Safety Nets and Endogenous Financial Dollarization

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Abstract
This paper presents a simple model of financial intermediation in a bicurrency economy where local currency assets can be funded by either local or foreign currency-denominated deposits. We show that banking intermediation fosters dollarization by introducing an implicit cross-transfer from local to foreign currency asset, as the latter are protected from exchange rate risk if the bank does not default, and subject to the same default risk as local currency claims in case of default. This cross-transfer is reinforced by the existence of deposit insurance. Moreover, the presence of a lender of last resort, by reducing the cost of risk to banks, stimulates foreign currency funding. These results suggest that, in most highly dollarized countries, the peso-dollar deposit spread may overestimate the pure currency risk. We also present an extension of the model in which the liquidity services of the local currency may provide an additional driver of endogenous dollarization.

1. Introduction

Financial dollarization is a widespread phenomena among developing economies. Argentina, Peru, Latvia and Croatia are some of the many countries with high levels of financial dollarization. In many of these countries financial dollarization
has risen as a consequence of the local currency losing its basic characteristic of store of value. These episodes are usually associated with hyperinflations and are driven by the drastic reduction in the (broad) demand for local currency. However, once the hyperinflation is gone, the local currency successfully stabilized and it’s credibility reestablished, dollarization persists.¹

To explain this behavior, referred to in the literature as dollarization “hysteresis”, a growing body of work on this issue has typically emphasized one side of the story, i.e. the portfolio decisions of depositors and borrowers, and its relation with macroeconomic stability.² In this paper we examine instead the other side of the story, namely, the bank’s behavior, and we show it to be a complementary force shaping the dollarization process and affecting its degree of persistence. We show that banking intermediation fosters dollarization by introducing an implicit cross-transfer from local to foreign currency asset, as the latter are protected from exchange rate risk if the bank does not default, and subject to the same default risk as local currency claims in case of default. This cross-transfer is reinforced by the existence of deposit insurance. Moreover, the presence of a lender of last resort, by reducing the cost of risk to banks, further stimulates foreign currency funding.

This paper presents a simple model of financial intermediation in a bi-currency economy where local currency assets can be funded by either local or foreign currency-denominated deposits. A basic ingredient of the model is that whenever the degree of financial dollarization exceeds the fraction of the real economy effectively dollarized (the share of debtors with dollar-indexed revenues), there is a currency mismatch somewhere in the economy. Then, in the event of a sudden devaluation, the erosion of the dollar value of peso-denominated assets impedes on the repayment capacity of debtors, dollar-indebted firms or currency-imbalanced banks, depending on the degree of currency mismatch of financial intermediaries.

¹Balino and Borensztein (1999) define a country as highly dollarized when Foreign Currency Deposits (FCD) exceed 30% of deposits. They find that 18 of the developing countries for which dollarization data is available satisfy this criteria. Ize-Levy Yeyati (1998), measuring financial dollarization as the ratio between foreign and total deposits, both at home and abroad, and that high and persistent dollarization is a characteristic of many developing countries across different regions.

²Most of the literature has a partial equilibrium approach that focuses on the depositor’s decision, and is biased in favor of the currency substitution aspect of dollarization, and its implications for monetary policy. On the other hand, with a view on the prudential implications of dollarization, Ize and Levy Yeyati (1998) use a CAPM model to derive financial dollarization as the result of the demand and supply of loanable funds, without paying much attention to the intricacies of financial intermediation.
In this context, dollar depositors are protected against exchange rate fluctuations whenever the devaluation does not precipitate a default, while they share the losses with peso depositors in the case of default. The fact that dollarized banks transfer part of their exchange rate risk to peso depositors should not be a concern as long as peso depositors adjust the demanded deposit rate accordingly. However, unless the DIS recognizes the differential contribution to default risk of deposits in each currency (something that it seldom does), in case of default dollar depositors will benefit from a higher reimbursement at the expense of peso depositors. Interestingly, we show that a DIS is not necessary to attain this result: inasmuch as the agency in charge of liquidating the failed bank recognizes part of the insurance value of dollar deposits (for example, by distributing the residual value of the bank according to the current value of the bank’s liabilities), it subsidizes dollar deposits widening the peso-dollar spread as a result and inducing unwarranted dollarization.

The presence of a LLR has the same effect although through a different channel. A LLR provides limited insurance to the bank in case of default, which in turn reduces the costs of risk-taking, which in the previous context entails a higher dollar share of deposits. Therefore, banks will be willing to increase their level of dollarization as part of the cost of this action is transferred to the provider of the bank insurance services, and eventually to the whole population.

At the extremes, full dollarization or the legal prohibition of dollar deposits, trivially eliminates the currency mismatch in the economy, thereby ruling out these sources of distortion. It could be argued that at high degrees of financial dollarization the mismatch becomes negligible as prices tend to follow movements in the exchange rate very closely. However, this is not necessary the case: financial dollarization may be consistent with low levels of real dollarization (alt. dollar indexation), and, even if it is not, the adjustment of prices to a sudden nominal exchange rate shock need not be instantaneous and smooth, leading to permanent bankruptcy losses.

In the case bank insurance, it is the combination of a bi-currency financial sector and a credible LLR (or any other pothat endogenously drives up dollarization. However, since the key factor underlying factor is the fair play that dollar depositors are usually given in the event of a bank default, it is easy to conceive (although less so to achieve in practice), LLR rules that undo the problem (for example, making the LLR condition its assistance on the degree of dollarization).

An important, and often overlooked, consequence of the previous discussion is the fact that the peso-dollar premium, as measured from the market rates of
return in each currency, is not independent from the existence of either deposit or bank insurance. In the presence of insurance schemes which do not discriminate across currencies, these results suggest that by simply measuring currency risk using the peso-dollar deposit spread we may be over-estimating the pure currency risk.

