Financial Dollarization and Central Bank Credibility.

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May 2008

Abstract

In this paper, we argue that foreign currency debt, by altering the effect of a devaluation on output, has a disciplining effect when the Central Bank’s objectives differ from the social optimum. Under imperfect information, bad priors about the Central Bank induce excess dollarization of liabilities, which in turn limits the ability of the Central Bank to conduct an optimal monetary policy. In addition the economy may become stuck in a “dollarization trap” in which dollarized liabilities limit the ability of agents to learn the true type of the monetary authority. The model has clear-cut policy implications regarding the taxation of foreign currency liabilities as a way to encourage perfect information and avoid dollarization traps. Moreover, it reinforces the existing argument for Central Bank independence. Finally, we believe this model to be consistent with a growing empirical literature on the determinants of foreign currency liabilities and their relationships to Central Bank credibility.

JEL Classification Numbers: E52, E61, F41, F36, G21.
Keywords: Dollarization, Monetary Policy, Learning Trap.

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*We thank (without implicating) Guillermo Calvo, Olivier Jeanne, Aart Kraay, Ugo Panizza, Roberto Rigobon and Sergio Schmukler for helpful comments on an earlier version of this paper. Cesar Serra provided outstanding research assistance. This paper represents the views of the authors not those of the World Bank, its Executive Directors, or the countries they represent.

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1 Introduction

Much has been written on the impact of foreign currency denominated debt in emerging market economies. A series of papers have argued that liability dollarization played an important role in recent crisis episodes in East Asia (and more recently in Argentina) and as such is an important source of financial fragility. Another line of research has discussed how governments should respond to dollar-debt, in particular how dollar-debt alters the trade-off between fixed and flexible exchange rates and therefore the optimal exchange rate policy. The debate on dollar-debt has been particularly vigorous in Latin America, where in many countries a substantial fraction of both domestic and foreign debt is denominated in dollars. Recently the debate has shifted towards “de-dollarization”, whereby the benefits to countries of keeping control of their monetary policy is being reassessed.

In this paper we argue that, by altering the effect of a devaluation on output, dollar-debt can play a role in disciplining an overly expansive monetary authority. This restraint does not come for free. In the short run dollar debt increases the likelihood of financial distress and limits the capacity of the Central Bank to conduct a stabilizing monetary policy. In the long run, the presence of dollar-debt may limit the ability of the monetary authority to gain credibility, as it is difficult for agents to determine how the Central Bank would behave in the absence of dollarized liabilities.

In our model, when information is complete, interest rates adjust to incorporate the disciplining effect of dollar-debt, leading to an optimal currency composition choice by firms. In particular, when the Central Bank has a devaluation bias, lenders are willing to offer dollar loans cheaper than peso loans. Responding to the interest rate differential, borrowers increase their share of dollar-debt, making a devaluation more costly and thus mitigating the initial bias. In this framework, portfolio compositions optimally trade-off the cost of an excessive devaluation with the likelihood of such an event.

The central argument of this paper considers the case when agents are no longer certain about the true parameters of the economy. If the Central Bank lacks credibility, then dollarization may exceed its full-information level. The immediate effect of this lack of credibility is that agents tie the hands of the Central Bank excessively, restricting the effectiveness of monetary policy. In the long-run, the effects of imperfect information can be exacerbated, as excess dollarization has additional dynamic effects. By taking on dollar-debt, agents limit the Bank’s capacity to reveal its type so that the economy can be stuck in an a long run equilibrium with suboptimal (too high) levels of dollar-debt and imperfect learning. A useful analogy to the dynamic effects of dollarization on learning is that of a prison board deciding whether to release a convict. Leaving the convict in prison will make it extremely costly for the good prisoner to differentiate himself from the guilty individual. Priors about the convict will remain unchanged, as any good behavior in prison is attributed to the restrictions placed on the convict’s actions. Similarly, a period of seemingly responsible monetary policy can be interpreted as the outcome of large amounts of dollar-debt rather than an absence of a devaluation bias, making dollarization a persistent phenomenon.

The key result of this paper is that giving agents the option to mute the Central Bank has perverse effects when the latter is welfare maximizing but lacks credibility. We then raise the

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1 Following much of the literature, we call foreign-currency-denominated-liabilities, dollar-debt. Peso debt therefore refers to domestic currency denominated liabilities.
question of dollar-debt taxation and capital account liberalization. In particular, we argue that, by temporarily restricting agents’ ability to take on dollar-debt, governments can give the opportunity to the Central Bank to gain credibility at a lower cost, no longer making costly dollarization the preferred alternative.

We believe that this model helps explain one of the more puzzling stylized facts surrounding dollarization of liabilities in emerging economies: the persistence of high levels of financial dollarization in many economies despite falling inflation rates, as illustrated in figure (1) for countries in South America. If, as we argue, high levels of dollarization restrict the Central Bank’s capacity to generate credibility, it is not surprising that high levels of dollar-debt persist even after periods of “good” monetary policy. In addition, our model is consistent with a series of recent papers that find a positive and significant correlation between financial dollarization and measures of monetary policy credibility. The first of these is Haussman and Panizza (2002), that finds a positive and significant correlation between their measure of domestic original sin and inflationary history. The second is De Nicolo et al (2003), which finds a positive and significant correlation between the share of dollar deposits in total bank deposits and institutional determinants of monetary credibility.

The main contribution of this paper, is to explore the effects of dollarization on monetary policy credibility in an imperfect information setting. To do so, we build on two existing strands of the dollar-liability literature: (i) that which explores the effects of exchange rate policy on the optimal choice of debt composition by private agents and (ii) that which explores the effects of dollarized debt on the response of an economy to aggregate shocks, and therefore on exchange rate policy. In particular we argue that debt composition affects the optimal exchange rate policy and that simultaneously expectations about exchange rate policy have a bearing on the currency composition choices of private agents. This paper is also related to the literature on optimal monetary policy and to the debate on fixed versus floating exchange rates.

The paper proceeds as follows. In section 2 we provide a brief overview of existing empirical and theoretical literature on liability dollarization and by doing so, motivate some of the assumptions made elsewhere in the paper. Section 3 sets up our basic model and solves it under full information. The following section, section 4, introduces signalling issues and makes the main point of the paper: agents can be stuck in persistent states where they have imperfect knowledge about the parameters of the economy. Section 5 discusses possible policy implications and proposes some extensions, while section 6 concludes. Proofs of propositions and lemmas are given in the Appendix.

2 Causes and Effects of Dollar-Debt... What Do We Know?

At center stage in the discussion of dollar-debt is the mismatch that foreign currency debt may generate between the currency denomination of assets and liabilities. Following a devaluation, an agent with a currency mismatch will see the peso value of his debt expand more than the peso value of his assets or income. The key assumption in this literature, is that the resulting drop in the net worth has real costs: a balance-sheet effect. Consequently, the expansionary effect which a depreciation is typically assumed to have, may be attenuated or even reversed by the effects of a devaluation in firms that are highly leveraged in dollar-debt.

