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Carry Trade and Exchange Rate Regimes

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JEL Codes: F31, F34

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Abstract

Carry trade activities and foreign participation in local currency bonds in emerging countries have increased dramatically during the last decade. In line with this observation, we revisit the question of optimal exchange rate regime when developing countries can borrow internationally with local currency denominated debt. We obtain that a "pseudo flexible regime", in which the country accumulates reserves in conjunction with debt, is the best policy alternative under real external shocks.

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1 Introduction

In spite of its age, the debate about the optimal exchange rate regime keeps coming back in different forms. This paper revisits this debate making novel assumptions which reflect the new reality of capital flows to emerging markets. First and foremost, we consider that the growth of carry trade activities, and the associated increase in the foreign participation of local bonds markets, means that emerging countries are now borrowing internationally in domestic currency denominated bonds. This, of course, involves recognizing that interest rates are different across countries, and that there are risks associated with exchange rates depreciations. Second, we do not resort to money and its role to determine exchange rates or to provide fiscal adjustments. Third, we consider reserve accumulation in conjunction with debt accumulation as a policy alternative.

The first of our hypothesis, carry trade and foreign participation in local currency bonds markets in emerging economies, only became quantitatively relevant in this millennium. Although impossible to measure with precision, the amount of carry trade activity – the borrowing of resources in low interest rate currencies and investing in high interest rate currencies, without hedging for the exchange rate risk – have increased enormously. For just one example, the stock of foreign currency investments made by Japanese households through investment trust funds was almost non-existent in 2002 but reached 35 trillion yen in 2007 (BID paper). These resources, in search of high interest rates, often flow to Emerging Markets[1]. As Burger, Warnock and Warnock (2010) show, U.S. investors' participation in local currency bond markets in emerging economies has increased dramatically since 2001. By end-2008, the U.S. participation in local currency Latin American bonds were triple the share U.S. investors held of advanced economies. One should thus conjecture that this massive capital flows may be an important factor on the exchange rate determination and on the choice of the exchange rate regime in developing countries.

A technical consequence of taking into account that domestic interest rates may be different from international interest rates, and explicitly modeling its risks, is that exchange rate determination in our model does not depend on the existence of money. Rather than being the price of money, exchange rate is

[1] As Burnside, Eichenbaum and Rebelo (AER 2007) show, including emerging market currencies in the portfolio substantially increases the Sharpe ratio associated with the carry trade

such that the portfolio allocation is satisfied. We see our second hypothesis - the absence of money - as an advantage of our model, as in recent decades monetary base became increasingly erratic and irrelevant compared to the size of the economies. The institutional changes and advances in information technology that have eroded the role of base money in transactions will probably carry those trends still farther in the next few decades. Models designed with the purpose of studying optimal monetary policy consider that the central bank needs only to be able to control the level of short-term interest rates, and do not even explicit consider monetary aggregates. It is thus just natural to expect that exchange rate models should follow the same path.

The last characteristic of our model is to consider the role of reserve accumulation in the context of exchange rate management. There is a renewed interest in policy and academic circles about the optimal level of foreign reserves sovereign countries should hold, given the rapid rise in international reserves held by developing countries. This practice is not exclusive of China or the East Asian countries, but has become widespread phenomenon among emerging markets, including countries that hold a large amount of external debt. Given that the cost of holding reserves has been estimated at close to 1% of GDP (Rodrik (2006)), the question is what the benefits are. One possibility is that countries may have accumulated reserves as an insurance mechanism against the risk of an external crisis—self protection through increased liquidity. Another possibility, which we consider here, is that reserves are used as a device to manage exchange rates.

It turns out that when casted with these assumptions, the question of optimal exchange rate regime looks much like a problem of optimal debt management, in which a sovereign is choosing its debt denomination. And by looking at the exchange rate question as a sovereign debt problem, we are able to discuss its sustainability as something endogenous to the model. In other word, the viability of the exchange rate regime becomes an explicit part of the analysis.

The new consensus in policy circles (see e.g. Williamson (2010)) seems to be that exchange-rate regimes commonly discussed in the textbooks are impractical. Fixed exchange rate regime may even have desirable features in some cases. But since it is a system that has been historically condemned by speculative attacks, it should be disregarded. On the other extreme, freely floating exchange rates suffer from large currency misalignments despite the absence of any shocks that could conceivably have justified them, and thus impose large economic costs.