We also present an extension of the model that includes liquidity services of the local currency and show that it provides an additional factor that drives the endogenous dollarization. In most of the highly dollarized countries we observe that the legal tender still is the local currency (pesos). Therefore, wages and taxes, for example, can generally only be paid in pesos. If most transactions have to be done in pesos, depositors with a high share of dollar deposits in their portfolio will be willing to receive a liquidity discount in order to have a higher share of peso deposits and pay less in terms of transaction costs. We show that the bank can take advantage of this preferred behavior of depositors by forcing them to have a high level of dollarization since this benefits the bank in terms of lower costs of peso funding. This counterintuitive result provides another source for obtaining endogenous financial dollarization.

The paper proceeds as follows, in section 2 we present the basic model, and find the centralized and decentralized equilibria with no safety nets. In section 3, we analyze how does a DIS and LLR affect the level of dollarization in the economy and the peso-dollar interest rate spread. Section 4 attempts to provide the basis to correctly measure currency risk from the peso-dollar spread. Section 5 extends the basic model to include liquidity services. In section 6 we present some final remarks.

2. The Model

This section introduces a stylized model to illustrate how financial sector safety nets can induce dollarization in a bi-currency banking system.\(^3\)

Consider a bank that faces the following recursive problem: given the market peso and dollar deposit rates, it has to decide the optimal currency composition of its liability portfolio (or funding strategy). Expressing values in dollar terms,

\(^3\)As safety nets we understand two aspects in particular: the recovery value of bank deposits in case of default (through the liquidation of the residual value of the failed bank's assets, or through a DIS) and bank insurance (specifically, the presence of a LLR that bails out banks in distress).
and exploiting the recursive nature of the problem, we can express it as:

\[ V = \max_{\theta} \prod_{i=0}^\infty \theta P(\theta, i) \frac{\theta}{1 + \theta P(\theta)} \quad (2.1) \]

\[ \frac{\theta}{1 + \theta P(\theta)} = \max_{\theta} \prod_{i=0}^\infty \theta \max[0; \theta R_i (1 + \theta) r_p \theta + \theta r_d] f(\theta) d\theta \quad (2.2) \]

where \( \theta \) is the share of dollar deposits, \( f(\theta) \) is the p.d.f. of the (dollar-peso) exchange rate at the end of the period, with support \([0; 1]\), with the current exchange rate set to one for simplicity. We can think of \( \theta \) as driven by an exogenous shock, with low values (large depreciations) corresponding to bad states of nature. \( R \) denotes (gross) returns on bank assets, assumed to be fixed in nominal (peso) terms. This assumption captures a common feature of economies with a bi-monetary banking sector, the existence of a currency mismatch somewhere in the economy. For simplicity, in the model it appears in the bank's balance sheet. Finally, also for simplicity, we assume that the distribution of end-of-period devaluation rates is identical in each period (i.e., does not depend on history).

The profit function can be restated as:

\[ \frac{\theta}{1 + \theta P(\theta)} = \max_{\theta} \prod_{i=0}^\infty \theta \max[0; \theta R_i (1 + \theta) r_p \theta + \theta r_d] f(\theta) d\theta \quad (2.3) \]

where \( \theta \) denotes the critical value of end-of-period exchange rate below bank liabilities exceed bank assets, with

\[ e_c(\theta) = \frac{\theta}{1 + \theta P(\theta)} ; \quad P(\theta) = \frac{\theta}{1 + \theta P(\theta)} f(\theta) d\theta \]

\[ e_c(\theta) = \frac{R_1}{\theta e_c(\theta) \theta f(\theta) d\theta} ; \quad P(\theta) = \frac{\theta}{1 + \theta P(\theta)} f(\theta) d\theta \quad (2.4) \]

4An alternative would be to eliminate the bank's currency mismatch by imposing some currency mismatch regulation and introducing firms which have to borrow from the bank to invest. Since for every dollar deposit the bank receives it has to give a dollar loan, some of the firms will be indebted in dollars but still receive all their income in pesos. In other words, loans are in dollars but not in dollar producing sectors. The currency mismatch is simply shifted to the firms.

With the assumption in the main text we are simply merging the bank and the firms.

5For future reference, \( g(\theta) = \frac{\theta}{1 + \theta P(\theta)} \). Also note that \( P^0 < 0 \) since \( e_c^0 > 0 \).
Depositors are assumed to be risk neutral and can either invest in dollar deposits, peso deposits or an outside risk-free asset with return $r_f$. Depositors do not observe the bank's dollarization share. We implicitly assume that the bank cannot commit to a posted interest rate, reflecting the fact that rates are customarily pacted with each client on a personal basis.

2.1. Centralized equilibrium

As a useful benchmark, we present the solution for the optimal dollarization ratio in a centralized equilibrium. A central planner maximizes the expected return of the investment minus expected liquidation costs. Replacing (2.1) into (2.1) before computing the FOC of the bank, we obtain:

$$\max_{\lambda} \lambda \cdot Z \cdot e^{R} - \left( e^{r_f} \cdot [1 + P(\lambda)](1 + \mu) e^{R} \right) .$$

From the fact that expected liquidation costs (the third term in the numerator) increase with dollarization, it follows that the optimal share of dollar deposits is $\lambda^* = 0$.

The intuition is straightforward: dollarization does not entail any gain in terms of investment returns, while on the other hand generates a potential risk of default with the associated liquidation costs.

2.2. Decentralized equilibrium

In general, we can show that dollarization depends crucially on depositors' payoffs in case of default, as expected returns (and, in turn, interest rates) on deposits must satisfy the following arbitrage conditions:

$$r_p^e = P(\lambda) e^{r_p} + S_p(\lambda) = r_f$$
$$r_d^e = P(\lambda) e^{r_d} + S_d(\lambda) = r_f$$

Since the focus of this paper is to study the effect of the banks' behavior on the share of dollarization we keep the depositor's problem decision as simple as possible (for a complete discussion of this portfolio decision see Ize-Levy Yeyati (1998)).

