = 100 1990

Based on data from IMF.

Figure 1.6   The current account deficit in Argentina, 1990–2000

Millions of dollars

Based on data from IMF.

Turning to fiscal policy, immediately following the adoption of the currency board the fiscal deficit fell to zero from an average of 5 percent of GDP during the 1980s. By 1994, the current account had moved into surplus thanks to past growth achievements and better fiscal policies. That year ended in deficit, however, and the deficit worsened throughout the remainder of the currency board period, reaching around 3.5 percent of GDP by 2001 (figure 1.7).

Figure 1.7   Ratio of fiscal deficit to GDP in Argentina, 1991–2001
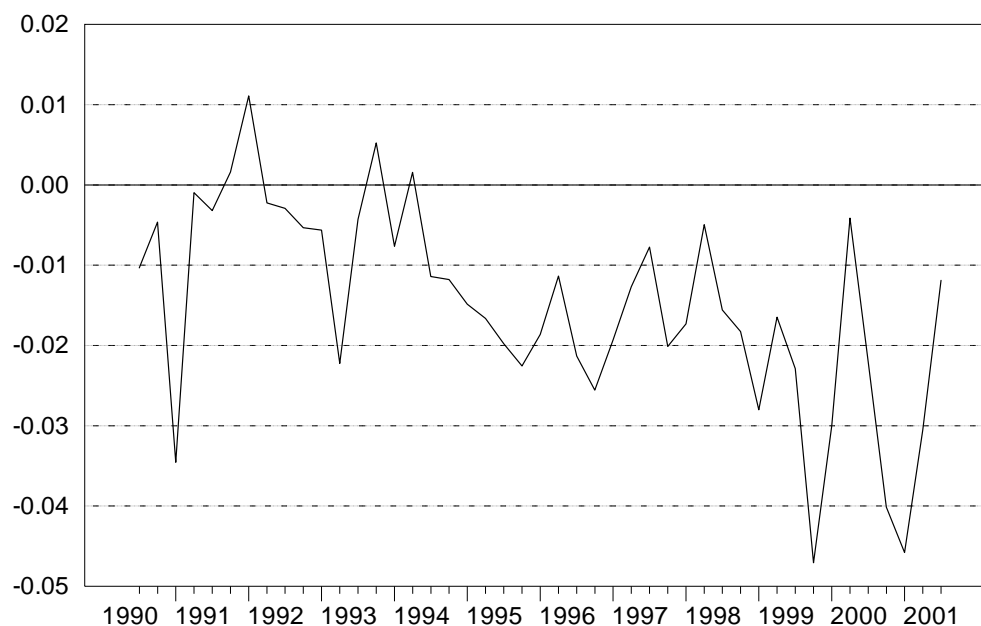
Source: Centro de Economía Internacional.

The procyclical reaction of revenues to GDP, combined with less downward flexibility of fiscal expenditures, contributed to this result. In general, however, both public expenditures and government revenues were sensitive to business cycles, causing the fiscal balance to fluctuate widely during the entire period.

The country's deficits were financed by capital inflows stimulated by a policy of capital liberalization. The inflows led, however, to higher external indebtedness, which seems to have been the only feasible adjustment mechanism, given the existence of the currency board.

When the currency board was adopted, Argentina's total public debt was $87 billion, or 40 percent of GDP. By 2001, it had reached $145 billion (53 percent of GDP)—a 67 percent increase.

Figure 1.8   Argentina's public debt, 1992–2003

Millions of dollars
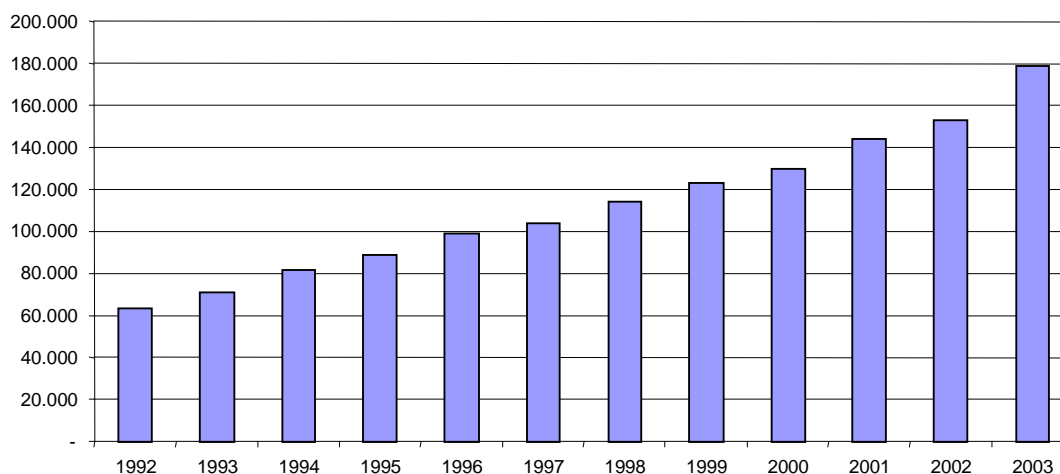
Source: Ministry of Economy, Republic of Argentina.

Looking at these results, one might conclude that the currency board produced a degree of macroeconomic stability and may have protected the country temporarily from effects of exchange rate volatility, with a positive impact on growth. However, the nation's economic system proved incapable of making sound fiscal adjustments and restoring competitiveness. In the end, the explosion of external debt led to an acute recession.

2. A model of intertemporal adjustment in an open economy with a fixed exchange rate

The model analyzes the process of intertemporal adjustment in a small to medium size open economy operating with a fixed exchange rate regime. Individuals live in an infinite horizon world with perfect foresight, and the home country produces and consumes a single good, referred to in the paper as the domestic good, while also consuming a good imported from abroad. Since the nominal exchange rate is pegged, the real exchange rate is the relative price of domestic and imported goods.

Individuals face sequential decisions in order to optimize their welfare. First, within each period, they choose an allocation of consumption between domestic and imported goods. This process determines the relationship between the consumption price index and the real exchange

rate. Second, individuals have to decide on the intertemporal distribution of consumption and savings within the standard dynamic of an open economy over an infinite horizon.