\footnote{See Rogoff (1995) for an overview of the literature.}
A first strand of the literature has developed models to explore the macroeconomic implications of these currency mismatches. In the work of both Krugman (1999a, 1999b) and Aghion, Bachetta, and Banerjee (2001), the balance-sheet effect is assumed to be large enough to dominate the expansionary Mundell-Fleming effect. This strongly negative relationship between investment and depreciation can give rise to multiple equilibria, and hence the potential for an expectation-driven exchange rate crisis. The potentially destabilizing effects of a devaluation in the presence of dollar-debt are also discussed in Céspedes, Chang and Velasco (2001) – although the authors emphasize that dollar-debt does not necessarily lead to “macroeconomic damnation”.

Although it is clear that many economies in East Asia as well as Argentina had substantial levels of dollar-debt both in the banking sector and on firms’ balance sheets, empirical evidence on how large the resulting balance-sheet effects may have been is far from conclusive. On the one hand, Claessens and Djankov (2000) argue that inflated domestic debt and interest payments may have led to wide scale insolvency and liquidity problems in East Asian firms. On the other hand, Bleakley and Cowan (2002) provide evidence that the negative balance-sheet effect of a devaluation is dominated by the competitiveness gains from a devaluation in a sample of Latin American firms.

Independently from where the empirical and theoretical debate on the effects of dollar-debt may stand, there is evidence that suggests monetary authorities factor debt composition variables into their exchange rate policies. Although they do not test it empirically, Calvo and Reinhart (2002) argue that pervasive liability dollarization may be one cause of what they term “fear of floating”. Panizza, Hausmann and Stein (2001) investigate this proposition, and find a relationship between a country’s exchange rate policy and its ability to borrow internationally in its own currency – which they argue is an indicator of a country’s ability to avoid currency mismatches. More specifically, they find that countries that can borrow abroad in their own currencies hold lower levels of reserves and allow larger fluctuations in the exchange rate relative to fluctuations in reserves and interest rates. Along these same lines, Levy-Yeyati, Sturzenegger and Reggio (2003), using a de facto and de jure exchange regime classification, find that foreign currency-denominated liabilities (measured relative to money stocks) are positively correlated with the probability of pegging the exchange rate against a major currency.

A second strand of the literature on dollar-debt looks at firm and country level determinants of dollar liabilities. The key question here being, if dollar-debt exposes firms to substantial exchange rate risk, why not borrow in local currency? Most explanations put forward argue that a failure of uncovered interest rate parity leads to a lower ex ante dollar rate, which encourages dollar borrowing. One set of models argues that dollarized debt entitles the creditor to larger payments in states of the world in which default is likely, lowering the required interest payments on dollar-debt. Another set of models emphasizes how interest rates adjust to incorporate disciplining effects of dollar-debt on firm behavior. In Jeanne (2000a and 2000b), for example, dollar-debt reduces information asymmetry and moral hazard. Lenders then incorporate these effects into the rates they charge on peso and dollar debt loans. In Calvo (1999) and (2001) the failure of uncovered interest parity can be attributed to the interaction of information asymmetries, regulatory restrictions in the banking sector and to the costs of forming devaluation expectations. A final explanation (see

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3 See Eichengreen and Hausmann (1999), World Bank (2001) for data on dollarization in East Asia
4 For Schneider and Tornell (2001) these transfers takes place between the government and the banking sector, where bailouts to dollar indebted banks accompany devaluations. Chamon (2001), on the other hand, argues that as defaults are often correlated with depreciations holders of dollar debt receive a larger share of the liquidated assets. In this case transfers take place between holders of peso and dollar-debt.
5 Regulatory constraints on currency mismatch encourage foreign banks to lend in their own currency so that
Ize and Levy-Yeyati (1998) introduces risk averse borrowers that choose the currency composition of their deposits to minimize the variance of the real returns on their savings. The higher is price volatility relative to the variance of the real exchange rate, the higher the relative demand for dollar deposits. Interest rates will adjust so that firms are willing to borrow in dollars and the market clears. The extent to which the currency composition of firm debt will respond to cheaper dollar credit is in turn determined by the costs of the increased exposure to exchange rate volatility. In this context, a pegged exchange rate regime is a form of insurance against exchange rate fluctuations. In the words of Mishkin (1996): “daily fluctuations in the exchange rate in the flexible regime have the advantage of making clear...that there is a substantial risk involved in issuing liabilities denominated in foreign currencies”.

Another explanation for dollarized debt is domestic financial underdevelopment. According to Eichengreen and Hausmann (1999) the lack of an adequate long-term domestic currency debt market leads firms to take on exchange rate risk so as to avoid the interest rate risk inherent to short-term peso liabilities. Alternatively, Caballero and Krishnamurthy (2003) argue that underdeveloped domestic financial markers reduce the incentives for firms to insure themselves against an international liquidity shock. One way in which this underinsurance manifests itself is excessive financial dollarization.

Empirically there is no evidence of the alleged failures of uncovered interest rate parity and some evidence that higher exchange rate volatility reduces currency mismatch. Using cross-country data for the banking sector, Arteta (2002) finds evidence that more volatile exchange rate regimes reduce the share of foreign currency denominated loans and deposits. Additional evidence is provided by Martinez and Werner (2001) using a sample of Mexican firms. They find that matching is higher and average dollarization lower after the “tequila” crisis, a period of flexible exchange rates. Cowan (2002) obtains similar results for a sample of five countries from Latin America.

Probably because of lack of data, there is scarce empirical work on other possible cross-country determinants of dollar-debt. One exception to this is the recent work by De Nicolo, Ize and Honohan (2003). Using data on the currency composition of bank deposits, the authors find a positive correlation between dollarization and the relative variance of the price level and real exchange rate, and negative partial correlations between dollarization and measures of Central Bank credibility. Another exception is Eichengreen, Hausmann and Panizza (2002). The title of their paper (“The Mystery of Original Sin: The Case of the Missing Apple”) sums up their main conclusion, namely countries with very similar macroeconomic situations have vastly different levels of dollarization. Amongst the few variables that are positively correlated with their measure of “domestic original sin” (foreign currency debt in total domestic borrowing) are the level, variance and maximum past value of inflation, and financial development - all proxies for monetary policy credibility.

\begin{itemize}
\item They charge a premium on peso rates. Similar regulatory constraints force domestic banks to match dollar deposits with dollar loans. Because of information advantages, these banks have incentives to place this debt domestically leading to a lower equilibrium rate on dollar loans.
\item That risk averse firms choose debt composition to hedge exchange rate shocks (i.e. to “match”) is discussed for the banking sector by Ize and Levy-Yeyati (1998) and Arteta (2002), and for firms by Conesa-Labastida (1997), Calvo (2001), Martinez and Werner (2001) and Cowan (2002).
\item In addition, the correlations obtained by Hausmann, Panizza and Stein (2001) and Levy-Yeyati, Sturzenegger and Reggio (2003) also suggest that dollarization is higher in pegged exchange regimes.
\end{itemize}
3 A Preliminary Framework

Consider an economy with one representative agent and one good used for both production and consumption. The country has a Central Bank, which controls exchange rates. We denote by $s$ the change in the exchange rate $e$ (the price of dollars in terms of pesos) between $T = 0$ and $T = 1$. The timing of the economy is as follows:

- at time $T = 0$, the agent chooses to invest in either peso or dollar dominations. $D$ denotes the chosen dollarization level.
- at time $T = 1$, a demand shock $\tilde{x}$ is realized, the Central Bank observes the contracts signed at time $T = 0$ and sets its exchange rate policy $s$. $\tilde{x}$ is assumed to be distributed over the positive real line with distribution function $F(.)$ with mean $m$.
- at time $T = 2$, output $Y$ is realized. Payments are made, consumption takes place and agents die.

