Does fiscal policy matter in a currency board regime? The case of Argentina

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Some emergent economies have adopted a currency board as an attempt to increase the credibility of monetary authorities and therefore attract foreign investment with the aim of achieving a balance of payments equilibrium and balance the lack of domestic saving by capital inflow.
This paper investigates the links between indebtedness, balance of payments equilibrium, and economic growth, in an optimizing monetary endogenous growth model with imperfect capital mobility under a currency board regime.
We show that in a currency board regime, the fiscal policy plays a major rule influencing the dynamic path of a small open economy. The impact of the fiscal policy on aggregates is assessed in the case of the Argentina currency board experience implementing a VAR modelling approach.

1 Introduction

Emergent economies have often adopted a fixed exchange rate regime as an attempt to increase the credibility of monetary authorities and therefore attract foreign investment with the aim of achieving a balance of payments equilibrium and compensating for the lack of domestic saving with capital inflows. Unfortunately, most of them faced recurrent balance of payments crises and consequently are unable to maintain a fixed exchange rate, leaving exchange rate stabilization to the market. One of the main reason why balance of payment crises take place so frequently is that governments do not commit themselves to respecting rigorous fiscal and monetary rules. Therefore, private agents will feed devaluation expectations until the foreign exchange reserves will be exhausted.

In the light of recent research on currency crises, setting monetary rules, like renuncing to seignorage and making the supply of domestic credit consistent with the long run output growth rate, are necessary to maintain a fixed exchange rate[1]. Moreover, a recent strand of thought suggests that, in addition, the present value of budget surpluses consistent with the pegged rate must be integrated in the fiscal policy program[2].

In the nineties some open economies, facing international monetary instability (Argentina, Bulgaria), sometimes operating in post war conditions (Bosnia), or just abandoning a central planned system, have decided to reduce the scope of the monetary policy by adopting a currency board regime. A currency board is a fixed exchange rate regime in which a tight link exists between foreign reserves and money creation: considering recent experiences in Argentina or Bulgaria, for instance, the coverage ratio should be 100%[3]. The monetary discipline implied by this agreement can broadly be viewed as a mean to rule out the depletion of foreign exchange resources due to ongoing expansion of domestic credit.

Since the first currency board arrangement up to the most recent in Bosnia, 80 currency boards are operating or have been operated in small size countries as well as medium size ones[4]. One may think, considering historical stylized facts, that the currency board remains a means of achieving a stable monetary standard. However, if the performance of currency boards in

[1] These points are discussed in a quite different theoretical framework by Alberola and Molinas (2000).

[2] See Daniel (2001) for an interesting fiscal theory of currency crises.

[3] Kopcke (1999).

[4] See for instance the excellent review provided in A.R Ghosh and alii (2000).

terms of inflation and growth in low indebted countries is broadly verified, many issues remain uncertain in the case of quasi currency boards such as Argentina, an indebted country which is not insulated from international financial instability. Thus, the current Argentina crisis seems to be, at least at the beginning, the consequence of a growing foreign debt which was not compatible with an increasing current account deficit and the currency board principle.

Whichever is involved, whether a classical or a currency board, a fixed exchange rate regime raises many questions in the field of economic growth theory. Firstly, few papers have been devoted to the analysis of the balance of payment equilibrium problem in the context of monetary optimal growth models[5]. However, under a fixed exchange rate regime and PPP hypothesis, the money supply is endogenous and domestic prices grow at the same rate as do foreign prices. Therefore in a money-in-utility function setting, the agents' welfare will depends on the country's ability to exhibit a balance of payments surplus.

Secondly, macrodynamic analysis of a currency board under a debt sustainability constraint, as far as we know, has not been yet developed. Among others, questions arising concern first the interest rate level which, due to the risk premium, is expected to be notably higher than abroad. What should be the consequence of a durable interest rate differential on growth rate and debt even if price stability is achieved?

Thirdly, considering that in a currency board, monetary authorities abandon their autonomy, does fiscal policy matter to control the time path of the economy, from theoretical as well as empirical perspectives? This issue is widely developed in the following sections.

This paper is an attempt to stress these issues. It is organized as follows. The second section introduces stylized facts on Argentina .The third section presents an optimal monetary growth model for an open economy under a currency board. This section emphasizes the links between fiscal policy, monetary constraints and growth. The fourth section develops an empirical application on the currency board experience in Argentina. The approach is based on cointegrated VAR methodology.

The fifth section concludes.

[5] Chang and Tsai (1998) analyze an optimizing monetary model of open economy under PPP hypothesis, assuming capital immobility and equilibrium in the government budget balance. More recently, Daniel (2001) arises this question under the restrictive hypothesis of an exogenous endowment income.

Other papers, such as Turnovsky (1996) and Normandin (1999), deal with fiscal policy issues in a small open economy without money.

2 ANALYSIS OF THE ARGENTINA CASE

Poor economic management and high volatility characterized the Argentinean economy during the 70s and 80s. The public sector was seriously deteriorated and the confidence in the financial sector was severely eroded, as reflected by a large volume of savings held abroad. Both the public and private sectors were mainly being financed with external funds, which led to the 1982 debt crisis. On the other hand, excessive monetary creation led to an episode of hyperinflation in 1989. Failed stabilization attempts during the 80s revealed the fact that serious structural imbalances were lying behind high fiscal deficits and current account imbalances.

The Convertibility Plan that was launched in 1991, with the establishment of a currency board arrangement, was accompanied by a sweeping set of reforms intended to alter the monetary system, liberalize trade, improve fiscal policy and reform the public sector. The banking system was strengthened through improvements in regulation and supervision. Impressive improvements in the banking regulation system, coupled with the hard peg, contributed to maintaining high shares of dollar deposits and loans in dollars. Tax reforms removed many distortions, a new federal public sector financial management system was implemented, health and education public expenditures were decentralized to the regions and the scope of the public sector was reduced through privatizations.

The results observed during the 90s as a result of this reform package, were initially considered to be quite dramatic by international standards. Not only did the size of the Argentinean economy expanded from $141 billion in 1990 to $282 billion in 1999, but poverty was also reduced from a peak of 41% in 1989-90 to 29% in 2000. Inflation was kept at low levels and the total external debt was reduced from almost 100% of GDP in 1989 to 51% of GDP in 2000.

However, three types of endemic problems persisted during the 90s. First of all, raising income inequality, high unemployment, low investments in education, health and infrastructure, inadequate safety nets and regional disparities point to the fact that the benefits of growth were not shared by all.

Secondly, a number or structural rigidities persisted mainly as a result of an incomplete transformation of public institutions, low levels of transparency and accountability in the public sector, increased fiscal disparities in the provinces, and an excessively regulated labor market with still high payroll taxes and inadequate coverage by health insurance and pensions.

Thirdly, the domestic capital market remained shallow, with low domestic saving levels and an increased dependence on international capital markets, aggravated by the effects of the Tequila and Russia/Brazil crises.

As a result of all these country-driven factors, country risk perceptions by the markets remained high, thus translating into an increased cost of capital, affecting negatively all sectors of the economy. The serious deterioration of capital flows to Argentina that followed at the end of the decade and during 2000-2001 acted as an amplifier of the domestic factor effects.

What was the role of the currency board in these episodes? Argentina's real effective exchange rate (RER, weighted with all trade partners) experienced a considerable appreciation when the currency board was established in 1991 and through the 90s, affecting negatively exports performance and therefore the current account. However, this appreciated RER was not interpreted as a sign of any imbalance but rather as a result of apparent increased traded-goods productivity and also considered for some time as the adequate equilibrium level to maintain a sustainable long run foreign assets position.

The crisis that precipitated in 2001 revealed, however, that observed productivity gains had been only a temporary reaction to the reform package introduced in 1991 and that it was not possible to achieve the desired net foreign assets position. High current account deficits due to increasing private and public sector imbalances, and decelerated growth contributed to a an escalation of external liabilities relative to GDP in 1999-2001.

Domestic imbalances were aggravated by a deterioration of the terms of trade and an appreciation of the US dollar in the late 90s, both factors contributing to the RER appreciation, since the currency peg did not allow for any nominal adjustments.

With the exchange rate being fixed and a decline in net foreign assets, severe deflation would have been the only possible mechanism for RER adjustment. However, this adjustment was only feasible to a small extent, for both economic (downward price and wage rigidities) and political reasons (unemployment and social disparities already high).