The resolution of the intertemporal open macroeconomic model provides us with a set of two first-order-difference equations for capital accumulation and the real exchange rate.

2.1. Intratemporal optimization: consumption patterns and price level determination

Denote by d_t the consumption at time t of the good produced domestically and by z_t the consumption of the imported good. c_t is the aggregate consumption of d_t and z_t. The consumption price level is P_t. The aggregate consumption c_t at current price is equal to:

$$P_t c_t = E_t Pf_t z_t + Pd_t d_t \tag{1}$$

Pf and *Pd* represent respectively the prices of the imported good and the domestic good.

Aggregate consumption can be defined as a weighted combination of *d* and *z*:

$$c_t = d_t^{1-\sigma} z_t^{\sigma} \tag{2}$$

σ is the weight of the imported good in aggregate consumption.

With regard to the prices of the domestic and imported goods, the real exchange rate R_t can be written as:

$$R_t = \frac{E_t Pf_t}{Pd_t} \tag{3}$$

Under a hard peg regime the nominal exchange rate E_t is irrevocably fixed. Since exchange rate fluctuations are not allowed, E_t can be normalized to one.

Consumers optimize the allocation of consumption expenses between domestic and imported goods according to their relative price. In order to achieve an optimal consumption distribution between the goods, they maximize real consumption (equation 2) under the constraint defined by equation (1).[8] The optimal relationship between the consumption of the two goods is given by the first-order condition:

$$d_t = \frac{1-\sigma}{\sigma} \frac{z_t Pf_t}{Pd_t} \tag{4}$$

Solving equations (1) and (2) for z_t produces the following expression:

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[8] $Max \left\{ d_t^{1-\sigma} z_t^{\sigma} + \lambda (E_t Pf_t z_t + Pd_t d_t - P_t c_t) \right\}$

$$z_t = \sigma \frac{P_t c_t}{R_t P d_t} \qquad (5)$$

and therefore:

$$d_t = (1-\sigma) \frac{P_t c_t}{P d_t} \qquad (6)$$

Replacing in equation (2) d_t and z_t with their value in terms of aggregate consumption provides a determination of the consumption price as a log-linear function of the real exchange rate and the domestic production price. The consumption price index is given by one of the following equations:

$$P_t = R_t^{\sigma} P d_t \omega \text{ or } P_t = R_t^{\sigma-1} P f_t \omega \qquad (7)$$

where $\omega = \dfrac{1}{1-\sigma}\left[\dfrac{1-\sigma}{\sigma}\right]^{\sigma}$

The aggregate consumption price level is a combination of the real exchange rate and domestic or foreign prices.

These results will be reintroduced hereinafter in the form of Euler equations generated by the intertemporal optimization program.

2.2. Macroeconomic equilibrium

2.2.1. Goods-market equilibrium

The economy produces only the domestic good. The output at time t, denoted y_t, is governed by a production function depending on the stock of capital[9]:

$$y_t = F(k_t) \qquad (8)$$

Assuming no capital depreciation, the investment (made up solely of domestic goods) is equal to:

$$I_t = k_{t+1} - k_t \qquad (9)$$

Exports are a function of exogenous world demand W and the real exchange rate:

$$x_t = X(R_t, W) \quad X_R > 0, X_W > 0 \qquad (10)$$

The government raises a proportional tax τ and commits itself to purchase only domestic

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[9] All variables are expressed in per capita terms. We assume no population growth. Population size is normalized to one.

goods g_t. Under these hypotheses, the instantaneous domestic-goods-market equilibrium for this small open economy is given by the following equation:

$$y_t = g_t + d_t + X(R_t, W) + I_t \tag{11}$$

2.2.2. Balance-of-payments equilibrium in nominal and real terms

For simplicity, our approach here relies on the assumption that all government debt is held by foreigners who feel secure because of the fixed exchange rate. In such a regime, regardless of private capital movements, which are unpredictable in most emerging economies, the balance-of payments-equilibrium in current prices at time t is given by:

$$M_{t+1} - M_t + A_{t+1} - A_t\left(1 + i^*\right) = Pd_t y_t - P_t c_t - Pd_t g_t - Pd_t I_t \tag{12}$$

The constant nominal foreign interest rate[10] is denoted by i^*.

The left side of equation (12) refers to the change in net foreign assets. In this simple appraisal, movements of net foreign assets are equal to the algebraic sum of changes in money supply ($M_{t+1}-M_t$) and net foreign public assets ($A_{t+1}-A_t$).

Transferring debt service $i^* A_t$ to the right side, we obtain the current account at time t.

Substituting (1) and (11) in (12) implies the conventional balance-of-payment equation:

$$M_{t+1} - M_t + A_{t+1} - A_t = Pd_t X(R_t, W) - E_t Pf_t z_t + i^* A_t \tag{13}$$

From equation (12), the balance-of-payments equilibrium in real terms (at consumption price), denoted by small letters, is:

$$(1+\pi_{t+1})a_{t+1} - a_t\left(1+i^*\right) + (1+\pi_{t+1})m_{t+1} - m_t = \left[(k_t + F(k_t) - g_t - k_{t+1})\frac{Pd_t}{P_t}\right] - c_t \tag{14}$$

where $\pi_{t+1}= \left(\dfrac{P_{t+1}}{P_t} - 1\right)$ is the rate of growth of the consumption price index.

Equation (14) is the wealth dynamic constraint in an open economy under a fixed exchange rate regime.

It does not seem unrealistic to consider public expenditures as being endogenous. Therefore, we introduce them into the utility function.

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[10] Against this simplifying assumption, it can be argued that i^* should be a function of the debt-output ratio, as in models with country-risk premium or models with imperfect capital mobility (see, for example, Agénor 2006). But, according to Fisher (1996), "The monetary theory of the currency board is exactly that of the gold standard.

2.2.3. Intertemporal optimization

The satisfaction of individuals relies on private consumption, public expenditures, and real cash balances. For a given time preference factor *β,* agents optimize each control variable time path, benefiting from the availability of foreign loans in an open economy.