3.1 Technology and Preferences

Characterizing the output function $Y$ is crucial to our paper. We take the view that exchange rates have real effects on output. On the one hand, by raising the exchange rate, the Central Bank is able to have a positive effect on aggregate demand - a Mundell-Fleming effect. On the other hand, following Lahiri and Végh (2001) and Jeanne (2002), we assume that changes in the exchange rate also have adverse effects on output - a distortionary effect. Thus, the exchange rate has a non-monotonic impact on output, depending on which of the Mundell-Fleming or distortionary effects dominates.

An additional feature of $Y$ is specific to our model. We assume that the effects of exchange rate fluctuations on firm balance sheets are increasing in the level of dollar-debt. Higher levels of dollar-debt increase the cost of a devaluation. In order to account for the effects previously described, we will specify the output function as follows:

$$Y(x|s,D) = x + \theta s - L(s, D),$$

where $x + \theta s$ is aggregate demand, and the $\theta s$ term captures the Mundell-Fleming effect. The function $L(s, D)$ is increasing convex in both terms. Furthermore, for any $s, D$, $L(.)$ is continuously differentiable with respect to $(s, D)$ and

$$L_s(s,0) = 0, \text{ and for } D > 0, \ L_{sD}(.) > 0.$$  

Hence, the loss function $L(.)$ incorporates the distortionary effect of exchange rate changes at each positive level of dollarization $D$, as well as the balance-sheet effect through condition (2).\(^8\)

The agent is risk-neutral, maximizing time $T = 2$ expected output. Furthermore, in this economy, the Central Bank sets exchange rate policy in order to maximize an exogenous objective

\(^8\)A costly-state-verification model augmented with a Mundell-Flemming effect would generate such a loss function (see Chamon 2002, or Jeanne 2003).
function. The crucial assumption is that there is a mismatch between the Central Bank’s objective function and the welfare of the representative agent. Indeed, we assume that the Central Bank values inflation more than what is socially optimal, so that the Central Bank gross utility function (i.e. before debt repayments) is given for any $x$ by

$$W_{CB}(x, s, D) = Y(x|s, D) + \phi s$$

where the term $\phi$ captures additional Central Bank utility gain from devaluation. Although the text refers to the term $\phi$ as seniorage, it could equally well be a result of Central Bank time inconsistency. The mismatch is captured by the fact that the agent’s welfare is given by

$$W_A(s, D) = E_x Y(x|s, D).$$

### 3.2 Equilibrium Analysis

In order our initial intuition to hold, it is critical that there is some coordination among agents, that translates into a representative agent framework.

**The Central Bank’s reaction function**  The Central Bank observes dollarization levels $D$ at time $T = 0$. Thus, the second-best exchange rate policy is given by the Central Bank’s $T = 1$ first-order conditions, i.e.

$$\theta + \phi = L_s(s, D).$$

The regularity conditions assumed previously imply that for any non-negative level of dollar-debt, the exchange rate response is well-defined, continuous and differentiable with respect to $D$. We henceforth denote the exchange rate response to a level $D$ of dollarization $s_D$. The implicit function theorem implies that, for any $D$,

$$\left(\frac{ds_D}{dD}\right)_D = -\frac{L_{sD}(s_D, D)}{L_{ss}(s_D, D)} < 0,$$

making $s_D$ a decreasing function of dollar-debt.

**Agent’s equilibrium level of dollarization**  The agent internalizes the Central Bank’s reaction function defined by (5) and choose a level of dollarization in order to maximize (4). The first-order necessary and sufficient condition defines the equilibrium dollarization level $D^{SB}$:

$$\left(\frac{ds_D}{dD}\right)_{D^{SB}} [\theta - L_s(s_{D^{SB}}, D^{SB})] = L_D(s_{D^{SB}}, D^{SB}).$$

Equality (7) captures the well-known tension between balance-sheet effects and disciplining effect. By increasing their dollarization levels, agents put a downward pressure on seignorage, which translates into output gains (left-hand side). On the downside, they subject themselves to higher distortionary costs due to an aggravated balance-sheet effect (right-hand side).

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9Note that for a given level of $D$ the level of $s$ that maximizes output is independent of $x$, the demand shock. Thus in this specification there is no role for anticyclical exchange rate policy. A simple modification to the output function, $g(x + \theta s) - L(s, D)$, where $g(\cdot)$ is a concave function would generate such a policy.
The assumption of non-atomistic agents (e.g., too-big-to-fail financial institutions) is crucial for positive dollarization levels to be chosen in equilibrium. Although this assumption might be strong, this first stage is one among many mechanisms that provide a rationale for why agents might be willing to diversify their portfolio currency denomination. The key contribution of this paper is that if dollarization levels are a response to priors about the Central Bank and come at some social costs, uncertainty might generate inefficient dollarization in the long run. We now turn to this second part of our model.

4 A Signaling Model of Central Bank Credibility

Consider now that some characteristics of the economy are unknown to agents, and that they therefore learn about the parameters of the economy. To be more specific, assume that agents have imperfect knowledge about \( m \), the mean of the distribution of \( \tilde{x} \); the Central Bank’s effectiveness at smoothing macroeconomic shocks \( \theta \); and the devaluation bias \( \phi \). Hence, the parameters \((m, \theta, \phi) \in M \times \Theta \times \Phi\) are unknown, while we assume that other functional forms, such as the distributions and the function \( L(\cdot) \), are perfectly known to agents. To simplify the analysis, we will assume that the Central Bank can have only two types

- a “good” type, \( \phi^g \), where \( \phi^g = 0 \).
- a “bad” type \( \phi^b \), where \( \phi^b > 0 \).

Thus, the set of possible Central Bank’s types is reduced to \( \Phi = \{\phi^g, \phi^b\} \). Although our analysis will hold irrespective of what type is the true type, for the policy relevance of our argument, we will assume that the Central Bank does not exhibit a devaluation bias and hence is of type \( \{m^g, \theta^g, \phi^g\} \). The plausibility that the true type could be type \( b \) is the starting point of our discussion on Central Bank’s credibility.

Moving away from the static framework, we now consider dynasties of entrepreneurs. Each dynasty, in generation \( t \geq 0 \), is endowed with some priors \( \mu_t(m, \theta, \phi) \) about the values of the parameters of the economy. For any \( t \geq 0 \), dynasty-\((t+1)\) agents’ priors are equal to dynasty-\(t\) agents’ posteriors. The transmission of information is then as follows. For any \( t \geq 0 \), given their priors \( \mu_t(m, \theta, \phi) \), agents choose a dollarization level \( D_t \), the Central Bank sets an exchange rate depreciation \( s_t \) and the output is realized according to the stochastic process defined by (1). While they do not observe the realization of \( \tilde{x} \), agents observe the exchange rate and realized output and update their beliefs accordingly. They then bequeath their beliefs to the next generation. As in the static version of the model the exchange rate is normalized to one for \( T = 0 \) of each generation. We assume that there is no savings technology, so that all output in a given generation is consumed. However, there is some intergenerational altruism so that the Central Bank as well as agents maximize a discounted flow of payoffs, with discount factor \( \delta \). We assume that \( \delta \) is the same for agents and the Central Bank and that this property is common knowledge.