We assume that $R$ is big enough so that investing is optimal.
where $S_i$ is the recovery value of deposits in currency $i$ when the bank defaults. It follows that the peso-dollar spread is given by

$$\frac{r_p}{r_d} = \frac{1}{e^\epsilon} \left[ 1 + s(\epsilon) \right];$$

(2.7)

where

$$s(\epsilon) = \frac{S_d}{r_i d} \frac{S_p}{r_i p} > 0$$

(2.8)

is the expected cross-transfer from peso deposits to dollar deposits in the event of a default. We can distinguish two basic scenarios at this point, one without deposit insurance in which the central bank distributes the residual value of the failed bank’s assets among depositors, and one in which the deposits are (partially) covered by a DIS where the recovery value is equal to a share of the end-of-period value of the deposit.

### 2.2.1. No DIS

We assume that, whenever a bank fails, the Central Bank (CB) takes control over its assets and liquidates them at a discount $\mu < 1$, such that $\mu R < r_f$. Thus, in the absence of a DIS, interest rates depend crucially on the way the bank’s assets are distributed among depositors in case of failure.

If the salvage value of deposits is higher in dollars than in pesos (due, e.g., to the partial recognition of the exchange rate insurance implicit in dollar indexation) then depositors will require a larger spread to invest in peso deposits (that is, for the bank, dollar-deposits become relatively cheaper)\(^8\). If the contrary is true (e.g., if the residual asset value is distributed among peso depositors) the insurance in the event of default goes the other way. On the other hand, both $r_d$ and $r_p$ are increasing in the level of dollarization, as it implies a higher probability of default.\(^9\) Moreover, for any given value $s(\epsilon)$, the spread decreases with dollarization as the insurance services of the dollar in the event the bank does not default become decreasingly valuable (in other words, $r^0_d(\epsilon) > r^0_p(\epsilon) > 0$).

They are several ways in which the CB can deal with the repayment of the deposits in the event of the failure of a bank. We assume here that the CB

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\(^8\)This condition ensures that under our distribution scheme, depositors are never better off in case of default.

\(^9\)As we $s(\epsilon)$ declines, we go back to the first case.

\(^10\)This simply requires that both depositors receive a lower return when the bank fails. In other words, $S_d < r_d$ and $S_p < r_p$ respectively and $S^0_i$ small enough.
distributes the residual value of the bank according to the current value of the amount they originally deposited (that is, the principal), thus recognizing dollar depositors the new, higher peso value of their deposits. Then,

\[ S_d = Z_{e_c}(\pm(\cdot; e) f(e) de); \]
\[ S_p = \int_0^1 e f(\cdot; e) f(e) de; \]  

(2.9)

where

\[ \pm(\cdot; e) = \frac{e \mu R}{e(1 \cdot P(\cdot)) + \cdot}; \quad \pm(\cdot; e) < 0 \]  

(2.10)

and \( S_d > S_p \) favoring dollarization.\(^{12}\)

We can think of alternative distribution schemes.\(^{13}\) However, as long as the sign of \( s \) is not obvious. The cross-subsidy grows from zero at \( \cdot = 0 \), as the interval of \( e \) for which the subsidy is activated widens \( (e^0_c > 0) \), but may decrease for high degrees of dollarization as the fraction of peso holders from which the transfer is extracted falls \( (\pm(\cdot; e) > 0) \). On the other hand, the peso-dollar spread falls with dollarization, as the states for which dollar depositors are perfectly insured (those in which the bank does not default) become less frequent.\(^{13}\) For instance, if the CB instead pays depositors the same fixed return per deposit (independent of its currency), we obtain \( S_p = S_d = (1 \cdot P(\cdot)) \mu e R \), where

\[ e = \frac{\int_0^1 e f(\cdot) de}{1 \cdot P(\cdot)}; \]

and \( s(\cdot) = 0 \), for all \( \cdot \), so that the peso-dollar spread becomes:

\[ \frac{r_p}{r_d} = \frac{1}{e} \]

which falls with \( \cdot \).

Alternatively, if the CB distributes the remaining value of the bank according to the current value of outstanding liabilities, \( e(1 \cdot r_p + \cdot r_d) \). Then,

\[ \pm(\cdot; e) = \frac{e \mu R}{e(1 \cdot r_p + \cdot r_d)}; \quad \pm(\cdot; e) < 0; \]

in which case \( s(\cdot) \) is positive but smaller than under the assumption considered in this paper. See Broda and Levy Yeyati (2000) for a more detail discussion.
distribution recognizes part of the insurance value of dollar deposits, the qualitative results of the paper still hold.

A rational expectations equilibrium is defined as the triplet \((\gamma, N_d; r_p, r_d)\) such that \(\gamma^N = \gamma^e\) and condition (??) holds, and the bank maximizes (2.1). Differentiating (2.1) with respect to the dollarization ratio, we obtain the following FOC:

\[
\frac{\partial V}{\partial \gamma} = \frac{1}{1 + \partial P(\gamma)} (\gamma^0 + \partial P^0 V);
\]

(2.11)

In turn, using \(e^0 = \frac{\partial e^0}{\partial P} \gamma^0 e^0 = \frac{\partial^2 e^0}{\partial P^2} \gamma^0 \), and \(P(\gamma_p i, r_d) = S_d i \gamma S_p\) from (2.6), we get

\[
\gamma^0 = (P^0 + P \gamma^0) (R i (1 i \gamma) r_p) i P^0 \gamma^0 r_d + P(\gamma_p i, r_d)
\]

\[
= P^0 e_c (R i (1 i \gamma) r_p) i \gamma^0 r_d] + P(\gamma_p i, r_d)
\]

(2.12)

and

\[
\gamma^0 = P^0 (e_c \gamma_p i, r_d), 0;
\]

(2.13)

The reader can easily see that:

i) The solution to the static problem (maximization of current profits) is always at the corner \(\gamma = 1\),

\(\gamma^0 \)
due solely to the presence of the cross-transfer \(s\);

ii) The cross-transfer effect is offset by the negative impact of dollarization on the bank's expected future value, as given by the term \(\partial P^0 V\).