In such a framework, agents maximize the utility function below under the motion constraint specified in equation (14). The optimization program can be expressed as:

$$MaxV_t = \sum_{j=0}^{\infty} \beta^j \left(ln(c_{t+j}) + \gamma \, ln(g_{t+j}) + \phi \, ln(m_{t+j}) \right)$$

$$uc: (1+\pi_{t+1})a_{t+1} - a_t\left(1+i^*\right) + (1+\pi_{t+1})m_{t+1} - m_t = \left[(k_t + F(k_t) - g_t - k_{t+1})\frac{Pd_t}{P_t} \right] - c_t \quad (15)$$

The log linear[11] utility function V_t is maximized under the balance-of-payments constraint analyzed above. The first-order conditions are:

$$g_t = \gamma \frac{P_t c_t}{Pd_t} \quad (16)$$

$$c_t = \frac{(1+\pi_{t+1})}{\beta(1+i^*)} c_{t+1} \quad (17)$$

$$M_{t+1} = \phi \frac{P_{t+1}c_{t+1}}{i^*} \quad (18)$$

$$1 + F_{kt+1} = \frac{c_{t+1}}{\beta c_t}\left(\frac{R_{t+1}}{R_t}\right)^\sigma \quad (19)$$

Equation (19) results from price definition (7).

In the rest of the paper, the real foreign interest rate r^* is assumed to be time invariant. We use π^* to denote the foreign inflation rate. Since $1 + r^* = \dfrac{1+i^*}{1+\pi^*_t}$, the assumption of a constant

real foreign interest rate implies that the foreign rate of inflation is also constant [$(Pf_t/Pf_{t-1})-1 = \pi^*_t = \pi^*$].

Provided the arrangement is credible, it brings the benefit of rapid convergence toward international inflation and interest rates, as can be seen in the Argentine experience."

[11] Supportive empirical evidence of the hypothesis of separability with respect to government spending is provided by Karras (1994), McGrattan, Rogerson, and Wright (1997), Chiu (2001), and Okubo (2003), among others.

2.2.3.1. Money-demand dynamics

Equations (17) and (18) can be solved to obtain the dynamics of money demand. The solution results in an Euler equation for the demand for nominal cash balance:

$$M_t = \frac{1}{\beta(1+i^*)} M_{t+1} \tag{20}$$

At the steady state $\left(\dfrac{M_{t+1}}{Pd_{t+1}} = \dfrac{M_t}{Pd_t} \right)$ time preference coincides with the discount rate $\left(\beta = \dfrac{1}{1+r^*} \right)$. Since β and r^* are exogenous, we assume that this condition is always fulfilled: it implies that the optimal money growth rate must be equal to the foreign inflation rate, which is assumed to be constant:

$$M_{t+1} = (1+\pi^*)M_t \tag{21}$$

and at the steady state, the inflation rate on domestic prices will be equal to the foreign inflation rate:

$$\frac{Pd_{t+1}}{Pd_t} = 1 + \pi^* \tag{22}$$

This result complies with one of the main expected results of a currency board arrangement (see footnote 10).

2.2.3.2. Real interest rate parity

Expanding the domestic inflation rate according to the aggregate price level definition, and in terms of the real exchange rate (7), the first-order condition (17) becomes[12]:

$$c_t = \frac{c_{t+1}}{\beta(1+r^*)} \left(\frac{R_{t+1}}{R_t} \right)^{\sigma-1} \tag{23}$$

Solving (18) and (19) with respect to the real exchange rate provides us with an

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[12] From the aggregate consumption price definition (equation 7), $P_t = R_t^{\sigma-1} Pf_t \omega$, it follows that

$$\frac{P_{t+1}}{P_t} = 1 + \pi_{t+1} = \left[\frac{R_{t+1}}{R_t} \right]^{\sigma-1} \frac{Pf_{t+1}}{Pf_t} = (1+\pi^*)\left[\frac{R_{t+1}}{R_t} \right]^{\sigma-1}$$. Inserting this definition of the inflation rate and the

ratio $\dfrac{1+i^*}{1+\pi^*} = (1+r^*)$ in (17) leads to the result in 23.

expression of the intertemporal real exchange rate adjustment:

$$R_t = \frac{1+r^*}{1+F_{k,t+1}}R_{t+1} \tag{24}$$

This relationship demonstates that in our fixed exchange rate model, the *ex ante* real interest rate parity between the home country and the rest of the world holds.

2.2.3.3 Money supply

Money supply is at the heart of the model because it determines the dynamic between the real exchange rate and capital stock.

By inserting the optimum value of imports (5) into the balance-of payments-equation (13) we obtain the money supply dynamic:

$$M_{t+1} - M_t = Pd_t X(R_t, W) - \sigma P_t c_t - (A_{t+1} - (1+i^*)A_t) \tag{25}$$

The dynamics of public foreign debt (assets) are governed by a natural accumulation process, where τ stands for the proportional output tax, and $\gamma P_t c_t$ for nominal public expenditures (equation 16):

$$A_{t+1} = (1+i^*)A_t + \tau Pd_t F(k_t) - \gamma P_t c_t \tag{26}$$

Substituting public debt (asset) accumulation in (25) we obtain:

$$M_{t+1} - M_t = Pd_t [X(R_t, W) - \tau Pd_t F(k_t)] + (\gamma - \sigma) P_t c_t \tag{27}$$

Demand for government spending and demand for imports are both proportional to consumption. That being so, if $\gamma > \sigma$, (goods and services provided by the government weigh more than imported goods) an increase in private consumption spending will automatically affect the money supply because of the resulting drop in foreign assets (26). Given the mechanical reaction of the money supply, fiscal policy remains the government's only instrument of economic. If private consumption leads to an increase in the delivery of public services, for example, a tax increase will be needed to maintain the balance of payments (27).

To move toward resolution of the model it is necessary to express nominal consumption in terms of money demand. From equation (18) it follows that:

$$P_t c_t = \frac{i^*}{\phi} M_t \tag{28}$$

Given that, on the demand side, the optimal flow of money depends solely on the foreign

inflation rate (21), and that the money supply is endogenous (because it results from the balance of payments in a currency board regime), equation (28) demonstrates that consumption is driven by the nominal quantity of money.