At this stage it is useful to provide a brief description of the main results we obtain in this section. The first of these is straightforward: given that agents choose the level of dollar-debt based on their priors regarding Central Bank preferences, imperfect information will always lead
to inefficiently high levels of dollarized debt. The key issue then becomes how these priors evolve over time. Assuming that Central Banks can affect learning by signaling their types leads us to our second result. The learning process can be characterized by two possible outcomes: a pooling and a separating equilibrium.

- In the pooling equilibrium each generation updates their beliefs based on the observed values of the exchange rate and output. Learning is imperfect, however, as agents only have two equations (1) and (5)) to identify three parameters. They observe output but do not know how much is due to the macroeconomic component, \( \bar{x} \), and how much is due to the monetary component, \( \theta s \); similarly, while they observe the exchange rate level \( s \), agents do not know whether the Central Bank has chosen \( s \) because of a high ability to increase productivity (high value of \( \theta \)) or a large seignorage motive (large \( \phi \)). The result is that economies can be stuck in persistent states of high dollar-debt when agents wrongly attribute the observed outcomes to a Central Bank of type-b.

- In the separating equilibrium the full information outcome \( (D = 0) \) ensues in every period after separation.

Which equilibria is selected will depend on the costs to the Central Bank of playing a signaling strategy. This leads us to our third main result: this cost depends on the initial level of dollarization. If the level of dollar-debt is too high, the Central Bank will decide to induce coordination on the pooling equilibrium. The intuition behind this result is straight-forward: dollarization narrows the wedge between the optimal policies of “good” and “bad” central banks, making it harder for a good Central Bank to distinguish itself.

As initial priors determine initial dollarization the optimal strategy for the Central Bank will ultimately be determined by these priors. If initial priors are “bad” then high initial levels of dollar-debt will lead the Central Bank to select the pooling equilibrium. Going back to our prison board analogy: if the board believes that the prisoner is a menace to society it will leave him in prison, making it very difficult for a good prisoner to prove them wrong. Observed good behavior is believed to be the outcome of constraints rather than sign of a “good” individual. On the other extreme, “ good” priors will lead to efficient \( (D = 0) \) levels of dollar debt and the signaling equilibrium. This would be the case of a board that believes the prisoner is reformed, and releases him on parole. Once out of prison the prisoner finds it easy to prove to the parole board that their trust was merited, so successive renovations of the parole are granted.

The rest of this section proceeds as follows. We start by characterizing the pooling equilibria and the updating process. In the following subsection we characterize the separating equilibria. We finish by analyzing the optimal strategies of the Central Bank and individual agents.

4.1 Signaling Game: definition

In this section, we analyze the ability of the Central Bank to signal to the markets its willingness to conduct a “good” exchange rate policy. We start by defining the signalling game that Central Banks and agents are playing. In this standard overlapping generation model, for each generation
$T \geq 0$, the Central Bank of type $(m, \theta, \phi)$ has expected payoffs

$$W_{CB} (T | \phi) = \sum_{t \geq T} \delta^{t-T} \left[ (m + \theta s_t) + \phi s_t - L (s_t, D_t) \right],$$

while agents maximize payoffs

$$W_A (T) = \mathbb{E}_{\mu_T} \sum_{t \geq T} \delta^{t-T} \left[ \mathbb{E}_{\mu_t} (m + \theta s_t) - L (s_t, D_t) \right].$$

While agents choose a sequence of dollarization levels $(D_t)_{t \geq 0}$, Central Banks choose a sequence of exchange rate regimes $(s_t)_{t \geq 0}$. The question is now to investigate whether the “good” Central Bank can signal her type to markets.

While a complete analysis of the signaling game is not the purpose of this section, we analyze conditions of existence of a separating equilibrium, and characterize the pooling equilibria in a dynamic learning game. Thus, we restrict attention to stationary strategies, adopting a Markov perfect equilibrium concept.

### 4.2 Pooling Equilibria: Characterization

When the only possible equilibria are pooling equilibria, agents have imperfect knowledge about the parameters of the economy. This section characterizes the behavior of agents’ beliefs along an infinite sequence of pooling equilibria. The issue of whether such sequence exists will be discussed some paragraphs below. As a common feature of these models is to exhibit many pooling equilibria, we restrict attention to the best sequence of pooling equilibria, so that off-equilibrium beliefs are somewhat “reasonable”.

#### 4.2.1 Equilibrium Characterization and the Transmission of Information

Building on the results of section 3, the sequence $(D_t)$ of dollarization levels verifies: $\forall t \geq 0$,

$$D_t \in \arg \max_D E_{\mu_t} \left\{ E_{\mu_t} [Y (x|s, D) | m, \theta, \phi] \right\}$$

subject to the Central Bank’s reaction function: $\forall (m, \theta, \phi) \in \text{Supp} (\mu_t)$,

$$\theta + \phi = L_s (s, D).$$

Existence and uniqueness of such contracts is given by regularity properties considered previously. Note that under the assumed regularity conditions, $D (\cdot)$ is a continuous functions.

Some additional points on the notation: instead of considering the random variable $\tilde{x}$, we will focus on $\tilde{Y} \equiv \tilde{x} + \theta s - L (s, D)$. $F (\cdot|m, \theta, s, D)$ will refer to the distribution function of $\tilde{Y}$, were $(m, \theta, \phi)$ the true parameters and $(s, D)$ is given by the Central Bank’s reaction function (9), while $D$ is agents’ choice of dollarization. Finally, $dG (\cdot|m, \theta, \phi)$ denotes the conditional distribution function of the pair $(Y, s)$. 

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We now turn to the learning process per se. Agents update their information rationally, so that Bayes’ rule induces the following transition process: \( \forall (m, \theta, \phi) \in \text{Supp}(\mu_t) \)

\[
\mu_{t+1}(m, \theta, \phi|Y, s) = \mu_t(m, \theta, \phi) \frac{dG(Y, s|m, \theta, \phi)}{\sum_{(m', \theta', \phi') \in M \times \Theta \times \Phi} dG(Y, s|m', \theta', \phi')} \quad (10)
\]

While the transition process is well-defined, the evolution of beliefs is ambiguous. When agents observe a high realization of output, they can either update their beliefs so that higher values of \( m \) are more likely, or so that the Central Bank has a larger impact on output (i.e. \( \theta \) is large). Similarly, a given devaluation can be attributed either to an effective Central Bank (high \( \theta \)) or a large objective mismatch \( (\phi = \phi^b > 0) \). As such priors condition the choice of dollarization, one can now guess what is likely to happen: starting with priors that the Central Bank has no positive impact on the output function, agents will take on large amounts of dollar debt, taking exchange rate policy off the hands of “supposedly ineffective” Central Bankers. Any high realization of output is then attributed to large exogenous demand shocks. Similarly, starting with priors that the Central Bank has a strong preference for devaluation agents will take on dollar debt to avoid excessive devaluation. Low realizations of \( s \) are seen as the response to the dollar debt and not a confirmation of low devaluation preferences.

