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Dollarization of Financial Intermediation: Causes and Policy Implications

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Abstract

This paper presents a portfolio model of financial intermediation in which currency choice is determined by hedging decisions on both sides of a bank's balance sheet. Minimum variance portfolio (MVP) allocations are found to provide a natural benchmark to estimate the scope for dollarization of bank deposits and loans as a function of macroeconomic uncertainty. Dollarization hysteresis is shown to occur when the expected volatility of the inflation rate is high *in relation to* that of the real exchange rate. The evidence shows that MVP dollarization generally approximates actual dollarization closely for a broad sample of countries, and policy implications are explored.

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SUMMARY

This paper presents a model of asset substitution, based on a capital assets portfolio model (CAPM) formulation, in which currency choice is determined on both sides of a bank's balance sheet by hedging against inflation and foreign exchange risk. Thus, the dollarization of deposits and loans interact through the loanable funds market. The paper shows that this interaction leads to portfolio equilibria that gravitate around the minimum variance portfolio (MVP). Hence, MVP provides a natural benchmark for measuring underlying dollarization and relating it to macroeconomic stability. Underlying dollarization is correlated positively with the variance of inflation but negatively with the variance of the rate of depreciation. Hence, stabilization may fail to reduce dollarization if accompanied by policies that target the real exchange rate. The evidence seems to support these conclusions: underlying dollarization generally approximates actual dollarization closely for a broad sample of countries.

Financial dollarization (i.e., the dollarization of financial assets and liabilities) is also shown to be related to real sector dollarization, as measured by the pass-through coefficient of exchange rate changes on prices. This limits the feasibility of using exchange rate policy as a means to reverse dollarization in highly dollarized economies. It also implies that dollarization should be, at least in part, a natural consequence of trade liberalization and international economic integration. Hence, attempts to limit it can be ill-advised.

The paper also shows that the dollarization of deposits and loans can deviate from MVP as a result of changes in the location of deposits (domestic or foreign), the magnitude and currency of denomination of domestic public debt, the implicit taxation of financial intermediation through unremunerated reserve requirements, and regulatory restrictions. Policy implications are explored.

INTRODUCTION

While substantial progress has been achieved during the last decade in controlling inflation throughout the world, dollarization, the holding by residents of a significant share of their assets or liabilities in foreign currency, remains a common feature of both developing economies and economies in transition.² In several developing countries that have experienced severe inflationary experiences, particularly in Latin American countries such as Argentina, Bolivia, and Peru, dollarization remains very high, notwithstanding several years of stable macroeconomic policies that have gradually improved confidence (Figure 1). While dollarization trends in the transition economies are somewhat more subdued, dollarization also appears to have become entrenched in many cases (Figure 2).

Although the literature on dollarization is very vast, it leaves some important gaps.³ While the importance of macroeconomic expectations as a key determinant of the demand for dollar assets is well recognized, few attempts have been made at systematically estimating dollarization levels across countries, based on macroeconomic conditions. In addition, most of the literature is concerned with currency substitution (i.e., the use of foreign currency as a means of payment), rather than asset substitution (i.e., the use of foreign currency instruments for investment purposes). However, the latter generally accounts for the bulk of measured dollarization.⁴ Moreover, the papers that specifically address the issue of asset substitution as a portfolio choice generally do not recognize the implications of dollarization for financial intermediation.⁵ Yet, the fact that the dollarization of bank deposits generally has as mirror image that of loans is important to determine the nature and extent of dollarization. In particular, the extent of loan dollarization determines the financial system's exposure to systemic credit risk in the case of large devaluations. Finally, while there is a general presumption that dollarization restricts the scope for independent monetary and exchange rate

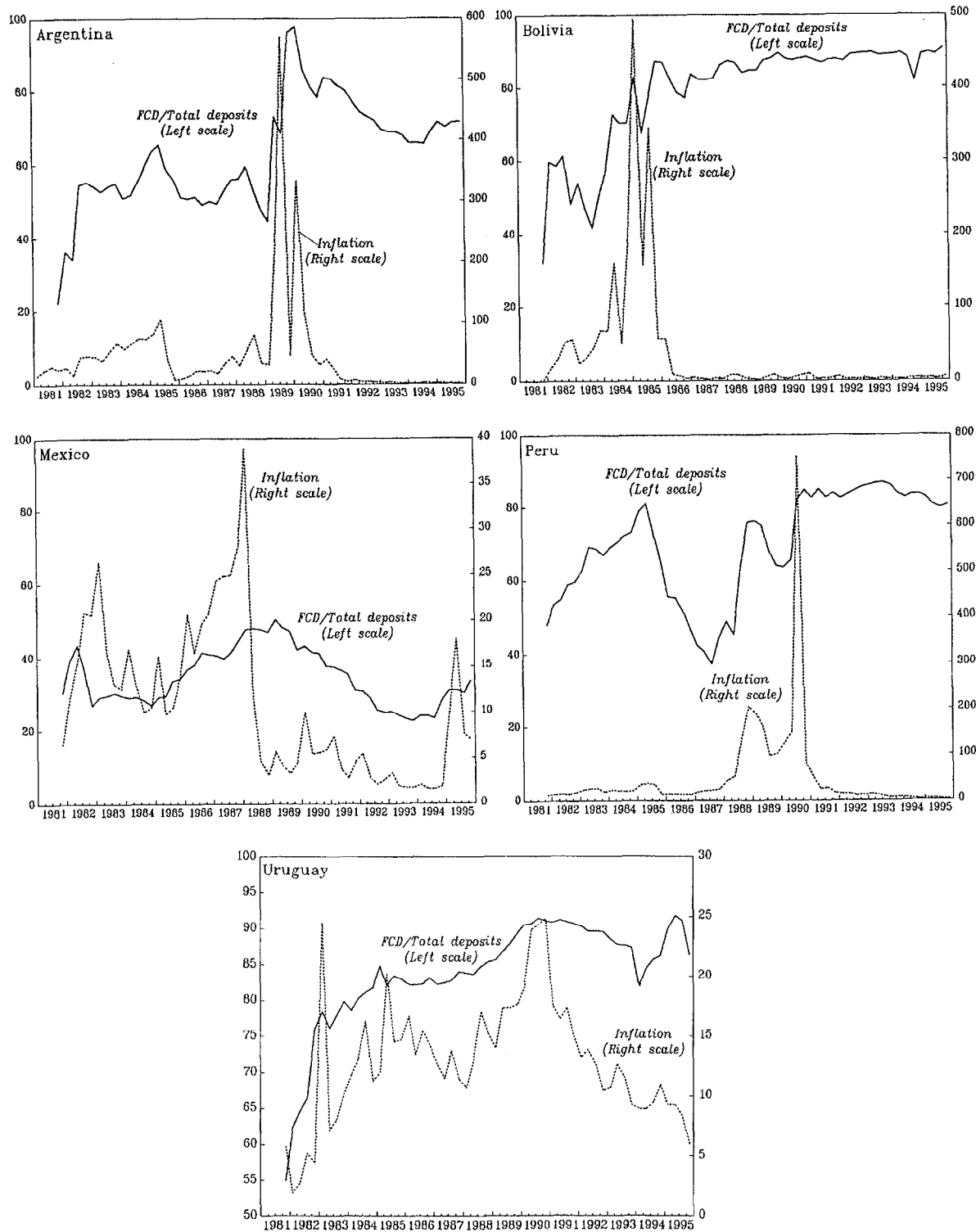
²The term "dollarization" is applied generically to the use of foreign currency assets and liabilities, although in some cases the dollar is not the main foreign currency of choice of domestic residents.

³The dollarization literature is quite extensive and has grown rapidly in recent years. Recent surveys can be found in Calvo and Vegh (1992 and 1997), Giovannini and Turtleboom (1994), and Savastano (1996). Guidotti and Rodriguez (1992) present a model of hysteresis based on switching costs.

⁴Hence, as noted by many observers, much of the empirical literature is plagued by a definitional problem, as interest bearing deposits are used to estimate money demand equations.

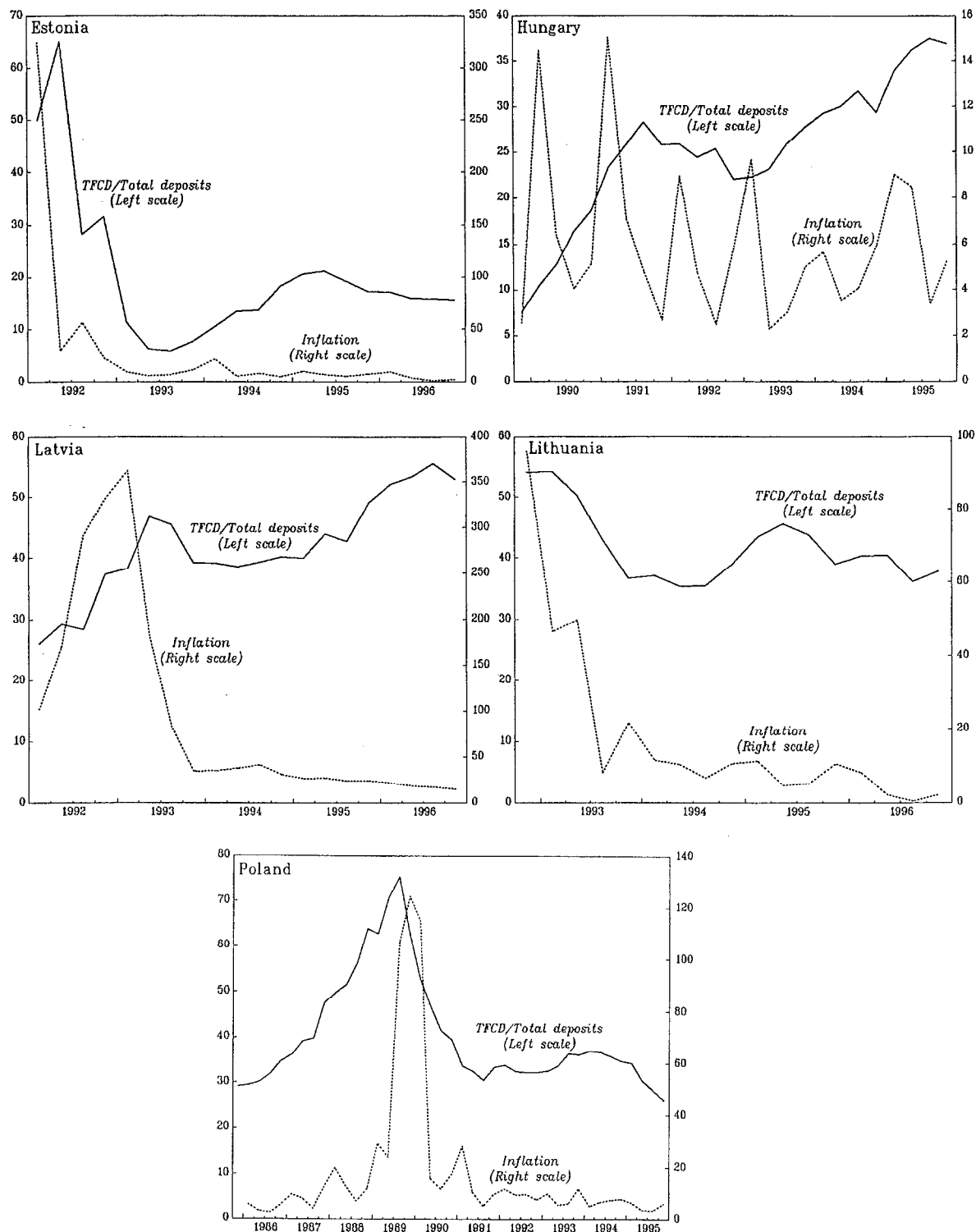
⁵See, e.g., Sahay and Vegh (1996). An exception is Ize (1981), which provides a basis for the model developed in this paper.

FIGURE 1
DOLLARIZATION RATIOS AND INFLATION IN
LATIN AMERICAN ECONOMIES
(In percent)



Sources: IMF, International Financial Statistics; and Central Bank Bulletins (various issues).