Substituting (28) in (27), the final expression of the money-supply adjustment in terms of variables, R_t and k_t, is:

$$M_{t+1} = \left[1 + (\gamma - \sigma)\left(\frac{i^*}{\phi}\right)\right]M_t + Pd_t\left(X(R_t, W) - \tau F(k_t)\right) \tag{29}$$

Equation (29) describes the change in money supply change (identical to the change in foreign exchange reserves) resulting from the balance-of-payments equilibrium, $(\Delta M = CA - \Delta A)$, in a fixed exchange rate regime, where *CA – ΔA = (X –Z) + (T – G)*.

From the equation above, we infer the following conclusions:

- Other things being equal, a tax cut will increase both the domestic money supply (29) and foreign debt (26). This is the consequence, in the absence of sterilization, of the capital inflow required to ensure equilibrium in the balance of payments.

- A depreciation in the real exchange rate will increase exports, and therefore external reserves and the money supply.

- Because consumption is driven by the quantity of money (equation 28), the bracketed term in equation (29) conveys a simple relationship between the dynamics of money and the balance between public expenses *G* and imports *Z*, both of which are proportional to the consumption level and therefore to the existing money stock. For example, the rate of growth of money supply will be greater if $\gamma > \sigma$, other things being equal. In this case, the quantity of money will stimulate government spending (inducing a public deficit, capital inflows, and an increase in the money supply) more than imports (which induce a current account deficit, depletion of external reserves, and a decrease in the money supply).

2.2.3.4. Money market equilibrium

Substituting the expression for optimal money demand (equation 21) into the equation for the money supply or balance of payments (29), gives the condition for money market equilibrium:

$$M_t = \frac{Pd_t\left[X(R_t,W) - \tau F(k_t)\right]}{\pi^* + (\sigma - \gamma)\left(\dfrac{i^*}{\phi}\right)} \tag{30}$$

This equation shows the optimal money balance at each period. Given the endogenous money-supply dynamics reflected in equation (29), Euler equation (21) will always be satisfied—that is, the rate of money growth will be equal to π^*— provided individuals hold this particular amount of cash balance in period *t*.

Following equation (29), a tax cut, other things being equal, will induce an increase in money supply at time *t+1*. Whenever $\gamma > \sigma$, individuals must hold less money at time *t* in order to compensate for this undesirable money growth.

2.2.3.5. *Capital accumulation*

Because the optimal real cash balance (30) is endogenous and depends on the real exchange rate and capital stock, the model must be completed by adding the dynamics of these two variables. The dynamics of the real exchange rate are given in equation (24). After simplifications, the combination of the balance-of-payments equilibrium (equation 12), first-order conditions (16, 18), and equations (26) and (20), yields the following equation for capital accumulation:

$$k_{t+1} = (1-\tau)F(k_t) + k_t - \left[\pi^* + \left(\frac{i^*}{\phi}\right)\right]\frac{M_t}{Pd_t} \tag{31}$$

Equation (31) is nothing else but the movement of the balance of payments under a fixed exchange rate regime expressed in terms capital stock change. The capital stock is defined as the difference between the level of production (net of taxes) and the sum of change in cash balances and the level of private consumption. Thus, the terms between the brackets introduce the two following elements:

- First, from (21) it is easy to show that $\pi^* M_t = \Delta M_{t+1}$. For any given foreign inflation rate, the greater the predetermined cash balance, the greater its variation. Other things being equal, this will reduce capital accumulation, as domestic agents will increase their cash balance instead of physical capital.

- Secondly, from (28), the term *(i*/ϕ).M_t* drives household consumption: higher real cash balances induce greater consumption and, in consequence, less capital accumulation.

2.3. The dynamics of the model

2.3.1. The reduced form

The structural form of the model is composed of equations 30, 31, and 24. The reduced form is obtained replacing the real money assets with their equilibrium level (substituting equation 30 in equation 31). This substitution provides a backward–forward system of two first-order-difference nonlinear equations:

$$k_{t+1} = (1 - \tau)F(k_t) + k_t + \Theta\left[X(R_t, W) - \tau F(k_t)\right] \qquad (32)$$

$$R_t = \frac{1 + r^*}{1 + F_{k,t+1}} R_{t+1} \qquad (24)$$

In equation (32), we define: $\Theta = -\dfrac{\pi^* + \left(\dfrac{i^*}{\phi}\right)}{\pi^* + (\sigma - \gamma)\left(\dfrac{i^*}{\phi}\right)}$.

The coefficient Θ is <0 if $\gamma < \sigma$ [13] or if $\gamma - \sigma < \dfrac{\pi^* \phi}{i^*}$, and positive otherwise.

In equation (32), the standard withdrawal effect of fiscal policy on transitional dynamics is captured by the term: $-\tau F(k_t)$. A new term $(-\Theta \tau F(k_t))$ is introduced to account for the endogeneity of the money supply. The latter effect encompasses all of the mechanisms described in the sub section 2.2. Provided that $\sigma > \gamma$ (public expenditures are lower than imports) and $\sigma < 1 + \gamma$, Θ is negative and less than –1. As long as $\Theta < -1$, a tax increase stimulates capital accumulation during the transitional dynamics, contrary to the standard withdrawal effect. Econometric estimates (see section 2.3.3) appear to verify this assumption.

The reduced form of the model requires some commentary. First, as the tax rate τ goes up, the stock of capital rises in accordance with equation (32), owing to the relationship between the money supply and the tax rate, as analyzed in the previous section. Second, the capital stock increase induces a drop in the marginal productivity of capital . As a consequence, the real exchange rate depreciates (24), exports are stimulated, and capital stock returns to its long-run value.

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[13] σ and γ denote the share of imports and of public consumption in global consumption.

The country may be also face an external shock, for instance a rise in the foreign real interest rate. In that case, a depreciation in the real exchange rate (equation 24) will strengthen exports and deplete capital stock. This pushes up the marginal productivity of capital , causes the real exchange rate to appreciate, and, as exports dwindle, capital stock increases. If the increase in the real interest rate is permanent, capital stock converges toward a new and lower long-run level.