The rigidities imposed by the choice of currency regime appear to be clear in the ex-post analysis. However, during the 90s, the very same currency peg allowed for "hiding" deviant fiscal behavior behind initially external financing of the deficits with no devaluation, and later by private sector debts as a result of the pressure in the domestic markets and a loss of foreign reserves. The fiscal reforms introduced in 1991 did not reverse the fiscal deterioration trends that preceded the adoption of the hard peg. Those pre-conditions may have played a more important role than what the data allowed to show during the 90s.

In spite of the fiscal surpluses achieved during the beginning of the 90s, partly due to increased privatization receipts and the Brady plan deal, fiscal balances both at the federal and provincial level deteriorated gradually from 1994 through 2001, as a result of several factors. Firstly, the fiscal reform initiated in the 90s did not eliminate important fiscal constraints as a result of hidden fiscal liabilities associated with the pension system, arrears and provincial expenditures, which only crystallized after 1994.

Second, fiscal policy was clearly pro-cyclical, contributing to aggravate the economic cycles. A significant expansionary stance during the boom years was followed by a deterioration of the government overall balance during the slowdown period. During that time, the tax increases and expenditure cuts that were introduced only contributed to aggravate the recession.

>From the viewpoint of the public debt sustainability, the currency peg choice became the pernicious instrument that triggered the worst possible scenario: while growth rates were decreasing in a deflationary context, implicit public debt interest rate were increasing as a result of higher foreign liabilities and the perception of the markets, which did not overlooked the imbalances and hidden liabilities behind an appreciated RER.

The analysis also illustrates that a currency board without fiscal stability may lead to an appreciation of the real effective exchange rate, which results, into current account deficits and also a loss of foreign reserves, which can trigger a financial crisis.

In this paper we explore the links between indebtedness, balance of payments equilibrium, and economic growth, in an optimizing monetary endogenous growth model with imperfect capital mobility and hard pegged exchange rates. Changes in the levels of tax revenue to GDP (used as the main fiscal policy variable) contribute to the imperfect mobility of capital by influencing the spread of interest rates, net foreign indebtedness and the financial risk premium, and therefore the real exchange rate as a result.

On the theoretical level we find out that the real exchange rate time-path is unstable and the fixed exchange rate regime is unsustainable which means that the dynamics of the model degenerate. The initial conditions are crucial to reach the steady state, and must be respected at each moment of time. Otherwise, the real exchange rate diverges from the long run equilibrium values, promoting the emergence of the crisis.

In a currency board, fiscal policy becomes the only tool the government can use to achieve the stability of the real exchange rate and growth objectives. The model allows identifying optimal tax revenues to GDP ratio that ensures the stability of the real exchange rate. In order to reach this goal, the debt to GDP ratio must remain constant, at the levels existing when the currency board regime starts.

The analysis of the Argentina case shows that using fiscal policy, as the only tool was not sufficient due to structural difficulties to stabilize the overall government budget balance. In addition, these results reflect other difficulties undermining the stability of the currency board such as domestic supply shocks, externally determined real exchange shocks, and the financial risk premium as perceived by the markets.

Fiscal policy adjustments have not played a significant role on the evolution of GDP during the years of the currency board regime. Most of the GDP fluctuations have been caused by domestic supply shocks and external shock on US\ real interest rate. Although tax reforms generated a positive and significant response in all variables, they do not seem to have played a major role in the dynamics of GDP.

A similar conclusion applies to the dynamics of foreign exchange reserves and the real exchange rate, whose fluctuations seem to have depended heavily on externally determined shocks and to some extend on fiscal and domestic supply shocks (about 25% each).

3 The model

In this simple one good model of endogenous growth, aggregate output y is determined by the capital stock k, using a simple linear technology[6]:

$$y_t = \alpha . k_t \tag{1}$$

Domestic and foreign prices (P, P^*) are linked by a PPP relationship. Under a fixed exchange rate regime, the PPP hypothesis implies that domestic prices are constant since we assume that the rate of foreign inflation is zero. Thus, normalizing to unity the foreign price index ($P^* = 1$), the domestic prices index is equal to the pegged nominal exchange rate (S_0):

$$S_t = P_t = S_0 = P_0 \qquad \forall t \tag{2}$$

Let r the real interest rate, τ the constant rate of tax on domestic output and since α is the constant marginal productivity of capital, firm profit maximization leads to adjust the real interest rate to the after tax marginal productivity of capital:

$$r = \alpha \left(1 - \tau\right) \tag{3}$$

[6]Small letters denotes real values and capital letters denotes nominal values.

Equation 2 is the no arbitrage condition between physical and financial assets that ensures the portfolio equilibrium for domestic assets. Thus, in what follows, an increase in the tax rate must be considered as equivalent to a decrease in the domestic real interest rate.

3.1 Money supply and the financial market

We assume that the economy faces an imperfect world capital market. So, on the financial market the equilibrium is obtained when the real interest rate parity - which under the fixed exchange rate, constant foreign prices index and PPP hypotheses is equivalent to the nominal one - holds, taking account of a risk premium proportional to the net debt over total wealth ratio[7]:

$$r = r^* + \beta \frac{f_t - b_t}{a_t} \tag{4}$$

r^* is the given real interest rate prevailing internationally, f_t is the government debt : foreigners are supposed to hold the overall home government debt and r represents the interest rate at which the government can borrow from abroad given the risk premium. b_t represents the foreign assets held by private domestic agents: considering there is no financial domestic market, the private sector only accumulates foreign assets in addition to money and physical capital. β is a parameter measuring the investors risk aversion and a_t is the domestic wealth, to be defined latter.

The preceding equation can be interpreted as an upward-sloping schedule for net domestic debt:

$$f_t - b_t = \left(\frac{r - r^*}{\beta} \right) a_t \tag{5}$$

The money supply M_t in a currency board is endogenous and defined by its counterpart, namely foreign reserves (R_t) expressed in domestic currency:

$$\frac{M_t}{S_0} = \frac{R_t}{S_0} \tag{6}$$

In this case, the only instrument the monetary authorities have at their disposal is the bank reserves requirement which can significantly modify the credit multiplier. Herein after, we assume that the multiplier is fixed and set to one. So, the central bank does not control the money supply which is determined by the balance of payments equilibrium.

[7] See for instance Turnovsky (1997).

3.2 Balance of payments equilibrium and wealth accumulation

The balance of payments equilibrium can be obtained by adding the private wealth constraint and the public sector dynamic of the debt.

The private sector wealth constraint may be written as follows:

$$\frac{1}{S_0}(R_{t+1} - R_t) + (k_{t+1} - k_t) + (b_{t+1} - b_t) = \alpha k_t - \tau\alpha k_t - c_t + rb_t \quad (7)$$

The accumulation of the private sector wealth, broken down in money (R), capital (k), and foreign assets (b), is defined by the surplus of income (domestic output αk and interest earnings on foreign assets rb) over consumption c and taxes on output $\tau\alpha k$. Notice that, for the sake of simplicity, government does not tax interest earnings on foreign assets.

Assuming proportional tax on output, the government debt motion is the following:

$$f_{t+1} - f_t = rf_t + g_t - \tau\alpha k_t \quad (8)$$

where g represents government consumption expenditures.

Aggregating both constraints leads to the balance of payments global account, which is equal to the rate of change of the foreign reserves :

$$R_{t+1} - R_t = [\alpha k_t - (k_{t+1} - k_t) - c_t - g_t - r(f_t - b_t) + (f_{t+1} - f_t) - (b_{t+1} - b_t)]\, S_0 \quad (9)$$

where c_t is the aggregate consumption. Since population is assumed to be constant, infinitely lived and normalized to one, this aggregate consumption level (and thus the government consumption expenditures) is identical to the consumption of the individual agent.

We define the domestic wealth as the sum of real money balance $\left(\frac{R}{S_0}\right)$, physical capital k and net foreign assets$(b - f)$:

$$a_t = \frac{R_t}{S_0} + k_t + b_t - f_t \quad (10)$$

which, differentiating with respect to time implies:

$$a_{t+1} - a_t = \frac{(R_{t+1} - R_t)}{S_0} + (k_{t+1} - k_t) + (b_{t+1} - b_t) - (f_{t+1} - f_t) \quad (11)$$

If the upward-sloping schedule relationship is substituted for the net the domestic debt equation (equation 5) in the wealth definition (equation 10) a simple expression emerges:

$$a_t \left(1 + \frac{r - r^*}{\beta}\right) = \frac{R_t}{S_0} + k_t \tag{12}$$

Finally, using equations 11, 5, 12 and 9 we arrive, after simplifications, to the following aggregate wealth constraint, i.e. the accumulation of wealth consistent with the balance of payment equilibrium:

$$a_{t+1} - a_t = \Omega a_t - \alpha \frac{R_t}{S_0} - c_t - g_t \tag{13}$$

with: $\Omega = \alpha + (\alpha - r)\left(\frac{r-r^*}{\beta}\right)$ or, using equation 3: $\Omega = \alpha\left(1 + \frac{(\alpha - r^*)}{\beta}\tau - \frac{\alpha}{\beta}\tau^2\right)$

One can note that the proportional tax on output τ has two opposite effects on the wealth accumulation:

- a first order and positive effect $\frac{(\alpha - r^*)}{\beta}\tau$ results from the negative relationship between the interest rate and the tax rate. As a consequence, the interest rate on the debt, that equals the after-tax marginal productivity of capital, decreases in the case of an increase of the tax rate. Thus, the debt pay off reducing favors the wealth accumulation.