FIGURE 2
DOLLARIZATION RATIOS AND INFLATION IN
TRANSITION ECONOMIES
(In percent)



Sources: IMF, International Financial Statistics; and Central Bank Bulletins (various issues).

policies, the operational implications have not been well explored. Nor has the scope for reversing dollarization through monetary and exchange rate policies been sufficiently analyzed.

Following contributions by Thomas (1985) and others, this paper presents a model of asset substitution based on a Capital Assets Portfolio Model (CAPM) formulation. However, unlike in the earlier literature, currency choice is determined on both sides of a bank's balance sheet by hedging against inflation and foreign exchange risk. Thus, the dollarization of deposits and loans interact through the loanable funds market. The paper shows that this interaction leads to financial equilibria which gravitate around interest rate parity and minimum variance portfolio allocations (MVP). Hence, MVP, which is found to be a simple function of the volatility of inflation and real depreciation, provides a natural benchmark to measure underlying dollarization and relate it to macroeconomic stability. The evidence seems to support this conclusion as underlying dollarization generally approximates actual dollarization closely for a broad sample of countries.

In MVP equilibria, dollarization is explained by the second moments (i.e., volatility) of inflation and real exchange rate depreciation, rather than the first moments (i.e., expected inflation and depreciation), as in the case of currency substitution models.⁶ For a given variance of inflation, an increase in the variance of the rate of depreciation reduces dollarization as it limits the hedging benefits of dollar assets. Hence, stabilization may fail to reduce dollarization if accompanied by policies that target the real exchange rate. This provides an alternative explanation for the permanence of dollarization to the ones based on switching costs or long lasting memories. In the model presented here, hysteresis can occur even when the memory of past macroeconomic unbalances has faded away, if the expected volatility of inflation remains high *in relation to* that of the real exchange rate.

While this conclusion suggests that a floating exchange rate policy could, in principle, be used as a means to limit dollarization (i.e., by increasing real exchange rate volatility relative to price volatility), financial dollarization is also shown to be related to real sector dollarization, as measured by the pass-through coefficient of exchange rate changes on prices. Hence, in highly dollarized economies, it may not be possible to increase the volatility of the exchange

⁶These conclusions are reminiscent of those reached for Bolivia and Peru by McNelis and Rojas-Suarez (1996) who conclude, on the basis of a similar CAPM approach, that dollarization is related to devaluation uncertainty. However, the results in this study differ in that they focus on MVP allocations, rather than deviations from MVP, and on asset substitution, rather than currency substitution. Thus, while McNelis and Rojas-Suarez find that devaluation uncertainty promotes dollarization, in our model underlying dollarization is correlated positively with the variance of inflation but *negatively* with the variance of the rate of depreciation.

rate, without increasing that of inflation. This limits the feasibility of using exchange rate policy as a means to reverse dollarization. It also implies that dollarization should be, at least in part, a natural consequence of trade liberalization and international economic integration. Hence, attempts to limit it may be ill-advised.

The paper also explores how actual dollarization can deviate from underlying dollarization. Based on portfolio interaction between country risk (i.e., confiscation and banking system risk) and macroeconomic risk (i.e., inflation and foreign exchange risk), dollarization and the structure of interest rates are shown to depend on the location of deposits (domestic or foreign), the magnitude and currency of denomination of public domestic debt (including the central bank's domestic liabilities), the taxation of financial intermediation (e.g., through unremunerated reserve requirements), and the introduction of regulatory restrictions. In particular, capital inflows due to declining country risk, a tightening of monetary policy or a shift in the currency composition of public domestic debt toward the domestic currency increase the differential between home currency and local foreign currency interest rates, thereby reducing deposit dollarization while increasing loan dollarization. Instead, unremunerated reserve requirements on foreign currency deposits can contain dollarization on both sides of a bank's balance sheet. However, such policies also induce capital flight and financial disintermediation, to an extent that depends on the strength of the demand for dollar hedging and the level of dollarization.

The paper is organized as follows. Section II presents the model and derives expressions for the deposit and loan dollarization ratios as a function of MVP allocations and deviations from interest rate parity. Section III analyzes in more detail the determinants of underlying dollarization, defined as that resulting from MVP allocations, and discusses policy implications. The section also presents empirical evidence of the link between actual and underlying dollarization ratios. Section IV explores the short-run macroeconomic policy implications of the model for small deviations from MVP. Section V summarizes the paper's main conclusions and suggests possible extensions.

II. THE PORTFOLIO MODEL

A. Depositors' Portfolio Choice

Domestic depositors' portfolios comprise three assets: domestically held home currency deposits (HCD), domestically held foreign currency deposits (FCD) and cross-border foreign currency deposits (CBD), with real returns in terms of the domestic price index expressed as r_D^H , r_D^F and r^C , respectively. For simplicity, all domestic public bonds are assumed to be intermediated by the banking system. In accordance with the emphasis of this paper on asset substitution, rather than currency substitution, agents hold no cash.

Due to foreign exchange rate risk, dollar deposits or loans (at home or abroad) are imperfect substitutes for home currency deposits or loans. In addition, deposits held locally are imperfect substitutes for deposits held abroad, because of country risk. The latter is assumed

to incorporate all sources of risk which are not strictly macroeconomic in nature. Thus, it includes confiscation risk, as well as banking system risk. Although it would be reasonable to expect some correlation between macroeconomic risk and country risk, these risks are assumed to be independent for purposes of analytical tractability.

Thus, it is assumed that:

$$\begin{aligned} r_D^H &= E(r_D^H) + \mu_\pi + \mu_c \\ r_D^F &= E(r_D^F) + \mu_s + \mu_c \\ r_D^C &= E(r^C) + \mu_s \end{aligned} \tag{1}$$

where μ_π , μ_s and μ_c are disturbances associated with inflation, the real exchange rate, and country risk, respectively, distributed with zero mean and variance-covariance matrix $[S_{ij}]$, and E is the expectations operator. In addition, it is assumed that:

$$S_{sc} = S_{\pi c} = 0 \tag{2}$$

Depositors' preferences are represented by:

$$U_D = E(r_D) - c_D V(r_D)/2 \tag{3}$$

where r_D is the average real return of the deposit portfolio, $c_D > 0$ reflects depositors' aversion to risk and V is the variance operator. If λ_D is the share of total dollar deposits (including CBD) and γ the share of cross-border deposits in the deposit portfolio, familiar CAPM formulations are found to hold for total dollar deposits and deposits held abroad as a function of excess returns (see Appendix I. A):

$$\lambda_D = \lambda^* - \delta_D^I / h_D \tag{4}$$

$$\gamma = 1 - \delta^X / h_C \tag{5}$$

where δ_D^I and δ^X are the expected internal and external deposit rate differentials:

$$\delta_D^I = E(r_D^H - r_D^F) \tag{6}$$

$$\delta^X = E(r_D^F - r^C) \tag{7}$$

h_D and h_C are volatility-adjusted risk aversion coefficients, such that:

$$h_D = c_D V(r_D^H - r_D^F) = c_D (S_{ss} - 2S_{s\pi} + S_{\pi\pi}) \quad (8)$$

$$h_C = c_D V(r_D^F - r^C) = c_D \sigma_{cc} \quad (9)$$

and λ^* is the dollar share of MVP with respect to foreign exchange risk, which is represented as:

$$\lambda^* = [V(r_D^H) - \text{Cov}(r_D^H, r_D^F)] / V(r_D^H - r_D^F) \quad (10)$$

Thus, the choice of currency (as reflected in the dollar share of deposits) depends only on foreign exchange risk, as measured by the variance of the internal interest rate differential. On the other hand, the choice of location (as reflected in the cross-border share of deposits) depends only on country risk, as measured by the variance of the external interest rate differential.⁷ As country risk favors holding assets abroad, a positive country risk premium is needed to induce depositors to hold FCD. It can also readily be checked from equation (4) that, except in the limiting cases where h_D equals zero, MVP implies interest rate parity.⁸

As nominal interest rates are assumed to be fixed during the life of the deposit or loan contract, uncertainty about real rates of return arises only from price or exchange rate volatility. Using the following approximations:

$$r_D^H \approx R_D^H - \pi \quad (11)$$

$$r_D^F \approx R_D^F + s \quad (12)$$

with: $s = e - \pi \quad (13)$

and where R_D^H and R_D^F are the nominal deposit rates in home and foreign currency, π is the inflation rate, and e and s are the rates of change of the nominal and real exchange rate, respectively, MVP dollarization can be expressed as a simple function of the volatility of inflation and the rate of real depreciation:

$$\lambda^* = \frac{V(\pi) + \text{Cov}(\pi, s)}{V(\pi) + V(s) + 2\text{Cov}(\pi, s)} \quad (14)$$

⁷This follows from the assumption that country risk is uncorrelated with variations in the real exchange rate and inflation rate.

⁸The reader can easily verify that, if h_D is equal to zero, interest rate parity must hold for any equilibrium allocation in which depositors hold assets in both currencies.

B. Borrowers' Portfolio Choice

In most developing and transition economies there appears to exist an asymmetry of access to foreign capital markets between deposits and loans. Thus, all cross-border loans (CBL) are assumed to be intermediated by the local banking system. As borrowers only have access to local loans, in dollars (FCL) or home currency (HCL), there is incomplete arbitrage between local and foreign rates in the dollar loan market. Hence, local dollar loan rates can be above comparable foreign rates adjusted for country risk.

Denote λ_L as the dollar share of the loan portfolio. The borrower's portfolio preferences are similar to the depositor's, with the sign of the expected return terms inverted, reflecting the fact that this is a loan portfolio, rather than an asset portfolio:

$$U_L = -E(r_L) - c_L V(r_L)/2 \quad (15)$$

where r_L is the average cost of the loan portfolio. The dollar share of the borrower's optimal portfolio has the same form as in the case of the depositor—although with an inverted sign—and the same MVP:

$$\lambda_L = \lambda^* + \delta_L^I / h_L \quad (16)$$

where δ_L^I is the loan rate differential:

$$\delta_L^I = E(r_L^H - r_L^F)$$

and:

$$h_L = c_L V(r_L^H - r_L^F) \quad (18)$$

The representative borrower uses the funds to invest in a project that produces $Q(L)$, [$Q' > 0$, $Q'' < 0$] of a good that sells at $P = 1$, where L is the amount borrowed.⁹ Hence, the return on the project is riskless and the borrower borrows up to the point where the marginal return equals the risk-adjusted cost of borrowing, $Q'(L) = -U_L$. Hence, the loan demand function is such that:

$$L = L[E(r_L) + c_L V(r_L)/2], \quad L' < 0 \quad (19)$$

The demand for borrowing declines with an increase in the average real borrowing cost or its variance.

⁹This implies that the share of dollar-priced goods in the producer price index is the same as in the consumer price index.

C. Financial Equilibrium

In the absence of differential taxes on financial intermediation, the internal interest rate differentials on deposits and loans should be the same. In this case, equations (4) and (16) readily imply that deposit and loan dollarization ratios should always be on opposite sides of MVP, if not at MVP. For example, starting from MVP, an increase in the domestic interest rate differential in favor of home currency should increase the attractiveness of home currency deposits and lower that of home currency loans, thereby reducing deposit dollarization below MVP and raising loan dollarization above MVP. But suppose, in addition, that the economy is closed to capital flows and that there is no public domestic debt (nor bank reserves at the central bank). In this case, all bank deposits should necessarily have bank loans as a counterpart. Hence, depositors' and borrowers' portfolios should be identical. If banks maintain balanced open foreign exchange positions, it is then obvious that MVP is the only possible financial equilibrium. Thus, deviations from MVP can only occur if the supply and demand of loanable funds do not coincide or in the presence of differential taxation of financial intermediation in each currency.