If the latter is small enough, the stimulus to dollarize may prevail, eventually leading to full dollarization, as the following Proposition formally states:

Proposition 1. i) If \(P^0 \gamma^0 \), for sufficiently small, the decentralized equilibrium implies full dollarization, \(\gamma^N = 0\).

Proposition 2. Proof: In Appendix.

To understand the intuition behind this simple example, a natural benchmark is the hypothetical case of banks specialized by currency. In this context, risk are assigned according to their sources: only the dollar rate is adjusted for default risk, while the peso rate continues to be affected by devaluation expectations.

\(\text{\footnote{The problem is convex, and } \gamma^0 \gamma \text{ for all } \gamma^0.}\)
From \( r_d^0(\cdot) > 0 \) and \( r_p^0(\cdot) > 0 \) we can directly infer that for any given \( \cdot \), the peso dollar spread narrows in this case, since:

\[
\begin{align*}
    r_{pj,0} &= \frac{r_f i S_p(0)}{e(0) P(0)} = \frac{r_f i S_p(\cdot)}{e^m eP(\cdot)}; \\
    r_{dj,1} &= \frac{r_f i S_d(1)}{P(1)} = \frac{r_f i S_d(\cdot)}{e^m eP(\cdot)}.
\end{align*}
\]

(2.16)

Note that, in this case,

\[
S_d = \mu R_{e^c} \int_0^{\infty} e^c e^m eP(\cdot) \, de < r_p \int_0^{\infty} e^c e^m eP(\cdot) \, de = S_p 
\]

(2.17)

Thus, bi-currency banks, by aggregating both portfolios, transfer part of the devaluation-related exchange rate risk to peso depositors, benefitting dollar holders by reducing the set of default events \( (e^c(\cdot) > 0) \) and enhancing the bank’s probability of survival in the process. Then, in the absence of a cross-transfer \( (s = 0) \), the peso-dollar spread simply reflects exchange rate risk considerations, as default risk affects deposits in both currencies in the same way. However, as long as the central bank recognizes part of the insurance value of dollar deposits in the event of a default \( (S_d > S_p) \), it subsidizes dollar deposits widening the peso-dollar spread.

It is important to note that this cross-transfer does not entail any subsidy from the Central Bank. Indeed, banks would be better off if they could commit not dollarize at all. This can be easily verified by noting that specialized dollar banks would be less proﬁtable than peso ones; hence, they would not exist in equilibrium. However, given this automatic transfer implicit in the distribution of the residual bank value, it is optimal for banks to proﬁt from the wide peso premium by increasing their dollar funding. Then, in this simple example, dollarization is solely due to the cross-transfers implicit in the distribution mechanism.

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15Fully differentiating (??) and (2.6) and rearranging:

\[
\begin{align*}
    r_d^0 &= e^c \left[ f(\cdot, e^c) \int_0^{\infty} R_{e^c} e^m eP(\cdot) \, de \right] > 0 \quad (2.14) \\
    r_p^0 &= e^c \left[ f(\cdot, e^c) \int_0^{\infty} R_{e^c} e^m eP(\cdot) \, de \right] > 0 \quad (2.15)
\end{align*}
\]

16This can be readily seen from: \( \frac{1}{2} Q = [P(1)e(1) + (1 - P(1))]\mu R_{e^c} r_f < e^m R_{e^c} r_f \)
2.3. Full DIS

The argument of the previous example can be applied to analyze the effect of an implicit or explicit DIS on dollarization, as long as the insurance scheme does not discriminate across currencies. Assume for simplicity that a full DIS is funded through lump sum taxes on depositors.\footnote{The analysis can be easily generalized to a partial DIS. Similarly, the results remain unaltered if we assume that the DIS is financed through a tax on banks, such that $V_{DIS} = (1_i x) \max \{ \frac{(1_i x)}{(1_i x) + e} \} \mu R$, and the tax $x = (1_i p(e)) \max \{ (1_i x) \mu R + (1_i x) r_p + (1_i x) r_d \}$ is computed ex-ante based on rational expectations, so that the expected net outlays of the DIS are fully funded by banks.}

The first thing to note is that the peso-dollar spread now depends on the expected devaluation $e^m$, rather than the conditional (and larger) $e$. That is,

$$\frac{r_p}{r_d} = \frac{1}{e^m} > \frac{1}{e};$$

while both deposit rates are default risk-free and, in particular, $r_d = r_f$. Thus, the DIS enhances the insurance properties of the dollar by enlarging the set of events under which dollar depositors are fully protected, in contrast with the previous case in which this insurance was only partial.

Proposition 3. With a full DIS, the optimal share of dollarization is weakly higher than in the centralized equilibrium,

$$\mu_D > \mu_{ND}.$$

Proof: Denoting the cases with and without DIS with the supraindex $D$ and $ND$, we have that

$$S^D_d = r_d Z_{e^c} \int e^m f(e) \, de;$$

$$S^D_p = r_p Z^0_{e^c} \int ef(e) \, de;$$

$$S^D_d - S^D_p = r_f \int_0^1 \frac{e^m}{e^m} f(e) \, de > r_f \int_0^1 (1_i e) f(e) \, de > 0$$

while,

$$S^D_d - S^D_p = \mu R \int_0^1 \frac{(1_i e)}{(1_i e) + e} f(e) \, de < \mu R \int_0^1 (1_i e) f(e) \, de:$$

(2.20)
From $\mu R < r_f$, it follows that $\frac{1}{2} \rho = P(\mu R | r_d) = S_d^D i S_p^D - S_d^{ND} i S_p^{ND}$.\textsuperscript{18} 

The intuition from the proof should be straightforward. Full DIS improves the insurance coverage of dollar deposits relative to peso deposits ($S_d i S_p$), widening the peso-dollar spread and fostering dollarization. It is interesting to note that whenever the cost of the DIS is sustained by the government, the mechanism is no different than a tax on peso depositors which proceeds are transferred to dollar depositors in case of bank default. Peso (dollar) depositors react by demanding a higher (lower) rate, which in turn fuels dollarization. However, the result still holds when the DIS is funded through bank contributions (e.g., a tax on profits), as long as the insurance premium does not depend on risk (i.e., the currency of denomination).