Academic literature has reached very different conclusions about the optimal exchange rate regime, depending on the hypothesis. Some contrasting examples are Helpman (1981), Devereux and Engel (2003), Céspedes Chang and Velasco (2004), and Lahiri, Singh and Vegh (2007). This paper contributes to this literature by making assumptions that capture recent trends toward globalization and international flow of funds. In the sense our hypothesis reflect the new reality, our conclusions may be increasingly relevant.

The paper has four main results. First, as in many studies of optimal exchange rate regimes we obtain that this choice depends crucially on the type of shock to the economy. In our framework, flexible exchange rate regimes are optimal for domestic shocks, whereas fixed exchange rates are ideal for external shocks. This is reminiscent of Mundell's result about nominal versus real shocks, which is obtained in a model with money and only domestic shocks.

Second, we obtain that even though fixed exchange rates are ideal in the presence of external shocks, the traditional fixed exchange rate regime in not a sustainable one. Third, by means of issuing local currency bonds a flexible exchange rate regime can reduce exchange rate volatility. We dub this policy a "pseudo flexible regime". Fourth, this regime can achieve even better welfare levels if implemented with conjunction with reserve accumulation.

The rest of the paper is organized as follows. Section 2 presents the model. Sections 3, 4, 5 and 6 discuss how adequate are different exchange rate regimes. Section 7 calibrates the model and performs some quantitative simulation to evaluate welfare. Section 8 concludes.

2 Model

Our economy is populated by a sovereign country that borrows funds from a continuum of international risk-neutral investors. The economy faces uncertainty in output. As preferences are concave in consumption, households prefer a smooth consumption profile, both of tradable and non-tradable goods. In order to smooth consumption, the benevolent government may choose optimally issue foreign debt both in domestic currency (denominated in the price of the non-tradable good) and in international currency (denominated in the price of tradable good).

In more precise terms, we assume the sovereign's preferences are given by

$$U = E\sum_{t=0}^{\infty}\beta^t u(c_t^T ,c_t^N) \tag{1}$$

with,
$$u(c^T ,c^N) = \frac{[\, \omega(c^T)^{-\eta} + (1-\omega)(c^N)^{-\eta}]^{(\frac{1-\sigma}{-\eta})} - 1}{(1-\sigma)} \tag{2}$$

where $c^T{}_t$ and $c^N{}_t$ denote household consumption of tradable and non-tradable goods, $\sigma > 0$ measures the curvature of the utility, η measures the degree of substitution between tradable and non-tradable goods, ω indicates the relative importance of these goods for household's preferences, and $\beta \in (0, 1)$ is the discount factor.

The country's budget constraint is given by

$$c_t^T + \frac{c_t^N}{e_t} - B_t - \frac{D_t}{e_t} = A^T\, exp(z_t^T) + \frac{A^N\, exp(z_t^N)}{e_t} - B_{t-1}(1+\rho_{t-1}) - \frac{D_{t-1}(1+r_{t-1})}{e_t} \tag{3}$$

where B_t denotes the foreign denominated debt level in period t, D_t denotes the domestic denominated debt level, $z^T{}_t$ and $z^N{}_i$ are the tradable and non-tradable technology states in this period, which determines the output level of each type of good in conjunction with the constants A^T and A^N. ρ_t is the exogenous international real interest rate, r_t is the endogenously determined real interest rate on the domestically denominated debt, and e_t is the endogenously determined real exchange rate.

Note that we are assuming there is no money, and thus the nominal exchange rate not even appears in the budget constraint. Thus, in principle, all discussions and analysis under this model should be about the *real* exchange rate, and its regime. However, if we implicitly assume that prices are sticky, as in any Mundell-Fleming analysis, we can think of the real exchange rate as the nominal exchange rate. In fact, in the absence of nominal rigidities the choice of the fixed versus flexible exchanges often becomes irrelevant (Helpman (1981)). There is wide evidence that variations in the nominal exchange rate are almost mostly due to variations in the real exchange rate (i.e., prices are sticky), and this hypothesis is hardly a controversial one. In any case, we discuss in each case in which sense price flexibility would affect the results.