- a second order and negative effect $\frac{\alpha}{\beta}\tau^2$ emphasizes that beyond a critical level of the tax rate (say $\tau = 1 - \frac{r^*}{\alpha}$), the net debt becomes negative ($b > f$) since beyond that point $r < r^*$. All subsequent increases of tax rate reduce the earnings on foreign assets and therefore the wealth accumulation. The shape of the curve $\Omega(\tau)$ pleads in favor of an optimal tax maximizing the output growth rate.

3.3 The representative agent problem

The representative agent's intertemporal utility function is assumed to be the following:

$$V_t = \sum_{j=0}^{\infty} \left(\frac{1}{1+\rho}\right)^j \left(\ln(c_{t+j}) + \phi \ln(g_{t+j}) + \gamma \ln\left(\frac{R_{t+j}}{S_0}\right)\right) \tag{14}$$

The objective is then to maximize the log linear intertemporal utility function (V) in which ρ is the time preference parameter, with respect to private and government consumption, and real money balance. Money, by facilitating transactions, is assumed to yield a direct utility which is not captured by bonds which provide only an indirect utility through the income they generate. The introduction of the government spending in the utility function results, at the aggregate level, in a proportional relationship between the private consumption and the public expenditure. This assumption seems to be captured on stylized facts in emergent economies and particularly in Argentina

To achieve a first order optimum, the government is assumed to act as a central planner, maximizing V with respect to c, g and R/S_0 subject to the constraint given by equation 13. Ruling out Ponzi games, this constraint means that at infinity the following condition must be fulfilled:

$$a_t = \sum_{j=0}^{\infty} (1+\Omega)^{-(1+j)} \left(\alpha \frac{R_{t+j}}{S_0} + c_{t+j} + g_{t+j} \right) \tag{15}$$

since:

$$\lim_{T\to\infty} (1+\Omega)^{-T} a_{t+T+1} = 0 \tag{16}$$

The first order condition describes the perfect foresight optimal time path for the households consumption:

$$c_{t+1} = \left(\frac{1+\Omega}{1+\rho} \right) c_t \tag{17}$$

This clearly shows, as expected, a modified Keynes-Ramsey rule, due to the presence of proportional taxes and of an upward-sloping schedule for net domestic debt. Furthermore, the same set of first order conditions gives the following demand for money and government consumption expenditures:

$$\frac{R_t}{S_0} = \frac{\gamma}{\alpha} c_t \tag{18}$$

$$g_t = \phi c_t \tag{19}$$

As a consequence, the rate of growth of the demand for money and government consumption expenditures will be identical to the consumption rate of growth, say $\frac{\Omega-\rho}{1+\rho}$. If the modified interest rate (Ω) is greater than the rate of time preference ρ the agent is relatively patient and finds it optimal to reduce consumption in the short run, allowing it to increase over time. The same conclusion can be drawn about the demand for money.

The influence of the tax rate on the consumption growth rate relies upon the shape of the function $\Omega(\tau)$. Ω and consequently the consumption rate of growth reach their maximum when the tax rate equals $\frac{r-r^*}{2r}$. Below and beyond that threshold, fiscal policy can be adjusted to regulate the output growth rate according to the external financing capacity of the economy.

3.4 Macroeconomic dynamics and long run solutions

The preceding results can be used to obtain the optimal equilibrium time path of the physical capital and thus of the output according to the dynamic characteristics of the model: dynamic stability, steady state and initial conditions.

Firstly, from the definition of wealth (equation 12), the wealth motion (equation 13), and first order conditions (equations 17, 18, and 19) it can be shown that:

$$k_{t+1} = (1+\Omega)\, k_t - \Psi c_t \tag{20}$$

with: $\Psi = (1+\gamma+\phi)\left(1+\frac{r-r^*}{\beta}\right) - \frac{\rho\gamma}{\alpha}\left(\frac{1+\Omega}{1+\rho}\right)$

That is the expression of the time path of physical capital compatible with FOC's of optimization and balance of payment equilibrium. Since cash balance is provided by the balance of payment equilibrium (equation 9), and given the optimal time path of private and public consumption and money demand, under the constraint of the upward-sloping schedule for net domestic debt, equation 20 describe the time path of capital able to adjust money supply to money demand.

The macrodynamic system is made up of a pair of linear difference equations, equation 17 and the equation below (20):

$$\begin{bmatrix} c_{t+1} \\ k_{t+1} \end{bmatrix} = \begin{bmatrix} \frac{1+\Omega}{1+\rho} & 0 \\ -\Psi & (1+\Omega) \end{bmatrix} \begin{bmatrix} c_t \\ k_t \end{bmatrix} \tag{21}$$

The dynamics of the output (respectively, physical capital) in this endogenous growth model results from the equilibrium on the money market. Precisely, 20 defines the equilibrium the money supply and the demand for money. Under a currency board regime, the balance of payments surplus provides the money supply 9. Taking into account the optimal values for private consumption, demand for money and public expenditures, the money market time path is described by 20.

If we put aside the transitional dynamics[8] and just look at the steady state solutions, a quite simple result comes out. At the steady state, all variables must grow at the same rate:

$$\frac{c_{t+1}-c_t}{c_t}=\frac{k_{t+1}-k_t}{k_t}=\frac{R_{t+1}-R_t}{R_t}=\frac{g_{t+1}-g_t}{g_t}=\frac{\Omega-\rho}{1+\rho} \tag{22}$$

It must be emphasized that this common rate of growth depends non linearly on the taxation rate, since $\Omega=\alpha\left(1+\frac{(\alpha-r^*)}{\beta}\tau-\frac{\alpha}{\beta}\tau^2\right)$. Provided that marginal productivity of domestic capital exceeds international real interest rate ($\alpha>r^*$), it is easy to show that the maximizing-growth rate of taxation is: $\bar{\tau}=\frac{1}{2}\left(1-\frac{r*}{\alpha}\right)$. It depends only on the real international interest rate and the marginal productivity of capital.

In order to satisfy this steady state condition, the physical capital rate of growth must be equal to the private consumption rate of growth, say, from equations 17 and 20:

$$\frac{k_{t+1}}{k_t}-1=\frac{c_{t+1}}{c_t}-1\Leftrightarrow\Omega-\Psi\frac{c_t}{k_t}=\frac{\Omega-\rho}{1+\rho} \tag{23}$$

It results that, in order to fulfill the steady state solution, the (constant) private consumption to capital ratio must be:

$$\frac{c_t}{k_t}=\frac{\rho}{\Psi}\left(\frac{1+\Omega}{1+\rho}\right) \tag{24}$$

Nevertheless, up to this point an additional condition is necessary to fix the exchange rate at a sustainable level.

3.5 Economic Policy Implications

In order to further suggest economic policy recommendations, is necessary to point out the initial conditions consistent with the steady state solutions. Therefore, initial conditions and specially the initial real exchange rate value must be fixed in compliance with the intertemporal wealth constraint. Thus, to highlight this point it is necessary to figure out the intertemporal budget constraint (15):

$$a_t=\sum_{j=0}^{\infty}(1+\Omega)^{-(1+j)}\left(\alpha\frac{R_{t+j}}{S_0}+c_{t+j}+g_{t+j}\right) \tag{25}$$

[8] Confer appendix.