2.4. Lender of last resort

In the absence of deposit insurance, a LLR policy (or any other bank insurance policy) has the same effect as a DIS inasmuch as it enlarges the range of end-of-period exchange rates over which dollar depositors are insulated from exchange rate risk.\textsuperscript{19} However, as opposed to deposit insurance, the LLR introduces a new incentive to dollarize beyond and above the channel analyzed in the previous examples. To distinguish between these two different channels, we assume in hat follows that depositors are already covered by a full DIS.

\textsuperscript{18}Alternatively, defining 

$$e = \frac{R_e e^f (e) d e}{1 - P};$$

we obtain:

$$P e + (1 - P) e = e^m;$$

and

$$P \left( \frac{e}{e^m} \right) \left( 1 r_f = (1 - P) \left( 1 - \frac{e}{e^m} \right) \right),$$

which is lower than

$$S_d^{ND} i S_p^{ND} < \mu R \left( 1 - e \right) f (e) d e = (1 - P) (1 - e) \mu R;$$

\textsuperscript{19}For bank insurance we understand any policy that, in the event of a devaluations that renders banks insolvent, provides the needed funds to cover banks liabilities and avoid default.
For the moment, we make the (realistic) assumption that the LLR policy is blind to the degree of dollarization of the failed institution. The blanket LLR policy that we have in mind is the following: whenever the exchange rate at the end of the period falls below $e_c$, with a probability $\bar{\theta}$ the central bank covers the gap between bank assets and liabilities at no cost. The bank's probability of survival is then given by

$$b(,) = (1 \bar{\theta})P(,) + \bar{\theta};$$

(2.21)

where $b(,) > P(,)$ and $0 > b^0(,) = (1 \bar{\theta})P^0(,) > P^0(,)$. The bank's problem then becomes:

$$V_{LLR} = \max \frac{P(,) \left[ e(,) R i C(,) \right]}{1 \bar{\theta} b(,)};$$

(2.22)

Proposition 4. Under a blanket LLR policy, the equilibrium level of dollarization is weakly higher than otherwise,

$$\bar{\theta}_{LLR} \geq \bar{\theta}_{DIS};$$

(2.23)

Proof: From $b^0(,) > P^0(,)$, it follows that

$$\frac{\frac{\partial V_{LLR}}{\partial \bar{\theta}}}{\frac{\partial V_{DIS}}{\partial \bar{\theta}}} = \frac{1}{1 \bar{\theta} s(,)} (FOC_{DIS} + \bar{\theta} V_{LLR}) > \frac{\partial V_{DIS}}{\partial \bar{\theta}} \ \¥$$

(2.24)

Thus, a LLR policy results in a reduction in the cost of risk to the banks (the loss of future rents) that induces risk-taking incentives, which in the context of our model can only take the form of engaging in less costly (although riskier) dollar funding. It should be clear to the reader that these results rely on the (quite realistic) assumption that the LLR facility is available to banks irrespective of their dollarization ratio, so that the chances of preserving the insurance benefits in the event of a devaluation are enhanced, without any increase in the effective cost of dollar funding to the bank. In other words, the bank benefits from lower dollar rates, transferring the cost to the LLR.\footnote{Again, the results remains true even if the LLR facility is fully funded through a tax on bank profits ex-ante.}

However, it is easy to conceive a LLR rule contingent on the degree of dollarization of the bank, such that $\bar{\theta}(,), \bar{\theta}^0(,) < 0$, which can readily undo the distortion associated with the insurance policy. In this case,

$$b^0(,) = (1 \bar{\theta})P^0 + (1 \bar{\theta}) P^0;$$

(2.25)
which can be set to the desired level of dollarization by making \( (, \) arbitrarily steeper.

[Incomplete.]

2.5. Financing

As was mentioned above, one can think of several inobstrusive ways of financing either the DIS or a LLR. For the purpose of the model, the easiest way is an up-front tax on profits that does not interfere with the bank's problem, or an ex-post lump-sum tax on depositors (including the issuance of public debt to distribute this tax over a longer time period). Whenever the financing needs cannot be resolved through taxes (or, similarly, when projected fiscal deficits induce current inflation), there is still an inflation tax such that holders of pesos (consumers in general) and peso assets cross-subsidize dollar asset holders. In this case, however, the injection of peso liquidity that drives up prices may have a feedback effect on the exchange rate.\(^{21}\)

An interesting aspect of the problem, and one that we implicitly assumed, is that, as long as dollar deposits do not require repayment in hard currency (alternatively, as long as banks are allowed to convert dollar deposits at the attendant exchange rate) there is always a tax that redistributes resources from peso to dollar holders without the need to resort to dollar reserves. Note that in principle, since the dollar in our model is used as store of value, the banks (or the central bank) could always offer to pay an amount of domestic currency equal to the current dollar value of the deposit. As long as dollar deposits are used for transaction purposes but rather to protect the purchasing power of savings, our deposits are equivalent to dollar-indexed instruments, hence we can ignore the dollar liquidity problem usually associated with dollarized economies, and reduce everything to a fiscal issue.