Another implicit model assumption that deserves attention is that it is the sovereign and not the households who borrows and lends resources. There are two different issues here. First, the model analysis would be unchanged if one includes domestic debt or transactions between the private sector and the government (households and sovereign), as far as there are no tax distortions or other imperfection. Second, in principle households access to international markets could affect the model results, even in the case the sovereign is benevolent. However, as we discuss, time-inconsistency problems do not appear in our model, and households do not have incentives to borrow or lend internationally in equilibrium. Hence, the hypothesis that it is the sovereign rather than the households who does the borrowing and lending is not really relevant.

We assume the technology states z^T_t and z^N_t can take a finite number of values and evolves over time according to a Markov transition matrix with elements $\pi^T(z^T_i, z^T_j)$ and $\pi^N(z^N_i, z^N_j)$, respectively. That is, the probability that $z^T_{t+1} = z^T_j$ given that $z^T_t = z^T_i$ is given by the matrix π element of row i and column j, and analogously for z^N. As for the timing, we consider that in each period z^T_t and z^N_t are revealed before the sovereign chooses B_{t+1} and D_{t+t}.

We assume there is debt ceiling, or a maximum amount of sustainable debt, given by $(B + D/e) \leq M$. There is, of course, a long literature about sustainability of debt which analyses the incentives of the sovereign to repudiate its debt, and endogenously determine this debt ceiling. But, for our purposes, and to make things simpler, we assume it to be exogenously given.

International investors are risk neutral and have an opportunity cost of funds given by ρ_t, which denotes the risk-free rate denominated in the tradable good prices. For these investors to be indifferent between the riskless asset and lending in a country's non-tradable good denomination, it must be that

$$(1+r_{t-1})E_{t-1}\left(\frac{e_{t-1}}{e_t}\right) = 1+\rho_{t-1} \tag{4}$$

which is the uncovered interest parity. Given this equation, and taking the prices as given, the utility maximization of the sovereign country model implies in the two usual Euler equations. One of them is the intertemporal decision, which reflects the desire to smooth consumption. The other describes the intratemporal choice between the two types of consumption, and is given by

$$e_t = \frac{\omega}{(1-\omega)}\left(\frac{c_t^N}{c_t^T}\right)^{1+\eta} \tag{5}$$

A final useful equation is the market clearing condition for non-tradable goods:

$$c_t^N = A^N exp(z_t^N) \tag{6}$$

3 Optimal Exchange Rate with Domestic and International Shocks

Before actually discussing the implementation of exchange rate regimes through the use of different types of debt, we need to know the exchange rates that are consistent with the optimal allocation. With this purpose, in this section, we look at the optimal allocation how when the economy is subject to the different types of shocks, and obtain the exchange rate in this situation.

We start by analyzing the optimal exchange rate in a situation where the economy is only subject to the domestic shocks. To better understand this situation, it is useful to first consider a case in which the households' preferences is separable in the two types of consumption, that is, $\frac{\partial u^2(c^T, c^N)}{\partial c^T \partial c^N} = 0$. For example, when the utility function has a CES specification as in (1), this happens when $\eta = 0$ and $\sigma = 1$.

Under the hypothesis that the level of non-tradable consumption does not affect the marginal utility of tradable goods, the households would like to smooth tradable consumption as much as possible. And given that shocks are exclusively domestic, they can achieve perfect smoothing of tradable consumption by keeping debt constant. To see that, notice that plugging (6) into (3), and making $D_t = 0$ one obtains

$$c_t^T - B_t = A^T exp(z_t^T) - B_{t-1}(1+\rho_{t-1}) \tag{7}$$

and that z^T and ρ are constant.

Given that the optimal solution to the households problem imply in constant c^T, we can use equation (5) to obtain the optimal exchange rate. Since there are domestic shocks, c^N will change overtime and, therefore, the optimal exchange rate will also change with time. The answer in this case is thus simple. By keeping debt (or reserves) constant, and letting the exchange rate freely float the sovereign implements the optimal allocation.

In the case in which the utility function is not separable, households will prefer not to perfectly smooth the consumption of tradables. However, even in this case, the optimal exchange rate should fluctuate, as the optimal allocation should balance intertemporal smoothing with intratemporal substitution. Thus, again, it would *not* be optimal to have a fixed exchange rate regime. In this case, however, it is not optimal to have debt constant, as it would imply in constant consumption of tradables.