Taking the FOC's into account, this leads to:

$$\begin{aligned} a_t &= (1+\phi+\gamma)\, c_t \sum_{j=0}^{\infty} (1+\Omega)^{-(1+j)} \left(\frac{1+\Omega}{1+\rho}\right)^j \\ &= \frac{1+\phi+\gamma}{1+\Omega} c_t \sum_{j=0}^{\infty} (1+\rho)^{-j} \\ &= \left(\frac{1+\phi+\gamma}{\rho}\right)\left(\frac{1+\rho}{1+\Omega}\right) c_t \end{aligned}$$

As a consequence, the transversality condition to be satisfied requires the following initial condition (for $t = 0$) to be held:

$$c_0 = \left[\left(\frac{1+\Omega}{1+\rho}\right)\left(\frac{\rho}{1+\phi+\gamma}\right)\right] a_0 \tag{26}$$

Indeed this condition must be respected at each instant of time so that the macroeconomic system remains on the long run equilibrium path.

We can express this condition on initial consumption in a slightly different way using equation 12 for the definition of wealth and equation 18 for the demand for real cash balance, which leads after simplifications to the steady state condition 24:

$$c_0 = \frac{\rho}{\Psi}\left(\frac{1+\Omega}{1+\rho}\right) k_0 \tag{27}$$

This last relation can be more easily interpreted. Remembering that the macroeconomic framework is based on an AK production function, the average propensity to consume must remain fixed at the initial level. The influence of the fiscal policy through the tax rate channel is not straightforward and difficult to assess. Econometric experiments can only bring out the links between fiscal policy and aggregate consumption for a given value of the physical capital.

>From 18 and solving with respect to S_0, we obtain the equilibrium level for the initial pegged exchange rate, given an initial endowment of external reserves (R_0) and of physical capital (k_0):

$$S_0 = \left[\frac{\Psi}{\rho}\left(\frac{\alpha}{\gamma}\right)\left(\frac{1+\rho}{1+\Omega}\right)\right] \frac{R_0}{k_0} \tag{28}$$

In this fixed price model the left hand side of 28 is nothing else that the real exchange rate since the nominal rate is equal to one in a strict currency board approach. In ordee to be sustainable, a currency board must rely on an initial price level (real exchange rate) consistent with the ratio of exchange reserves to the output.

To put the economy on the long run path, given an initial endowment k_0 and R_0, this initial condition on the exchange rate level S_0 must hold. We must emphasize that the relationship between the initial value of exchange rate and the initial endowment of reserves is close and positive[9].

At last, to complete the economic policy design, it seems necessary to bring out a fiscal rule. If the public debt is not sustainable, the intertemporal equilibrium of the balance of payments 9 does not hold, since we assume that the public debt as a whole is held by foreigners and therefore that the government either cannot issue domestic bonds or money to finance the budget deficit without jeopardizing currency board commitments. This assumption may be considered being too restrictive but, under a currency board regime, the restraints that bear on the macroeconomic policy are very tight and require an active fiscal policy.

The variable f_t represents, as it was indicated above, the government debt held by foreigners. The natural government debt dynamic is the following:

$$f_{t+1} - f_t = r.f_t + \phi c_t - \tau\alpha k_t \tag{29}$$

Since there is an equilibrium relationship between consumption and capital, equation 27 may be rewritten as:

$$c_0 = \Phi(\tau)k_0 => c_t = \Phi(\tau)k_t \tag{30}$$

where: $\Phi(\tau) = \frac{\rho}{\Psi}\left(\frac{1+\Omega}{1+\rho}\right)$
So:

$$f_{t+1} = (1+r)\, f_t + [\phi\Phi(\tau) - \tau\alpha]\, k_t \tag{31}$$

Ruling out Ponzi games implies:

$$f_t = \sum_{j=0}^{\infty} (1+r)^{-(1+j)}\, [\phi\Phi(\tau) - \tau\alpha]\, k_{t+j} \tag{32}$$

[9] The positiveness of this relationship relies on the sign of Ψ that is necessarily positive since consumption is positive

since:

$$\lim_{T\to\infty}(1+r)^{-T} f_{t+T+1}=0 \tag{33}$$

As regards to the forward looking optimization problem, the government must thus enforces the NPG condition:

$$\begin{aligned}
f_t &= \sum_{j=0}^{\infty}(1+r)^{-(1+j)}\left[\phi\Phi(\tau)-\tau\alpha\right]k_{t+j} \\
&= \left[\phi\Phi(\tau)-\tau\alpha\right]\sum_{j=0}^{\infty}(1+r)^{-(1+j)}k_{t+j} \\
&= \left[\phi\Phi(\tau)-\tau\alpha\right]k_t\sum_{j=0}^{\infty}(1+r)^{-(1+j)}\left(\frac{1+\Omega}{1+\rho}\right)^j \\
&= \frac{\left[\phi\Phi(\tau)-\tau\alpha\right]}{1+r}k_t\sum_{j=0}^{\infty}\left(\frac{1+\Omega}{(1+\rho)(1+r)}\right)^j
\end{aligned}$$

The initial government debt must be equal to the present value of primary surplus.

The NPG condition can be solved if we assume $\frac{1+\Omega}{(1+\rho)(1+r)}<1$, that is: $\rho>\alpha\tau\frac{\beta+\alpha(1-\tau)-r^*}{\beta(1+\alpha(1-\tau))}$.

In this case, the initial condition (for $t=0$) reduces to:

$$f_0=\left[\phi\Phi(\tau)-\tau\alpha\right]\frac{(1+\rho)}{(1+\rho)(1+r)-(1+\Omega)}k_0 \tag{34}$$

If this restriction on the underlying parameters is satisfied, the rate of tax on domestic output satisfying the NPG condition can be derived from solving the implicit equation:

$$\tau=\frac{\Psi(\tau)\phi}{\alpha}+\left[\frac{1+\Omega}{1+\rho}-(1+r)\right]\frac{f_0}{\alpha k_0} \tag{35}$$

A quite simple and more intuitive solution can be obtained in the simplest case in which tax rate does not affect after-tax earnings on physical capital, and the real interest rate only depends on the marginal productivity of capital ($r=\alpha$). In this case, the main results of the model holds, substituting α for Ω and for r.

As it concerns the optimal taxation rate, the main consequence of this simplifying assumption is that in the NPG condition, the discounting factor reduces to $\frac{1}{1+\rho}$ instead of $\frac{1+\Omega}{(1+\rho)(1+r)}$, while the optimal tax rate is reduced to: $\tau = \frac{\Psi\phi}{\alpha} + \left(\frac{1+\alpha}{1+\rho}\right)\frac{\rho f_0}{\alpha k_0}$, Ψ being independent of τ.

4 Empirical analysis

4.1 Methodology

In order to investigate the joint dynamic path of the key macroeconomics series outlined in the theoretical framework above, we examine a data system ($\mathbf{z}_t$) composed of the logarithm of US real interest rate (*lusrir*), the logarithm of Argentina real government receipt (*ltax*), the logarithm of Argentina real GDP (*ly*), the logarithm of Argentina central bank external reserves expressed in billions of current pesos (*lres*), the logarithm of the sum of Argentina real households and government consumption (*lcons*) and the logarithm of real effective exchange rate (*lreer*). Because these time series are likely to be integrated of order one $I(1)$ and since we assume that the US real interest rate is strongly exogenous, the model is expressed in a vector error correction model (VECM) form:

$$\Delta\mathbf{y}_t = \sum_{i=1}^{p-1}\Psi_i\Delta\mathbf{z}_{t-i} + \Lambda\Delta x_t + \mathbf{a}\mathbf{b}'\mathbf{z}_{t-p} + \mathbf{m}_1.t + \mathbf{m}_0 + \boldsymbol{\varphi}\mathbf{D} + \mathbf{u}_t \tag{36}$$

where $\mathbf{z}_t$ is the vector of variables in the VAR model (*ltax, ly, lres, lcons, lreer, lusrir*) partioned in $\mathbf{y}_t$, the vector of endogenous variables (*ltax, ly, lres, lcons, lreer*), and x_t, the exogenous variable (*lusrir*); $\Delta = 1 - L$ (L is the lag operator); p denotes the lags length; $\{\Psi_i\}_{i=1}^{p-1}$ are the short-run response matrices; $\mathbf{a}$ is the $(l \times r)$ loading matrix and $\mathbf{b}$ the $(n \times r)$ matrix of cointegrating vectors (r, l and n being respectively the number of cointegrating vectors, the number of series which are not weakly exogenous, and the number of series which cannot be excluded from the cointegrating vector); $\mathbf{m_0}$ denotes the constant and $\mathbf{m}_1$ the trend coefficients, both evenly restricted to enter only in the cointegrating vector; $\mathbf{D}$ is a vector of seasonal and an historical dummy (1995:1) variables, $\boldsymbol{\varphi}$ is the matrix of coefficients associated to $\mathbf{D}$; and $\mathbf{u}_t$ the vector of residuals.

