The Argentinean Real Exchange Rate Misalignment in the Pre-Crisis*

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Abstract

This paper develops and estimates the medium run non stationary Real Exchange Rate (RER) for Argentina and studies the degree of RER misalignment in the period before the abandonment of the Currency Board.

Here, two approaches are taken to compute the misalignment: one is to take as reference the RER consistent with Current Account (CA) equal to zero and the other is to take RER consistent with the external debt sustainability.

Both measures give important information regarding the probability of the crisis in relation with the degree of RER misalignment.

1 Introduction

The vast evidence supporting the fact that devaluation often take place when currency is overvalued and exchange rate crises are preceded by an appreciated RER motivates this study.

The empirical support for this observation is robust. Klein and Marion (1997)[25], for example, analyze 61 episodes of exchange rate management drawn from 16 Latin American countries and Jamaica. They find strong evidence that more appreciated RER is associated with higher likelihood of

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devaluation. Similar relations have been found by Frankel and Rose (1996) [15], Kaminsky and Reinhart (1997) [24] and Esquivel and Larrain (1998)[12], among others.

In this paper, the goal is to understand how the peso misalignment forecasted the 2001 Argentinean crisis. Since misalignment is computed by comparing the observed RER with a benchmark RER, we can collect the different strategies into two approaches. One is the Purchasing Power Parity (PPP) and the other is the Fundamentals or Macroeconomic Approach (FA).

Although the empirical verification still remains questionable (see for example the problem of slow speed of convergence in the Rogoff's PPP Puzzle [31]), the concept of PPP is widely used in many studies. They base their conclusions on long spans of data and high power univariate and multivariate econometric techniques. Examples of this kind of studies are M. P. Taylor (1995) [33], Froot and Rogoff (1995) [16] or A. Taylor (2002) [34].

The idea behind PPP is simple. In the long run, prices will adjust in a manner that makes RER equal to one. Flexible prices, absence of market segmentation and other kind of long run sources of nominal stickiness are ruled out in this approach. PPP implications can be interpreted in the following way: there exists a *deterministic steady state* level of RER towards which the current RER converges in the long run.

In line with this statement, Mc. Closkey and Zecher (1984) [30] show that PPP worked under Gold Standard before 1914. Diebold, Husted and Rush (1991) [7] explore a very long run data set for six countries during the nineteenth century finding evidence of PPP. Abauf and Jorion (1990) [1], studying a century of the dollar-franc-sterling exchange rate, also find evidence of PPP while Lothian (1990) [28] gives some evidence of RER's stationarity for Japan, United States, United Kingdom and France for the period 1875-1986.

But the lack of explanatory power of PPP at medium/long run horizons and the impossibility of considering not only market clearing conditions but also productivity and other kind of shocks, has facilitated the emergence of alternative theories of equilibrium RER which can be labeled as the FA approach. These models reject every form of PPP, even those restricted to traded goods sector, and instead define the equilibrium RER from fundamentals ensuring at the same time internal equilibrium -when output is at its potential level- and external equilibrium -when current account is equal to zero-. Then, the equilibrium RER is the result of the interaction between trade and capital flows.

From this theoretical framework, three approaches are derived: The Fundamental Equilibrium Exchange Rate (FEER) of Willamson (1985) [36], (1994)[37] and its main departure developed by Isard and Faruqee (1998)[22] called Macroeconomic Balance Approach, the Natural Real Exchange Rate (NATREX) of Stein (1990, 1994, 1995a, 1999) [32], and the Behavioral Equilibrium Exchange Rate (BEER) of Clark and MacDonald (1998)[6].

One theoretical feature of NATREX and BEER is that they base their analysis on a stock / flow perspective where the main fundamentals of the long run RER are identified. But, these interactions between stocks, flows and the RER are omitted in the FEER approach. In this last strategy, not even the fundamentals of the RER enter in the model, they are taken into account only through an out-of-the-model analysis which aims at setting up potential output and structural capital flows.

From an empirical point of view, NATREX and BEER rely on cointegrating relationship between the RER and its fundamentals to provide a *moving* equilibrium RER, while FEER estimates are built upon comparative static analysis. In the set of dynamic approaches, NATREX seem to be the most suitable because is a fully consistent model in which the exogenous fundamentals like time preference, technological progress and terms of trade are clearly identified. The empirical implementation of NATREX usually relies on estimating a cointegrating relationship between the RER and these fundamentals. On the contrary, BEER directly models the equilibrium RER for tradables as a function of the net external position This ad-hoc choice does not make clear what the exogenous fundamentals are, since the net external position is an endogenous variable. However, the BEER approach provides at least two specific contributions. One is the fact that allows for the Balassa-Samuelson effect, through the distinction between tradables and non tradables, and, second, it models the dynamic adjustment of RER through a modified interest parity condition.

Among the applied studies for the Argentinean RER misalignment we find Carrera, Felix and Panigo (1998) [5]. They show that PPP and the FA performed quite similarly during the instability period (before the 90's) but very dissimilarly during the stable one. Since this finding is against the PPP claim that RER oscillates around a unique equilibrium value, it is clear that the correct approach to measure the misalignment has to be the one based in a *nonstationary* equilibrium benchmark. Gay and Pellegrini (2002)[20], using a microfounded model and co-integration techniques, show that after the Asian devaluation, the Argentinean Exchange Rate regime was not able to correct endogenously the RER misalignment.

The paper is organized as follows: **Section 2** explains and estimates the Natural Real Exchange Rate for Argentina. **Section 3** derives the RER misalignment during the nineteenths. **Section 4** presents a departure from this approach related with external debt sustainability. **Section 5**, concludes and hints directions for future improvements.

2 The NATural Real EXchange rate

The idea of NATREX (NATural Real EXchange rate) approach, born with Stein (1990, 1994, 1995a, 1999) [32], is the derivation of the medium/long run RER. It corresponds simultaneously to internal and external equilibrium reflecting the behavior of the fundamental variables behind the investment and saving decisions. The internal equilibrium is defined as output at its potential level while external equilibrium means current account equal to zero (absence of cyclical factors and movements in the capital and international reserves).

This approach is a departure from the standard representative agent optimization model in two respects. The first one is that the hypothesis of perfect foresight is relaxed. Agents use efficiently all *available* information and take their decisions based on a Sub Optimal Feedback Control rule (SOFC) (see Infante and Stein (1973) [21] and Stein (1995a) [32] and its derivation in **Appendix B**)[1]. The second is that expenditure is separated into consumption and investment decisions derived according to the SOFC through dynamic optimization techniques with feedback control. This can be thought as agents taking consumption decision and firms taking investment decisions.

NATREX does not consider the short run, but it makes a distinction between medium and long run. In the medium run it is assumed that the stock of capital and debt are given and the explanatory variable is the capital flow (the difference between investment and saving), while in the long

[1] How important is the lack of future information is related to the fact that the optimal solution, derived from the standard perfect knowledge and perfect foresight models, has the saddle path stability property. This means that a small error in implementing this stable arm would place the system in a trajectory that does not lead to the optimal steady state. Then, since all this information is not avaibable, a rule has to be used in order to ensure that the system arrives to the steady state.

run capital and debt stock are allowed to change and the movements of the NATREX are explained by the net debtor (or creditor) position. Generalizations of NATREX for small or large economies can be done by making explicit distinction of the country role in financial and goods markets.

Summing up, since this equilibrium concept changes in time, NATREX is a non stationary dynamic equilibrium rate which reflects the behavior of the fundamental variables behind the investment and saving decisions.

2.1 The Investment Decision

The investment function is derived from an intertemporal optimization program with a robust feedback control. This dynamic program is set in a way that guarantees the system convergence to the perfect foresight steady state which is *unknowable* at any time.

In standard models, the solution for the optimal control or for consumption is derived by *knowing* the steady state value of the capital intensity k^*. Here, if the economy travels along the stable arm of the system, a unique trajectory to the steady state can be found. But, there must be *perfect knowledge* not only of the steady state capital intensity, which changes over time, but also of the production and utility functions.

The impossibility of having this perfect knowledge makes the optimal control derived from the Maximum Principle not implementable. Therefore, if we take this information problem into account, a solution can be derived by using the (Infante and Stein 1973 [21])'s suboptimal feedback control rule (SOFC) that drives the system to the unknown steady state. This rule is characterized by the fact that all necessary measures used are *current values*. Then, the perfect foresight assumption is not needed.