4.2.2 Limit Beliefs and Actions

We can then characterize the set of limit beliefs and actions along an infinite sequence of pooling equilibria. The first result is that the process defined by (10) converges with probability one to some limit beliefs that we denote \( \mu_\infty(m, \theta, \phi) \). The property is standard to Bayesian learning. As expected posteriors are equal to the priors (any bias would be incorporated into the prior), the learning process has the martingale property, and thus converges with probability 1. Then, equation (9) implies by continuity that dollarization levels and exchange rate policy variables also converge with probability 1 to some values \( D_\infty \) and \( s_\infty \).

**Lemma 1:** For any initial distribution of beliefs \( \mu_0(.) \), the process \( (\mu_t)_{t \geq 0} \) defined by (10) converges almost surely to some limit beliefs \( \mu_\infty(.) \). The processes \( (D_t)_{t \geq 0} \) and \( (s_t)_{t \geq 0} \) converge almost surely to some limit actions \( D_\infty = D(\mu_\infty) \) and \( s_\infty = s(\mu_\infty) \) respectively.

It is worth investigating whether the argument made in the previous paragraph indeed holds. In cases where initial priors are such that \( (m^b, \theta^b, \phi^b) \in \text{Supp}(\mu_0) \), a necessary characteristics of limit beliefs is given in the following proposition:

**Proposition 1:** For any initial distribution of beliefs \( \mu_0(.) \) such that \( (m^b, \theta^b, \phi^b) \in \text{Supp}(\mu_0) \), along an infinite sequence of pooling equilibria, limit beliefs \( \mu_\infty(.) \) and actions \( D_\infty \) and \( s_\infty \) are characterized by:

- \( (m^b, \theta^b, \phi^b) \in \text{Supp}(\mu_\infty) \)
- If \( (m^b, \theta^b, \phi^b) \in \text{Supp}(\mu_\infty) \), then \( \theta^b + \phi^b = \theta^a \),

\( (11) \)
and 

\[ m^b + \theta^b s_{\infty} = m^g + \theta^g s_{\infty}. \]  

(12)

The lack of identification is precisely why learning does not occur. Agents potentially face imperfect learning as they only have two equations ((11) and (12)) to identify the three parameters \( (m, \theta, \phi) \). As actions (dollarization levels) affect the information that they receive from observing exchange rate regimes and output levels, imperfect learning occurs as agents do not have enough degrees of freedom to properly identify the parameters of the economy, when as econometricians, they want to regress output on exchange rate and a constant.

4.2.3 Comments

Along a sequence of pooling equilibria, agents can be stuck in persistent states where they have imperfect knowledge about the parameters of the economy. If agents believe that the Central Bank objectives differ from social welfare (i.e. \( \phi > 0 \)), they will take on a large amount of dollar-denominated debt. In turn the Central Bank reacts in such a way that it does not contradict agents’ beliefs. Then, observing realized output, agents can potentially attribute all the difference to the exogenous demand shock \( \bar{e} \). High output can be interpreted as a high value of \( m \) while keeping priors about \( \phi \) constant. On the other hand, agents can attribute low output not to a bad productivity shock but to bad behavior from the Central Bank (steep \( \phi > 0 \)). In the long-run, experience is entirely consistent with expectation and no additional learning takes place. Countries can therefore be locked in “dollarization traps”, putting themselves in situations where low output is more likely to occur and attributing crises to bad governance of monetary policy, while at the same time tying the hands of potentially potent (and beaning) policy makers.

4.3 Separating Equilibria: Characterization

As we only focus on Markov perfect equilibria, we will analyze the conditions for existence of separating equilibria at time \( t = 0 \). As agents observe the Central Bank’s exchange rate policy and the realization of output, we can state the first result:

**Lemma 2:** Along any equilibrium path, \( \forall t > 0 \), the following holds:

\[
\Theta \cap \text{Supp} (\mu_t) \subset \{ \theta^b, \theta^g \},
\]

(13)

\[
M \cap \text{Supp} (\mu_\infty) \subset \{ m^b, m^g \},
\]

(14)

where

\[
\theta^b + \phi' (s_t) = \theta^g,
\]

(15)

\[
m^b + \theta^b s_{\infty} = m^g + \theta^g s_{\infty}.
\]

(16)

If complete separation is achieved at any point in time, then separation is sustained in all subsequent periods, and corresponding subgames are characterized by full-information outcomes.
Indeed if separation occurs, then agents know perfectly the type of the Central Bank they are facing; optimal portfolio composition ensues. As we restrict attention to stationary strategies, we can consider, without loss of generality, the game played at time $T = 0$. We will henceforth restrict ourselves to initial priors which verify (13) to (16). We denote by $D_0$, the initial level of dollarization adopted by agents, and $(\sigma^g_D, \sigma^b_D)$ the exchange rate regimes adopted in period $t = 0$ by Central Banks of each of the types $(g, b)$ respectively. Furthermore we write $s^g_D$ and $s^b_D$ the complete information exchange rate response of a Central Bank of type $g$ and $b$ respectively. Note that given the convexity of the loss function $L(.)$ with respect to $D$, Central Banks’ preferences satisfy the single-crossing property. The short-term cost of limiting monetary expansion is larger for a Central Bank of type $b$ than it is for a Central Bank of type $g$. Separating equilibria are then characterized by the following conditions:

- Optimality for type-$b$ Central Banks: $\forall D_0 \geq 0$,
  \[ s^b_{D_0} = s^b_{D_0} \]

- Central Bank’s reaction function (equation (11)):
  \[ s^b_{D_0} = s^g_{D_0} \]

- Incentive-compatibility constraint for type-$b$ Central Banks:
  \[
  \begin{align*}
  &\left[ \theta^b s^b_{D_0} - L \left(s^b_{D_0}, D_0 \right) + \phi s^b_{D_0} \right] - \left[ \theta^b \sigma^a_{D_0} - L \left(\sigma^a_{D_0}, D_0 \right) + \phi \sigma^a_{D_0} \right] \\
  \geq &\delta \left\{ \left[ \theta^b s^b_{D_0} - L \left(s^b_{D_0}, 0 \right) + \phi s^b_{D_0} \right] - \left[ \theta^b s^b_{D_0} - L \left( s^b_{D_0}, D \right) + \phi s^b_{D_0} \right] \right\} 
  \end{align*}
  \] (17)

Separation requires a depressed exchange rate, so that a Central Bank of type $b$ is not willing to mimic a Central Bank of type $g$. The single-crossing property ensures that the incentive-compatibility constraint for type $g$ Central Banks holds. As we did for the analysis of pooling equilibria, and to simplify further discussions, we will assume that off-equilibrium beliefs are reasonable, selecting as unique separating equilibrium, the outcome such that (17) holds with equality: a Central Bank of type $g$ will choose an exchange rate regime which is the least costly, given that (17) must hold.