After checking the integration order of the series, we will test some restrictions concerning lags length, the specification of constant and trend, and restrictions on loading matrix and cointegrating vectors, in order to identify long run relationships consistent with the theoretical model.

In a second step, we will compute impulse response functions and error variances decomposition using *ltax*, *ly*, *lres*, *lcons*, *lreer* ordering in an usual recursive Choleski decomposition, to identifying the contemporaneous disturbances: this order of the five Argentina domestic series obeys roughly to the "a priori" restrictions outlined in the theoretical model.

Nevertheless, since the decomposition of variance is known to be dependant on the order of factorization when there is substantial correlation among innovations in series, we will try alternative ordering schemes.

4.2 Data and unit root tests

4.2.1 The data

The data set consists in quarterly observations over the sample period covering the currency board experience (1991:2-2001:2). The US real interest rate is computed by subtracting the annualized five quarter centered moving average of US inflation (US GDP deflator) to the US 3 years bond rate. The price deflator of Argentina macroeconomic series (Total consumption, GDP, Government receipts) is the consumer price index. Argentina central bank external reserves are converted into pesos on the basis of the current Pesos/Dollar exchange rate and are expressed in current value. The data set was retrieved from the International Monetary Funds *International Financial Statistics.*

The following figure plots the series over the main period 1980-2002, the subperiod covered in our econometric analysis being delimited by two vertical lines.

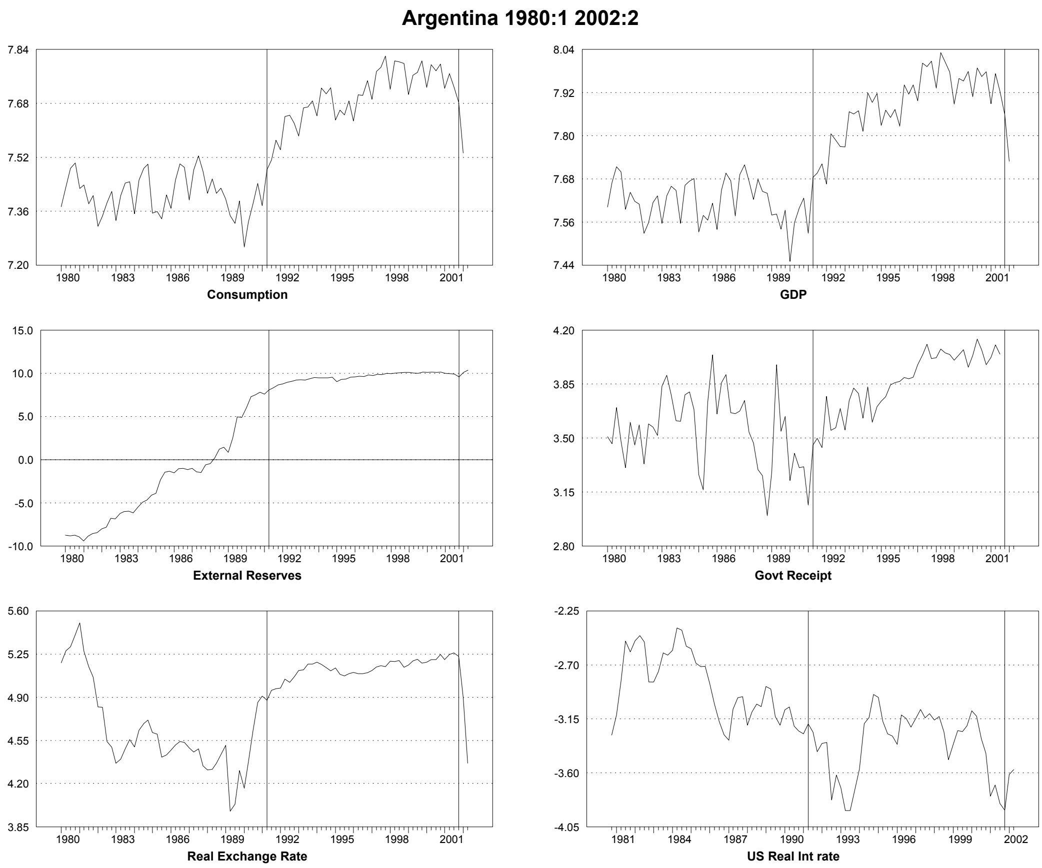

Fig. 1. Plots of the data in logs

4.2.2 Tests for units roots and cointegration rank

Test for units roots are carried out within the main sample period (1980-2001). The results outlined in Table 1 are globally consistent with I(1) hypothesis for all series.

Table 1. Tests for unit roots

Series/test	*lusrir*	*ltax*	*ly*	*lres*	*lcons*	*lreer*
Level						
ADF(τ)	-2.672	-3,822*	-1,675	-0.835	-2.274	-2.871
KPSS	0.130	0.222**	0.205*	0.260**	0.182*	0.202*
First diff.						
ADF(τ)	-7.354**	-5.632**	-3.623*	-3.430	-3.876*	-8.615**
KPSS	0.07	0.033	0.104	0.131	0.047	0.0785

* and ** denotes the rejection of the null at 5% and 1% respectively.

Both tests are carried out using a constant and a linear trend. ADF includes seasonal dummies.

ADF denotes the Augmented Dickey-Fuller test statistics for the unit root null hypothesis versus the trend-stationary hypothesis. Lag length was based on the Akaike criterion.

KPSS denotes the Kwiatkowski, Phillips, Schmidt, Shen test of the null of trend stationarity, with Newey-West bandwidth automatic selection using Bartlett kernel. Asymptotic critical values: 1%: 0.216 5%: 0.146 10%: 0.119

Before examining the cointegration rank, some specification tests about lags length and restrictions on constant and trend must be implemented. Tests results figured out in appendix (tables A and B) are carried out over the sample period 1991:2-2001:3 under a 3 cointegrating relations assumption, using unrestricted constant and restricted trend in table A and two lags in table B.

Using two lags and the restriction on trend, the cointegration rank test is carried out, taking into account the fact that our VAR model contains an exogenous I(1) variable[10]: *lusrir*. Asymptotic p-values reported in table 4 support r=3.

Table 2. I(1) Cointegration analysis

H0:rank<=	Trace test	Prob	
0	179.69	[0.000]	**
1	96.129	[0.000]	**
2	47.116	[0.016]	*
3	19.699	[0.246]	
4	4.6053	[0.658]	

Overall tests lead to restrict our analysis to a VAR I(1), including two

[10]See Pesaran, Shin, Smith (2000).

lags, unrestricted constant, restricted trend and three cointegrating relations.

4.3 Identification of the cointegrating vectors

In order to identify the three long-run relations, we need to restrict some parameters in the cointegrating matrix **b** using some key relationships of the theoretical model.

Firstly, since the theoretical model use the taxation rate as a key variable, we restrict the first cointegrating relation to be the following:

$$ltax = b_{11}.ly + b_{12}.trend + CI_{1t} \tag{37}$$

The idea behind this restriction is that tax receipts in the long run depend on GDP and trend. The discrepancy between long run and current tax receipts (CI_{1t}) may reveal some disturbances in fiscal policy. Under the additional restriction $b_{11} = 1$, this relationship will describes the taxation rate as a trend-stationary process. Nevertheless, since this additional restriction was rejected by the LR test, we leave b_{11} and b_{12} unrestricted. The point estimate of b_{11} is about 1.6, as we shall see later.

The second key relationship in the theoretical model expresses the equilibrium consumption over GDP ratio as a (non-linear) function of the taxation rate and the foreign interest rate. Since the stationary combination of tax, GDP and trend is stated in the first cointegration vector, we identify the consumption function as the following linear long-run equation:

$$lcons = b_{21}.ly + b_{22}.lusrir + CI_{2t} \tag{38}$$

The same remark may extended to the additional restriction on b_{21}: if we restrict this parameter to be equal to one, we obtain a stationary relationship involving the consumption over GDP ratio and the US real interest rate (in log). Nevertheless, this additional restriction is not supported by the data (the point estimates is about 0.45). Moreover, we may emphasize that the sign on b_{22} is not constrained by the theoretical model, and our estimate exhibits a positive value: the point estimate of the elasticity of domestic consumption to foreign real interest rate is about 0.08.