The advantages of this suboptimal rule can be understood in the following way: Suppose that the decision making unit attempts to maximize the social utility Ω from time 0 to infinity subject to the accumulation of capital.

$$\Omega = \int_0^\infty U(c)e^{-\rho t}dt \tag{1}$$

$$\frac{dk}{dt} = f(k) - \lambda k - c \tag{2}$$

Where c is the consumption per capita, $f(k)$ is the output per capita, k the capital intensity, the social discount rate is ρ and λ is the sum of the growth rate of labor and the depreciation rate ($\lambda \equiv n + \delta$). In the steady state $k = k^*$, the marginal net product of capital must be equal to the sum of the growth rate of labor, the depreciation rate and the discount rate.

$$f_k(k^*) = \lambda + \rho \tag{3}$$

In the neighborhood of the steady state (see derivation in **Appendix A**), the optimal control is:

$$V(k) = \frac{dk}{dt} = -A(k^*)(k - k^*) \tag{4}$$

Where the investment, $V(k)$, is proportional ($-A(k^*)$) to the gap between the actual and the steady state level of capital intensity.

As it was explained before, the investment equation is implementable if we know the steady state level of the capital intensity and the production function. However, by means of the SOFC (which is robust to perturbations) we can guarantee that the system will go to the changing and unknown k^*. The SOFC is given by the following expression (see derivation in **Appendix B**):

$$I(k,r) = V_1(k) = \frac{dk}{dt}_{SOFC} = \frac{-A(k)}{f_{kk}(k)} \left[f_k(k,u) - (\rho + \lambda) \right] \tag{5}$$

This expression represents the optimal investment depending positively on the marginal product of capital and negatively on the discount rate in a closed economy (which can be substituted by the real long run interest rate for estimation purposes). As we can see, when the current marginal product exceeds the discount rate, there is an increment in the level of investments (the rate of change of capital intensity rises)[2].

2.2 The Saving Function

Consumption (called from now on *social consumption*) will be taken as the sum of public and private. As a result of the optimization problem, the

[2]Note that this feedback control is nonlinear, stable and robust to perturbations. It is also asymptotic in time to the optimal control $V(k)$ (in the neighborhood of the steady state, the slopes $V'(k)$ and $V_1'(k)$ are identical) See Infante and Stein (1973) [21].

representative consumer will find it optimal to consume a proportion[3] of his wealth (see derivation in **Appendix C**). So, the implicit representation of the social consumption function will be given by:

$$C = C(f(k), M(R)) \tag{6}$$

Where k is the capital intensity, M the Argentinean stock exchange index and R is the real interest rate (measured by means of the return in the stock exchange) and $C_k > 0, C_R < 0$.

Social savings are defined as the difference between GDP and the social consumption:

$$S = f(k) - C(f(k), M(R)) = S(f(k), M(R)) \tag{7}$$

2.3 The Structural Equations

We have presented the saving and investment equations derived from an intertemporal optimization problem. Then, three structural equations are needed to close the model.

The **GDP Accounting Identity** or, in other words, the market equilibrium condition (output at it capacity level ignoring the cyclical components):

$$Y \equiv C + I + TB = C(f(k), M(R)) + I(f(k), M(R)) + TB(RER, f(k), f(k^*)) \tag{8}$$

On the left hand side there is GDP (aggregate supply $Y = f(k)$), where k is the capital intensity. On the right hand side there is social consumption (private + public), investment and trade balance.

The second equation is the **Trade Balance** which includes as determinants domestic and foreign outputs, as well as the RER[4]. It is positive related to the RER since a rise in it, (a currency depreciation) generates an increase in the "relative competitiveness" inducing a trade balance surplus.

[3]For example, when the instantaneous utility function is $U(c) = \ln c$, the factor of proportionality is the discount rate $c = \rho a$, where $a = k - F$. But, since in general the factor of proportionality is a complicated term, it is not easy to know a priori whether an increase in the mean rate of return of capital will rise or lower consumption.

[4]Along the paper the RER is defined as $RER = e\frac{P^*}{P}$, where P is the domestic price level and P^* the US price level and e is the nominal exchange rate (units of peso for one dollar).

The relation with the domestic output is negative because more output rises the domestic absorption generating trade balance deficits. Then, there is a positive relation with the foreign GDP for analogous reasons.

$$TB \equiv X(RER, f(k^*)) - M(RER, f(k)) \tag{9}$$

The third equation is the **Domestic Assets Equation.** It relates the level of the Argentinean stock exchange index to the interest rate of deposits nominated in foreign currency (in this case, for deposits nominated in dollars). Although there is no theory behind the introduction of this equation, the need of having a functional relation between the stock exchange index and the interest rate justifies its use when the objective is to derive the RER consistent with the debt sustainability explained in **Section 4**.

$$M = M(R) \tag{10}$$

The expected relation is obviously negative. A higher interest rate increase the opportunity cost of investing into the stock exchange market and reduces the discounted value of firms.

2.4 Characteristics of the Model

The general equilibrium model chosen to estimate the RER for Argentina has the following characteristics:

(1) Since it is a small economy and it cannot influence the 'rest of the world' variables, all foreign variables are taken as given. In this case, the foreign output is considered an exogenous variable.

(2) There are five equations in the model. Two are derived from an explicit optimization problem with SOFC: Social Consumption and Investment. Two identities (the definition of trade balance and the accounting equality for the GDP) and the relation between the interest rate for deposit in foreign currency and the index of the stock exchange market (MERVAL (M_t)).

(3) The endogenous variables of the model are I_t, C_t, TB_t, Y_t, M_t,while the predetermined and exogenous variables are $I_{t-1},\ C_{t-1}$ and $Y_t^*,\ RER_t,\ R_t$ respectively.

3 The NATREX and the RER Misalignment

The main objective of this section is to estimate the medium run path of the equilibrium RER. To do this, it is necessary to take into account the conditions that define the natural level of RER (Internal and External equilibrium).

Although the natural level of RER is such that makes at the same time the CA balanced and brings the current output to its potential level, we will first impose the external equilibrium[5]. Doing this, a RER that ensures CA=0 will be derived.

In papers like Stein 1995 [21], the estimation procedure is to derive NATREX using reduced form co-integration analysis. But, we will estimate the whole system using Full Information Maximum Likelihood (FIML) because the co-integration analysis has the following limitations: **(1)** Only the reduced form equation for the equilibrium RER[6] is estimated, implying that none of the theoretical hypotheses of the model are empirically tested. **(2)** The estimation of the single equation error correction model *a la Phillips-Loretan* via co-integration techniques, does not allow to impose the analytical condition that NATREX guarantees (the internal and external equilibrium).

Summing up: the equations of the model are: the Investment Function, the Consumption Function, the Trade Balance, the Domestic Assets and the Goods Market Accounting Identity.

$$I = I(f(k), M(R)) \tag{11}$$

$$C = C(f(k), M(R)) \tag{12}$$

$$TB = TB(RER, f(k^*), f(k)) \tag{13}$$

$$M = M(R) \tag{14}$$

$$Y \equiv C + I + TB \tag{15}$$

[5] This first estimation is done in this way because measures of output gap are not available for Argentina.

[6] This reduced form is derived from the structural form only in analytical terms.

The **Investment Function** is derived solving the intertemporal optimization problem described before and using the SOFC. From this problem (see **Appendix A** and **B**), the investment function depends on marginal productivity of capital $f_k(k)$, the social discount rate ρ and the sum of growth rate of labor[7] and depreciation rate ($\lambda \equiv n + \delta$). But, since this is a medium/long run analysis, λ can be substituted by the long run real interest rate.