Now consider a situation case in which the economy is subject only to international shocks. In this case the consumption of non-tradables will be constant and, regardless of the utility functional form, households would prefer to perfectly smooth the consumption of tradable goods. As a consequence, the optimal regime would be one in which the exchange rate is fixed.

The simple conclusion from this discussion is that the optimal exchange rate depends on the type of shock the economy is subject to. When the shock is domestic, the optimal allocation implies that exchange rate changes overtime. When the shock is international, the optimal allocation is consistent with fixed exchange rate. This is reminiscent of Mundell's (1968) work, which implies that the optimal choice of exchange rate regime should depend on the type of shocks hitting an economy. In his framework, with money and only one sector, real shocks would call for a floating exchange rate whereas monetary shocks would call for a fixed exchange rate. It also related to more recent utility-maximizing work, as Devereux and Engel (2003), who show how optimal exchange rate results are sensitive to whether prices are denominated in the producer's or consumer's currency.

Another conclusion is that when shocks are domestic and the utility function separable in tradable and non-tradable goods it is simple to implement the optimal allocation by the keeping debt constant, the traditional pure flexible exchange rate regime. However, when shocks are international, and it is optimal for the exchange rate to be fixed, we have not discussed how to implement it. This is the topic of the next sections.

Importantly, most of the discussions in policy circles are exactly about this situation, when international shocks drive emerging economies exchange rates to levels that cannot be rationalized by fundamentals. Policymakers' reaction is that this large currency misalignments result in important economic costs, and their question is how to proceed to in order to make exchange rate less volatile.

There have been different types of international shocks. Some seem to be associated with Terms of Trade and the price of commodities, other to the international interest rate. For simplicity reasons, in our model we are considering that all international shocks can be represented by variations in z^T. But notice that shocks in ρ would be qualitatively the same, since it would also affect the availability of (tradable) wealth, affecting the smoothness profile of the tradable good.

4 The Traditional Fixed Exchange Rate Regime

In this and the next sections we assume the economy is subject only to international shocks[2]. Consequently, as we discussed, it is optimal to smooth as much as possible the path of the tradable goods. The question is how to do it.

As a first possibility, we consider the traditional fixed exchange rate regime, in which the sovereign assets must change in order to keep exchange rate constant, and that sovereign only issue debt on the international currency. By plugging (5) and (6) into (3) and making $D_t = 0$ we obtain the path that debt must follow as

$$B_t = B_{t-1}(1+\rho) + A^N \, exp(z^N) \left[\frac{\omega}{(1-\omega)e} \right]^{\frac{1}{1+\eta}} - A^T \, exp(z_t^T) \tag{8}$$

Notice that the only time varying variable in this expression is $z^T{}_t$, which completely determines the evolution of debt B_t for any given and constant exchange rate e. For each z^T this is a difference equation that determines one steady state for B, that is, an exchange rate e that makes B constant. This steady state is unstable, since $(1 + \rho) > 1$. Since $z^T{}_t$ is an stochastic variable, we should be looking for an invariant distribution for B_t. However, since $(1 + \rho) > 1$, this distribution is unbounded. In other words, B_t can be as large as one wants, contradicting the sustainability constraint $B \leq M$.

[2] Notice that we are abstracting from discussing the situation in which shocks are domestic but preferences are not separable, which implies a very particular optimal profile for the tradable goods, a situation in which the exchange rate is "not flexible" but also not constant. In a sense, the case with only international shocks is a particular and clearer case, in which the optimal exchange rate is "not flexible" and constant.

This result has an important and widely recognized implication for the traditional fixed exchange rate regime. Although it may be optimal, as in the case of international shocks in our model, it is not sustainable. A sequence of bad shocks (low values for z^T) would imply that the level of debt B_t increases too much, reaching values above its sustainability ceiling. Just before this happens the international investors would anticipate that the sovereign would default and not honor her obligations, and therefore will not lend more resources. And as the debt B_t cannot increase, the sovereign is forced to abandon the fixed exchange rate regime.