Thirdly, the demand for money is expressed in real terms, subtracting the (log) real exchange rate from the (log) nominal reserves (in pesos).

$$lres - lreer = b_{31}.lcons + b_{32}.lusrir + b_{33}.trend + CI_{3t} \tag{39}$$

We expect b_{32} to be negative and the estimate supports this assumption (point estimate = -0.36). The theoretical model restriction on the unit elasticity of money demand with respect to consumption $b_{31} = 1$ is nevertheless not supported by the data, the point estimate points out a surprisingly high value of about 6.3.

This set of restrictions are sufficient to ensure the (over) identification of the cointegrating matrix.

According to our small sample size of data, we need to increase the number of degrees of freedom introducing in addition some exclusion restrictions on the elements of the loading matrix.

Joint restrictions on the loading matrix (table 4) and cointegrating vectors (table 3) may be tested implementing an LR test (Boswijk, Doornick, 2003): they are not rejected (LR test of restrictions: $\chi^2_{(9)} = 11.140$, significance level : 0.2662).

Tables 3 and 4 figure out estimates and standard errors.

Table 3. The restricted cointegrating vector

Variable	CI_1	CI_2	CI_3
LTAX	1.0000	0.0000	0.0000
LY	-1.6181	-0.4479	0.0000
	(0.1591)	(0.0621)	
LRES	0.0000	0.0000	1.0000
LCONS	0.0000	1.0000	-6.3163
			(0.4392)
LREER	0.0000	0.0000	1.0000
LUSRIR	0.0000	-0.0827	0.3636
		(0.0260)	(0.1041)
Trend	-0.0066	0.0000	-0.0098
	(0.0013)		(0.0028)

Standard errors shown in parentheses

Table 4. The restricted loading matrix

Equation	CI_1	CI_2	CI_3
LTAX	-1.1904	-0.8359	0.0000
	(0.2353)	(0.2181)	
LY	0.0821	-0.2248	0.0000
	(0.0559)	(0.0667)	
LRES	0.2865	-2.0885	-0.3748

	(0.1740)	(0.1694)	(0.0766)
LCONS	0.0000	-0.1923	0.0489
		(0.0538)	(0.0186)
LREER	0.1530	0.0000	-0.0672
	(0.0976)		(0.0398)

Standard errors shown in parentheses

4.4 Impulse responses and errors decomposition

On the basis of the restricted VAR model developed in the previous section, impulse response functions and forward error variance decomposition (full line) and their standard errors at 5% level (dashed line) are computed and presented in figure 2 and 3.

In these estimations, the US real interest rate is introduced as an exogenous variable. The ordering decomposition sets up the series by an increasing order of endogeneity. The sequencing assumed in the theoretical model is the following: first, the level of tax is fixed by the government; second, the GDP reacts instantaneously to a shock on tax policy; third, foreign exchange reserves adjust instantaneously to the two preceding shocks: for instance, a positive supply shock on GDP tends to increase foreign exchange reserves due to the emergence of balance of payment surplus; fourth, according to the optimal level of consumption outlined in the theoretical model, total consumption is assumed to be determined by the change in GDP and tax and reacts to shocks involving that variables; finally, due to the optimal demand for money, the real exchange rate adjust to shocks in consumption and tax.

The results in figures 2 and 3 point out three main features:

- the FEVD shows that the main source of fluctuations in GDP relies on its own shocks, namely supply shock. It means that in the case of Argentina, macroeconomic policy shocks and specifically fiscal shocks didn't have a significant impact on this aggregate, which remains largely out of control of the government. Moreover, the real exchange rates fluctuations depend heavily on its own shocks and to some extend on fiscal and supply shocks (about 25% each).

- furthermore, an overview of FEVD points out that supply shocks mainly drives (above 50% of the FEV) the dynamics of all aggregates: foreign exchange reserves, consumption and tax. Tax shocks contribute only marginally to FEV of these aggregates.

- If quantitatively, tax shocks do not play major rule in the dynamics of aggregates, the IRF shows that tax shocks impulse significantly positive responses of all variables. These empirical results are consistent with the intuitions provided by the theoretical model. According to the model, a positive tax shock implies a decrease in the domestic interest rate, and as a consequence, reduces the debt burden that favors the domestic assets accumulation.