The lack of measures for the marginal productivity of capital in Argentina constraints us to use a proxy derived from the Keynes-Tobin's q, where q is the present value of the stream of returns to an increment of capital, relative to its supply price:

$$q = \int_0^T f_k(k)e^{-Rt}dt = f_k(k)\int_0^T e^{-Rt}dt = \frac{f_k(k)}{R} \tag{16}$$

The supply price is taken here as the long run real interest rate, while the present value of the stream of returns q will be proxied by the Argentinean Stock Exchange Index (MERVAL). Then, the investment function can be written in the implicit following way:

$$I = V_1(k) = I(q) = I(k, M(R)) \tag{17}$$

Assuming that investments take time to adjust and this adjustment is modeled using the lagged value of the dependent variable, the function of investment estimated in the model is:

$$I_t = \alpha_{0I} + \alpha_{1I}I_{t-1} + \alpha_{2I}M_t + e_t \tag{18}$$

Based on the optimization problem just described and the Theory of Permanent Income, we find that **Consumption Function** depends on the level of wealth and on the interest rate which will be proxied by the MERVAL index since we also assume that agents owns firms. It has been also assumed that the adjustment to the desired consumption level takes time, hence, the consumption function can be written as follows:

$$C_t = \alpha_{0C} + \alpha_{1C}C_{t-1} + \alpha_{2C}M_t + e_t \tag{19}$$

Within the structural equations we have the **Trade Balance**:

[7] Which is assumed to be zero.

$$TB_t = \alpha_{0TB} + \alpha_{1TB} RER_t + \alpha_{2TB} Y_t + \alpha_{3TB} Y_t^* + e_t \qquad (20)$$

Then, the **Domestic Asset** equation:

$$M_t = \alpha_{0M} + \alpha_{1M} R_t + e_t \qquad (21)$$

3.1 Derivation of the NATREX

The fact that **(a)** in developing countries policy makers, with the intention of maintaining a desired level of competitiveness in foreign markets, often link the rate of depreciation of the domestic currency to the level of the RER, and **(b)** devaluations often take place when the currency is overvalued[8], requires to know the currency misalignment. This is even more important when the final objective is to understand up to what extent the Currency Board was abandoned because of a persistently overvalued currency.

Therefore, the strategy followed here is to derive NATREX plugging the external equilibrium condition ($CA = 0$) into a general equilibrium model estimated by FIML.

Although the strategy of measuring misalignment by plugging the CA=0 condition will not be the one supported by the paper, it will be presented just to give the reader a flavor of how the (partial[9]) NATREX-based RER misalignment looks like in the Argentinean economy. Taking into consideration that CA can be defined as the trade balance plus the net factor income from abroad and unilateral transfers (*NFIAUT*): $CA \equiv TB + NFIAUT$, it is possible to have a first derivation of NATREX by imposing the condition that $CA = 0$ into the system estimated and presented in **Appendix E**.

This condition implies:

$$CA = 0 \Leftrightarrow I = S \Leftrightarrow TB = -NFIAUT = -R_t D_t \qquad (22)$$

Then, it is possible to derive the RER from the system which is consistent with the CA=0 condition. The misalignment is then computed as

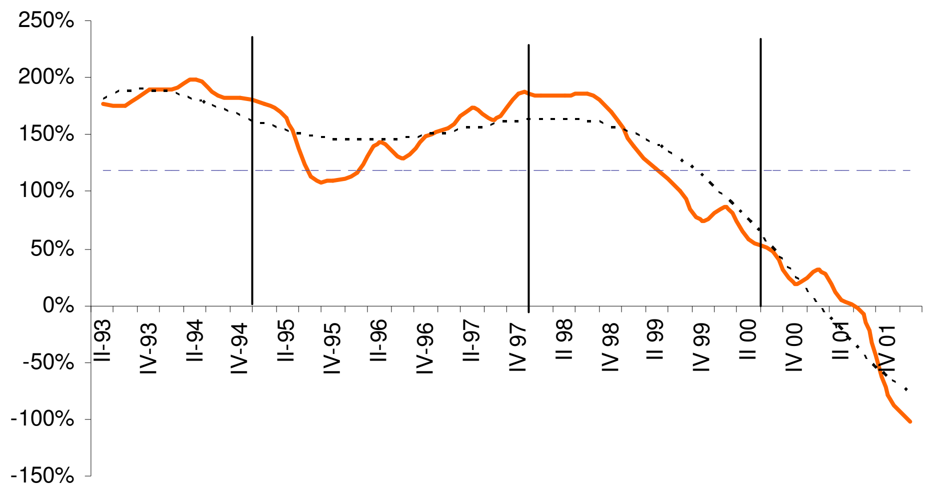
[8] Klein and Marion (1997)[25].

[9] I use the world "partial" because NATREX is a concept embodied with two equilibrium notions: the internal equilibrium (GDP growing at it potential level) and the external equilibrium ($CA = 0$ at every point in time).

the percentage deviation of the observed RER and the equilibrium concept estimated from the model.

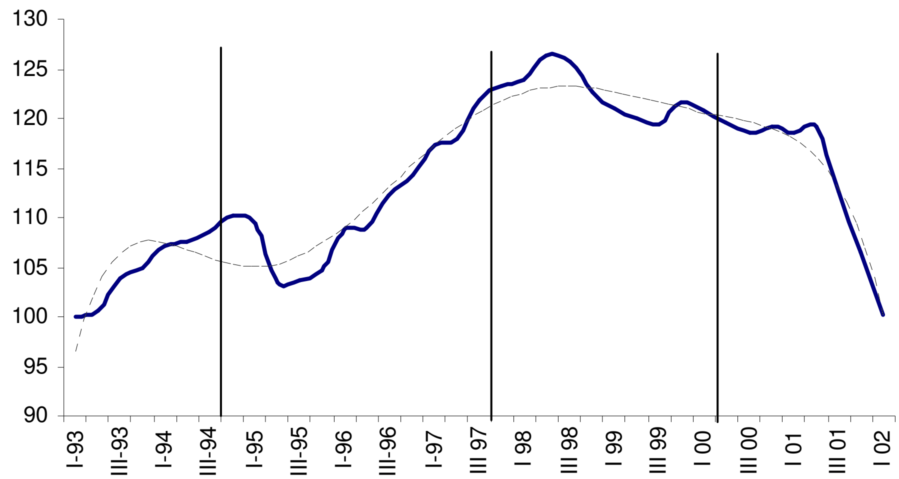
We observe that this measure will be driven mainly by the output gap between the Argentina and United Stated and the relation between investments and savings (the CA deficit or surplus). As implied by construction (TB is equal to the net factor income at every point in time because CA has to be equal zero), there is no misalignment in the point where the CA was equilibrated and then, due to a depreciation of RER which generated a CA surplus, the sign of the misalignment is reverted.

Figure 1: Misalignment #1.(In % Points)



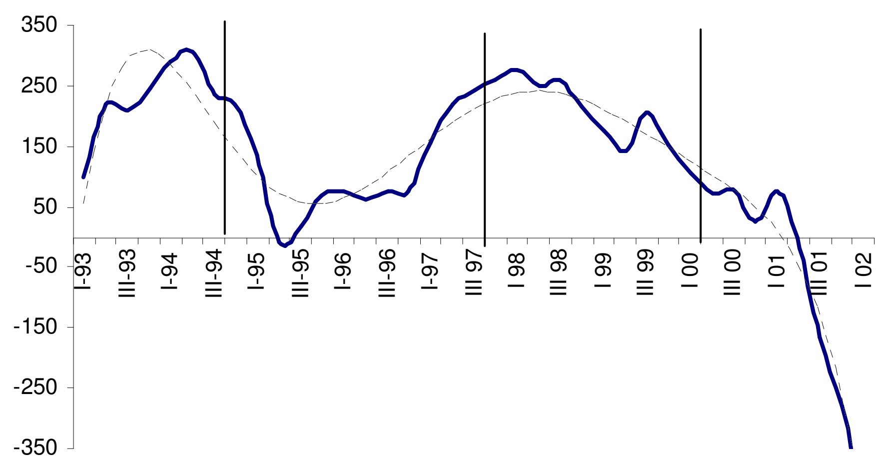
On average the Argentinean peso was 120% overvalued. A clear picture of what was going on can be done by analyzing GDP, CA and the net factor income plus unilateral transfers in subperiods of two or three years. As can be seen in the first two analyzed years, RER overvaluation was the result of the increasing GDP, the increment in absorption evidenced by the rise of the CA deficit and the reduction of the net factor income plus unilateral transfers.

Figure 2: Argentinean GDP. (Index 1993:1=100)



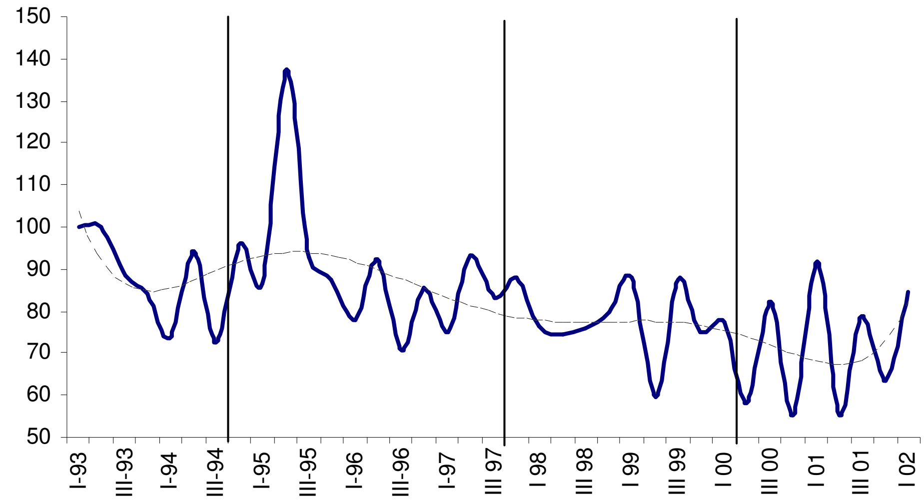
The event that characterizes the second subperiod, 1994:4 to 1997:4, is the Mexican Crisis. Although the financial system survived the reduction of almost 20% in bank deposit in just two weeks, the real side of the economy was the adjusting variable. As can be seen in **Figure 4**, there was an important capital outflow in the last quarter of 1994 and the following two of 1995. The external balance was also affected making a change in the sign of the CA. In terms of RER overvaluation, this capital contraction and the improvement in the CA were the source of its reduction.