4.4 Equilibrium Concept and Equilibrium Outcome

4.4.1 Equilibrium Refinement

Imposing strategies to be stationary implies that the equilibrium is Markov Perfect. However, we have seen in the previous paragraphs, that for any initial level of debt $D_0$, pooling and separating equilibria could coexist, while voluntarily ignoring semi-separating equilibria. We further adopted a domination-based refinement of beliefs, which consisted of assuming that off-equilibrium beliefs were reasonable, as they do not assign positive probability to a player taking a strictly dominated action. Thus, in the pooling equilibrium, no action that is not short-term optimal was ruled out; similarly, in separating equilibria, any action that made (17) hold strictly was considered as unreasonable.
However, refinements such as the Cho-Kreps intuitive criterion (see Cho and Kreps, 1987) consistently select as unique equilibrium outcome the best separating equilibrium as described in the previous paragraph. We will thus depart from this refinement and adopt a Pareto-dominance-based equilibrium concept: agents coordinate on the Pareto-dominating equilibrium. We believe that such refinement is relevant for the situation we are modeling: a Central Bank of type $g$ might not want to play an expensive signaling strategy if the costs compared to a pooling equilibrium situation are large.

### 4.4.2 Equilibrium Outcome

Under such equilibrium selection assumption, the initial level of dollarization $D_0$ determines the “cost” of separation. When the cost is too high, the Central Bank may decide to induce coordination on the pooling equilibrium. The next proposition formalizes the result:

**Proposition 2:** There exists a threshold $\hat{D}$ such that for any level $D_0$ of initial dollar-debt level, we have the following:

- If $D_0 > \hat{D}$, then the unique equilibrium exhibits pooling strategies at time $t = 0$.
- If $D_0 < \hat{D}$, then the unique equilibrium is a separating equilibrium.

The intuition of the result can be found in the proof, yet some comments can be helpful. The whole objective of dollarization is to narrow the wedge created by the inflationary bias of a Central Bank of type $b$. Thus, as dollarization levels increase, the second-best solution for Central Banks $g$ and $b$ get closer and closer. Thus, in order to discriminate the two types, it is necessary for the type-$g$ Central Bank to inflict itself a large cost, in order to deter mimicking from a type-$b$ Central Bank (condition (17)). Thus, as dollarization increase, the cost of getting a separating equilibrium increases, eventually making the separating payoff worse than the pooling case, so that (24) holds.

We now turn to agents’ behavior. Depending on their priors, agents may or may not be willing to lower their level of dollarization at time $T = 0$ in order to obtain a separating equilibrium. The willingness to experiment depends on the perceived costs and benefits at the beginning of the period. For any beliefs $\mu_t(\cdot)$, we then denote, by abuse of notation, $\mu_t(\cdot) = \sum_{m \in M} \mu_t(m, \theta, \phi(t^b, \phi^b))$, the prior that the Central Bank is of type $b$. We conclude the paragraph with the following important result:

**Proposition 3:** There exists a threshold $\hat{\mu}$, such that an equilibrium with separating strategies at time $t = 0$ exists if and only if $\mu_0 \leq \hat{\mu}$.

These results can well be summarized in figure (3). The horizontal line graphs $\mu_0$, agents’ priors that the Central Bank is of type $b$. A high value of $\mu_0$ thus indicates a low credibility. The vertical axis plots the corresponding initial levels of dollar-denominated liabilities. The dotted line is the linearized one-period optimal level of dollar-debt, while the plain line is the dynamic optimal level. Although the true type is $\phi^g$, yet agents set off with “bad” priors about the Central Bank, not only don’t they wish to experiment and give authorities a chance to prove their good behavior, but they
take on high levels of dollar-debt, which makes separating equilibria not sustainable (right). With “better” priors about the parameters of the economy, agents are willing to experiment, taking on smaller dollar denominated loans than their priors would have suggested in a static game (center). Finally, when dollarization levels are low anyway, experimentation does not involve any additional cost in terms of short-term suboptimal portfolio composition (left). Depending on its priors on the Central Bank, the market puts restrictions to Central Bank’s discretion.

### 4.4.3 Equilibrium Dynamics

In the previous paragraphs, we characterized pooling and separating equilibria. We have seen that once separation occurs at a given period, then there is separation ever after, and dollar-debt holdings are unconstrained-optimal. Given that the true type of the Central Bank is $\phi^g = 0$ the question is to know whether and under what conditions imperfect learning can arise. Obviously, if agents start with single-valued priors, no learning takes place and they keep these priors for ever. Similarly, if agents put a zero-probability on the true parameters $(m^g, \theta^g, \phi^g)$ then, imperfect learning will trivially persist. Finally, it is possible that an economy which starts with priors such that $(m^g, \theta^g, \phi^g) \in \text{Supp}(\mu_0)$ will remain for ever with such beliefs. The next proposition formulates the result:

**Proposition 4:** Let’s consider some stationary beliefs $\mu_\infty(.)$, along with an infinite sequence of pooling equilibria, such that $(m^g, \theta^g, \phi^g) \in \text{Supp}(\mu_\infty)$ and $\mu_\infty(.)$ verifies (11) and (12). For any initial distribution of beliefs $\mu_0(.)$, such that $\text{Supp}(\mu_0) = \text{Supp}(\mu_\infty)$, the following propositions hold:

- If $\mu_0(m^g, \theta^g, \phi^g) \leq \mu_\infty(m^g, \theta^g, \phi^g)$, then $\mu_t(.)$ converges to some stationary beliefs characterized by imperfect learning with probability 1.

- If $\mu_0(m^g, \theta^g, \phi^g) > \mu_\infty(m^g, \theta^g, \phi^g)$, then $\mu_t(.)$ converges to some stationary beliefs characterized by imperfect learning with positive probability.

We thus showed that economies that are very similar in many respects, can have very different equilibrium trajectories. In any neighborhood of $\hat{\mu}$, identical countries that differ only by initial priors can experience drastically different behavior from investors. Under some conditions of the parameters of the economy, namely $\hat{\mu} > \mu_\infty$, identical countries with identical priors have a positive probability to be on two different long-run trajectories.

### 5 Policy Implications

Throughout this paper we have discussed cases in which imperfect learning can lead to sub-optimal levels of dollarized liabilities if initial priors are regarding Central Bank objectives are “bad”. Our argument therefore reinforces the commonly accepted wisdom that Central Bank credibility is an important element in a sound monetary policy. We are well aware that these issues have been discussed extensively in the literature of monetary policy. Our contribution is to emphasize that
dollarization of liabilities provides an additional justification for providing markets with the means to identify the relevant parameters in the economy. In addition, our model has clear implications for the taxation of dollar-debt. As discussed in section 4 dollar-debt makes separating equilibria costly. A tax on dollar-debt will “encourage” agents to lower their dollar-debt holdings giving the authorities a chance to prove their good behavior. We discuss these issues in detail in the rest of this chapter.

5.1 Central Bank’s Independence and Transparency

Even though the case for Central Bank’s credibility and monetary policy transparency is not new, our paper reinforces the argument by emphasizing that periods of “good” monetary policy will not always shift private agents’ priors regarding the Central Bank objectives, so that deeper institutional changes may be needed to generate a shift in agents’ priors. A reform that generates credible Central Bank independence is one way of achieving such a shift. In our model establishing Central Bank independence is equivalent to credibly setting $\phi = 0$. Agents therefore choose $D = 0$ and the Central Bank sets $s$ to maximize social welfare, given $D$ and the realization of $\theta$. A verifiable mandate therefore allows the market to make decisions under perfect information, at least along the dimension of interest in this paper.