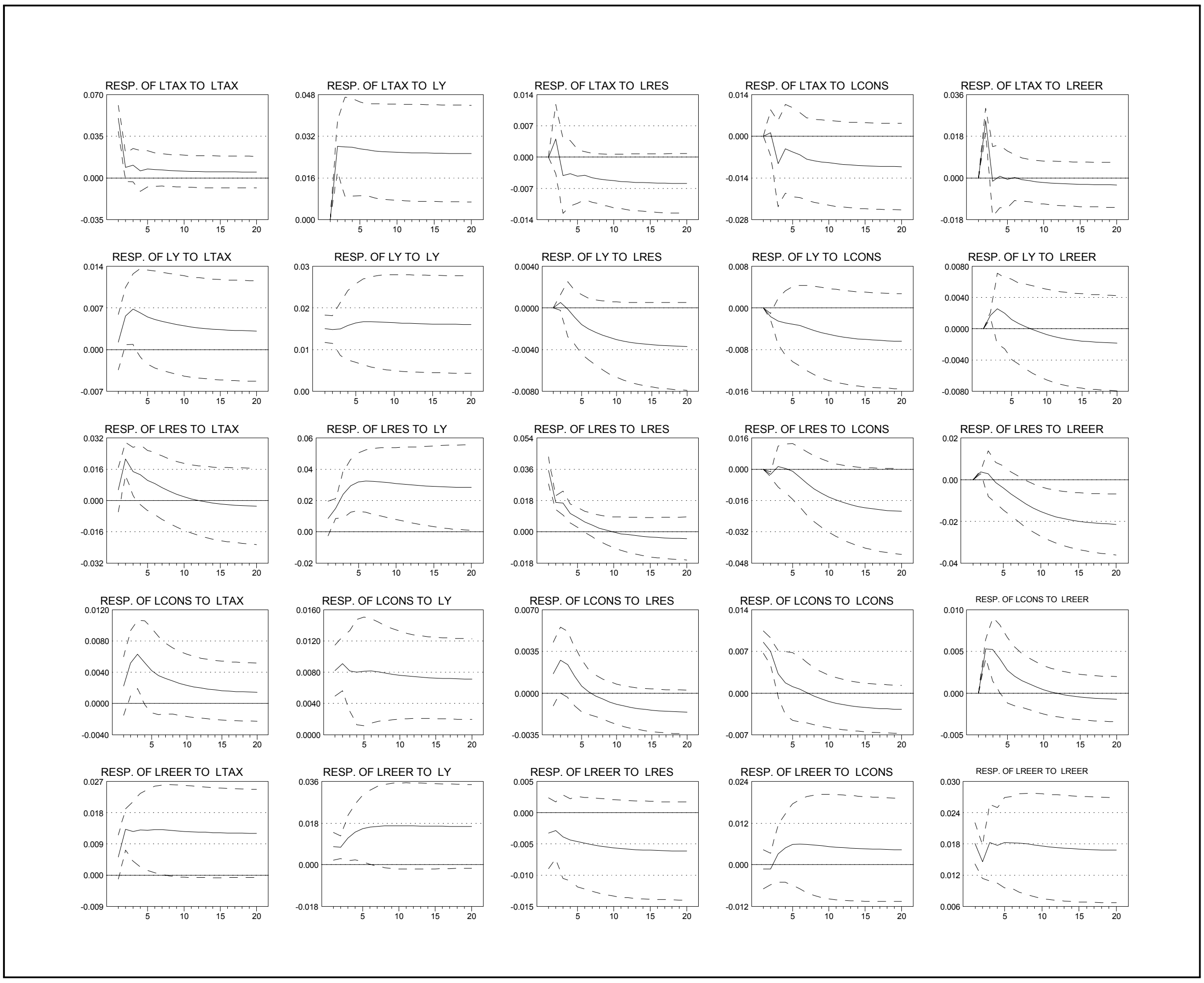

Figure 2: IRF

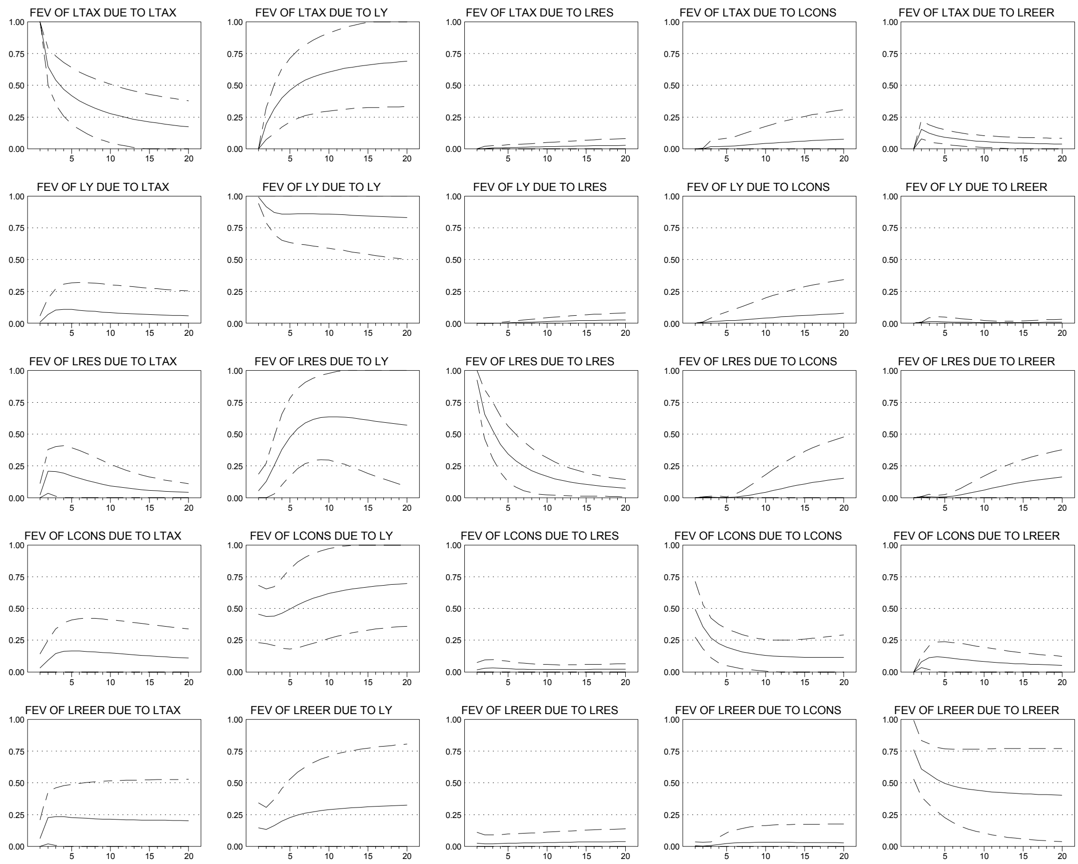

Figure 3: FEVD

4.5 Alternative ordering and historical decomposition of errors

In order to improve the specification of the model and to increase the number of degrees of freedom, we have exclude lagged variables affected with non significant parameters. Thus, the model is estimated using SUR estimation, according to Pesaran Shin, Smith (2000) guidelines.

In order to generate shocks on the exogenous US real interest rate, we have added a simple autoregressive data processing of fourth order for this variable.

Moreover from an econometric viewpoint, it is well known that the presence of highly correlated residuals may affect qualitative results of IRF and FEVD. Table 5 confirms highly correlated residuals, above all between *ly* and *lcons*.

Table 5: Correlation matrix of residuals

	ltax	ly	lres	lcons	lreer	lusrir
ltax	1.0000					
ly	0.0828	1.0000				
lres	0.1468	0.3053	1.0000			
lcons	0.1580	0.6912	0.3033	1.0000		
lreer	0.2297	0.3689	-0.0191	0.2262	1.0000	
lusrir	0.0673	-0.0724	-0.0887	-0.0445	0.0001	1.0000

To cope with this problem and assess the robustness of our results, we undertake to estimate IRF and historical decomposition of FEV, introducing two different ordering in the Choleski decomposition.

The baseline ordering is the same as the preceding (*lusrir* -> *ltax* -> *ly* -> *lres* -> *lcons* -> *lreer*). The alternative introduce reverse ordering of the main variables (*lusrir* -> *lreer* -> *lcons* -> *ly* -> *ltax* -> *lres*). On the following graphs, the baseline ordering is full lined and the alternative dash lined.

Figure 4 shows that responses of aggregates to tax shocks are not affected by the ordering: all of them react positively to the tax shock. As it concerns US real interest rate, a positive shock of this variable affects positively all the Argentina aggregates, except the real exchange rate whose sign is ambiguous. The former effect is due to the reduction of foreign net debt as a consequence of an increase in the foreign interest rate.

The historical decomposition of forward error variances seems to indicate that fiscal policy shocks did not play a significant role on the evolution of GDP during the currency board experience. Most of the fluctuations in GDP have been caused by his own supply shocks and external shocks on US real interest rate, whatever the ordering of decomposition. The same conclusion broadly applies to the dynamics of foreign exchange reserve and the real exchange rate.

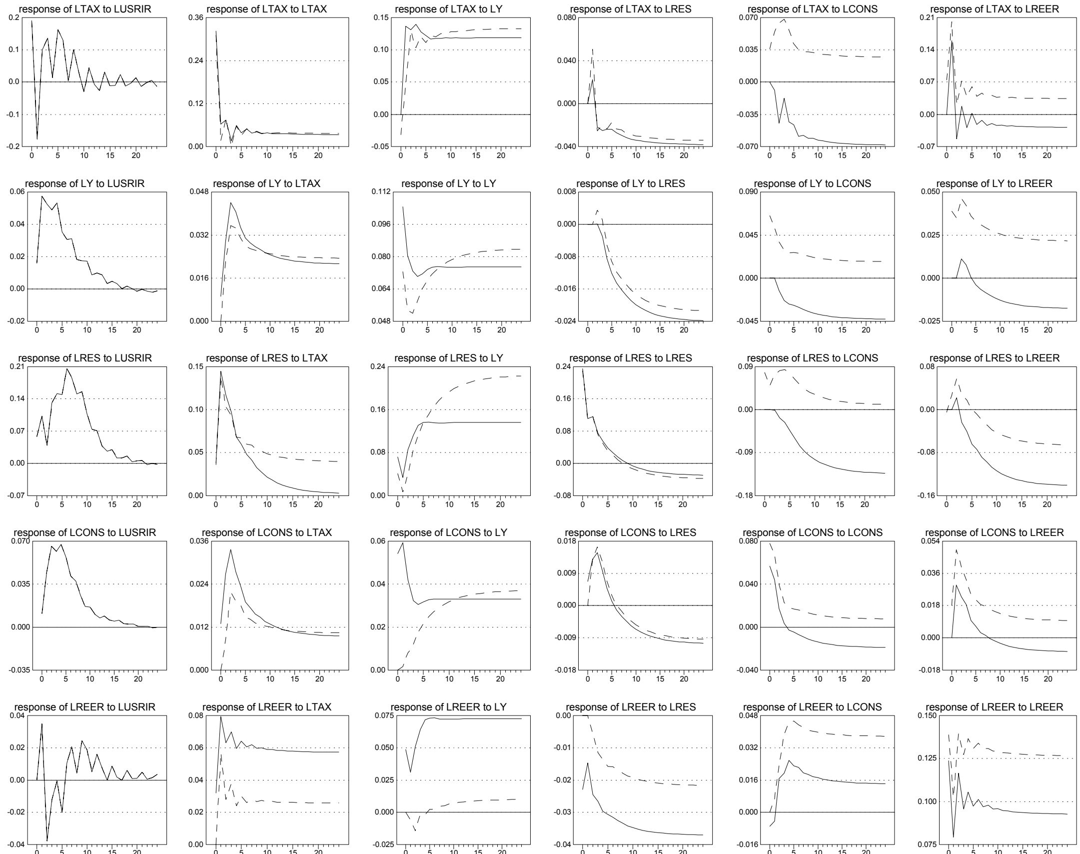
response of LTAX to LUSRIR
response of LTAX to LTAX
response of LTAX to LY
response of LTAX to LRES
response of LTAX to LCONS
response of LTAX to LREER
response of LY to LUSRIR
response of LY to LTAX
response of LY to LY
response of LY to LRES
response of LY to LCONS
response of LY to LREER
response of LRES to LUSRIR
response of LRES to LTAX
response of LRES to LY
response of LRES to LRES
response of LRES to LCONS
response of LRES to LREER
response of LCONS to LUSRIR
response of LCONS to LTAX
response of LCONS to LY
response of LCONS to LRES
response of LCONS to LCONS
response of LCONS to LREER
response of LREER to LUSRIR
response of LREER to LTAX
response of LREER to LY
response of LREER to LRES
response of LREER to LCONS
response of LREER to LREER