Figure 3: Current Account Deficit. (Index 1993:1=100)



In the third subperiod 1997:4 to 2000:2, we have the Russian and Brazilian crisis as external factors and the beginning of some policy measures to ensure the payment of the debt services. As shown in **Figure 1**, in the middle of this subperiod the peso overvaluation started its negative trend. In that period, $-R_t D_t$ behavior did not change much, but instead, the GDP began its negative trend that ended just after the Currency Board abandonment.

Figure 4: $TB - CA = -R_t D_t$. (Index 1993:1=100)



In the last analyzed subperiod we find of course that, as a result of the important real contraction and the CA surplus, the RER misalignment not only disappeared, but also it changed sign.

The focus of the paper is based on the fact that smoothing consumption by means of the capital market implies an important increase in welfare. Then, it does not seem natural to think of a country that obeys CA=0, a condition that means capital inflows and outflows exactly compensated or no capital flows at all! In line with this statement, in the following section it is presented a departure from the NATREX approach in which countries are allowed to incur in CA deficits if and only if this situation does not hurt the sustainability of its debt nominated in foreign currency.

4 A Departure From the Traditional NATREX Concept.

In standard perfect foresight optimization models there is an intertemporal budget constraint which states that the present value of the sum of future trade balance surpluses must be equal to the present level of indebtedness. A country that begins period t with an initial foreign debt $F(t)$ must run future trade surpluses in order to payback the debt. When the change in time of debt is defined as $\frac{dF}{dt} = I - S = -CA$, we can derive its steady state value, $F^*(t)$, such that the trade balance surplus in steady state is enough to pay the interest services rF^* on that debt.

If we take into account that countries live an infinite number of years and the fact that the present value of a stock of debt payable after an infinite number of periods is zero, we arrive to the conclusion that, for sustainability, it is enough to ensure that debt does not grow. Hence, by paying services we ensure sustainability.

The reality of many underdeveloped countries shows that movements in RER have important effects in debt sustainability. Big changes generate balance sheet effects that affect the repayment capacity when liabilities are nominated in foreign currency. This is the so called *Original Sin* of underdeveloped countries. See Eichengreen, Hausmann and Panizza (2003)[9], Eichengreen and Hausmann (2003a)[10], Jeanne and Zettelmayer (2002)[23], Calvo (2002) [3], Eichengreen and Hausmann (2003b) [11], Krugman (1999) [27] and Aghion, Bacchetta and Banerjee (2001)[2].

Taking into account the role that debt had in the Argentinean crisis and the motivation of understanding how RER overvaluation predicted the crisis, a measure of misalignment with an explicit attention to external debt has to be derived. Therefore, to analyze the misalignment of the Argentinean currency during the nineties we will use as a benchmark the RER consistent with the debt sustainability. This benchmark is the RER that makes the rate of growth of the debt/output ratio (b_t) equal zero.

$$b_t \equiv \frac{D_t}{GDP_t} \tag{23}$$

Of course, it can be argued that maintaining the repayment capacity does not necessary mean to make the b_t ratio to grow at zero rate. It is also possible to allow for deviations which will be cancelled out afterwards.

The introduction of debt sustainability changes the condition that NATREX has to obey at any point in time. Now, unbalanced CAs are allowed and it is possible to think of situations where countries are net debtors or net creditors.

To explain how this change will be introduced, we will first take the accounting identity (24). Then, using the intertemporal approach for the CA determination, it is possible to write equation (25). Where R_tD_t are debt services and TB_t trade balance.

$$GDP_t \equiv C_t + I_t + TB_t \tag{24}$$

$$CA_t = S_t - I_t = TB_t + R_tD_t \tag{25}$$

Since the strategy of the paper is to ensure debt sustainability by making the rate of growth of b_t equal zero, we can say that debt is stabilized if $\frac{b_{t+1}-b_t}{b_t} = 0$ for all t. Then, the following expression holds:

$$\frac{GDP_t - GDP_{t-1}}{GDP_{t-1}} = \frac{D_t - D_{t-1}}{D_t} \tag{26}$$

Using a standard asset pricing equation, like Calvo et. al (2004) [4] ,b_t can be expressed in equation (27). θ_t is the rate of growth of the GDP, R_t the real interest rate and s_t is the private and public surplus (assumed to be zero for simplicity). The condition of sustainable debt implies (28)[10].

$$b_{t+1} = b_t\left(\frac{(1+R_t)}{(1+\theta_t)}\right) - s_t \tag{27}$$

$$\theta_t = R_t \tag{28}$$

Knowing the condition that this new measure of misalignment has to obey, what we have to do is to express RER in terms of the exogenous and predetermined variables:

$$RER_t = \alpha_0 + \alpha_{TB}TB_t + \alpha_{I_{t-1}}I_{t-1} + \alpha_{R_t}R_t + \alpha_{C_{t-1}}C_{t-1} + \alpha_{Y_t^*}Y_t^* \tag{29}$$

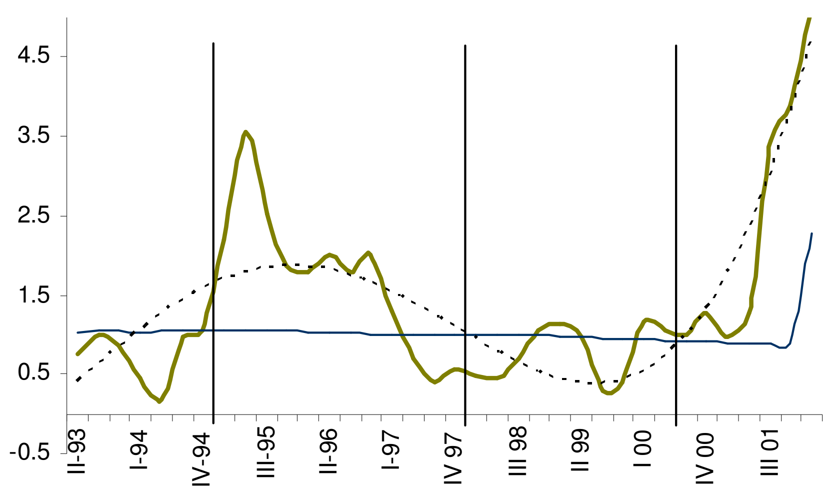
[10] The algebraic steps are: $b_{t+1} = b_t\left(\frac{(1+R)}{(1+\theta)}\right) \Rightarrow b_{t+1} - b_t = b_t\left(\frac{(1+R)}{(1+\theta)}\right) - b_t = \frac{(1+r)-(1+\theta)}{(1+\theta)}b_t$, then $\frac{\dot{b}}{b} = \frac{b_{t+1}-b_t}{b_t} = \frac{R-\theta}{(1+\theta)}$, $\frac{b_{t+1}-b_t}{b_t} = 0 \Rightarrow R = \theta$

Using a consistent Full Information Maximum Likelihood estimation, we can define the coefficients of (29) being sure that they are good representations of the transmission mechanisms inside our model:

$$\alpha_0 \equiv -\left[\frac{C(6)C(2)C(8) + C(6)C(4)C(8)}{C(5)}\right] = 1.1547$$
$$\alpha_{TB} \equiv \frac{[1 - C(6)]}{C(5)} = 1.2332$$
$$\alpha_{I_{t-1}} \equiv -\frac{C(6)C(1)}{C(5)} = 2.819\,5 \times 10^{-2}$$
$$\alpha_{R_t} \equiv -\frac{C(6)C(2)C(9) + C(6)C(4)C(9)}{C(5)} = -5.6620 \tag{30}$$
$$\alpha_{C_{t-1}} \equiv -\frac{C(6)C(3)}{C(5)} = 3.6509 \times 10^{-2}$$
$$\alpha_{Y_t^*} \equiv -\frac{C(7)}{C(5)} = -9.418\,1 \times 10^{-4}$$