The result that the traditional fixed exchange rate regime is unsustainable in our model raises a question about the sustainability of gold standard (or "true" currency board regimes). We are used to think that the gold standard regime has a self-correcting mechanism that makes it sustainable. Why is not it so in our model? There are two reasons. First, and more important, the gold standard system implicitly assumes that countries cannot issue debt, or at least not enough debt that makes it unsustainable. Second, it considers that prices (or wages) are flexible in the long run, and their changes would make the necessary adjustments, and hence the real exchange rate would also adjust. By assuming that prices are perpetually fixed we are missing this channel.

5 Debt Denomination and the Pseudo Flexible Regime

Assume again that the economy is subject only to international shocks and, consequently, that is optimal to smooth as much as possible the path of the tradable goods and have the exchange rate constant. But, rather than issuing internationally denominated debt the sovereign issues domestically denominated debt. In particular, assume that the sovereign decides to keep the (real) level of this debt constant, that is, $\frac{D_t}{e_t} = d$. Making $B_t = 0$ and plugging into (4) and (6) into (3), one obtains

$$c_t^T = A^T \exp(z_t^T) + d\left[1 - \frac{(1+\rho)}{e_t E_{t-1}(1/e_t)}\right] \tag{9}$$

Where, plugging (6) into (5), the exchange rate is given by

$$e_t = \frac{\omega}{(1-\omega)}\left(\frac{A^N \, exp\, z^N}{c_t^T}\right)^{1+\eta} \quad (10)$$

The solution of the system of equations (9) and (10) determines the consumption of tradables c^T and the exchange rate e_t as a function of exogenous variables. And we can use d to do comparative statics.

To understand how this equilibrium looks, consider a period of a good shock, that is, high z^T. The first term of the Right Hand Side of equation (9) implies that the consumption of tradable should be relatively larger. However, the second term of this Right Hand Side makes the consumption of tradable relatively smaller, since the exchange rate is smaller (from (10)). As a consequence, as d increases, the final consumption ends up not increasing so much, in a period of good shock, when compared to a case where d is equal to zero.

The economics of this result is well known. In a stochastic environment, government liability should include state-contingent securities in order to hedge against macroeconomics shocks in order to achieve consumption (or tax) smoothing (Bohn (1990), Alfaro and Kanczuk (2010)). In the present case, debt denomination is useful as a means to smooth consumption since debt services is negatively correlated with the endowment shock.

Perhaps less recognized is the fact that potential gains of contingent services are greater than those of contingent debt. That is, as Grossman and Han (1999) show, a constant amount of debt with contingent service may engender more smoothing than the one attained through varying the amount of outstanding debt (without contingent services).

Back to our case at hand, we obtained that in order to achieve consumption smoothing the sovereign would have to increase d, but there is a limit to this strategy, since there is a sustainability ceiling expressed by the constraint $d = D/e \leq M$. Of course there is here a quantitative question as to whether this constraint is binding. But anticipating the results of section 7 we find that it is indeed binding, and that the optimal policy under this regime, the situation in which consumption and exchange rate are smoother, is obtained by setting $d = M$.

How should we call the policy of setting a constant debt and having the exchange rate fluctuate? Traditionally this is called flexible exchange rate regime, since the sovereign assets are kept constant. However, as discussed, this is the policy in which the exchange rate is less volatile. In lack of better name, we refer to this as a "Pseudo Flexible Exchange Regime".

In spite of its smoothing effect, one should expect that in this regime exchange rates tend to fluctuate nevertheless. And, as a consequence of the exchange rate risk, interest rates of the domestically denominated bonds should be different from the riskless rate. In particular, when the technology state z^T is good (high), the exchange rate is more appreciated. In this situation, using a revert to mean argument, the exchange rate is expected to devaluate. As a consequence, the "contractual" yields of local currency bonds of this emerging country should be higher than the international rate. International investors who opt to borrowing of resources in the international low interest rate and invest in this country high interest rate bond (without hedging for the exchange rate risk) are practicing a carry trade strategy. Of course, by construction, in our model the "peso problem" completely explains the return to carry trade. That is, exchange rate devaluations occur as often as to make ex-post returns in local bonds equal to the riskless rate.

6 Reserves Accumulation

In the previous section we have considered that the sovereign issues exclusively domestically denominated debt. An additional possibility would be for the sovereign to have liabilities (or assets) in the international denomination. Although the reasons are not clear, the rapid accumulation of reserves is recently a common practice among emerging countries. And given that the interests that these countries earn from these reserves are much lower than the interests paid in their debt, this policy seems extremely costly.