Figure 4: IRF

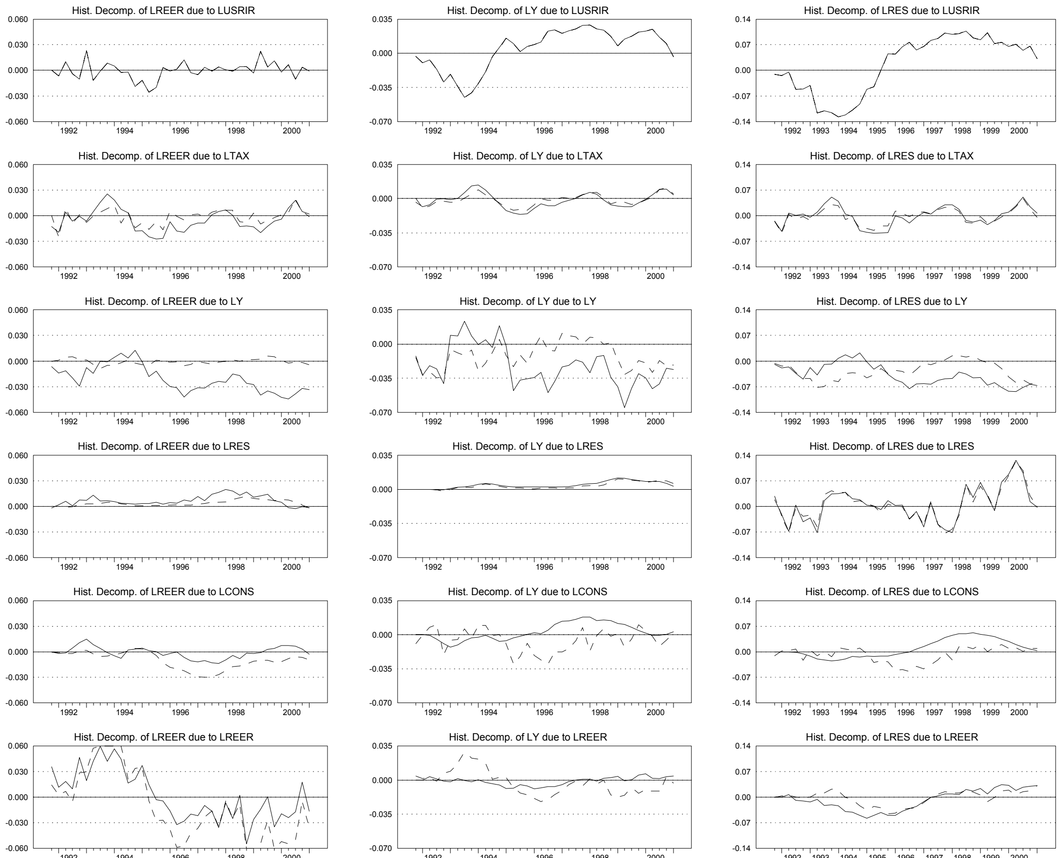

Figure 5: Historical decomposition of FEV

5 Conclusion

In this paper we have explored the links between indebtedness, balance of payments equilibrium and economic growth, in an optimizing monetary endogenous growth model with imperfect capital mobility and hard pegged exchange rates.

The main theoretical conclusions is that under the fairly restrictive assumptions of the model, a currency board regime may be highly influenced by fiscal policy through the interest rate channel. From a theoretical viewpoint, the influence of fiscal policy on aggregates is ambiguous. Two cases may be considered: if the country is a net debtor, increasing tax rate will produce a decrease in interest and then a decrease of the debt burden which favors accumulation and growth. If the country is net creditor, a decrease in interest will reduce the gains from investment abroad and diminish the total wealth, to the detriment of accumulation and growth.

Empirical investigations do not confirm a significant rule of the fiscal policy during the currency board experience in Argentina. Argentina's economy has been broadly affected by external shocks (foreign interest rate and real exchange rate) and domestic supply shocks. These results emphasize the inefficiency of macroeconomic policies and the difficulty to manage macroeconomic variables under a currency board regime.

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7 Appendix

7.1 Transitional dynamics

The dynamic system is the following:

$$\begin{bmatrix} c_{t+1} \\ k_{t+1} \end{bmatrix} = \begin{bmatrix} \left(\frac{1+\Omega}{1+\rho}\right) & 0 \\ -\Psi & (1+\Omega) \end{bmatrix} \begin{bmatrix} c_t \\ k_t \end{bmatrix} \tag{40}$$

in which:

$\Psi = (1+\gamma+\phi)\left(1+\frac{r-r^*}{\beta}\right) - \frac{\rho\gamma}{\alpha}\left(\frac{1+\Omega}{1+\rho}\right)$

$\Omega = \alpha + (\alpha - r)\left(\frac{r-r^*}{\beta}\right)$

The characteristic polynomial is: $\left(X - \frac{1+\Omega}{1+\rho}\right)(X - 1 - \Omega)$, and the roots: $\begin{pmatrix} \frac{1+\Omega}{1+\rho} \\ 1+\Omega \end{pmatrix}$

7.2 Econometric results

Maximum lag analysis leads not to reject two lags in the VAR while tests for the trend polynomial are in favor of an unrestricted constant ($\mathbf{m}_0$=$\mathbf{m}_0$) and a trend restricted to enter only the cointegrating vectors ($\mathbf{m}_1$=$\mathbf{ab}_1$).

Table A. Maximum lag analysis

	INFORMATION CRITERIA			LR-Test	Portmanteau (1)
LAG	AKAIKE	HANNAN-QUINN	SCHWARZ	sig. level	sig. level
1	-34.790	-33.917	-32.358	0.677	0.034
2	-35.401	-34.069	-31.690	0.890	0.093
3	-35.205	-33.414	-30.214		0.155

LR-Test is sequential ascendant from 3 lags to 1, and use small sample correction. Portmanteau is the multivariate Godfrey's test of residuals serial correlation of order one, using small sample correction.

Table B. Test for the trend polynomial (r=3)

HO	HA	SIG.LEV.
m0 = m0 ; m1 = ab1	m0 = m0 ; m1 = m1	0.258
m0 = m0 ; m1 = 0	m0 = m0 ; m1 = m1	0.012

m0 = ab0 ; m1 = 0	m0 = m0 ; m1 = m1	0.034
m0 = 0 ; m1 = 0	m0 = m0 ; m1 = m1	0.053
m0 = m0 ; m1 = 0	m0 = m0 ; m1 = ab1	0.007
m0 = ab0 ; m1 = 0	m0 = m0 ; m1 = ab1	0.029
m0 = 0 ; m1 = 0	m0 = m0 ; m1 = ab1	0.052
m0 = ab0 ; m1 = 0	m0 = m0 ; m1 = 0	0.779
m0 = 0 ; m1 = 0	m0 = m0 ; m1 = 0	0.631
m0 = 0 ; m1 = 0	m0 = ab0 ; m1 = 0	0.400

The hypothesis is accepted when significance level > 0.05

Since most of above tests rely upon the multivariate normality assumption of residuals, table C shows results of two usual normality tests, Jarque-Bera and Mardia multivariate, in the two lags, three cointegrating relations, and restricted trend VAR model. The latter test clearly does not rejects the normality assumption, while the former exhibits some kurtosis deviations from normality.

Table C. Normality tests (baseline model)

EQUATION	SKEWNESS	p-value	KURTOSIS	p-value	SKEW.&KURT.	p-value
Jarque-Bera						
ltax	0.006	0.936	6.104	0.013	6.110	0.047
ly	0.000	0.990	8.831	0.003	8.831	0.012
lres	0.246	0.620	9.410	0.002	9.656	0.008
lcons	0.225	0.635	9.722	0.002	9.947	0.007
lreer	0.023	0.880	6.081	0.014	6.104	0.047
SYSTEM	0.220	0.999	38.657	0.000	38.877	0.000
Mardia						
SYSTEM	0.738	0.735	0.263	0.608	26.092	0.888

Normality is accepted when p-value>0.05

Mispecification tests of the final restricted VAR are the following:

Test/Equation	ltax	ly	lres	lcons	lreer
Portmanteau (1)	1.100	0.038	0.045	2.737	0.44
Normality $\chi^2(2)$	5.651	2.120	8.325*	7.788*	0.073
Hetero $\chi^2(24)$	28.798	32.095	18.699	28.476	18.480

*: p-value < 0.05

Vector Portmanteau statistic for 1 lags and 42 observations: 25.1282

Vector Normality test: $\chi^2(10) =$ 15.114 [0.1280]

Vector heteroscedasticity using squares $\chi^2(360) = 369.09$ [0.3592]