2.3.3. Dynamic analysis of the linearized system

At this point, we need to identify the steady state vector. Equation (24) provides a value for long-term capital stock. At the steady state $R_t = R_{t+1}$. Therefore:

$$F_k(\overline{k}) = r^* \Rightarrow \overline{k} = F_k^{-1}(r^*) \tag{33}$$

To compute the value of the real exchange rate in the steady state, we insert this result in equation (32) at the point: $k_{t+1} = k_t = \overline{k}$, $R_t = \overline{R}$. After simplifications, we obtain the following value for the long-run real exchange rate:

$$X(\overline{R}) = \frac{\tau(1-\Theta)-1}{\Theta} F(\overline{k}) \rightarrow \overline{R} = X^{-1}\left\{\frac{\tau(1-\Theta)-1}{\Theta} F(\overline{k})\right\} \tag{34}$$

Since the functions of *F* and *X* are monotonic and concave, their inverses allow us to compute steady-state solutions (equations 33 and 34). The two first-order-difference equations can be linearized in the neighborhood of their long-term values.

We must observe that while the long-run value of capital stock is independent of the tax rate, the long-run value of the real exchange rate is influenced by the tax rate. At equilibrium, whatever the time horizon considered, the higher the tax rate, the lower the money supply and consumption. So, a higher level of exports, accompanying reductions in consumption, will correspond to a depreciated real exchange rate. Thus it is clear that fiscal policy may have a significant influence on economic patterns, even in the long run, by turning the economy toward or away from exports.

As agents are assumed to have perfect foresight, the model can be solved by writing the two equations backward. In the long run $F_{\overline{k}} = \overline{r} = r^*$. A Taylor series expansion of equations (32)

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and (24) in the neighborhood of $\overline{R}, \overline{k}$ leads to the expressions below.[14]

$$k_t = \left[1 + r^* - r^*\tau(1+\Theta) \right] k_{t-1} + \Theta X_{\overline{R}} R_{t-1} + cst \tag{35}$$

$$R_t = \left(1 + \frac{\Theta \overline{R} X_{\overline{R}} F_{\overline{kk}}}{1+r^*} \right) R_{t-1} - \left[\left(1 - \left(\frac{1+\Theta}{1+r^*} r^*\tau \right) \right) F_{\overline{kk}} \overline{R} \right] k_{t-1} + \frac{\overline{R}\overline{k}}{1+r^*} \tag{36}$$

In matrix form, the linear system becomes:

$$\begin{bmatrix} k_t \\ R_t \end{bmatrix} = \begin{bmatrix} a_0 & a_1 \\ b_0 & b_1 \end{bmatrix} \begin{bmatrix} k_{t-1} \\ R_{t-1} \end{bmatrix} + \begin{bmatrix} a_2 \\ b_2 \end{bmatrix} \tag{37}$$

with: $a_0 = 1 + r^* - (\Theta+1)r^*\tau$; $a_1 = \Theta X_{\overline{R}}$; $b_0 = (1+r^* - (\Theta+1)r^*\tau)\dfrac{\overline{R}F_{\overline{kk}}}{1+r^*}$; $b_1 = \Theta X_{\overline{R}} \dfrac{\overline{R}F_{\overline{kk}}}{1+r^*} + 1$

In the rest of the paper, we consider the case where $\Theta < -1$, as assumed in the previous sections.

The characteristic polynomial of the above matrix is: $P(\lambda) = \lambda^2 + (-b_1 - a_0)\lambda + a_0 b_1 - a_1 b_0$

The values of the characteristic polynomial for $\lambda = 1$ and $\lambda = -1$ are, respectively:

$$P(1) = - \frac{\overline{R}F_{\overline{kk}} \Theta X_{\overline{R}}}{(1+r^*)} < 0 \text{ and } P(-1) = 3 + \frac{(1+r^* + \overline{R}F_{\overline{kk}} \Theta X_{\overline{R}})}{1+r^*} - 2(\Theta+1)r^*\tau + 2r^* > 0$$

From the signs of P(1) and P(–1) we conclude that the system is unstable, and the steady state is a saddle. We verified these conditions for any tax rate between zero and one. Turning to fiscal policy, it appears that the tax rate selected by the government can magnify or diminish the impact of a change in the real exchange rate on capital accumulation. The eigenvector associated with the characteristic root (λ) corresponding to the stable path can be defined by the following equation:

$$v_1 = - \left[\frac{-(\Theta+1)\tau r^* + r^* + 1 - \lambda(\tau)}{\Theta X_{\overline{R}}} \right] u_1 \tag{38}$$

If $\Theta < -1$ and for all positive values of $\lambda < 1$, the expression in brackets is negative, with the consequence that the eigenvector slope corresponding to the stable path is positive. Thus,

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[14] X_v, F_w denote derivatives with respect to variables *v* and *w*.

along the stable path an increase in capital stock is followed by depreciation of the real exchange rate. This mechanism relies on the fact that capital increases as the foreign real interest rate falls. That is one of the reasons why if the interest rate parity holds the real exchange rate depreciates, other things being equal, and a given value of the real exchange rate in the next period (24). But, as we have already seen in the previous section, in a fixed exchange rate regime a tax increase triggers an increase in exports. This effect is also included in relation (38).

To strengthen this result, we experimented with numerical simulations.[15] These show that for relevant values of parameters, roots are positive. The derivative of the eigenvector slope with respect to the fiscal ratio is also positive, but its value is small with respect to the tax rate. As a consequence, a tax increase will raise the numerator of the above equation (38) and will push the ratio up.

In conclusion, with a fixed exchange rate regime, an active fiscal policy designed to reduce external debt and promote exports should gradually raise the tax rate until the desired export level is reached. Used in that way, fiscal policy may be an efficient way to promote macroeconomic stability. In the transition period it encourages convergence toward long-run equilibrium, while in the long run it modifies the distribution of exports and consumption, private and public.

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[15] A program written using MAPLE software is available on request.

3. Empirical investigations

The objective of our empirical investigations is to estimate the parameters involved in our dynamic model. Our ultimate purposes are to test the model's ability to explain Argentina's currency board experience and to measure the dynamic effects of changes in fiscal policy and foreign real interest rates.