\(^{21}\) On the other hand, dollar deposits are not legally dollar-indexed deposits, so they can be converted at an arbitrary rate in a way quite close to a confiscation. Of course, rational dollar depositors anticipate this demanding higher rates, so that the desired reduction in financing costs will not materialize while, the peso-dollar spread narrows, and dollarization is reduced.
3. Empirical measurement of currency risk

In many highly dollarized we observe high spreads between peso and dollar assets (including deposits), usually attributed to devaluation expectations. Similarly, peso-dollar spreads of comparable securities are widely used as the standard way to compute these expectations. However, an important, and often overlooked, consequence of the previous discussion is the fact that the peso-dollar premium, as measured from the market rates of return in each currency, is not independent from the existence of either deposit or bank insurance, a point particularly relevant when comparing currency risk across countries. We will show in this section that the spread itself can be under- or over-estimating the “pure currency risk”. In reality, since in many of these countries deposit insurance does not discriminate between currency denominations (as is the case for all Latin American countries with the exception of Colombia and Venezuela) and since, even in the absence of an explicit insurance scheme, the central bank is likely to recognize part of the insurance value of dollar deposits in case of default, the spread overestimates the currency risk.

When deciding on their portfolio strategy, asset holders take into account the expected return of the asset in the event that the issuer defaults on its obligation. This expected return depends both on the probability of default and on the repayment received in case of default (the share of the residual value of the asset allocated to each creditor). Since non-specialized banks do not default on only part of its liabilities, peso and dollar deposits share the same default risk. However, the expected repayment in case of default is affected by the scheme that the CB, DIS agent or LLR applies. We attempt to provide a guide to calculate, from the observed peso-dollar deposits spread, the “pure currency risk” under different behaviors of the central bank and different insurance schemes.

3.1. No DIS or LLR

In the absence of a DIS or a LLR, we showed above that interest rate arbitrage implies the following relationship between peso and dollar rates:

\[
\frac{r_p}{r_d} = \frac{1}{e^s} \left[ 1 + s(e) \right] \tag{3.1}
\]

22 This observation has usually been referred to as the “peso problem”.
23 Indeed, only 27 out of the 72 countries surveyed by Garcia (1999) exclude foreign currency deposits from their schemes.
A quick look at the expression for the peso-dollar premium shows that it does not only reflect devaluation expectations but also the expected salvage value of the financial instrument. The spread can be decomposed into what we called above "pure currency risk", $\frac{1}{e}$; and a second term, $1 + s(\cdot)$; which is the expected cross-transfer from peso-deposits to dollar-deposits in the event of default.

Note that the spread is identical to expected devaluation only when this cross-transfer is equal to zero, so that in equilibrium we get no dollarization and a (virtual) spread of

$$\frac{r_p}{r_d} = \frac{1}{e^m},$$

that can be correctly interpreted as pure currency risk.

If, on the other hand, we assume a more plausible scheme where the CB recognizes part of the insurance value of dollar deposits in case of default, then $s(\cdot) > 0$ and the above result breaks. In this case, the equilibrium spread becomes,

$$\frac{r_p}{r_d} = \frac{1}{e}[1 + s(\cdot)];$$

(3.2)

that is, depositors require a larger premium to invest in pesos, and the spread overestimates pure currency risk, the more so, the larger the value recognized to dollar depositors by the CB in case of default. Similarly, it is immediate to see from (3.2) how empirical measures of expected devaluation based on the currency spread are positively correlated with this implicit cross-transfer for any given degree of dollarization.

3.2. With DIS

In this case, since the DIS completely ensures the nominal value of deposits no matter what the exchange rate turns out to be, the spread is solely determined by the depositors' behavior, namely

$$\frac{r_p}{r_d} = \frac{1}{e}.$$

This result shows that other things equal, we should expect a higher spread in countries that do not exclude dollar deposits from their deposit insurance scheme.

---

24For example, in the special case where the CB pays depositors the same fixed return per deposit (independent of its currency), we get: $S_p = S_d = (1 - P(\cdot)) \mu eR$, where $e = \frac{\mu c_{ef}(\cdot)d_{ef}}{g P(\cdot)}$. 

16
For example, since Colombia’s DIS that does not exclude FCD deposits while Ar-
gentina’s pre-95 DIS does, in periods where the expected devaluations are similar,
we should expect Colombia’s spread to be higher than Argentina’s.

A similar logic as in the previous subsection is driving this result. The impact
of a (partial) deposit insurance scheme (DIS), implicit or explicit, as long as the
scheme does not discriminate across currencies will increase the peso-dollar spread
which correctly measures the currency risk.

In the absence of explicit insurance, this is directly related with the way in
which the residual value of the debtor is assigned among creditors. If the remaining
asset value of a failed bank is distributed according to the current value (i.e.,
the value at maturity), this imply the recognition of the hard currency value of
dollar bonds, which according to our argument should be reflected in higher peso
premias.

The higher the expected coverage of the DIS, the higher the peso premium.
This intuitive results follows directly from

\[
\frac{S_d}{r_f} - \frac{S_p}{S_d} > 0
\]

and

\[
S^P_d - S^P_p = i_S^D_d - S^D_p - \cdot
\]

where the supraindex \( P \) denotes partial insurance and \( \cdot \) is the coverage level. In
general, then, the peso premium will be the highest in assets that are expected to
be covered by government guarantees.