This can be formalized as follows. For simplicity, assume that all commercial bank assets on government are held in the form of domestic and foreign currency reserves at the central bank, R^H and R^F .¹⁰ In addition, assume that banks can borrow abroad and define X as their net (dollar) foreign indebtedness. If banks maintain balanced foreign exchange positions, the home currency and foreign currency components of their balance sheet may be written:

$$D^H = L^H + R^H \quad (20)$$

$$D^F + X = L^F + R^F \quad (21)$$

Defining D , L , and R as total deposits (including CBD), total loans and total reserves, respectively, equation (20) may be expressed, defining λ_R as the foreign currency share of bank reserves, as:

$$(1 - \lambda_D)D = (1 - \lambda_L)L + (1 - \lambda_R)R \quad (22)$$

which indicates that the dollarization of deposits is obtained as a weighted average of that of loans and reserves.

When the rate of remuneration of bank reserves is below market levels (as in the case of unremunerated reserve requirements), lending rates deviate from deposit rates and the domestic interest rate differential on the asset side of a bank's balance sheet may differ from

¹⁰The reserves may be required or free, remunerated or unremunerated. Moreover, nothing of substance would be altered in the model if the reserves were in the form of marketable central bank or treasury securities.

that on the deposit side. Let ρ^H and ρ^F be the ratios of bank reserves to bank loans in home and foreign currency ($\rho^H = R^H/L^H$, $\rho^F = R^F/L^F$) and ϵ^H and ϵ^F the shares of reserves that are not remunerated. If banks are competitive with zero intermediation costs, intermediation spreads may be expressed as:

$$E(r_L^H - r_D^H) = \rho^H \epsilon^H E(r_D^H) = t^H \quad (23)$$

$$E(r_L^F - r_D^F) = \rho^F \epsilon^F E(r_L^F) = t^F \quad (24)$$

where t^H and t^F are the implicit tax rates on home and foreign currency intermediation that derive from unremunerated reserve requirements. With equations (4) and (16):

$$h_D (\lambda_D - \lambda^*) + h_L (\lambda_L - \lambda^*) = \delta_L^I - \delta_D^I \quad (25)$$

or, with equations (23) and (24):

$$h_D (\lambda_D - \lambda^*) + h_L (\lambda_L - \lambda^*) + \tilde{\tau} = 0 \quad (26)$$

where $\tilde{\tau}$ is a differential tax wedge defined as:

$$\tilde{\tau} = t^F - t^H \quad (27)$$

If D^C represents cross-border deposits, using equations (22) and (26), the model can then be solved for the dollarization shares:

$$\lambda_D - \lambda^* = (h_L / h) [(1 - \lambda^*) (D^C - X) / L + (\lambda_R - \lambda^*) R / L] - \tilde{\tau} / h \quad (28)$$

$$\lambda_L - \lambda^* = - (h_D / h) [(1 - \lambda^*) (D^C - X) / L + (\lambda_R - \lambda^*) R / L] - (D / L) \tilde{\tau} / h \quad (29)$$

with:
$$h = (Lh_D + Dh_L) / L \quad (30)$$

These expressions indicate that the equilibrium portfolios deviate from MVP in the presence of wedges that introduce asymmetries between depositors' and borrowers' portfolios. These include: (i) a net external wedge, when cross-border deposits are not matched one-for-one by external loans ($D^C - X \neq 0$); (ii) a public debt wedge, when the currency composition of bank reserves (or assets on government) deviates from MVP ($\lambda_R - \lambda^* \neq 0$); and (iii) a tax wedge on financial intermediation, when financial intermediation in domestic currency and foreign currency are not taxed at the same rates ($\tilde{\tau} \neq 0$).

In the absence of such wedges, the symmetry between depositors' and borrowers' hedging opportunities leads to financial equilibria in which all portfolios follow MVP and interest rate parity holds. We denote the resulting dollarization ratio as "underlying dollarization." Note

that in such equilibria, an increase in devaluation expectations does not, by itself, induce more dollarization. Unless agents are led to revise their expectations of inflation and exchange rate volatility, an increase in devaluation expectations should only be reflected in an increase of the internal interest rate differential.

The introduction of an external wedge or a public debt wedge causes dollarization to deviate symmetrically from underlying dollarization on either side of a bank's balance sheet. If deposit dollarization exceeds (falls short of) MVP, that of loans must be below (above) MVP. If deposit dollarization falls, loan dollarization increases.¹¹ When a tax wedge is introduced, the deposit and loan internal interest rate differentials deviate from each other and move in opposite directions. Thus, a positive tax wedge (i.e., in favor of home currency intermediation) reduces dollarization on both sides of a bank's balance sheet.

Finally, notice that dollarization can be altered in this model in two ways: (i) through measures that have an impact on macroeconomic uncertainty, hence that affect underlying dollarization; and (ii) through measures that have an impact on the domestic interest rate differentials, hence that deviate dollarization from MVP allocations. Each of these two possibilities will be considered in turn.

III. UNDERLYING DOLLARIZATION

In this section the properties and policy implications of MVP equilibria are explored. The relevance of MVP as a benchmark to estimate a country's potential for dollarization is backed by empirical estimates presented in Section III. 2 which show that MVP explains the bulk of observed deposit dollarization.

A. Policy Implications

It can readily be checked from equation (14) that λ^* increases with inflation volatility, decreases with the volatility of real exchange rate depreciation and, when the former is higher than the latter, decreases with the correlation between the two rates (see Appendix I. B).¹²

¹¹Notice that λ_D and λ_L are affected in proportion to h_D and h_L , respectively. Thus, if borrowers are less risk averse than depositors, which would be the case if borrowers can hedge against foreign exchange risk better than depositors, loans are closer substitutes across currencies than deposits, and a change in the external or public debt wedges should have a larger impact on the currency composition of loans, than deposits. Moreover, if the difference in risk aversion is substantial, h_L / h should be small. In this cases, the deposit portfolio should closely approximate MVP in the absence of a tax wedge.

¹²A decline in the correlation between inflation and the real exchange rate implies an increase in the correlation of asset returns, which reduces the scope for hedging. Hence, it favors
(continued...)

Thus, stable inflation and a fluctuating real exchange rate should be associated with low dollarization. In particular, the combination of inflation targeting (to the extent it reduces inflation volatility) with a floating exchange rate (to the extent it increases real exchange rate volatility) should foster the use of local currency and discourage that of foreign currency, since it reduces the risk associated with the former and increases that associated with the latter. Instead, a stabilization policy that reduces inflation volatility, through lowering inflation, may not succeed in reducing dollarization if it is accompanied by a stable real exchange rate. This would be the case, in particular, if the authorities target the real exchange rate (for example, through a crawling peg policy) rather than the inflation rate.

The model can, in principle, be applied to the case of a pegged exchange rate peg with imperfect credibility, that is in the case of a peso problem such that the exchange rate is expected to collapse with a positive probability.¹³ However, the expected volatility of the rate of depreciation can no longer be inferred, in this case, from backward-looking exchange rate data during the period of the peg. On the other hand, with a fully credible peg, λ^* becomes indeterminate, as $V(s) = V(\pi) = -Cov(\pi, s)$. In this case, agents become indifferent in terms of portfolio choice between the home currency and the foreign currency, and dollarization needs to be explained through other factors.¹⁴

While a full discussion of the factors underlying real sector dollarization (i.e., the prevalence of dollar pricing in price and wage contracts) falls largely outside the scope of this paper,

¹²(...continued)

dollarization when inflation volatility is higher than real exchange rate volatility, as it reduces the attractiveness of domestic currency assets as hedging instruments against real exchange rate changes.

¹³Lingering differentials between local currency and foreign currency interest rates in countries such as Argentina and Estonia suggest that even currency board arrangements lack full credibility.

¹⁴Currency substitution may provide, in such cases, an alternative explanation for asset substitution, as funds invested in term deposits or other financial instruments will eventually be spent. Hence, to limit the need for currency conversion, agents may allocate the currency of denomination of their investments in accordance with spending shares.

linkages between real sector dollarization and financial sector dollarization (i.e., the extent of deposit and loan dollarization) can be usefully illustrated with a simple extension of the model.¹⁵ Suppose that inflation and the rate of change of the nominal exchange rate evolve according to:

$$\pi = \alpha e + (1 - \alpha)\epsilon \quad (31)$$

$$s = e - \pi = (1 - \alpha)(e - \epsilon) \quad (32)$$

where ϵ represents real or monetary-induced price shocks to the domestic component of the consumption basket and α represents the pass-through from the exchange rate to the price level (alternatively, the dollar good component of the domestic consumption basket). A high pass-through could result from an open economy (i.e., a large tradable sector) or from dollar pricing for non tradable goods.¹⁶ It can easily be shown (see Appendix I) that λ^* can then be expressed as:

$$\lambda^* = \alpha + (1 - \alpha)\rho_{e\epsilon}S_\epsilon/S_e \quad (33)$$

where S_ϵ and S_e are the standard deviations of the distributions of the price and exchange rate shocks and $\rho_{e\epsilon}$ is the correlation coefficient of these distributions. Thus, real and financial dollarization should generally be highly correlated.¹⁷

When ϵ is orthogonal to e ($\rho_{e\epsilon} = 0$), as would be the case when changes in the exchange rate are caused by purely exogenous shocks which are unrelated to the price shocks, real and

¹⁵Notice that the factors underlying the choice of currency in the pricing of contracts are likely to be similar to those underlying asset substitution. Moreover, currency substitution should promote dollar pricing, as it limits the scope for anchoring the price level through monetary policy. Such linkages between real and financial dollarization suggest that multiple equilibria could exist in which the choice of currency and the extent of dollarization become indeterminate. In the context of currency substitution, see the related discussion in Kareken and Wallace (1981) and the counter arguments presented by Giovannini and Turtelboom (1994).

¹⁶For simplicity, foreign inflation price shocks are ignored.

¹⁷As α increases, the volatility of changes in the real exchange rate declines and dollar assets become increasingly attractive. When $\alpha=1$, the real exchange rate is constant and dollar assets are risk-free.

financial dollarization should be the same.¹⁸ In such cases, by choosing portfolios in accordance with their consumption basket, agents eliminate the variance contributed by the dollar component of the domestic price index.¹⁹

More generally, price and exchange rate shocks are likely to be positively correlated ($\rho_{e,e} > 0$) when they are caused by common factors (for example, monetary shocks), or when a crawling peg policy is followed. In such cases, financial sector dollarization should exceed real sector dollarization. Inversely, when the authorities target inflation and use monetary policy to stabilize prices, the nominal exchange rate would be expected to appreciate following a price shock. In this case, $\rho_{e,e} < 0$ and financial dollarization should be below real sector dollarization.

The linkage between real and financial dollarization raises an important caveat to the finding that dollarization may be reduced by increasing the flexibility of the exchange rate regime. Indeed, in a highly dollarized economy with a floating exchange rate, the high elasticity and instability of money demand should result in a high volatility of the nominal exchange rate.²⁰ However, in an economy with extensive asset substitution, the linkage between real and financial dollarization that underlies equation (33) would suggest that α must also be high. Hence, the scope for affecting λ^* —which is proportional to $(1 - \alpha)\rho_{e,e}$ —may be limited, even when $\rho_{e,e}$ is significantly different from zero. Moreover, as α increases, nominal exchange rate volatility should increasingly translate into inflation volatility, rather than real exchange rate volatility. Hence, in terms of inflation variability, the welfare cost of reducing dollarization through the adoption of a flexible exchange rate regime may be large in highly dollarized economies, while the benefits, in terms of reduced dollarization, are likely to be small.

The correlation between real and financial dollarization also suggests that trade liberalization and international economic integration should promote financial dollarization over time as they are likely to result in rising α 's. In this context, financial dollarization should be viewed, at least in part, as a normal consequence of trade and financial integration. Hence, limiting it could be ill-advised.

¹⁸This could be the case, for example, of a pegged exchange rate with exogenous probabilities of collapse.

¹⁹Indeed, using equations (11)–(13) and equations (31)–(32), it is easy to check that MVP eliminates foreign exchange risk, since the average real portfolio return can be written in this case: $r = \alpha R^F + (1 - \alpha) R^H - (1 - \alpha)e$, which is independent of e .

²⁰This factor has been used to argue in favor of a pegged system when currency substitution is extensive. See Girton and Roper (1981) and Giovannini and Turtelboom (1994).