The model, based on nonlinear simultaneous equations, can be written in the following form:

$$k_{t+1} = (1-\tau)F(k_t) + k_t + \Theta\big[X(R_t,W) - \tau F(k_t)\big]$$
$$\rightarrow \frac{\Delta k_t}{k_{t-1}} = (1-\tau)\frac{y_{t-1}}{k_{t-1}} + \Theta\left[\frac{X(R_{t-1},W)}{k_{t-1}} - \tau\frac{y_{t-1}}{k_{t-1}}\right] \tag{39}$$

$$R_t = \frac{1+r^*}{1+F_{k,t}}R_{t+1} \rightarrow \log(R_t) = r^* - F_{k,t} + \log\big(R_{t+1}\big) \tag{40}$$

To estimate equation (39) we assume that exports expressed in constant prices are a function of the real exchange rate (*R*) and world demand (*WD*). Their relationship is given in a linear logarithmic expression:

$$\log(X_t) = x_0 + x_1 \log R_{t-1} + x_2 \log(WD_{t-1}) + SV_t \tag{41}$$

in which:

- *SV* denotes seasonal dummies.
- *R* is the effective real exchange rate released by the International Monetary Fund. The nominal exchange rate gives the amount of local currency in foreign currency terms. An increase in *R*, for example, corresponds to a depreciation that would be likely to improve exports.
- *WD* is a world demand index measured by imports by the member states of the Organisation for Economic Co-operation and Development.
- x_0 is the intercept.

Our reduced form defines a backward–forward dynamic system. Estimating the forward equation for the real exchange rate is done by introducing an ad hoc expectation process for the real exchange rate. The basic idea is to consider that the future real effective exchange rate, *REER (R $_{t+1}$)*, stabilizes exports (the level of which is given in equation 41) over the long run at the steady state ($\log(X_{t+1}) = \log(X_t)$).

Therefore the *REER* equation is written as follows:

$$\log(R_t) = r_{us,t} - \left[a \frac{y_t}{k_t} \right] + \delta + \left[\frac{1}{x_1} \left(\log(X_t) - x_2 WD_t - x_0 \right) \right] + SV_t \tag{42}$$

where:

- $r_{us,t}$ is the real U.S. interest rate (the Fed Funds rate minus a three-month centered moving average of the rate of growth of the U.S. consumer price index).

- δ is the capital depreciation rate.[16]

- $a.y_t / k_t$ is the marginal productivity of capital (a is the exponent of the Cobb-Douglas function).

According to exports equation (41), the second term of the right side of equation (39) is the value of the REER required to maintain exports at the same level in the next period.[17]

The estimated equation for the rate of growth of capital is very close to the theoretical equation:

$$\frac{k_t - k_{t-1}}{k_{t-1}} = \Theta \left[\frac{X_{t-1} - tx_{t-1} y_{t-1}}{k_{t-1}} \right] + \frac{(1 - tx_{t-1}) y_{t-1}}{k_{t-1}} - \delta + c_0 + SV_t \tag{43}$$

where tx_t is the exogenous tax rate.

Finally, the form of the production function is assumed to be:

$$y_t = g_t^{1-a} k_t^{a} \tag{44}$$

Since parameter (a) is estimated from equation (39), the index of exogenous efficient labor units (g_t) can be computed directly by solving (44) for g_t:

$$g_t = \left(\frac{y_t}{k_t^{a}} \right)^{\frac{1}{1-a}} \tag{45}$$

Thus the production function is used to simulate y_t at each period of time.

The set of equations (41), (42), and (43) is estimated using the nonlinear least squares system. Estimation results are presented in table 3.1. All coefficients have the expected sign and are very precisely estimated, using robust standard errors calculation. The elasticity of exports

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[16] The capital stock time series is computed by adding gross investments data and using an initial value given in the Argentina Central Bank database. We used a quarterly depreciation rate $\delta=0.01375$ in order to obtain the same profile as the annual series given in the database.

[17] $\log(X_{t+1}) = x_0 + x_1 \log REER_t + x_2 \log(WD_t) + SV_t = \log(X_t)$. Solving for $REER_t$ yields the expression in brackets.

with respect to relative price (2.18) and world demand (1.64) are relatively high. Moreover, the estimated elasticity of production with respect to capital in the Cobb-Douglas specification (0.33) is very close to the value expected in standard studies. The estimated value of the key parameter Θ is unambiguously negative and less than –1.

Table 3.1   Estimation of equations 41–43

Using nonlinear least squares system

Coefficients	Estimates	Standard error	T-stat
x_1	2.18464	0.28178	8.5915
x_2	1.64126	0.00718	242.3771
a	0.33055	0.03944	8.2536
Θ	−1.42972	0.102373	−13.6523
x_0	0.489195	0.687573	0.71148
c_0	−0.07861	0.000872	− 89.9925

Nonlinear system estimation
  Robust standard error calculations with flat window and 4 lags
Observations
  Quarterly data from 1991:04 to 2001:03
  Usable Observations   40
Dependent variable LREER
  Centered R²   0.5288   R Bar²   0.5406
  Uncentered R² 0.5821   T x R²   23.286
Dependent variable XR
  Centered R²   0.8086   R Bar²   0.8134
  Uncentered R² 0.9998   T x R²   39.992
Dependent variable TVK
  Centered R²   0.7099   R Bar²   0.709942
  Uncentered R² 0.8379   T x R²   33.519

Using *in-sample* historical values for world demand, productivity, and the U.S. real interest rate, and *out of sample* observations (from the third quarter of 2001) of the same series, a dynamic simulation of the model demonstrates that the nonlinear procedure we adopted is appropriate (figure 3.1). Correlation coefficients between observed and simulated time series total 0.992 for GDP, 0.756 for REER, 0.997 for capital stock, and 0.797 for exports.