For one example, in 2010 Brazilian government debt was approximately 65% of GDP, and paid an interest rate about 12% per year. At the same time, the interest rates received on its reserves, which amounted to 15% of GDP, were close to 2%. It is not clear why Brazil did not choose to use its reserves to reduce the amount of outstanding debt. The difference between the two interest rates, multiplied by the amount of reserves, implied a cost of about 1.5% of GDP.

Our model raises a potential rationale for this type of policy. As we discussed in previous section, in order to smooth consumption it is optimal for the sovereign to issue as much debt as possible. However, there is a sustainability limit to the amount of outstanding debt. By having reserves, or internationally denominated assets that bear the (risk free) international rate, the sovereign can keep the same level of net debt and increase the stabilizing effect of its domestically denominated debt. That is, suppose the instead of having $d = M$ domestically denominated debt, the sovereign asset position is $d' - R = M$, where R is the amount of reserves, or internationally denominated assets. Then, the amount of domestically denominated debt increased by the amount of reserves ($d' = M + R$) without increasing the net debt ceiling.

In this case, equation (9) becomes

$$c_t^T = A^T exp(z_t^T) + (M + R) \left[1 - \frac{(1 + \rho)}{e_t E_{t-1}(1 / e_t)} \right] + \rho R \tag{11}$$

Where e_t is given by (10). Keeping net debt equal to its ceiling (M), when the sovereign accumulate reserves, and at the same time accumulate debt, it increases the importance of the second term of the right hand side of (11), and thus makes consumption of tradable smoother. The following section contains a quantitative application of this logic and makes it clearer.

The logic of the scheme of accumulating both reserves and debt is, therefore, exactly for it to be very costly during good periods. When the international shock is favorable (z^T high), total debt services become higher and reduce consumption. In turn, when the international shock is unfavorable, debt services would be low and increase consumption. And when considering the whole invariant distribution of shocks, the country will have a more stable consumption level and higher welfare.

Notice that in the construction proposed the level of reserves stays high during unfavorable periods. Thus, contrary to the usual argument in policy circles, reserve is not an insurance that can be “used” in bad times. The idea is not to buy consumption goods depleting the stock of reserves. Rather, the reserves stock is kept constant, and works as an insurance by increasing the magnitude of the stabilizing effect of domestically denominated debt.

7 Quantitative Experiment

In order to sharpen the results, and quantifying the welfare costs of the alternative exchange rate regimes, in this sector we simulate the model under alternative hypothesis. To do so, we calibrate it using the following parameters.

We set the international interest rate $\rho = 0.04$ and the intertemporal substitution parameter $\sigma = 2$, as it is usual in the Real Business Cycle Research (see Kanczuk (2004)), when considering that each period corresponds to one year. In order to make the elasticity of substitution between tradable and non-tradable goods equal to 0.5, which is the evidence for Latin American countries (see for example Alves et alli (2003)), we make $\eta = 1$. The same evidence points to equal weight of tradeables and non-tradables, that is, $\omega = 0.5$. We also set $\rho = 0.05$, that $A^T = A^N = 1$, and that the debt ceiling is $(B + D/e) \leq M = 0.6$, which correspond to 60% of the tradable GDP in a neutral state ($z^T = z^N = 0$). In order to get reasonable levels of debt in equilibrium, we set we set the intertemporal factor to a relatively low value $\beta = 0.90$, which is a common practice in debt models (Alfaro and Kanczuk (2009))

In order to focus on the interesting case in which the shocks are external, we make $z^N{}_t = 0$ for any t. To calibrate the technology state z^T, we consider that for the (logarithm) of the tradable GDP follows an $AR(1)$ process, that is, $z^T_{t+1} = \alpha z^T_t + \varepsilon_{t+1}$, where $\varepsilon_t \approx N(0, \sigma^2)$. We assume that $\alpha = 0.5$ and use various standard deviations σ in our experiments. We discretize this technology state into five possible values, spaced so that the extreme values are 2.5 standard deviations away from the mean, and use the Quadrature Method (Tauchen (1986)) to calculate the transition probabilities. We also discretized the space state of debt, making it fine enough not to affect the decision rules.