The same argument can be extended to other financial instruments (for ex-
ample, bonds subject to a haircut in the case of the insolvency of the issuer)
and may help to explain differences in currency risk measured based on different
instruments, such as the higher spread displayed by bonds vis a vis domestic de-
posits. While one is tempted to interpret this behavior as a signal of a stronger
guarantee on the side of the latter, the intuition developed in this section suggests
the opposite: a level of (implicit) government insurance perceived to be higher for
bonds than for deposits. Indeed, we only need the more realistic assumption that
dollar bondholders would be treated on the same base as peso bondholders, while
dollar depositors are more likely to be penalized by a forced conversion.\(^\text{25}\)

\(^{25}\)This should be particularly visible in countries where the DIS excludes dollar deposits.
3.3. Liquidity Services

In this section we extend the depositor's problem to include specific liquidity services of the different currencies. We introduce these services by assuming that there are currency specific transactions. For example, if most transactions have to be done in pesos, depositors with a high share of dollar deposits in their portfolio will be willing to pay a liquidity premia in order to increase their peso share, thus economizing in transaction costs. The magnitude of these transaction costs may vary across countries.\(^{26}\)

We assume that a fraction $\gamma$ of the depositors' transactions can only be carried out in dollars, and, similarly, a fraction $1 - \gamma$ of them is done only in pesos.\(^{27}\) Thus, by reducing the cost of dollar transactions, dollar deposits provide liquidity services in the amount of $\gamma (\gamma - \gamma)$, where we assume that $\gamma > 0$; $\gamma < 0$, and $\gamma = 0$. Similarly, depositors benefit from liquidity services from peso deposits in the amount $((1 - \gamma) - (1 - \gamma))$. Defining the liquidity gain from the marginal dollar and peso deposits as $\gamma (\gamma - \gamma)) > 0$, and $\gamma (\gamma) > 0$, respectively, interest rate arbitrage implies that:

$$r_d + \gamma = r_p + \gamma = r_f.$$  

Note that $\gamma < 0$ if $\gamma > \gamma$. The previous assumptions imply that the relative liquidity value of peso (dollar) deposits increases (decreases) with the degree of dollarization, namely that $\gamma > 0$ and $\gamma > 0$. Moreover, if deposits' real expected returns are equal across currencies, the optimal degree of deposit dollarization for the individual depositor is $\gamma = \gamma$.\(^{28}\)

In most of the highly dollarized countries we observe that the legal tender still is the local currency. Therefore, wages and taxes can generally only be paid in pesos. Most daily transactions are also done in pesos. In light of this and for expositional purposes we suppose that $\gamma < \gamma$: In the appendix, we show the results for $\gamma \geq \gamma$.

\(^{26}\)In Argentina, for example, the currency board considerably reduces them, some banks even do this conversion electronically and at no fee. However, in countries like Bolivia and Ecuador prior to full dollarization, buying or selling dollars had to be done in the black market at non-negligible costs and risks.

\(^{27}\)The relaxation of this assumption to allow for some transactions to be completed in either currency does not modify the qualitative results.

\(^{28}\)For simplicity, we implicitly assume that the off-shore asset does not provide liquidity services. Alternatively, we may think of $\gamma$ as the differential liquidity services of domestic deposits vis a vis the foreign asset.

18
Finally, for future reference, using ?? and 2.6 we obtain,

\[ r_p = \frac{r_f i \cdot S_p(i, e)}{P(i, e)} e \]
\[ r_d = \frac{r_f i \cdot S_d(i, e)}{P(i, e)} e \]

note also that, \( e r_p i \cdot r_d = (S_d i \cdot S_p) + (d i \cdot p) \):

3.4. Centralized equilibrium

The central planner maximizes the expected return of the investment minus expected liquidation costs plus liquidity services. In this case we get,

\[
\max_{e} \sum_{i=0}^{X} e R f (e) \cdot R (\cdot r_f + l(\cdot)) = \max_{e} e \cdot e R \cdot r_f [1 \cdot P(\cdot)](1 \cdot e) e R + l(\cdot) :
\]

(3.4)

In general, since liquidity services are maximized at \( \cdot = \), the social optimum must belong to the interval \([0; \cdot]\).

FOC \( = i \cdot (1 \cdot e) R [((1 \cdot P)(e)](0) e + d i \cdot p \cdot e \cdot R \cdot f \cdot B \cdot W U = \).

Without any exchange rate uncertainty (hence without any liquidation cost), the first best is simply \( f \cdot W U = \).

3.5. Decentralized equilibrium without uncertainty (WU)

With no uncertainty the banks’ optimal portfolio decision simply becomes (for simplicity let \( e_t = 1 \) for all \( t \)):

\[
\max_{i} R i \cdot r_d i \cdot (1 \cdot e) r_p
\]

or using that \( r_i = r_f i \cdot e_i \) and that \( e = e \),

\[
\max_{i} R i \cdot (r_f i \cdot d(\cdot)) i \cdot (1 \cdot e) (r_f i \cdot e p(\cdot))
\]

19
\[ F\text{OC} = 'd_i 'p + 'd_0 + (1_i 'd) 'p \]

and since 'd_i 'p > 0 if 'p > 0 and 'd_0 > 0; then if 'p < \frac{1}{2} there is a unique equilibrium where 'd_F > 'p. The problem is well defined:

\[ SOC = 2('d_0 'p) + 'p + (1_i 'd) 'p \cdot 0 \]

At ' = 'p, by increasing ' the bank reduces 'p by the same amount as it increases 'd so the cost of changing the currency denomination of the marginal deposit is zero for the bank. However, since 'p < \frac{1}{2} at ' = 'p, banks hold a large portfolio of peso deposits so that they pro...t from the fall in 'p more than they lose from the rise in 'd. Hence, their choice of dollarization is higher than the optimal 'FBU = 'p.

3.6. Decentralized equilibrium with devaluation risk (DR)

The individual bank maximizes the discounted flow of pro...ts, taking into account the probability P(') of surviving the current period:

\[ V = \max \frac{\gamma_i (\cdot)}{1 - P_i (\cdot)} \quad \text{(3.5)} \]

where using 2.7, 29 30

\[ \gamma_i = P_i (\cdot) (\mu_i (\cdot) [R_i (1_i 'd) 'p_0] ) \]

\[ = P_i (\cdot) \mu_i (\cdot) R + \frac{p}{p_0} (1_i 'd) \frac{\mu_i}{\mu_0} (S_p(\cdot) + 'p(\cdot) r_f) + 'd(\cdot) r_f \]

Proposition: If 'p < \frac{1}{2} and ± small, then 'DR > 'p.