To learn the dynamics of the model we simulated a permanent 1 percent shock to the tax rate and another shock, also 1 percent but lasting for just one period, to the foreign real interest rate (figure 3.2). The panels in the figure show that an increase in the tax rate of one percentage point exerts a slight stimulus on capital stock (0.6 percent), at least in the short term, while causing a maximum depreciation of 0.7 percent in the REER. In the long run, these variables converge toward their steady-state values, with capital unaffected since the REER remains depreciated. Given the elasticity of exports with respect to the real exchange rate, we infer that the dynamic path of exports is the same as that of the exchange rate, though at a larger order of

magnitude. This implies that an increase of one percentage point in the tax rate leads to an increase (about 1.4 percentage point) in exports over the medium and the long run.

The responses following a transitory shock in the foreign real interest rate (returning to its initial level after one period) are instructive. During the dynamic transitional period, capital accumulation decreases, and the real exchange rate depreciates, causing a rise in exports. These effects are not symmetric with those observed in the case of a tax increase—capital moves adversely in both cases.

Figure 3.1   Dynamic response of Argentina's GDP, real exchange rate, capital stock, and exports to simulated shocks

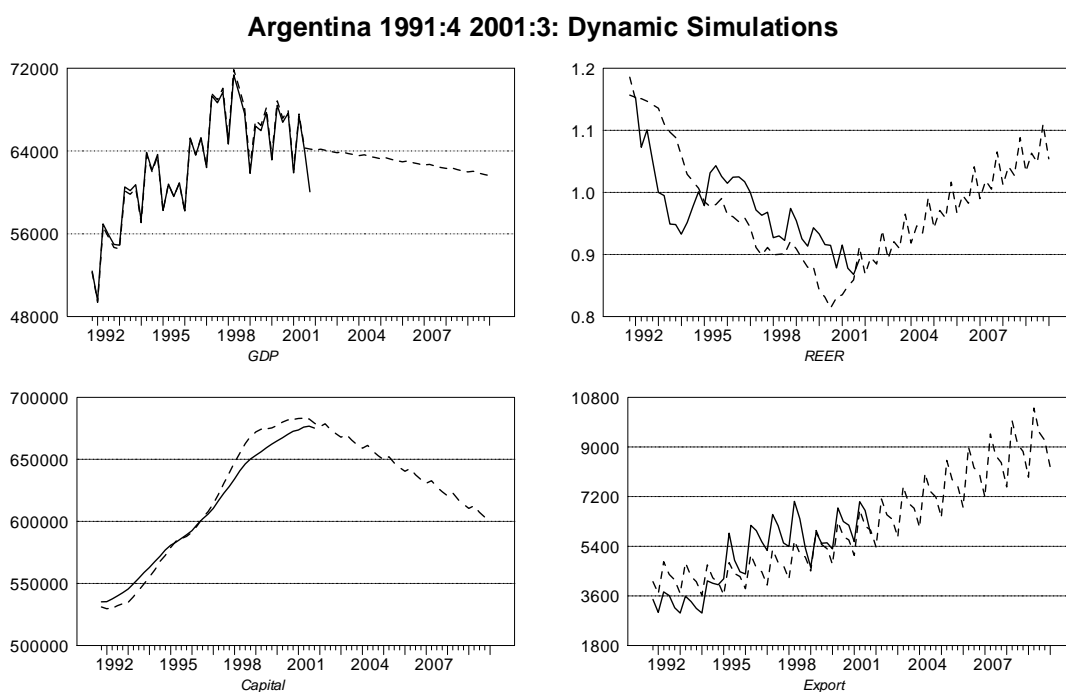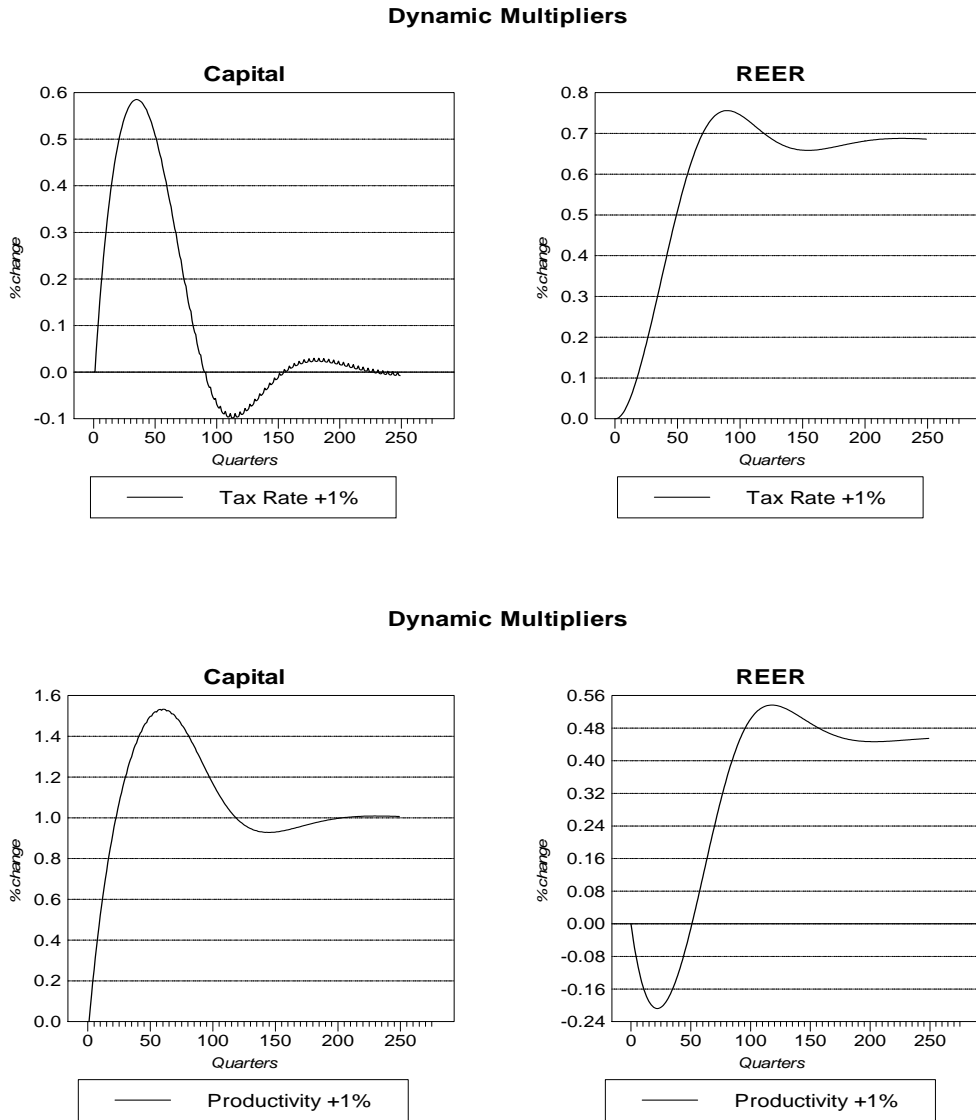**Bold line: actual values Dash line :simulated values in sample and out of sample**
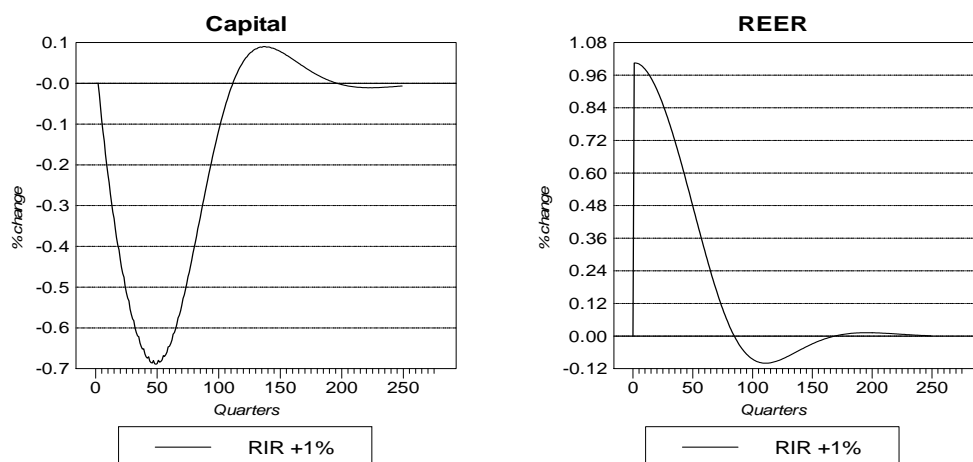