B. Empirical Estimates of Underlying Dollarization

The empirical evidence suggests that actual dollarization ratios can be largely explained in terms of underlying dollarization levels. Figure 3 compares actual dollarization with underlying dollarization for the sample countries. Actual dollarization is obtained as an average of total dollar deposits over total domestic and cross-border deposits for the period 1990–1996. Underlying dollarization is derived from the expression of λ^* in equation (14). In the absence of forward-looking data on inflation and real exchange rate expectations, the variance and covariance of these variables is obtained from quarterly observed data over the period 1980–1996, or for the longest period for which meaningful data exists.²¹ The fit is generally satisfactory, with some of the largest differences between estimated and actual ratios attributable to clearly identifiable country-specific characteristics.

For example, Uruguay has been for a long time an important offshore center for the region, and thus would be expected to show a higher level of deposit dollarization; the same is true for the United Kingdom. In the case of Pakistan, a number of policy measures, including the tax regime and forward foreign exchange cover provided by the central bank have favored foreign currency-denominated assets. In the case of Mexico, for which MVP overestimates actual dollarization, regulation limits domestic foreign currency deposits to less than 15 percent of total domestic deposits. In addition, dollar indexation of alternative assets (e.g., Tesobonos) was important until 1995, while derivative contracts to hedge against foreign exchange risk became a significant factor from 1995 onwards. In either case, bank deposit dollarization would be expected to understate total demand for dollar hedging instruments. Moreover, cross-border lending has increased very substantially during the 1990s thereby resulting in negative net external assets, which should also contribute to reducing dollarization.

The relevance of MVP as a key explanatory factor of dollarization is confirmed by estimating a regression of actual dollarization on underlying dollarization (Table 1). The table also shows how the explanatory power of the rate of inflation, significant when taken alone, disappears when underlying dollarization is included as a regressor.²² The relevance of net external assets (external wedge) in explaining deviations from MVP is confirmed by including them as an

²¹For some countries, data on cross border deposits held by residents were not available.

²²Average inflation is computed using quarterly data for the sample period used to compute underlying dollarization.

FIGURE 3

UNDERLYING DOLLARIZATION AND ACTUAL DOLLARIZATION RATIOS

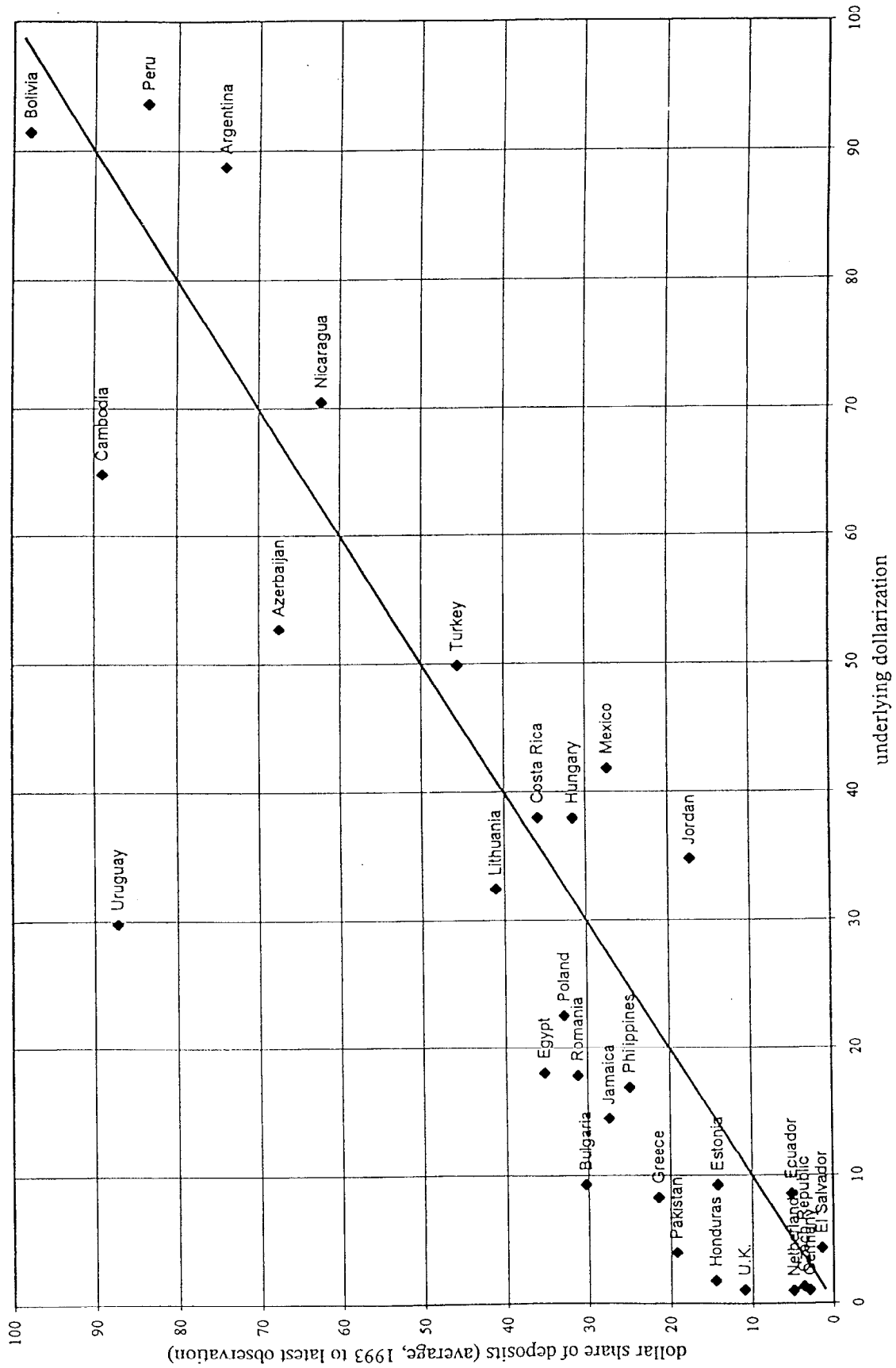


Table 1. Underlying Dollarization and Inflation

Model	Underlying dollarization	Average inflation	Net foreign assets (avg.)	R ² (adjusted)
(1)	0.8569** (0.0945)			0.7438
(2)		0.0832** (0.0180)		0.4302
(3)	0.9633 (0.1747)	-0.0135 (0.0214)		0.7324
(4)	0.8347** (0.0919)		0.2009* (0.0944)	0.7631
(5) Panel	0.6473** (0.0564)		0.2488** (0.0554)	0.5003

Number of observations: 29 in models (1)–(4), 146 in model (5). Standard errors in parentheses.
* and ** indicate significance at 5 and 1 percent, respectively.

Underlying dollarization and average inflation computed from quarterly CPI and exchange rate data for the period 1980 to 1996, or the longest period for which there is available data. The same sample period was used for both series. Actual dollarization computed from quarterly data, averaged for the period 1990–1996. Net foreign assets ratio computed from annual data as the ratio between commercial bank net foreign assets plus CBD minus CBL, over the total stock of loans (inclusive of CBL), averaged for the period 1990–1995.

additional explanatory variable.²³ Equation (4) is a single period cross-country estimate while equation (5) uses panel data. In both cases, the net external assets term has the correct sign and significant, with the level of significance increasing in the panel data regression.²⁴

²³Net external assets are computed as net external assets of the banking system plus CBD minus CBL (IFS data).

²⁴A similar analysis could not be conducted for the public debt wedge or the tax wedge, due to lack of systematic data on the currency composition of domestic public debt and regulations on reserve requirements.

MVP ratios become more volatile as the period during which they are estimated shortens, and deviations between MVP predictions and actual dollarization tend to increase, suggesting that expectations are formed over long time periods. Nevertheless, results for shorter time periods are still illustrative. Table 2 shows a comparison between underlying and actual dollarization levels for a subsample of countries for which pre- and post-stabilization periods could be clearly identified. With the exception of Mexico and Poland, underlying dollarization displays a behavior over the two periods that closely resembles that of actual dollarization. The sign of the change is in all cases correct.

Bolivia is particularly interesting because it is the only country for which MVP increases after stabilization. This is due to the fact that the decline in inflation volatility was offset by a simultaneous decline in real exchange rate volatility, as the authorities have followed a de-facto crawling peg policy that corrected for most past inflation (Figure 4). In the case of Peru, MVP also remained high after stabilization, due to the fact that the decline of inflation volatility in the post-stabilization period was more gradual than that of the real exchange rate. This explanation of the resilience of dollarization in both countries contrasts with that generally offered in the literature.

It is also interesting to test the model's predictions for countries that have developed alternative instruments to limit foreign macroeconomic risk, particularly price indexed or interest rate indexed instruments.²⁵ As long as indices can be found that follow purchasing power closely, such instruments should dominate dollar-indexed instruments as they eliminate most macroeconomic risk. Table 3 compares underlying dollarization with actual dollarization and with the use of alternative indexing instruments for countries in which price or interest rate indexation have been broadly used, such as Chile, Israel and Brazil.²⁶ As expected, underlying dollarization largely exceeds actual dollarization. At the same time, alternative hedging

²⁵Notice that the development of alternative hedging instruments, such as foreign exchange derivatives, and, more generally, the deepening of financial markets, including stocks, corporate bonds and mutual fund shares, that allow for alternative ways to hedge against foreign exchange risk, should also contribute to lessen the demand for dollar indexation. Indeed, the same risk exposure can be achieved with local currency intermediation, coupled with a foreign exchange futures market, as with bi-currency financial intermediation.

²⁶In Brazil, both price indexation and interest rate indexation have been broadly used. In particular, the indexation of deposits to the overnight interest rate protected the purchasing power of HCD throughout the turbulent period of the 1980's. In Chile, indexation has been facilitated by the introduction in 1967 of a unit of account, the UF, that is published by the central bank daily on the basis of the consumer price index. In Israel, a broad menu of indexed assets has been available to the public, including CPI-indexed assets, dollar-indexed assets (PATZAM), and dollar deposits (PATAM). However, the use of CPI-indexed assets has been mainly restricted to long-term time deposits and saving deposits.

Table 2. Dollarization Trends
(in percent)