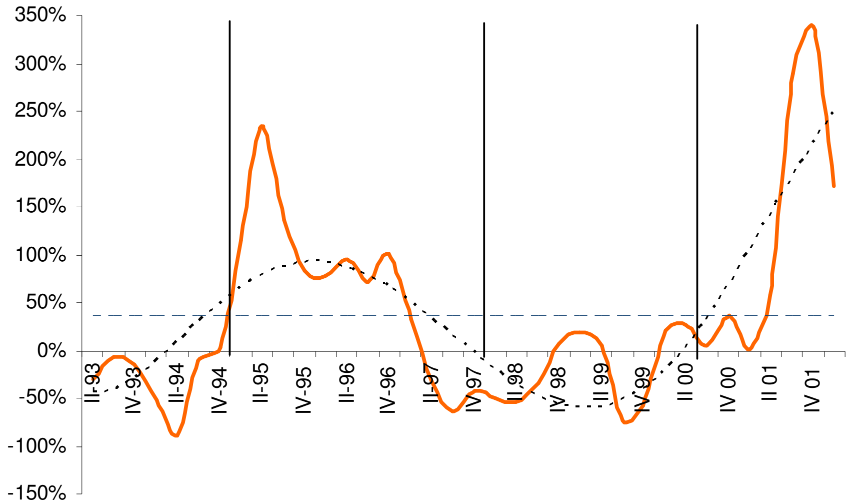
The next step is to plug into (29) the rate of growth of GDP in the place of the R_t. Doing this, a new benchmark to measure the misalignment is obtained. The path of this RER benchmark consistent with debt sustainability is shown in **Figure 5**.

Figure 5: NATREX Consistent with Debt Sustainability and RER (in blue) (In pesos for each dollar)



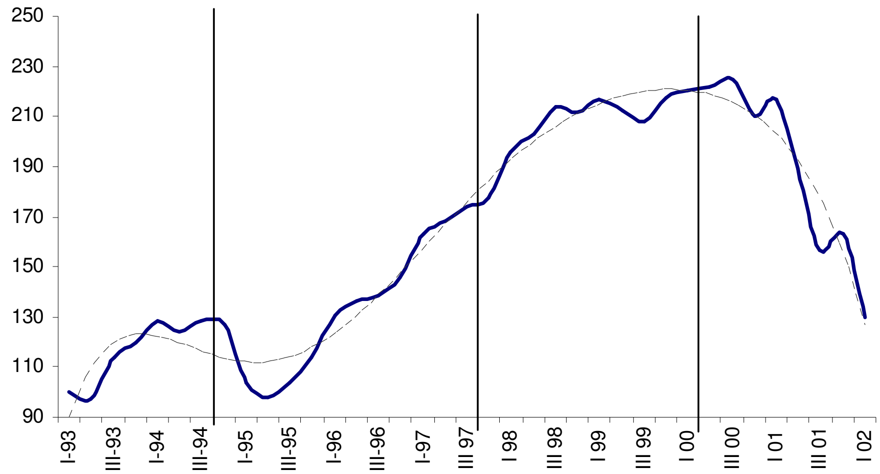
RER misalignment shown in **Figure 6** is computed by the percentage deviations of the observed bilateral RER and the simulated benchmark which is consistent with debt sustainability. As can be seen in **Figures 7, 8** and **9**, we can understand this misalignment by studying the evolution of GDP, Central Bank reserves and the interest rate.

Figure 6: Misalignment (observed and trend % Points)



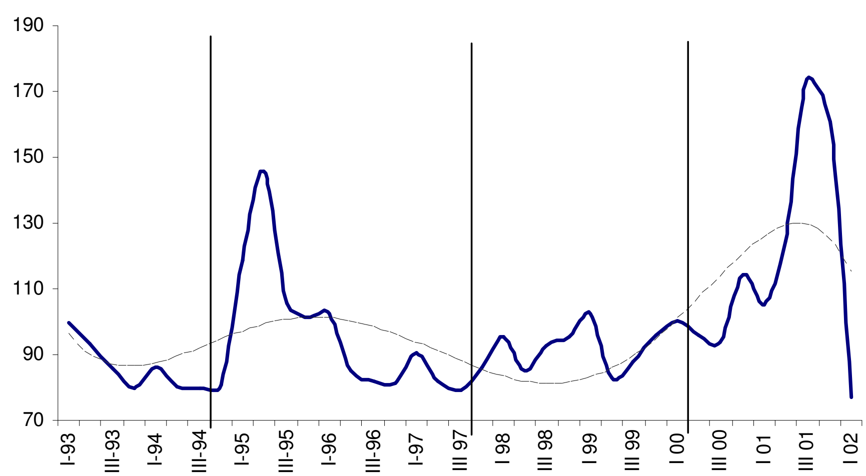
On average RER misalignment was 36.5%. In the first subperiod misalignment was not important because GDP was growing and the interest rate was not high. In the second subperiod, the capital reversal produced by the Mexican crisis and the important reduction in the GDP rate of growth generated a level of misalignment close to 100%. Then, this relation inverted and the misalignment fell till the beginning of 99s.

Figure 7: Central Bank Reserves. (Index 1993:1=100)



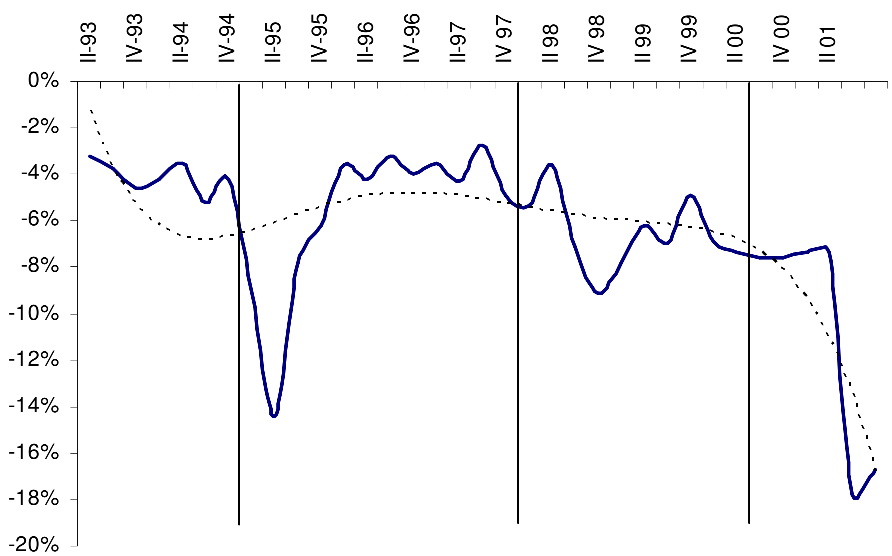
In the speculative attacks literature represented by papers like Krugman (1979)[26], Flood R and Garber M. (1984) [14] and Wyplosz (1986)[38], there is an explicit mention to the importance of the central bank reserves, in forecasting the duration of the peg. In line with this evidence, **Figure 7** shows how the sudden change in expectations reduced the stock of international reserves forcing the policy makers to abandon the peg.

Figure 8: Interest Rate for Deposits Nominated in dollars. (Index 1993:1=100)



Another natural way of analyzing the misalignment is by diving into the roots of the new benchmark. This misalignment is mainly driven by the difference between the interest rate chosen to measure the sustainability of debt and the rate of growth of the GDP. **Figure 9** gives another source of information to understand **Figure 6**. Here, we clearly see how the Mexican crisis and the bank run made an important contribution to make the debt, nominated in dollars unsustainable. Note, for example, that the gap between GDP growth rate and the interest rate was almost 18% before the crisis.

Figure 9: GDP Growth Rate-Interest Rate Differential



Summanizing, in this section we shed light into the role of RER in debt sustainability. From this analysis we can link the appreciated RER with the arrival of the crisis. But, many other questions can be done to this model. For example, we can have an idea of the GDP rate of growth consistent with this notion of debt sustainability.

4.1 The RER Misalignment in Terms of "Output Gap"

Other way of measuring currency misalignment is in terms of output gap. Of course this is not a conventional measure -which shows the gap between current and potential level of output-, but it can be used to answer to the question: How much greater the GDP should have been in order to make misalignment zero?