This may not be easily done in emerging markets with poor legal institutions. Not only must monetary policy choice be shielded from government intervention by law, but the law itself must be credible. An important lesson from the literature on fiscal theories of the price level (Woodford (1995)) is that irresponsible fiscal policy puts pressure on monetary authorities to monetize debt. Hence, an important step towards ensuring monetary policy credibility is to simultaneously put in place institutions that limit the pressure the Central Bank will receive from other government institutions. A series of authors have also argued that adoption of inflation targeting might further contribute to monetary credibility by increasing information disclosure on Central Bank policies and objectives and by contributing to shore up public support for Central Bank independence (Mishkin and Posen (1997) and Calvo and Mishkin (2003)).

Nevertheless, there may be cases in which domestic institutions are so weak that setting up an independent Central Bank is simply not feasible. In those cases the only remaining options are to turn over control of monetary policy to foreign agents. The traditional solution to this institutional failure is full dollarization of the economy. An alternative approach appeared in a recent article regarding the situation in Argentina. In it Caballero and Dornbusch (2002) emphasize the need for credibility to overcome existing devaluation priors, and propose that “(...) a board of experienced foreign central bankers should take control of Argentina’s monetary policy. This would have many of the virtues of a currency board without the costs of having to adopt a monetary policy tailored to somebody else’s needs.”

5.2 Taxation of Dollar Liabilities

This section is devoted to the determination of the tax policy on dollar debt that induces a separating equilibrium to form at time $t$. We are interested in looking at the tax policy that a Central Bank without devaluation bias (i.e. $\phi = 0$, the “good” Central Bank as we have been referring to
so far) should adopt when she faces priors $\mu_t(.)$ about her type.

The timing of the game is the following:

- The government observes agents priors $\mu_t(.)$ and sets a tax on dollar-debt $\tau_t$.
- Agents make their portfolio decisions
- The Central Bank sets an exchange rate policy
- Output is realized, beliefs are updated and bequeathed.

We assume that tax revenues are redistributed to agents in the form of a lump-sum transfer at the end of the period. We also make the critical assumption that a tax level $\tau_t$ does not convey information about the type of the Central Bank that agents may face. The rationale underlying taxation of dollar liabilities is that we make the assumption that unlike agents in the economy, the government knows the type of the Central Bank but does not have any credible way to convey the information. In addition, taxation adds an additional distortionary cost $\gamma(\tau_t)$, increasing and convex. Such cost is borne by entrepreneurs. A simple backward induction argument will guide our subsequent discussion. We characterize the fiscal incentive that the government should design in order to allow the “good” Central Bank to build credibility in the subsequent period. The government thus internalizes the behavior of each of the agents in the economy: given agents’ priors $\mu_t(.)$ and the tax scheme $\tau_t$, debt contracts are determined by

$$D_t \in \arg \max_D E_{\mu_t} \{ E_x [Y(x|s,D)|m,\theta,\phi] \} - \tau_t D$$

(18)

subject to:

- A type-b Central Bank reaction function:
  $$s = s_D$$
  where $\forall D \geq 0$, $s_D$ is defined by
  $$\theta^b + \phi'(s_D) = L_s(s_D, D)$$

- A type-g Central Bank reaction function defined by (17):
  $$s = \sigma^G_D$$

The first-order condition gives a dollarization choice $D_t$ satisfying:

$$E_{\mu_t} \left[ \left( \frac{ds}{dD} \right)_{D_t} [\theta - L_s(s,D_t)] - L_D(s,D_t) \right] = \tau_t.$$  

(19)

The optimal tax policy is then defined as the level of taxation $\tau_t$ that induces separation at lowest cost. Thus (18) implicitly assumed that separation occurs after $t$. Type-g Central Bank sets a tax level in order to maximize

$$\max_{\tau} E_x [Y(x|s,D)] - \gamma(\tau)$$

(20)
subject to agents’ reaction function (19)

\[ E_{\mu_t} \left[ \left( \frac{ds}{dD} \right)_{D_t} \left[ \theta - L_s (s, D_t) \right] - L_D (s, D_t) \right] = \tau_t, \]  

(21)

the separation condition:

\[ D_t \leq \tilde{D}, \]  

(22)

and the now standard Central Bank’s reaction function (9).

Additional regularity assumptions on the functions involved in the model allow us to apply the local inversion theorem to (19) in order to get for any \( D_t \leq \tilde{D} \),

\[ \left( \frac{dD_t}{d\tau} \right)_{\tau_t} = E_{\mu_t} \left[ \theta \left( \frac{d^2 s}{dD^2} \right)_{D_t} - \left( \frac{d^2 L (s, D)}{dD^2} \right)_{D_t} \right]^{-1} < 0. \]

An increase in the level of taxation decreases the initial level of dollar-debt that agents are willing to take. Such preliminary analysis finally yields the first-order conditions for an interior choice of a tax level \( \tau_t \):

\[ \left( \frac{dD_t}{d\tau} \right)_{\tau_t} \left[ \left( \frac{d\sigma_D}{dD} \right)_{D_t} \left[ \theta^g - L_s (\sigma^g_{D_t}, D_t) \right] - L_D (\sigma^g_{D_t}, D_t) \right] = \gamma' (\tau_t). \]  

(23)

The government trades off the distortionary costs of taxation (right-hand side of (23)) with the experimentation costs when dollarization levels are high (left-hand side of (23)). Indeed, an increase in the tax rate creates an incremental distortion, but by decreasing the initial level of dollarization, makes a separating strategy less costly in terms of foregone short-term productivity. This thus creates a minimum taxation level necessary to obtain separation.

Condition (23) defines the optimal one-period tax rate in the events of separation or pooling respectively. Whether the government wants to achieve separation in the first place or delay such intervention then depends on the equilibrium path of beliefs and the discount rate \( \delta \). In the current version of the draft, we will not formally characterize the optimal tax scheme. Yet, we want to provide some intuition regarding the tensions involved. A costly (separating) intervention will always be worth undertaking when agents are patient enough. This being said, the right timing of the intervention will crucially depend on the pre-intervention learning path. However, in cases where agents are eventually learning, the implementation of a separating tax policy trades off the distortionary losses of taxation and the learning speed. Thus if agents are learning quickly enough, it might be optimal not to appeal to separating taxes and restrict attention to mitigating short-term distortions stemming from excess dollarization. The reverse holds when agents are learning slowly the true parameters of the economy or they are not learning at all and converge towards a dollarization trap.

6 Concluding Remarks

In this paper, we argued that dollarized liabilities by creating a disciplining effect on the Central Bank are aimed at correcting a devaluation bias. However, when information is imperfect, the
economy can be stuck in a dollarization trap: a benevolent Central Bank lacking credibility may face high levels of dollarization, making a stabilization monetary policy harder to implement and at the same time, credibility costly to build. We finally analyzed the optimal tax incentive that governments should design to mitigate short-term distortions due to excess levels of dollarized liabilities and to allow long-term learning and avoid dollarization traps.

We believe the assumptions and results derived in the paper to be consistent with a growing empirical literature on financial dollarization and Central Bank credibility. Yet some further empirical investigation remain on the agenda.