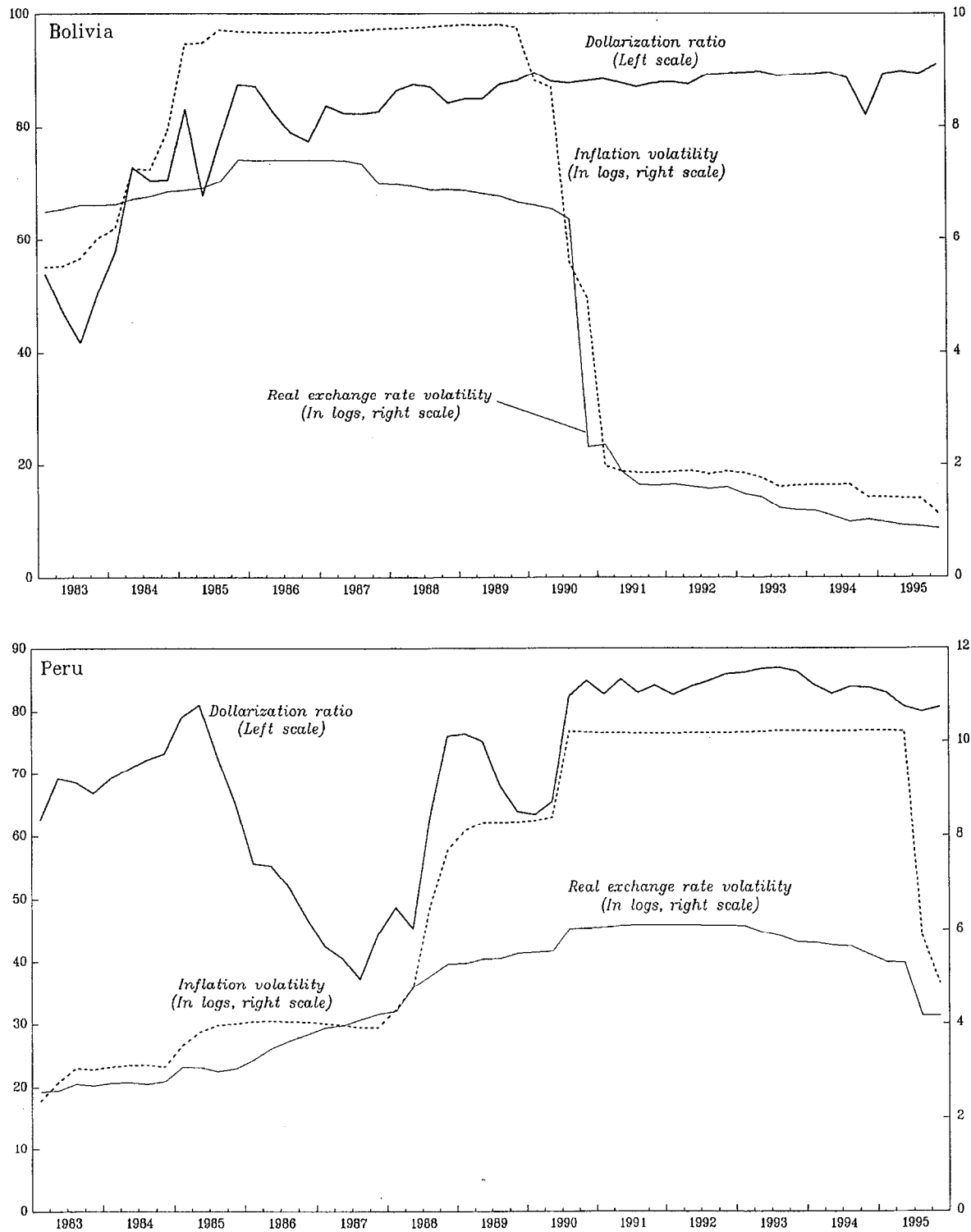
Country	Period	Underlying dollarization	Period average 1/
Bolivia	1980:I - 1989:IV	91.31	92.90
	1990:I - 1996:IV	91.97	97.90
Hungary	1980:I - 1991:IV	32.30	27.98
	1992:I - 1996:IV	44.13	36.89
Mexico	1980:I - 1988:IV	46.27	46.85
	1989:I - 1996:IV	10.29	32.10
Peru	1980:I - 1990:IV	93.31	84.79
	1991:I - 1996:IV	82.02	80.48
Poland	1980:I - 1990:IV	76.03	39.43
	1991:I - 1996:IV	22.52	24.09

1/ Actual ratio at the end of the period.

instruments are widely developed, which suggests that such instruments have been effective substitutes for dollarization.²⁷

²⁷Notice that price-indexed instruments should generally more than compensate for the missing dollar instruments, since they provide a superior alternative to limit macroeconomic risk. Indeed, abstracting from lags and other measurement problems, price indexed assets are free of inflation or currency risk.

FIGURE 4
ASSET RETURN VOLATILITY AND DOLLARIZATION
(In percent)



Source: IMF, International Financial Statistics.

Table 3. Deviations from MVP in the Presence of Indexation

	Period	MVP	Actual ¹
Chile	1975:1 – 1985:3	57.6	36.2
	1985:4 – 1996:3	32.0	14.2
Brazil ²	1980:1 – 1996:3	99.0	11.6
Israel	1980:1 – 1985:4	86.4	26.1
	1986:1 – 1996:4	10.4	18.2

1/ End of last year of corresponding period.

2/ CBD only. FCD are not allowed in Brazil

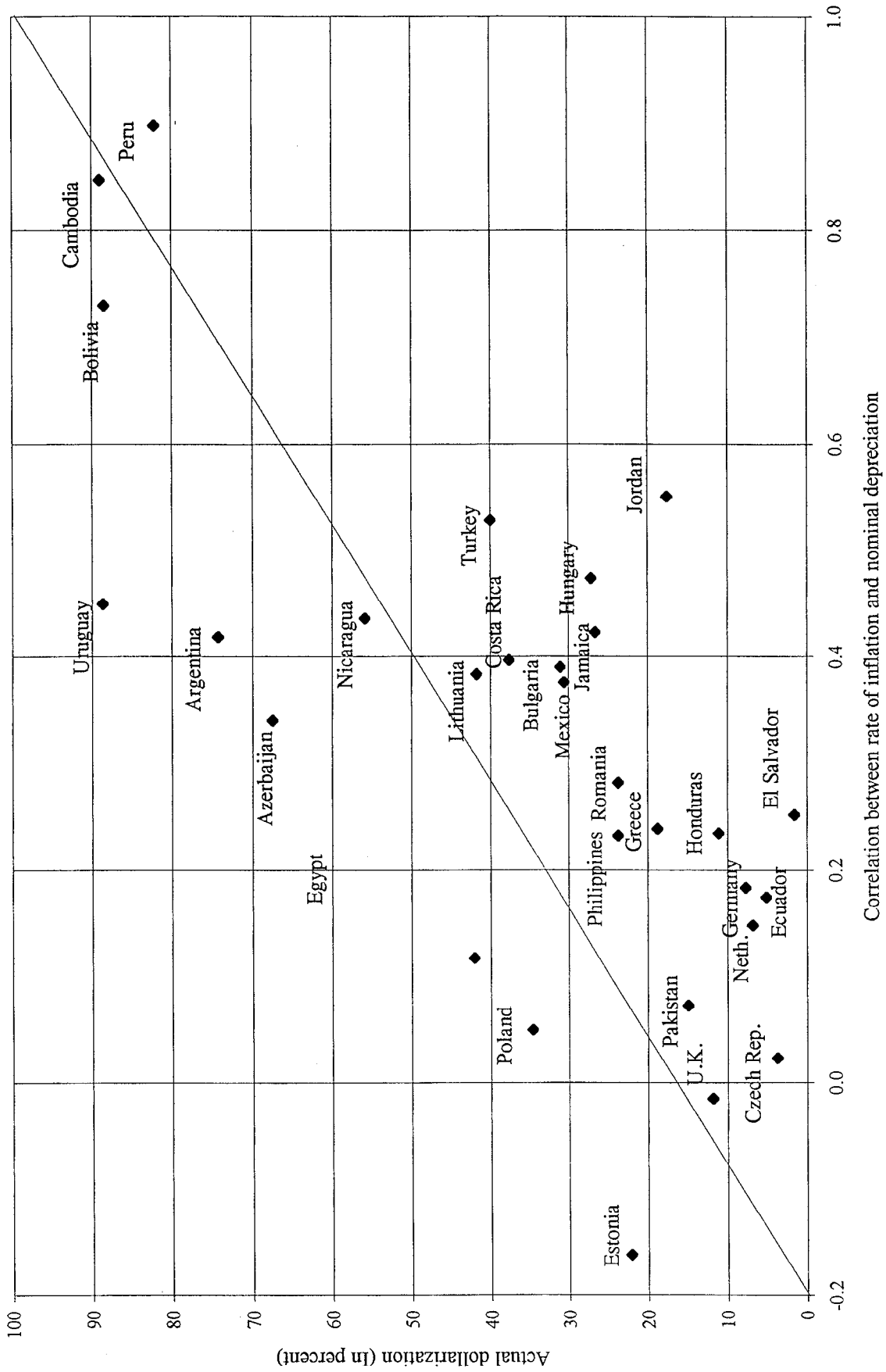
The linkage between real and financial sector dollarization can be explored by using the correlation between the quarterly rates of inflation and nominal currency depreciation as a proxy for the pass-through coefficient. This variable is plotted in Figure 5 together with actual financial sector dollarization levels.²⁸ The correlation between the two variables suggests that financial dollarization is likely to be substantially affected by real sector dollarization. Hence, the scope for altering financial dollarization needs to be assessed accordingly.

IV. DEVIATIONS FROM UNDERLYING DOLLARIZATION

This section explores the properties of the model for deviations from MVP. This analysis provides insights into the factors underlying changes in the internal and external interest rate

²⁸The same periods are used to calculate α and λ^* . Actual dollarization is computed as in Figure 3.

FIGURE 5:
REAL AND ACTUAL DOLLARIZATION



Sources: IMF, International Financial Statistics; and Central Bank bulletins (various issues).

differentials and the scope for using monetary policy to alter dollarization.²⁹ At the same time, the model can be used to analyze the implications for dollarization of removing or introducing regulatory limits, such as ones on deposits or interest rates. The response to liquidity shocks is determined by the interplay of the portfolio balance conditions expressed in (28) and (29), which determine the currency composition of deposits and loans as a function of the external wedge, the public debt wedge and the tax wedge, and the equilibrium condition in the market for loanable funds, which determines their location. The basic workings of the model in a fixed exchange rate setting are straightforward and can be easily described for changes in each of these wedges (the formal solution is presented in Appendix II).

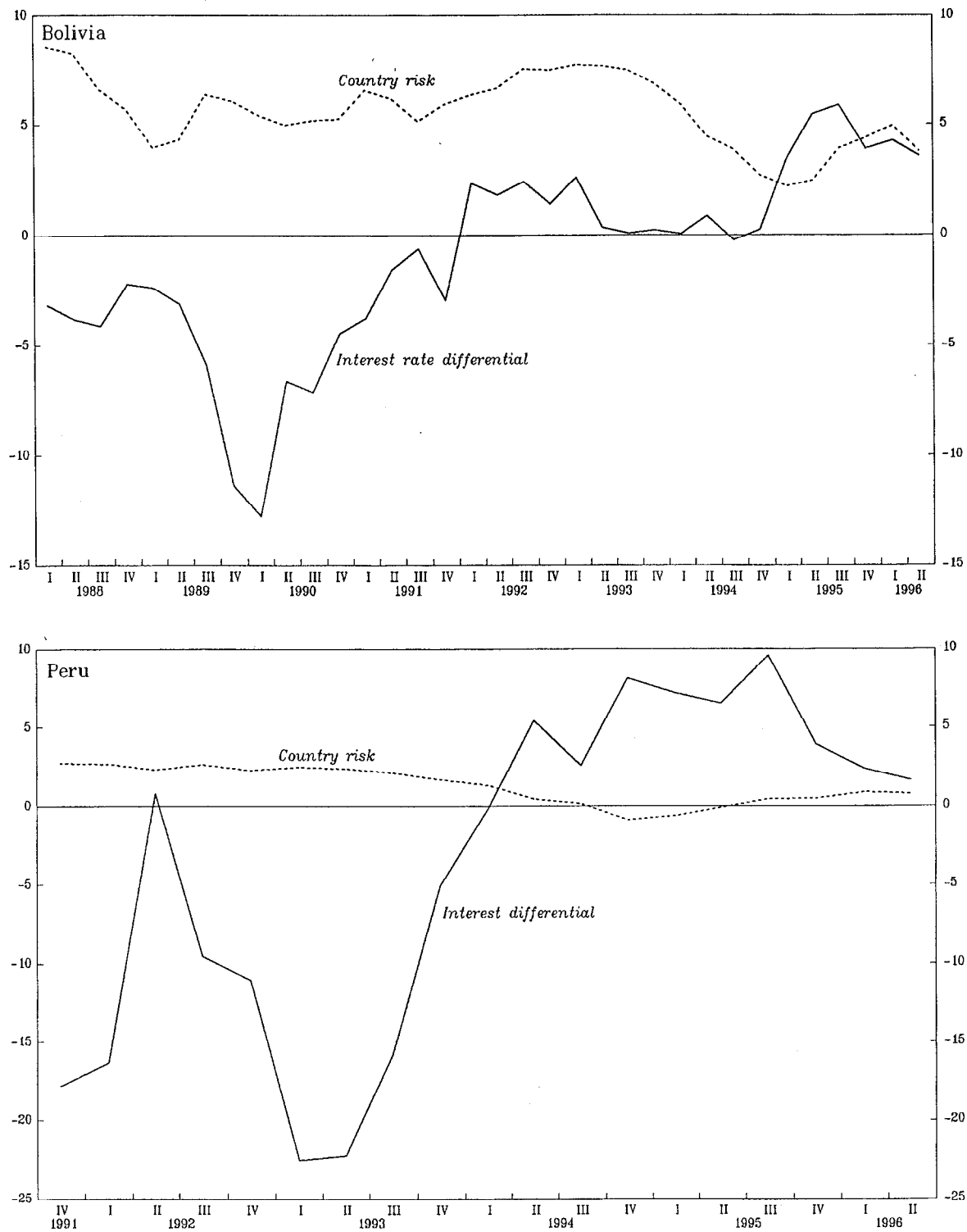
A. Capital Inflows

Consider first the impact of a change in the external wedge induced by a reduction in the cost of borrowing, because of, say, a decline in the world interest rate or the country risk premium (due to a fall in h_C). The resulting increase in loan demand stimulates capital inflows, raises the supply of dollar loanable funds, expands financial intermediation and tilts the internal interest rate differential in favor of the home currency, thereby raising the dollarization of loans and reducing that of deposits. A capital inflow due to an autonomous increase in foreign lending has a similar impact. Unless it fully crowds out local dollar deposits, thereby inducing a fully offsetting capital outflow, it increases the supply of dollar loanable funds and leads to a reduction in the local dollar interest rate which reduces deposit dollarization and increases loan dollarization. At the same time, it reduces borrowing costs, thereby stimulating loan demand and promoting financial intermediation.