To derive this measure, we first have to derive GDP consistent with sustainability of the external debt (GDP_t^*) by plugging into the following accounting identity $GDP_t^* = I_t + C_t + TB_t^*$ the following trade balance (where interest rate is replaced by the rate of growth of GDP):

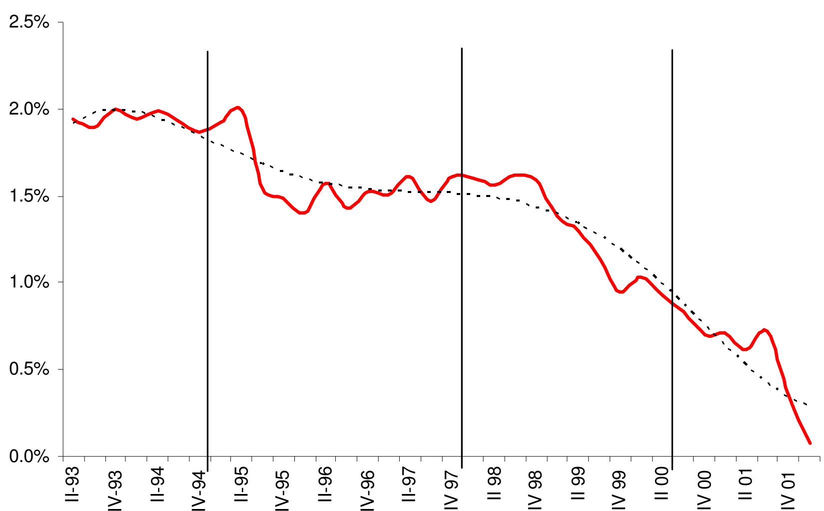
$$TB_t^* = \left[\begin{array}{c} NATREX_{\theta_t = R_t} + \left[\frac{C(6)C(2)C(8)+C(6)C(4)C(8)}{C(5)} \right] \\ + \frac{C(6)C(1)}{C(5)} I_{t-1} \\ + \frac{C(6)C(2)C(9)+C(6)C(4)C(9)}{C(5)} R_t \\ + \frac{C(6)C(3)}{C(5)} C_{t-1} + \frac{C(7)}{C(5)} Y_t^* \end{array} \right] \left[\frac{[1 - C(6)]}{C(5)} \right]^{-1}$$

$$TB_t^* = \left[\begin{array}{c} NATREX_{\theta_t = R_t} + 1.1547 + 2.819\,5 \times 10^{-2} I_{t-1} \\ -5.6620 R_t + 3.650\,9 \times 10^{-2} C_{t-1} - 9.418\,1 \times 10^{-4} Y_t^* \end{array} \right] \frac{1}{1.2332}$$

Then, output gap is simply defined as the percentage change in the GDP consistent with the sustainable debt and the current GDP. OG_t is output gap at time t. GDP_t^* is output consistent with debt sustainability (its rate of growth is equal to the interest rate paid for the external debt). GDP_t is current gross domestic product. Obviously, when the currency is not misaligned $OG = 0$. **Figure 10**, shows by how much GDP_t is below GDP_t^*.

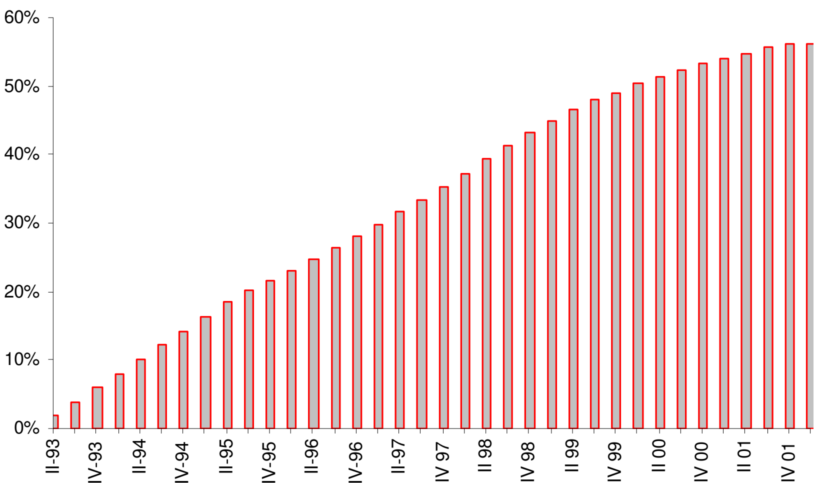
$$OG_t \equiv \frac{GDP_t^*}{GDP_t} - 1 \tag{31}$$

Figure 10: Output Gap in % Points.



If we want to have a flavor of how much GDP contributed to the increase in debt, the following question arises: for given R_t, what is the accumulated GDP Gap of the whole period? To answer this question we present in **Figure 11** the Accumulated GDP Gap as a percentage of the GDP of 1993:1. As can be seen, accumulated GDP mismatch reached almost 56% of the 1993 GDP.

Figure 11: Accumulated GDP Gap as % of GDP 1993:1.



4.2 The Comparison Between the two Misalignments

When we derived the long run equilibrium RER consistent with $CA = 0$ ($NATREX_{CA=0}$) in **Section 3**, we got a misalignment measure that gives information regarding the external balance. This measure does not make any explicit reference to internal market clearing conditions (output at its potential level, unemployment at the natural level) or any sustainability concept. However, when we follow the strategy presented in **Section 4**, $NATREX_{\theta_t=R_t}$, there is an explicit link between RER misalignment and debt sustainability. Then, the information given by this measures must be interpreted in a different way since they are constructed to answer different questions.

Among the characteristics that differentiate them we have that TB plus net factor income and unilateral transfers drive the first measure while financial sector, by means of the R_t, the second. The core features in both measures imply different transmission mechanisms for the same shock. For example, in $NATREX_{CA=0}$, a positive output shock deteriorates CA (increase in absorption) prescribing higher level of equilibrium RER, while in $NATREX_{\theta_t=R_t}$ implies lower level of equilibrium RER, for given R_t.

The correlations between some important variables of the model and the equilibrium RER are presented in **Table 1**.

Table 1: Correlations

	$NATREX_{CA=0}$	$NATREX_{\theta_t=R_t}$
GDP_t	.29	-.57
GDP_t^*	-.87	.45
TB_t	-.94	.84
$NFIAUT_t$	.10	-.37
R_t	.32	-.16
$\theta_t - R_t$	.29	-.06
$BCRARes$	.18	-.54

If we look at the table we find that signs are, by construction, the opposite. Then, as presented in **Figure 1** and **Figure 6** the path followed by both measures is close to be the opposite (correlation is -.7). As a matter of fact, **Figure 1** says that from the beginning of 1998, peso overvaluation fell. As shown in **Figure 6,** the reduction in the value of peso improved CA (the correlation between $NATREX_{CA=0}$ and CA is -.91). But, if we take into account that an improvement of CA is positively related to $NATREX_{\theta_t=R_t}$ (the correlation is .92) the overvaluation of the Argentinean peso is represented, by a negative misalignment, instead of positive. This is the result of how constraints were imposed into NATREX's derivation.

Other interesting difference is the assumption regarding the evolution of debt. Since change of debt reflects the CA in $NATREX_{CA=0}$ the stock of debt is assumed to be constant. In $NATREX_{\theta_t=R_t}$ debt is not assumed to be zero, what is forced to be zero it the rate of growth of the Debt/GDP ratio (b_t). In this way, we allow countries to be net debtor or creditor instead of having their capital account closed.

5 Conclusions

This paper contributes to the knowledge regarding the explanation of the Argentinean crisis. Instead of taking approaches based on the fiscal side, shocks in productivity or changes in expectations (Galiani, Heymann and Tommasi (2002) [17]), it explores the link between the RER overvaluation and debt sustainability. There is of course a general concern that the strong currency and excessive level of debt were among the roots of the crisis, however, an explicit link using NATREX theory has not been done for Argentina.

This essay computes the RER misalignment using as a benchmark a non-sationary notion (NATREX) that has many advantages respect to PPP. It then departs from the classical models of internal and external equilibrium by defining the condition under which the equilibrium RER is consistent with debt sustainability.

The advantage of this contribution is that it takes into account also other roots of the crisis, since it is built based on fundamentals. It also condition the equilibrium RER movements to the link between the debt/GDP ratio and the interest rate making it sensitive to capital flows, financial crises and structural braeks.