Proof: Di...erentiating with respect to the dollarization ratio, we obtain the following FOC:

\[ \frac{\partial V}{\partial '} = \frac{1}{1 - p_0 (\cdot)} (\gamma_d + p_0 (\cdot)) \quad \text{(3.6)} \]

29 We need the optimal individual currency mix for the bank to be the same as the optimal portfolio currency mix, i.e., ' = 'p, which is true if

\[ 'd_0 (\cdot) + (1_i 'd) 'p (\cdot) \]

is concave, or 'p_0 < 0.

30 In the appendix we show that for certain distribution functions the problem is concave.
In turn, using $\mathcal{E}^0 = i \frac{\epsilon_c^0}{p} \frac{f(e_c) e_c}{p} i \frac{p_e}{p} (e_c e \cdot \mathcal{E})$, and $e_c(\cdot) \cdot \frac{r_d}{R_i(1_i \cdot r_p)}$, we get

$$
\mathcal{V}_d^0 = P(\epsilon \mathcal{R}_p \cdot r_d) + \frac{P}{\mathcal{E}^0} \mathcal{E}(1_i \cdot r_p)^0 + \mathcal{E}(1_i \cdot r_p)^0 \mathcal{P}(1_i \cdot r_p)
$$

(3.7)

$$
= P(S_d \cdot S_p + \cdot d \cdot r_p) + \frac{P}{\mathcal{E}^0} \mathcal{E}(1_i \cdot r_p)^0 \mathcal{P}(1_i \cdot r_p)
$$

(3.8)

(reminder '0 < 0 and '0 > 0). At $\mathcal{E}^0 = 0$; '0 = 0 and $S_d \cdot S_p > 0$ by assumption. Once again, since $\mathcal{V}_d < \frac{1}{2}$; the last term is positive and therefore $\mathcal{P}_d > 0$.

Therefore, both with and without exchange rate risk, the market equilibrium induces a level of dollarization higher than optimal.

[Incomplete.]

4. Conclusions
[To be written.]

5. Appendix

5.0.1. Useful properties

$$
\epsilon_c^0(\cdot) = \frac{r_d(R_i \cdot r_p)}{[R_i(1_i \cdot r_p)]^0} = \frac{(R_i \cdot r_p)}{R_i(1_i \cdot r_p)} e_c > 0
$$

$$
\mathcal{E}^0 = i \frac{\epsilon_c^0}{p} \frac{f(e_c) e_c}{p} i \frac{p_e}{p} (e_c e \cdot \mathcal{E}) > 0
$$

$$
\epsilon_c(\cdot) = \frac{r_d p(R_i \cdot r_p)}{[R_i(1_i \cdot r_p)]^0} = \frac{\epsilon_c^0}{R_i(1_i \cdot r_p)} < 0
$$

$$
P^0(\cdot) = i \epsilon_c^0(\cdot) f(e_c) i \frac{p_e}{p} (e_c e \cdot \mathcal{E}) < 0
$$

$$
\mathcal{E}^\mathcal{W} = \frac{(R_i \cdot r_p)}{R_i(1_i \cdot r_p)} \frac{1}{r_p}
$$

$$
P^\mathcal{W}(\cdot) = i \epsilon_c^\mathcal{W}(\cdot) f(e_c) i [\epsilon_c^0(\cdot)]^2 f(e_c) \epsilon_c < 0
$$

5.0.2. Proof of Proposition 1:

We know that

$$
F OC = \frac{1}{1_i \mathcal{P}^d(\cdot)} (\mathcal{V}_d + \mathcal{P}^d(\cdot)) = 0;
$$

(5.1)

where
\[ \frac{1}{2} \theta = P(\epsilon_\text{pr} i \ r_d) \cdot 0 \]  
(5.2)
and
\[ \frac{1}{2} \phi = P(\epsilon_\text{cr} i \ r_d) \cdot 0; \]  
(5.3)
and
\[ \text{SOC} = \frac{1}{1 i \ \phi (\_)} [\frac{1}{2} \phi + \phi \ a V + 2P \ V] : \]

Suppose that \( b \ 2 \ (0; 1) \) is an interior equilibrium (FOC = \( V^0 = 0 \)). Then,
\[ \text{SOC} = \frac{1}{1 i \ \phi (\_)} [\frac{1}{2} \phi + \phi \ a V] > 0; \]

and, by contradiction, the equilibrium can only be at a corner.

We can compute a \( \pm \) such that for \( \pm, \ a, \ e \ = 1 \). Assuming that \( e = 1 \), and denoting by the subindex the value of \( \_ \) (alt., the corner), the condition to satisfy is:
\[ \mu \ V_1 i \ V_0 = \frac{P_1}{1 i \ \phi_1} \left\| \left\| \epsilon_1 R i \ r_f \frac{1}{P_1} \right\| _i \left\| \mu \ e^m R i \ \frac{r_f}{P_1} \frac{e^m (1 + S_1)}{\epsilon_1} \right\| > 0; \]
(5.4)
so that a bank does not deviate from the full dollarization equilibrium. Rearranging (2.9), we obtain:
\[ \pm. \ a \ < \frac{1}{P_1} \ \left( \frac{e^m}{\epsilon_1} \ R i \ \frac{r_f S_1}{P_1} (\epsilon_1 i \ e^m) \right) \ \left( \frac{r_f}{P_1} \ e^m \ \frac{r_f S_1}{P_1} + (\epsilon_1 i \ e^m) \ R i \ \frac{r_f}{P_1} \right): \]