Thus, periods of large capital inflows and rapid expansion of domestic financial intermediation, that result from improving confidence or increased access to world capital markets, should be accompanied by an increase in the domestic interest rate differential, a reduction in deposit dollarization and an increase in loan dollarization. These observations appear to be broadly corroborated by the recent experiences of Peru and Bolivia, following the consolidation of stabilization efforts. In both cases, the internal interest rate differential

²⁹Some countries may wish to limit dollarization on accounts of its potentially adverse prudential implications or to enhance the scope for monetary and foreign exchange rate policy independence, while other countries may wish to promote dollarization as a way to promote policy credibility. Although the paper does not address the welfare implications of dollarization, it is worth noticing that the variability of real borrowing costs is minimized when the currency composition of the lending portfolios equals MVP (see equation A-41 in Appendix II). Thus, because of its hedging benefits, dollarization has favorable prudential implications. However, this model ignores moral hazard. The distribution of real exchange rate disturbances, as perceived by firms, may be distorted if broad official support is expected to be forthcoming in the event of a catastrophic currency devaluation. In this case, firms would over borrow in dollars and measures to limit dollarization might be appropriate.

FIGURE 6
BOLIVIA AND PERU
INTEREST RATE DIFFERENTIAL AND COUNTRY RISK
(In percent)



Sources: International Financial Statistics; and Central Bank Bulletins (various issues).

Note: Interest rate differential measured as home currency deposit rates as a percentage of foreign currency deposit rates adjusted for the previous 12-month depreciation rate.

Country risk measured as foreign currency deposit rates as a percentage of 3-month LIBOR.

exhibited a clear upward trend while the external differential declined (Figure 6). At the same time, while deposit dollarization remained approximately constant during the same period, dollarization in the domestic financial system expanded sharply, which is likely to have resulted in a strong expansion of loan dollarization (Figure 7).

B. Monetary Policy

Monetary policy affects dollarization through the debt wedge. Consider first the case of a shift in the currency composition of the central bank's liabilities in favor of the home currency (i.e., a decline in λ_R) that leaves the monetary stance unaffected (i.e., the ρ 's remain unchanged). This can be obtained by: (i) issuing home currency denominated central bank securities and using the proceeds to retire from circulation an equal amount of foreign currency denominated securities;³⁰ (ii) raising reserve requirements on HCD and reducing reserve requirements on FCD (when reserve requirements are denominated in the same currency as the deposits to which they apply); or (iii) in the absence of a tax wedge, shifting the currency of denomination of reserve requirements on FCD from the foreign currency to the home currency.³¹

The injection of dollars and withdrawal of home currency liquidity tilt the internal interest rate differential in favor of the home currency, thereby stimulating loan dollarization and reducing deposit dollarization. In addition, an injection of dollars crowds out local dollar deposits and leads to a capital outflow. Thus, while deposit dollarization can be reduced through a debt swap that injects home currency public debt and withdraws foreign currency debt, this comes at the cost of an increase in loan dollarization. Moreover, using equations (20)–(22), note that the dollar share of deposits may be expressed as:

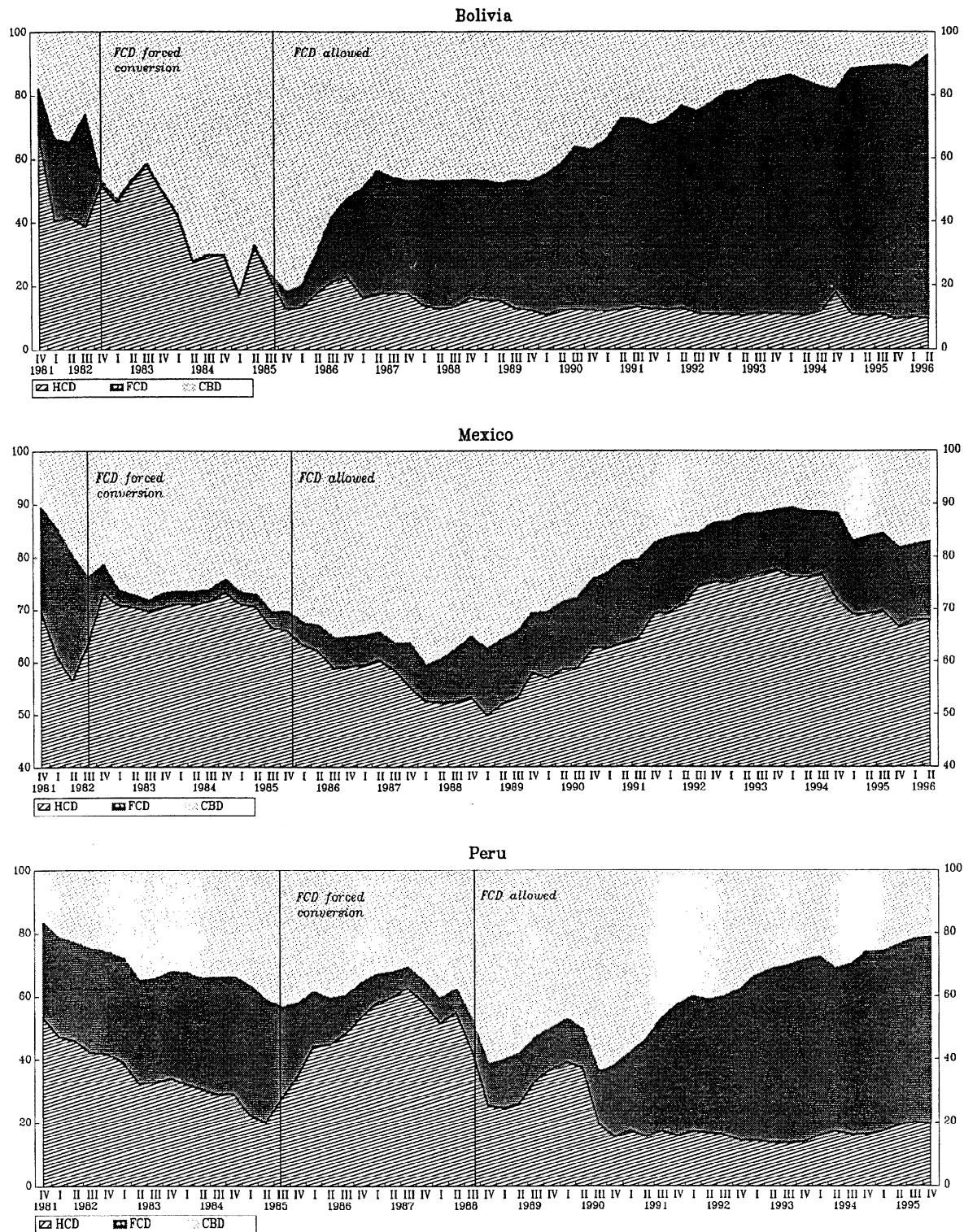
$$\lambda_D - \lambda^* = (L/D) (\lambda_L - \lambda^*) + (R/D) (\lambda_R - \lambda^*) + (1 - \lambda^*) (D^C - X)/D \quad (34)$$

From this expression, it can readily be inferred that the impact on λ_D of the decline in λ_R is partly offset by the increase in λ_L and by the capital outflow. In addition, it is proportional to

³⁰While banks' assets with the central bank were defined in the model as reserves, nothing of substance changes if these are defined as marketable central bank securities.

³¹In the presence of a tax wedge, changes in the currency of denomination of reserve requirements would generally affect the tax wedge. Notice also that a change in the currency composition of the government's debt held by the public should have similar effects to that of a change in the currency composition of the central bank's liabilities.

FIGURE 7
BOLIVIA, MEXICO, AND PERU
SHARE OF DEPOSITS, 1981-1996
(In percent)



Sources: International Financial Statistics; and Central Bank Bulletins (various issues).

Note: Share of cross border deposits (CBD), foreign currency deposits (FCD), and local currency deposits (LCD) over their total. Although in Mexico and Peru FCD were allowed once again in December 1985 and September 1988, respectively, exchange and capital controls were only removed in December 1987 in Mexico and August 1990 in Peru.

R/D, which is likely to be small for most countries, even after including all domestic government debt. At the same time, the interest cost of public debt should increase as its composition deviates from MVP. Thus, attempts to reduce deposit dollarization through increasing the domestic currency share of public debt in excess of MVP are likely to have large fiscal costs and questionable benefits.³²

Consider next the polar opposite case of a tightening of the monetary stance that is currency-neutral (i.e., an increase in fully remunerated reserve requirements that does not alter the currency composition of public debt at MVP). The contraction in the supply of loanable funds leads to a capital inflow which raises the internal interest rate differential. The result is that deposit dollarization falls while loan dollarization rises. At the same time, the average lending rate rises and financial intermediation contracts. Thus, a tightening of monetary policy is unlikely to be an appropriate policy to reduce dollarization on a sustainable basis because of its fiscal and real impacts, as well as its impact on the currency composition of lending. Moreover, a sterilization policy that aims at limiting the macroeconomic impact of capital inflows can have severe adverse prudential implications as it encourages firms to borrow in dollars. This appears to have been an important component of the recent financial crisis in several Asian countries.

C. Taxation and Regulatory Policies

Consider finally the impact of changes in taxation. An increase in the average tax rate that leaves the tax wedge constant only affects the cost of borrowing. Hence, its impact on dollarization is similar to that of increases in country risk or the world interest rate. By contracting the supply of local dollars, such an increase tilts the internal interest rate differential against the local currency and encourages deposit dollarization.