This suggested measure shows that the behavior of misalignment before the abandonment of the Currency Board was impressive. GDP contraction started in 1998 and the reduction in the Central Bank reserves coexisted with a RER misalignments that reached levels of 180%. The gap between the interest rate representing the debt services and the rate of growth of GDP was showing how difficult was to sustain the debt through the important increase in the RER misalignment.

The very simple approach followed in this paper gives many directions for future research. Among them we have that the introduction of tradables and no tradables would give information in terms of repayment capacity and the needed change in relative prices to get the required change in the RER. The small economy nature of this model also implies that the country takes the interest rate as given. It can be thought that the interest rate that the country pays for its debt is somehow determined by a block of countries.

6 Appendix A: The Investment Decision.

To derive the investment decision we start from a simple dynamic optimization problem of the standard type where we have an agent that maximizes Ω subject to the investment function:

$$\max_{c} \Omega = \int_0^\infty U(c) e^{-\rho t} dt \tag{A1}$$

$$\frac{dk}{dt} = f(k) - \lambda k - c \tag{A2}$$

Where $\lambda \equiv \delta + n$ $\quad U_c > 0 \quad U_{cc} < 0 \quad f_k > 0 \quad f_{kk} < 0$
$\lim\limits_{c \to 0} U_c(c) = \infty \quad \lim\limits_{c \to \infty} U_c(c) = 0 \quad \lim\limits_{k \to 0} f_k(k) = \infty \quad \lim\limits_{k \to \infty} f_k(k) = 0.$

The Hamiltonian of the problem can be written as $H = e^{-\rho t}U(c) + \mu\left[f(k) - \lambda k - c\right]$. where, μ is the Lagrange Multiplier or the costate variable. When introduce a new costate variable $q \equiv \mu e^{\rho t}$, the Hamiltonean can be expressed as $H = e^{-\rho t}\left[U(c) + q\left(f(k) - \lambda k - c\right)\right]$.

Then first order conditions are:

$$\frac{\partial H}{\partial c} = e^{-\rho t}\left[U_c(c) - q\right] = 0 \Rightarrow q = U_c(c) \tag{A3.1}$$

$$\frac{d\mu}{dt} = -\frac{dH}{dk} = -\mu\left[f_k(k) - \lambda\right] \tag{A3.2}$$

To transform this expression into the costate variable q observe that $\mu = qe^{-\rho t}$, hence$\frac{d\mu}{dt} = \left(\frac{dq}{dt}\right)e^{-\rho t} - \rho q e^{-\rho t}$. Then, by substituting into equation (A3.2) and collecting terms, we have:

$$\frac{dq}{dt} = -\left[f_k(k) - \lambda - \rho\right]q \tag{A4.1}$$

From which we get (A4.2) $f_k(k) + \frac{\frac{dq}{dt}}{q} - \delta - n - \rho = 0$ that can be interpreted as a zero net profit rate, where the net profit rate is defined as a gross profit rate (the marginal productivity of capital), plus the capital gains $\left(\frac{\frac{dq}{dt}}{q}\right)$, minus the losses due to depreciation (δ), minus the reduction due to the population growth (n), minus the intertemporal cost of waiting (ρ).

From the logarithmic differentiation of the optimality condition $q = U_c(c)$ with respect to time, we observe (A5) $\frac{\frac{dq}{dt}}{q} = \frac{U_{cc}(c)}{U_c(c)}\frac{dC}{dt} = -\sigma(c)\frac{\frac{dc}{dt}}{c}$ which can be substituted into the canonical equation (A4.2) to obtain (A6) $\frac{dc}{dt} = \frac{1}{\sigma(c)}\left[f_k(k) - \lambda - \rho\right]c$ (where $\sigma(c) = -c\frac{U_{cc}}{U_c}$). Doing this, we have transformed a *differential equation for the costate variable to a differential equation for the control variable*. Thus, the canonical equations for our optimal control problem are:

$$\frac{dc}{dt} = \frac{1}{\sigma(c)}\left[f_k(k) - \lambda - \rho\right]c \tag{A7.1}$$

$$\frac{dk}{dt} = f(k) - \lambda k - c \tag{A7.2}$$

This one is a system of two autonomous nonlinear differential equations. The singular points of this system give the steady state values c^*, k^* of c, k. In that steady state, we have $c^* = f(k^*) - \lambda k^*$ determining c^* and $f_k(k) = \lambda + \rho$ determining k^*. The optimal feedback control rule is found deriving $\frac{dk}{dt} = f(k) - \lambda k - c$ respect to k. See Stein (1995) [32].

$$\frac{d\left(\frac{dk}{dt}\right)}{dk} = f_k(k) - \lambda - \frac{dc}{dk} \tag{A8}$$

Since $\frac{dc}{dk} = \frac{dc}{dt}\frac{dt}{dk}$,we can write (A9) $\frac{d\left(\frac{dk}{dt}\right)}{dk} = f_k(k) - \lambda - \frac{dc}{dt}\frac{dt}{dk}$ as (A10) $\frac{d\left(\frac{dk}{dt}\right)}{dk} = f_k(k) - \lambda - \frac{U_c}{U_{cc}}\frac{[\lambda+\rho-f_k(k)]}{\frac{dk}{dt}}$.

Now, let's define for notational simplicity $V(k) \equiv \frac{dk}{dt}, V'(k) = \frac{\frac{dk}{dt}}{dk}$,then (A10) can be rewritten as (A11) $V'(k) = f_k(k) - \lambda - \frac{U_c}{U_{cc}}\frac{[\lambda+\rho-f_k(k)]}{V(k)} = F(k, V(k))$. Considering the neigborhood of the steady state, (A11) is equal to (A12) $V'(k)_{k=k^*} = V'(k^*) = f_k(k^*) - \lambda - \frac{U_c}{U_{cc}}\frac{[\lambda+\rho-f_k(k^*)]}{V(k^*)}$,where, $V'(k^*) = \rho - \frac{U_c(c^*)}{U_{cc}(c^*)}\frac{0}{0}$.Then, getting rid of the indeterminacy using l'Hopital and multiplying by $V'(k^*)$, we get:

$$V'(k^*) = \rho - \frac{U_c(c^*)}{U_{cc}(c^*)}\frac{f_{kk}(k^*)}{V'(k^*)} \tag{A13}$$

$$[V'(k^*)]^2 - \rho V'(k^*) - \frac{U_c(c^*)}{U_{cc}(c^*)}\frac{f_{kk}(k^*)}{V'(k^*)} = 0 \tag{A14}$$

Defining (A15) $A(k^*) \equiv \frac{\rho}{2}\left[\left(1 + 4\frac{U_c(c^*)}{U_{cc}(c^*)}\frac{f_{kk}(k^*)}{\rho^2}\right)^{\frac{1}{2}} - 1\right] > 0$ and knowing that local stability feedback rule requires (A16) $V'(k^*) = -A(k^*) < 0$,we can integrate (A16) in the neigborhood of the steady state between k and k^* and get (A17) $\int_k^{k^*} V'(\phi)d\phi = [V(\phi)]_k^{k^*} = V(k^*) - V(k) = -\int_k^{k^*} A(k^*)d\phi$.

But, since in the steady state $V(k^*) = 0$, then $\int_k^{k^*} V'(\phi)d\phi = -V(k)$ and $-A(k^*)\int_k^{k^*} d\phi = -A(k^*)(k - k^*)$ and $-A(k^*)$ is a constant, we get the Optimal Feedback control Law Stein (1995) [32], which will be our optimal investment function:

$$\frac{\partial k}{\partial t} = -A(k^*)(k - k^*) \tag{A21}$$

7 Appendix B: Derivation of the Sub-Optimal Feedback Control Rule

Taking into account that the optimal feedback control rule needs the assumption of prefect foresight, it is possible to derive what is called a sub-optimal feedback control rule (SOFC) in which the agents do not need to know the level of capital intensity in the steady state. Instead, only current values are needed to place the system in the stable arm leading it to the steady state.

For this purpose, we expand $f_k(k)$ in a Taylor serie:

$$f_k(k) = f_k(k^*) + f_{kk}(k)(k - k^*) \tag{B1}$$

In the steady state we have: $f_k(k) = \rho + \lambda + f_{kk}(k)(k - k^*)$ that can be rewritten in the following way: $(k - k^*) = \frac{f_k(k) - (\rho+\lambda)}{f_{kk}(k)}$.Plugging this expression into the optimal feedback control rule, we get the SOFC:

$$V_1(k) = \frac{dk}{dt}_{SOFC} = \frac{-A(k)}{f_{kk}(k)} \left[f_k(k) - (\rho + \lambda) \right] \tag{B2}$$

So, as we can see, it depends only on current variables. This rule is approximates quite well the optimal feedback control rule when t goes to infinite (Stein and Infante 1973 [21]).