References


7 Appendix

Proof of Proposition 1:
The proof uses a standard argument in the Bayesian learning literature (see e.g. Smith and Sorensen, 2000). First, consider the process generated by Bayes’ rule (10): stationary beliefs imply that any \((m, \theta, \phi(.))\) and \((m', \theta', \phi'(.))\) in \(\text{Supp}(\mu_\infty)\) must verify for any feasible \((Y, s) \in R^2, dG(Y, s|m, \theta, \phi(.)) = dG(Y, s|m', \theta', \phi'(.))\), which implies that \(dF(Y|m, \theta, \phi(.)) = dF(Y|m', \theta', \phi'(.))\). As these two distributions differ only with respect to their means, (12) must hold. Moreover, \(x\) and \(s\) are related by the central bank’s reaction function (9), thus stationarity holds only if (11) holds. Sufficiency can easily be checked. The second part of the argument is to notice that the likelihood ratio \(\lambda_t(m, \theta, \phi(.)) \equiv \mu_t(m, \theta, \phi(.)) / \mu_t(m^g, \theta^g, \phi^g(.))\) has the martingale property. Thus it converges with probability 1, which implies that \(\mu_\infty(m^g, \theta^g, \phi^g(.)) > 0\).

Proof of Lemma 2:
As agents observe the exchange rate adopted by the Central Bank, such choice must be consistent with (9), so that (15) must hold. Note that \(\phi^g = 0\). Furthermore, in the long run, the mean of \(F(.|s_\infty, D_\infty)\) is perfectly known to agents so that (16) must hold.
Rearranging the two equations while, sticking to a pooling equilibrium strategy, agents would get better information as a separating equilibrium can be achieved. Consider the initial level of dollar debt: $D_0$. Agents trade-off the expected loss of having a low level of dollar-debt level with the expected gains from

$$E_{\mu_0} \{ (1 - \delta) [m + \theta s_{D_0} - L (s_{D_0}, D_0) + \phi (s_{D_0})] + \delta V_p (m, \theta, \phi) \} ,$$

while the separating situation yields

$$E_{\mu_0} \{ (1 - \delta) [m + \theta s_{D_0} - L (s_{D_0}, D_0) + \phi (s_{D_0})] + \delta V_s (m, \theta, \phi) \} .$$

Thus a separating equilibrium forms if and only if

$$E_{\mu_0} \{ [V_s (m^g, \theta^g, \phi^g) + V_p (m^b, \theta^b, \phi^b)] - [V_p (m^g, \theta^g, \phi^g) + V_p (m^b, \theta^b, \phi^b)] \} .$$

In other words, the short-term losses due to costly signaling outweigh the long-term gains of an unconstrained optimal portfolio composition. Considering that (17) binds, we can rewrite (24) as

$$\left( \theta^g - \theta^b \right) \left( s_{D_0}^g - s_{D_0}^b \right) + \phi \left( s_{D_0}^g \right) - \phi \left( s_{D_0}^b \right) \leq \Delta,$$

where $\Delta$ is given by the parameters of the model and is independent of $D_0$. Applying the implicit function theorem to (17), we can conclude after observing that (2) holds, that the difference $s_{D_0}^g - s_{D_0}^b$ is continuously increasing in $D_0$ and

$$\lim_{D_0 \to \infty} (s_{D_0}^g - s_{D_0}^b) = +\infty.$$

There exists $\hat{D} \in R$, such that (25) holds if and only if $D_0 \leq \hat{D}$. For large enough values of $\delta$, we have $\hat{D} > 0$.

Proof of Proposition 3:

Agents trade-off the expected loss of having a low level of dollar-debt level with the expected gains from better information as a separating equilibrium can be achieved. Consider the initial level of dollar debt $\hat{D}$. Payoffs to borrowers in the separating case are given by

$$\mu_0 \left\{ (1 - \delta) \left[ E_{\mu_0} m^b + \theta^b s_{D_0}^b - L \left( s_{D_0}^b, \hat{D} \right) \right] + \delta \left[ E_{\mu_0} m^b + \theta^b s_{D_0}^b - L \left( s_{D_0}^b, \hat{D} \right) \right] \right\} \right\} + (1 - \mu_0) \left\{ (1 - \delta) \left[ E_{\mu_0} m^g + \theta^g s_{D_0}^g - L \left( s_{D_0}^g, \hat{D} \right) \right] + \delta \left[ E_{\mu_0} m^g + \theta^g s_{D_0}^g \right] \right\} ,$$

while, sticking to a pooling equilibrium strategy, agents would get

$$\max_{D_0} E_{\mu_0} \left\{ (1 - \delta) [m + \theta s_{D_0}^g - L (s_{D_0}^g, D_0)] + \delta [V_p (m, \theta, \phi)] \right\}$$

Rearranging the two equations (26) and (27), a separating strategy brings short-term losses equal to

$$\left( 1 - \delta \right) \left[ \max_{D_0} \left\{ E_{\mu_0} m + \theta s_{D_0}^g - L (s_{D_0}^g, D_0) \right\} \right]$$

Proof of Proposition 2:

Denoting by $V_p (m, \theta, \phi)$ and $V_s (m, \theta, \phi)$ the continuation values for Central Banks of type $(m, \theta, \phi)$, we first remark that such values do not depend on $D_0$. Indeed, the Markov perfection restriction implies that these continuation values depend only on posterior beliefs. We can now compare payoffs to the Central Banks in the separating and pooling cases. Under the pooling situation, the two types of Central Banks receive

$$E_{\mu_0} \{ (1 - \delta) [m + \theta s_{D_0} - L (s_{D_0}, D_0) + \phi (s_{D_0})] + \delta V_p (m, \theta, \phi) \} ,$$

Proof of Proposition 2:
while long-term gains are given by

$$
\delta \left[ \mu_0 \left[ E_{\mu_0} m^b + \theta^b s^b_{D^b} - L \left( s^b_{D^b}, D^b \right) \right] + (1 - \mu_0) \left[ E_{\mu_0} m^g + \theta^g s^g_0 \right] - E_{\mu_0} \left[ V_p \left( m, \theta, \phi \right) \right] \right] 
$$

(29)

Applying Jensen’s inequality to (28) and (29), we see that short-term losses are an increasing (and concave) function of $\mu_0$, while long-term gains are a decreasing (and convex) function of $\mu_0$. Thus, there exists $\check{\mu} \in [0, 1]$, such that for any initial beliefs $\mu_0$,

$$
D_0 > \check{D} \iff \mu_0 > \check{\mu}.
$$

**Proof of Proposition 4:**

This proposition is a result proved in McLennan (1984).
Figure 1: Dollarization of Bank Deposits and Inflation in Latin American Countries

Sources: Inflation data are from World Development Indicators (2002). Dollar deposit data are from De Nicoló et al (2003). Negative inflation values for Argentina were replaced with 1% to allow for log scaling. Sample determined by dollarization data availability.
Figure 2: Full Information Optimum

\[ m + \theta s - L(s, \text{DSB}) \]

\[ L(s, \theta) \]

\[ \theta + \phi'(s) \]

\[ E_4[V] \]

\[ s_{\text{DSB}} \]

\[ s_0 \]
Figure 3: Initial Priors and Equilibrium Outcomes

- Separating equilibrium without experimentation
- Separating equilibrium with experimentation
- Pooling equilibrium without experimentation