Consider next the polar opposite case of an increase in the tax wedge in favor of the home currency that leaves the average tax rate unchanged. The resulting increase in the intermediation spread in foreign currency, relative to the intermediation spread in local currency, raises the dollar lending rate, relative to the home currency lending rate, and depresses the dollar deposit rate, relative to the home currency deposit rate. As a result, dollarization declines on both sides of a bank's balance sheet. At the same time, the fall in the

³²It should also be stressed that measures that are sometimes advocated for reducing the dollarization of deposits, such as raising reserve requirements on FCD and reducing reserve requirements on HCD have perverse effects if reserve requirements are fully remunerated. In this case, the injection of local currency liquidity would affect the internal interest rate differential against the home currency, thereby promoting deposit dollarization.

local dollar deposit rate leads to capital outflows, thereby reducing the supply of loanable funds and raising the average borrowing rate. Hence, while a tax wedge may be effective to reduce dollarization, it causes capital flight, raises lending rates, and depresses financial intermediation.³³

The cost-effectiveness of tax-based measures can be assessed by contrasting their impact on dollarization and borrowing costs. Appendix II shows that the impact on dollarization increases after the macroeconomic environment has stabilized and the demand for dollar hedging weakened. At the same time, however, the impact on borrowing costs is smaller when dollarization is higher. Combining both effects in an effectiveness ratio leads to the conclusion that tax measures are more likely to be cost-effective in the context of stable macroeconomic conditions and high dollarization.³⁴

The intuition from this model can be used to discuss the impact of regulatory ceilings on interest rates or quantitative limits on FCD or FCL. Consider, in particular, the removal of a ceiling on home currency deposit rates. The impact should be similar to that of the removal of a tax wedge against home currency intermediation.³⁵ Dollarization should decline on both sides of a bank's balance sheet while financial intermediation should increase.³⁶ An outright prohibition on FCD or FCL, on the other hand, should reduce dollarization but at the cost of provoking capital flight and financial disintermediation.³⁷ Figure 7 illustrates the point for the cases of the forced conversions of FCD into HCD that occurred in Mexico (1982), Bolivia

³³At the same time, it is important to notice that the widening of the dollar intermediation spread can only occur as long as borrowers' direct access to CBL continues to be restricted. Direct access to foreign loans would allow dollar lending rates to decline and CBD to be recycled as CBL. Indeed, in the extreme case of complete access to foreign loans, the increase in the tax wedge would only shift dollar intermediation from local banks to foreign banks, with no impact on dollarization.

³⁴This is precisely the case of countries such as Bolivia where, although inflation volatility has declined sharply, it continues to be higher than real exchange rate volatility.

³⁵The only difference between a regulatory ceiling on deposit rates and unremunerated reserve requirements is that banks, rather than the central bank, appropriate the benefits of the higher intermediation margin.

³⁶The experience of Egypt in the late 1980s provides a particularly illustrative example. As both the deposit rate and the loan rate differentials shifted in favor of the home currency, both dollar deposits and dollar loans declined rapidly.

³⁷Total lending can only remain unaltered after the prohibition if all FCD are shifted into HCD. However, this involves a reduction of dollarization. Hence, the home currency interest rate must rise to allow the internal interest rate differential to shift in favor of the home currency. As a result, the cost of credit must rise, and total lending fall.

(1982), and Peru (1985). The short-term effect of the conversion reversed over time as agents substituted foreign deposits for domestic dollar deposits. As a result, financial intermediation declined abruptly, as shown in Figure 8 in the case of Bolivia and Peru.³⁸ Recent years have witnessed the opposite effect, as prohibitions were lifted and confidence started to build up.³⁹

V. CONCLUSIONS

This paper presented a portfolio model of dollarization in which agents hedge against macroeconomic risk on both sides of a bank's balance sheet. Due to the symmetry of portfolio decisions, this interaction led to MVP portfolio allocations in the absence of external, public debt or tax wedges. Hence, MVP provided an important benchmark to relate financial dollarization to macroeconomic policies and estimated the scope for dollarization quantitatively. A novel explanation for dollarization hysteresis was offered, based on the relative variabilities of inflation and the real exchange rate.

The policy implications are, in principle, clear. Countries that seek to limit asset substitution should target inflation rather than the real exchange rate. In practice, however, the scope for using exchange rate policy as an instrument to reduce dollarization may be limited in heavily dollarized economies, because of a possible inconsistency between increasing real exchange rate volatility and limiting inflation volatility. Tax-based policies, which may be relatively effective in a context of macroeconomic stability and high dollarization due to limited real exchange rate volatility, have, in general, substantial costs in terms of capital flight and financial disintermediation. On the other hand, a tight monetary policy that attempts to reduce dollarization by tilting the domestic interest rate differential in favor of home deposits is bound to increase the dollarization of bank loans. Moreover, when the tightening of monetary policy takes place in response to capital inflows, the increase in the dollarization of bank loans is likely to be more substantial and, hence, should have more severe prudential implications.

The paper also showed that there are tight linkages between real and financial dollarization. Thus, attempts at slowing down financial dollarization can be particularly ill-advised when the latter reflects real sector developments, including globalization and trade liberalization. In those cases, the potential benefits of reducing dollarization should be compared with the welfare loss from limiting the scope for currency risk hedging.

³⁸The dramatic decline in bank intermediation in Peru suggests that CBD in Figure 6 may be significantly underestimated. For a more complete description of these events and their impact, see Savastano (1992).

³⁹The December 1994 crisis in Mexico represented a step backwards in this direction.

FIGURE 8
BANK INTERMEDIATION
(In percent of GDP)



Sources: International Financial Statistics; and Central Bank Bulletins (various issues).

Note: HCD and FCD as a percentage of nominal GDP.

The paper could be extended in a number of directions. In particular, the statistical analysis may be refined, for example by using GARCH methods, to derive more efficient estimates of inflation and depreciation volatilities. In addition, linkages between real sector and financial sector dollarization need to be explored further. The analysis in Section IV should be extended to deal with the case of a flexible exchange rate. Finally, further statistical work is needed to test the macroeconomic implications of our model and confirm its policy relevance.

DERIVATION OF THE CAPM MODEL

A. Depositors' Optimal Portfolio

Defining x_F , x_C , and x_H as the portfolio shares of FCD, CBD and HCD, respectively, the reader can readily check that, from (1)–(2), the first and second moments of the probability distribution of portfolio real returns can be expressed, after substituting $x_H = 1 - x_F - x_C$, as⁴⁰

$$E(r) = \mathbf{x}'\mathbf{w} + r_H \quad (\text{A.1})$$

and

$$V(r_D) = \mathbf{x}'\mathbf{B}\mathbf{x} + 2\mathbf{C}\mathbf{x} + V(r_H), \quad (\text{A.2})$$

where

$$\mathbf{x} = \begin{pmatrix} x_F \\ x_C \end{pmatrix},$$

$$\mathbf{w} = \begin{pmatrix} r_F - r_H \\ r_C - r_H \end{pmatrix}, \quad (\text{A.3})$$

$$\mathbf{B} = \begin{pmatrix} S_{FF} - 2S_{FH} + S_{HH} & S_{FC} - S_{FH} - S_{CH} + S_{HH} \\ S_{FC} - S_{FH} + S_{HH} & S_{CC} - 2S_{CH} + S_{HH} \end{pmatrix}$$

$$\mathbf{C} = \begin{pmatrix} S_{FH} - S_{HH} \\ S_{CH} - S_{HH} \end{pmatrix},$$

E is the expectations operator, and S_{ij} denotes the covariance of real returns to assets i and j . Assuming that depositors' preferences are represented by

⁴⁰We drop the superscript for notational simplicity.

$$U_D = E(r_D) - c_D V(r_D) / 2 \quad (\text{A.4})$$

with $c_D > 0$, the first order condition for a solution to the portfolio selection problem can be expressed as

$$-w/c_D + \mathbf{B}\mathbf{x} + \mathbf{C} = 0 \quad (\text{A.5})$$

from which one obtains the optimal portfolio shares

$$\mathbf{x} = \mathbf{B}^{-1} [-\mathbf{C} + (1/c_D) \mathbf{w}] = \lambda^* + (1/c_D) \mathbf{B}^{-1} \mathbf{w} \quad (\text{A.6})$$

where $\lambda^* = -\mathbf{B}^{-1}\mathbf{C}$, characterizes the currency composition of the minimum variance portfolio (MVP). It can be shown that, from (2),

$$(\text{A.7})$$

$$\mathbf{B}^{-1} = \frac{1}{|\mathbf{B}|} \begin{pmatrix} S_{ee} - 2S_e + S_{cc} + S_{cc} & -(S_{ee} - 2S_e + S_{cc}) \\ -(S_{ee} - 2S_e + S_{cc}) & S_{ee} - 2S_e + S_{cc} \end{pmatrix}$$

where

$$|\mathbf{B}| = S_{cc} (S_{ee} - 2S_{e\pi} + S_{\pi\pi}). \quad (\text{A.8})$$

It is easy to check that $(C_1 - C_2) = S_{FH} - S_{CH} = S_{cc}$, from which

$$\lambda^*_2 = (S_{FH} - S_{CH}) (S_{ee} - 2S_{e\pi} + S_{\pi\pi}) / [S_{cc} (S_{ee} - 2S_{e\pi} + S_{\pi\pi})] = 1 \quad (\text{A.9})$$

and

$$\lambda^*_1 = -1 + S_{cc} (S_{FH} - S_{HH}) / [S_{cc} (S_{ee} - 2S_{e\pi} + S_{\pi\pi})] \quad (\text{A.10})$$

In turn, from (A.6) and (A.7),

$$\lambda_D = x_F + x_C = \lambda^*_1 + \lambda^*_2 - (1/c_D |\mathbf{B}|) S_{cc} (r_H - r_F). \quad (\text{A.11})$$

or,

$$\lambda_D = \lambda^* - (1/c_D V) S_{cc} \delta_D^I \quad (\text{A.12})$$

where

$$\lambda^* = (S_{HH} - S_{FH}) / V \quad (\text{A.13})$$

and

$$V = V(r_H - r_F) = (S_{ss} - 2S_{s\pi} + S_{\pi\pi}). \quad (\text{A.14})$$

Moreover, from (A.7),

$$x_C = 1 + (1/c_D S_{cc}) [(r_H - r_F) + (r_C - r_H)], \quad (\text{A.15})$$

or

$$x_C = 1 + (1/c_D S_{cc}) \delta_D^X. \quad (\text{A.16})$$

B. Determinant Factors of Underlying Dollarization

From (9), we know that

$$\lambda^* = \frac{S_{\pi\pi} + \rho_{\pi,s} S_{\pi} S_s}{[S_{\pi\pi} + S_{ss} + 2\rho_{\pi,s} S_{\pi} S_s]} \quad (\text{A.17})$$

It is easy to check that, for $\lambda^* \in [0,1]$,⁴¹

$$S_{ss} + \rho_{\pi,s} S_{\pi} S_s > 0 \quad (\text{A.18})$$

and

$$S_{\pi\pi} + \rho_{\pi,s} S_{\pi} S_s > 0. \quad (\text{A.19})$$

Then, taking derivatives,

$$\partial\lambda^*/\partial S_s = -S_{\pi} [2S_s S_{\pi} + \rho_{\pi,s} (S_{\pi\pi} + S_{ss})] / (S_{\pi\pi} + S_{ss} + 2\rho_{\pi,s} S_{\pi} S_s)^2 < 0, \quad (\text{A.20})$$

$$\partial\lambda^*/\partial S_{\pi} = -S_s [2S_s S_{\pi} + \rho_{\pi,s} (S_{\pi\pi} + S_{ss})] / (S_{\pi\pi} + S_{ss} + 2\rho_{\pi,s} S_{\pi} S_s)^2 > 0, \quad (\text{A.21})$$

and

$$\partial\lambda^*/\partial\rho_{\pi,s} = S_{\pi} S_s (S_{ss} - S_{\pi\pi}) / (S_{\pi\pi} + S_{ss} + 2\rho_{\pi,s} S_{\pi} S_s)^2. \quad (\text{A.22})$$

form which

$$\text{sign}(\partial\lambda^*/\partial\rho_{\pi,s}) = \text{sign}(S_{ss} - S_{\pi\pi}). \quad (\text{A.23})$$

⁴¹If this is not the case, under the “no short sales” changes in the parameters would not affect underlying dollarization.

Therefore, as expected, underlying dollarization is correlated positively with inflation volatility and negatively with the volatility of real exchange rate changes. Moreover, a reduction of the correlation between inflation and real exchange rate movements favors dollarization when inflation is more volatile than changes in the real exchange rate, since unstable domestic currency assets lose their hedging benefits against variations in dollar asset returns.