8 Appendix C: Saving Decision in a Infinite Horizon Model

The continuous time formulation of the optimization problem, where the agent maximizes a separable utility function (C1) $\max_c \chi = \int_0^\infty U(c)e^{-\rho t}dt$ subject to the flow budget constraint (C2) $\dot{a} = f(k) + ra - c$ and with the transvesality condition (C3) $\lim_{t\to\infty} ae^{-rt} = 0$, is the way in which we get the optimal consumption function and hence savings function. C2 states that the difference between any instant current revenue, which includes interest income on the stock of wealth a, and expenditure equals the change in the stock of wealth. Under (C3) the flow budget constraint (C2) is equal to the intertemporal budget constraint (C4) $\int_0^\infty ce^{-rt}dt = \int_0^\infty f(k)e^{-rt}dt + a(0)$ which says that the present value of consumption must be equal to the present value of the consumer income plus the initial wealth $a(0)$. This equivalence of the two expressions can be shown by multiplying (C2) by e^{-rt} and integrating in the $[0, \tau]$ interval as follows:

$$\dot{a}e^{-rt} = [f(k) + ra]e^{-rt} - ce^{-rt} \tag{C5}$$

$$\int_0^\tau \dot{a}e^{-rt}dt = \int_0^\tau f(k)e^{-rt}dt + \int_0^\tau rae^{-rt}dt - \int_0^\tau ce^{-rt}dt \tag{C6}$$

Integrating by parts the left hand sidewe get (C7) $\int_0^\tau \dot{a}e^{-rt}dt = [ae^{-rt}]_0^\tau - \int_0^\tau [-ra]e^{-rt}dt = a(\tau)e^{-r\tau} - a(0) + \int_0^\tau rae^{-rt}dt$ then substituting (C7) into (C6), rearranging, doing $\tau \to \infty$ and using the transversality condition, we get (C9):

$$a(\tau)e^{-r\tau} - a(0) + \int_0^\tau rae^{-rt}dt = \int_0^\tau f(k)e^{-rt}dt + \int_0^\tau rae^{-rt}dt - \int_0^\tau ce^{-rt}dt$$

$$a(\tau)e^{-i\tau} + \int_0^\tau ce^{-it}dt = \int_0^\tau f(k)e^{-it}dt + a(0) \tag{C8}$$

$$\int_0^\infty ce^{-it}dt = \int_0^\infty f(k)e^{-it}dt + a(0) \tag{C9}$$

The maximization showed above, can be also solved using the Pontryagin's Maximum principle. Then, introducing the costate $\mu(t)$ variable, we can write the Hamiltonian (C10) $H = U(c)e^{-\rho t} + \mu[f(k) + ra - c]$, that can be written, introducing (just for convenience) the new costate variable $\lambda = \mu e^{-\rho t}$ in the following way (C11) $H = e^{-\rho t}[U(c) + \lambda[f(k) + ra - c]]$. Then, computing the first order condition ($\frac{\partial H}{\partial c} = 0$), we look for the possible existence of interior maximum:

$$\frac{\partial H}{\partial c} = e^{-\rho t}\left[U_c - \lambda\right] = 0 \Rightarrow U_c = \lambda \tag{C12}$$

The law of motion for state and costate variables are (C2) $\dot{a} = f(k)+ra-c$ and (C14) $\dot{\mu} = -\frac{\partial H}{\partial a} = -\mu r$. Or, in terms of costate variable (C15) $\dot{\lambda} = -\frac{\partial H}{\partial a} = \lambda(\rho - r)$. Finally, we have the trasversality condition in the costate variable $\lim_{t\to\infty} \lambda e^{-\rho t} = 0$.

Rewriting $U_c = \lambda$ by taking logarithmic differentiation with respect to time, we get an expression of the change in consumption depending on the elasticity of marginal utility (C18):

$$\ln\left[U_c\right] = \ln\left[\lambda\right] \tag{C16}$$

$$\frac{\dot{\lambda}}{\lambda} = \frac{\dot{U}_c}{U_c} = \frac{U_{cc}}{U_c}\dot{c} = c\frac{U_{cc}}{U_c}\frac{\dot{c}}{c} = -\sigma(c)\frac{\dot{c}}{c} \tag{C17}$$

$$\sigma \equiv -c\frac{U_{cc}}{U_c} \tag{C18}$$

Substituting the elasticity of marginal utility (C18) into (C15), since $U_c = \lambda$ we get (C19) $-\sigma\frac{\dot{c}}{c} = (\rho - r) \quad \Rightarrow \dot{c} = \frac{1}{\sigma}(r-\rho)c$. So, the dynamic system that solves the dynamic optimization problem con be written in the following way:

$$\dot{a} = f(k) + ra - c \tag{C20.1}$$

$$\dot{c} = \frac{1}{\sigma}(r-\rho)c \tag{C20.2}$$

Then, C20.2 represents our optimal consumption function that will be used to get, independently of the investmend desicion, the optimal path for savings[11].

9 Appendix D: Data Sources and Variables

All the data set covers the period 1993:1 2003:3. and the frequency is quaterly. The *GDP*, *Trade Balance* and *Investments* are 1993 values expressed in pesos and the source is INDEC. *Social Consumption* was costructed as a residual of the variables just expresed. *Bilateral Real Exchange Rate* represents the units of peso for one dollar and the source is CEI. *Merval* represents the Argentinean Stock Exchange Index and the source is Bolsa de Comercion de Buenos Aires. The *Interest Rate* is the interest rate payed to the deposits nominated in dollars. The source is BCRA. The *US's GDP* is in current values and the source is www.economagic.com. The Central Bank reserves Index was constructed using the Reserves published by BCRA.

[11] Note that in steady state , we have that $\dot{a} = \dot{c} = 0 \Rightarrow f(k) + ra = c$ and $\rho = r$ (The revenue and expenditure are equal in the steady state equilibrium. The rate of interest is equal to the discount factor in steady state). Also, if ρ is constant, then, it has to be equal to r in order to have a steady state. If this happens, a zero root problem in the system will arise in the dynamic system. However, there is no reason to expect ρ that should be constant.

10 Appendix E: Some information of the Estimated Model

10.1 System Estimation

Estimation Method: Full Information Maximum Likelihood (Marquardt)

Sample: 1993:2 2003:3

Convergence achieved after 13 iterations

Coefficient	Std. Error	t-Statistic	Prob.
$C(1) = 0.742522$	0.043651	17.01062	0.0000
$C(2) = 0.024712$	0.004141	5.967768	0.0000
$C(3) = 0.961452$	0.021601	44.51057	0.0000
$C(4) = 0.016153$	0.008122	1.988903	0.0484
$C(5) = 0.836685$	0.207364	4.034863	0.0001
$C(6) = -0.031771$	0.004656	-6.823176	0.0000
$C(7) = 0.000788$	0.000153	5.143083	0.0000
$C(8) = 744.1592$	87.00712	8.552854	0.0000
$C(9) = -3648.763$	1565.722	-2.330402	0.0210

Log Likelihood: -481.1851. Determinant residual covariance:105037.2

Equation: $I_t = C(1)I_{t-1} + C(2)M_t$

R-squared:0.908904 / Adjusted R-squared: 0.906626 / Mean dependent var: 48.57176 / S.D. dependent var: 7.348272 / S.E. of regression: 2.245420 / Sum squared resid: 201.6765 / Durbin-Watson stat: 1.448166

Equation: $C_t = C(3)C_{t-1} + C(4)M_t$

R-squared: 0.937836 / Adjusted R-squared :0.936282 / Mean dependent var: 212.3030 / S.D. dependent var: 15.69975 / S.E. of regression: 3.963006 / Sum squared resid / 628.2165 / Durbin-Watson stat: 1.842614

Equation: $TB_t = C(5)RER_t + C(6)Y_t + C(7)Y_t^*$

R-squared: 0.919074 / Adjusted R-squared: 0.914924 / Mean dependent var: -0.148649 / S.D. dependent var: 2.047491 / S.E. of regression: 0.597208 / Sum squared resid: 13.90965 / Durbin-Watson stat: 0.599256

Equation: $M_t = C(8) + C(9)R_t$

R-squared: 0.289970 / Adjusted R-squared: 0.272219 / Mean dependent var: 519.0765 / S.D. dependent var: 126.6110 / S.E. of regression: 108.0119 / Sum squared resid: 466663.2 / Durbin-Watson stat: 0.365624

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