In our first experiment we consider the country issues only bonds denominated in international currency. In this situation, the sovereign changes the level of outstanding debt in order to smooth tradable goods consumption as well as possible. Figure 1 shows, for the case σ = 20%, the policy function, that is the level of debt B_t as a function of the state variables B_{t-1} (horizontal axis) and z^T_t (various curves). As a direct consequence of our hypothesis, the sovereign can only hold a maximum level of debt is 60% of GDP, even for unfavorable states. When this restriction is not binding, the sovereign adjusts the level of debt in the expected way: in favorable states of nature (high z^T) it prefers to decrease the level of outstanding debt.

Table 1 reports the results for different volatilities of the endowment process (σ). Notice that, as expected, the volatility of the consumption of tradables and the exchange rate increase with the volatility of the endowment. Less obvious is the fact that the average debt level decreases when the volatility of the endowment increases. This is so because when the volatility is high the sovereign opts to increase the volatility of debt, changing the level of outstanding debt to smooth consumption. However, since it faces a constraint in the maximum amount of debt, it is forced to operate with a smaller average debt level. In turn, when the volatility of endowment is low, debt is mainly used to front load consumption, and the sovereign chooses to hold the maximum allowed amount of debt.

Our second economy is one that issues local currency debt, and potentially holds reserves. Its results, for the case σ = 20%, are reported in Table 2. We choose this volatility level as a benchmark because it implies volatilities of exchange rate close to 40% (table 1), which is in line with the observed in emerging countries.

Starting with the case in which the sovereign has no reserves, note that it opts to hold the maximum amount of outstanding debt. In fact, the policy function (which we do not graph) is to hold the maximum amount of debt next period regardless of this period state. This happens because the stabilization effect that comes from issuing local currency debt allows for sufficient consumption smoothing that the level of debt can be only used to frontload consumption. When we increase the level of reserves the amount of *gross* debt also increases, so that the *net* debt remains at its maximum level. As discussed, this amplifies the consumption smoothing effect of local currency debt.

We report welfare of our second economy in relationship with the welfare of the *first* economy (only international currency bonds) with the same endowment volatility ($\sigma = 20\%$). Note that even without reserves, the local currency bonds economy achieves a substantially higher welfare (1.36% in consumption terms). In the case with a lot of reserves (400% of GDP), this economy performs even better (2.14% gain in consumption). Perhaps due to numerical imprecision of our computational experiments, higher holdings of reserves do not increase welfare further.

8 Conclusion

According to the Mundell-Fleming model, when an economy is hit by foreign real shocks, flexible exchange rates dominate fixed rates. The intuition, stressed by Milton Friedman, is that nominal rigidities make it both faster and less costly to adjust the nominal exchange rate in response to a shock that requires a fall of the real exchange rate. But what if it is possible to somehow offset the foreign shock, so that the real exchange rate does not have to change?

We revisit the exchange rate regime choice assuming that emerging markets can borrow internationally in local currency. This hypothesis reflects a new trend in international capital flows, characterized by carry trade and relevant foreign participation in local currency bonds markets. Our main result is that, by internationally borrowing in domestic currency, emerging countries can partially offset the foreign shocks. As a consequence, they can implement a less flexible exchange regime, which we call pseudo flexible. This regime is sustainable and leads to higher welfare than alternatives.

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Table 1: Invariant Distributions for International Currency Debt Economy

Endowment Standard Deviation (σ) (%)	Debt (% GDP)	Consumption Standard Deviation (%)	Exchange Rate Standard Deviation (%)
2	60	2.5	5.0
4	59.9	5.0	9.9
5	59.8	6.2	12.3
10	55.0	10.9	21.8
20	29.7	18.6	37.2
30	-15.2	25.0	49.9
40	-61.4	31.5	63.0

Table 2: Invariant Distributions for Local Currency Debt Economy with σ = 20%

Reserves (% GDP)	Debt (% GDP)	Consumption Standard Deviation (%)	Exchange Rate Standard Deviation (%)	Welfare (% GDP)
0	60	15.4	30.7	1.36
10	70	14.8	29.6	1.46
30	90	13.8	27.6	1.61
60	120	12.5	25.0	1.78
100	160	11.1	22.2	1.92
200	260	8.7	17.4	2.09
300	360	7.2	14.3	2.14
400	460	6.1	12.2	2.14
500	560	5.3	10.6	2.13

Figure 1: Debt Decision in the International Currency Debt Economy