Argentina 1991:4 2001:3: Dynamic Simulations

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Figure 3.2   Dynamic multipliers in Argentina

Percent change

Dynamic Multipliers

Dynamic Multipliers

Dynamic Multipliers

Capital

REER

4. Conclusions

The model proposed in this paper depicts a small to medium open economy that produces a single domestic good and trading with the rest of the world. The intertemporal optimization process leads, under market equilibrium constraints, to a reduced set of two dynamic equations describing the movements of the real exchange rate and capital accumulation. The money market equilibrium plays a major role in those movements insofar as the optimal rate of growth of the money supply driving adjustments in the balance of payments is fixed by the economy's structural patterns in the short run and by foreign inflation in the long run.

The model identifies two main structural patterns: the weight of imports, on the one hand, and the weight of public expenditures, on the other. The comparative weight of the two variables conclusively explains adjustments in the money supply—that is, the process of adjustment of the balance of payments. Other things being equal, the money supply increases faster when the weight of public expenditures exceeds that of imports. In this case, changes in the quantity of money exert a stronger stimulus on government spending (which induces a public deficit, capital inflows, and an increase in the supply of money) than on imports (which induce a current account deficit, a drawdown of external reserves, and a reduction in the money supply).

In other words, with a fixed exchange rate regime controlled by the monetary authority, the interaction between fiscal and monetary policies depends on the weight of the public sector

vis-à-vis the share of imports in total consumption.

If goods and services provided by the government outweighed imported goods, an increase in private consumption would automatically raise the money supply because the drop in foreign assets. Tax rates would be the government's only remaining instrument of economic policy, given the endogeneity of the money supply. For example, if private consumption led to an increase in the delivery of public services, a tax increase would be needed to maintain the balance of payments.

On the other hand, if the share of imports in the economy were greater than the share of public expenditures, an increase in domestic consumption would reduce the money supply (to maintain equilibrium in the balance of payments). A tax cut would therefore be necessary to offset the consumption effect and maintain the money supply.

Adapted to meet econometric standards, the model was applied to the Argentinean economy during the country's decade-long experience with a currency board—a vivid case of economic policy restriction. Indeed in a hard peg regime authorities wishing to diverge from the natural dynamic path of their economy (to accelerate convergence with long-run equilibrium, for example) have only fiscal policy at their disposal.

Econometric estimates confirm the sign of the parameters and thus uphold the theoretical analysis in the case of Argentina during the currency board, when public spending was more significant than imports in the composition of output. What this means for other countries is that, with a fixed exchange rate regime, a fiscal policy designed to shrink external debt and promote exports might consist of gradual increases in the tax rate until a desired level of exports was reached. In this sense, fiscal policy may be an efficient instrument to promote macroeconomic equilibrium because, in the transition period it encourages convergence toward long-run equilibrium, and, in the long run, modifies the distribution between exports and consumption, private and public.

To explore the dynamics of the model we simulated a permanent shock of one percentage point to the tax rate and a transitory shock of like magnitude to the foreign real interest rate. The simulations show that an increase of one percentage point in the tax rate exerts a slight effect on capital stock, at least in the short term, and causes the REER to depreciate. In the long run, if no action is taken to affect the money supply, the real exchange rate will stray from its long-run value. This means that fiscal policy can be used to move the economy toward a desired real

exchange rate.

In addition, given the elasticity of exports with respect to the real exchange rate, we conclude that exports react similarly to the exchange rate, although with a higher order of magnitude. This implies that an increase the tax rate will provoke an increase in exports over the medium and the long run.

Finally, a transitory shock to the foreign real interest rate will decrease the stock of capital and encourage exports. But the effects are not symmetric with those observed for a tax rate increase, since capital moves adversely in both cases.[18]

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[18] Volatility of foreign interest rates does not seem to have been the main cause of the decline in capital stock in Argentina, since the U.S. interest rate remained quite stable after 1995.

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