C. Impact of Dollar Pricing on Underlying Dollarization

Suppose that inflation and depreciation rates evolve according to

$$\pi = \alpha e + (1 - \alpha)\epsilon \quad (\text{A.24})$$

$$s = e - \pi = (1 - \alpha)(e - \epsilon) \quad (\text{A.25})$$

where α represents the pass through from exchange rate changes to inflation rate changes (alternatively, the dollar good component of the domestic consumption basket), and ϵ represents price shocks to the domestic component of the consumption basket.⁴² It follows that

$$S_{\pi\pi} = \alpha^2 S_{ee} + (1 - \alpha)^2 S_{\epsilon\epsilon} + 2\alpha(1 - \alpha)\rho_{e,\epsilon} S_e S_\epsilon, \quad (\text{A.26})$$

$$S_{ss} = (1 - \alpha)^2 (S_{ee} + S_{\epsilon\epsilon} - 2\rho_{e,\epsilon} S_e S_\epsilon), \quad (\text{A.27})$$

and

$$\rho_{\pi,s} S_\pi S_s = \alpha(1 - \alpha) S_{ee} - (1 - \alpha)^2 S_{\epsilon\epsilon} + (1 - \alpha)(1 - 2\alpha)\rho_{e,\epsilon} S_e S_\epsilon. \quad (\text{A.28})$$

Finally, replacing (A.26)-(A.28) into (A.17),

$$\lambda^* = \frac{\alpha S_{ee} + (1 - \alpha)\rho_{e,\epsilon} S_e S_\epsilon}{S_{ee}} \quad (\text{A.29})$$

or

⁴²This general formulation encompasses the cases of currency substitution (i.e., in which a number of domestic goods are priced and transacted in dollars), dollar indexation (in which prices of domestic goods are indexed to the dollar but actual transactions are conducted in the local currency) and trade openness (in which a portion of the consumption basket consists of imported-tradable goods). In this last case, a foreign inflation term has to be added in equation (31) and (32). This new term affects the results only marginally, and is therefore ignored. Again, dollar pricing refers to the indexation of domestic prices to *any* foreign currency.

$$\lambda^* = \alpha + (1-\alpha)\beta \quad (\text{A.30})$$

where

$$\beta = \rho_{ee} S_e / S_e. \quad (\text{A.31})$$

SHORT-RUN MACROECONOMIC MODEL UNDER A FIXED EXCHANGE RATE

A. Deviations from Underlying Dollarization

To derive a workable short-run macroeconomic model from the building blocks presented in Section II, simplifying assumptions need to be made and relations governing the behavior of the endogenous variables in (28)–(30) need to be specified. First, the model is solved for small deviations from MVP allocations. Second, the exchange rate is assumed to be fixed. Third, the share of non resident deposits over total resident deposits, $x = X/D$, is assumed exogenous.⁴³ Fourth, the tax rates, t^H and t^F , are taken as exogenous policy variables, thereby ignoring the second order effects on these rates induced by endogenous changes in interest rates.⁴⁴ Fifth, to distinguish movements in central bank liabilities due to changes in the policy stance from movements induced by changes in the deposit base, ρ , defined as the aggregate reserve ratio, i.e., $\rho = R/L = (1-\lambda^F) \rho^H + \lambda^F \rho^F$, is taken as a policy variable, with R adjusting endogenously to changes in L . Finally, the private sector's financial wealth, W , obtained as the sum of net external assets and assets with government:

$$W = D - L = R + (D^C - X) \quad (\text{A.32})$$

is assumed to be strictly positive and constant in the short run.

Define $\mu_i = \lambda_i - \lambda^*$ for $i = D, L, R$ are deviations from MVP, and since, by definition, $D^C = \gamma D$, (26), (28) and (29) can then be expressed in the following alternative format:

$$h_D \mu_D + h_L \mu_L + \tilde{r} = 0 \quad (\text{A.33})$$

$$\mu_D = (h_L / h) [\rho \mu_R + (1-\lambda^*) (\gamma - x)(L/D)] - \tilde{r} / h \quad (\text{A.34})$$

$$\mu_L = - (h_D / h) [\rho \mu_R + (1-\lambda^*) (\gamma - x)(L/D)] - (D/L) \tilde{r} / h \quad (\text{A.35})$$

where h is defined as in (30). From (A.32), it is easy to obtain

$$L / D = (1-\gamma + x)/(1 + \rho), \quad (\text{A.36})$$

and replacing it in (A.35) and simplifying, yields:

$$\mu_L = - \{ (1 + \rho) [h_D (1-\lambda^*) (\gamma - x) + \tilde{r}] - (1-\gamma + x) h_D \rho \mu_R \} / \kappa \quad (\text{A.37})$$

⁴³Alternatively, X , rather than x , could be assumed to be exogenous. While both formulations lead to the same conclusions, the formulation used here simplifies the derivations.

⁴⁴This simplification does not alter the analysis in any substantial way. Full derivations are available on request from the authors.

where

$$\kappa = (1 + \rho) h_L + (1 - \gamma + x) h_D.$$

Moreover, (A.32) may be expressed as a loan supply equation:

$$L = W (1 - \gamma + x) / (\rho + \gamma - x) \quad (\text{A.38})$$

To close the model, we use the loan demand equation from (20). The average real borrowing cost can be expressed as:

$$\begin{aligned} E(r_L) &= E[\lambda_L r_L^F + (1 - \lambda_L) r_L^H] = \\ &= E(r^C) + t + (1 - \lambda^*) \tilde{r} + h_C (1 - \gamma) + (1 - \lambda^* - \mu_L) h_L \mu_L \end{aligned} \quad (\text{A.39})$$

where t is the average implicit tax rate on financial intermediation:

$$t = (1 - \lambda^*) \tilde{r}^H + \lambda^* \tilde{r}^F \quad (\text{A.40})$$

On the other hand, the variance of the real borrowing cost can be expressed as:

$$V(r_L) = V(r_L^H - r_L^F) [\mu_L^2 - \lambda^{*2}] + V(r_L^H) \quad (\text{A.41})$$

Dropping the terms in μ_L^2 , which are of a second order of magnitude for small deviations around MVP, the variance term is constant and, hence, can be neglected when conducting comparative statics; and, with (20), (A.38) and (A.39), the following loan market equilibrium condition is obtained:⁴⁵

$$W (1 - \gamma + x) / (\rho + \gamma - x) = L [E(r^C) + t + (1 - \lambda^*) \tilde{r} + h_C (1 - \gamma) + (1 - \lambda^*) h_L \mu_L] \quad (\text{A.42})$$

which, together with the portfolio balance conditions (A.33) and (A.35), form a system of three equations in μ_D , μ_L , and γ . Note that, from (A.33), we know that $\partial \mu_L / \partial \mu_D < 0$, i.e., (A.33) defines a negatively sloped straight line in the space (μ_L, μ_D) . Likewise, from (A.35), it can be checked that $\partial \mu_L / \partial \gamma < 0$, so that (A.35) defines a downward sloping curve in the space (μ_L, γ) , around MVP.⁴⁶ Finally, differentiating (A.42) implicitly, we obtain

$$\partial \mu_L / \partial \gamma = [L' h_C - W (1 + \rho) / (\rho + \gamma - x)^2] / [L' h_L (1 - \lambda^*)] > 0 \quad (\text{A.43})$$

so that, around MVP, (A.42) characterizes an upward sloping curve in (μ_L, γ) .

⁴⁵We drop the variance term in the credit demand function for notational simplicity.

⁴⁶Some of the derivatives used in the Appendix are omitted, since they are tedious and do not shed any additional insight.

These results are represented in Figure A.1. With a capital outflow (a rise in γ), the supply of loanable funds falls. At the same time, the country risk premium declines, which induces a decline in the average lending rate and an increase in demand for loanable funds. To restore balance, the average lending rate must rise. This is obtained through an increase in μ_L which raises the foreign exchange risk premium. Thus, the loan equilibrium schedule, LL on the rightward quadrant of Figure A.1, is upward sloping. In the portfolio equilibrium conditions, a capital outflow leads to a relative scarcity of domestic dollars which tilts the domestic interest rate differential against the domestic currency and, hence, reduces μ_L and increases μ_D . Thus, (A.35) corresponds to a downward sloping portfolio balance schedule, PP_0 , on the rightward quadrant of Figure A.1. The equilibrium value of μ_D is obtained from (A.33), which is represented as the downward sloping line PP_1 on the leftward quadrant of Figure A.1.

B. Comparative Statics

External wedge

Consider first the impact of a decline in the world interest rate or the country risk premium (through a fall in h_C), that reduces the average lending rate and, hence, increases loan demand. Directly from (A.42), it can be checked that this implies that LL shifts leftward and γ and μ_D fall while μ_L rises.

Consider next an autonomous increase in foreign lending, x . This reduces net external assets, thereby shifting the PP_0 upward, and increases the supply of loanable funds, thereby shifting the LL rightward. It is immediate to see that γ increases as a result. Thus, the inflow crowds out local dollar deposits, which induces an offsetting capital outflow. The net effect on μ_L is given by:

$$\partial \mu_L / \partial x = \partial \mu_L / \partial x|_{\gamma} + (\partial \mu_L / \partial \gamma) \partial \gamma / \partial x. \quad (A.44)$$

Inspecting equation (A.37) it is easy to see that

$$\partial \mu_L / \partial x|_{\gamma} = - \partial \mu_L / \partial \gamma > 0 \quad (A.45)$$

so that

$$\partial \mu_L / \partial x = - (\partial \mu_L / \partial \gamma) (1 - \partial \gamma / \partial x). \quad (A.46)$$

Differentiating implicitly (A.42) yields

$$\partial \gamma / \partial x = \{-L'[(1-\lambda^*) h_L (\partial \mu_L / \partial x|_{\gamma})] - W(1+\rho)/(\rho + \gamma - x)^2\} / G \quad (A.47)$$

where

$$G = \{L'[-h_C + (1-\lambda^*) h_L (\partial \mu_L / \partial \gamma)] + W(1+\rho)/(\rho + \gamma - x)^2\}^{-1} > 0, \quad (A.48)$$

FIGURE A-1
Financial Equilibrium

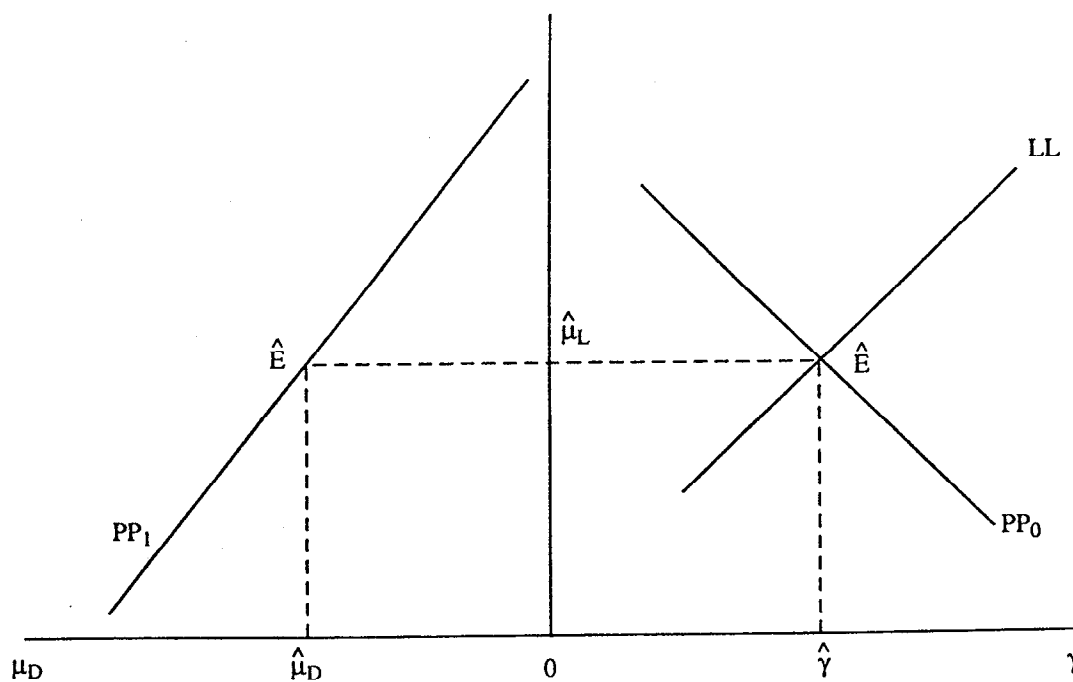
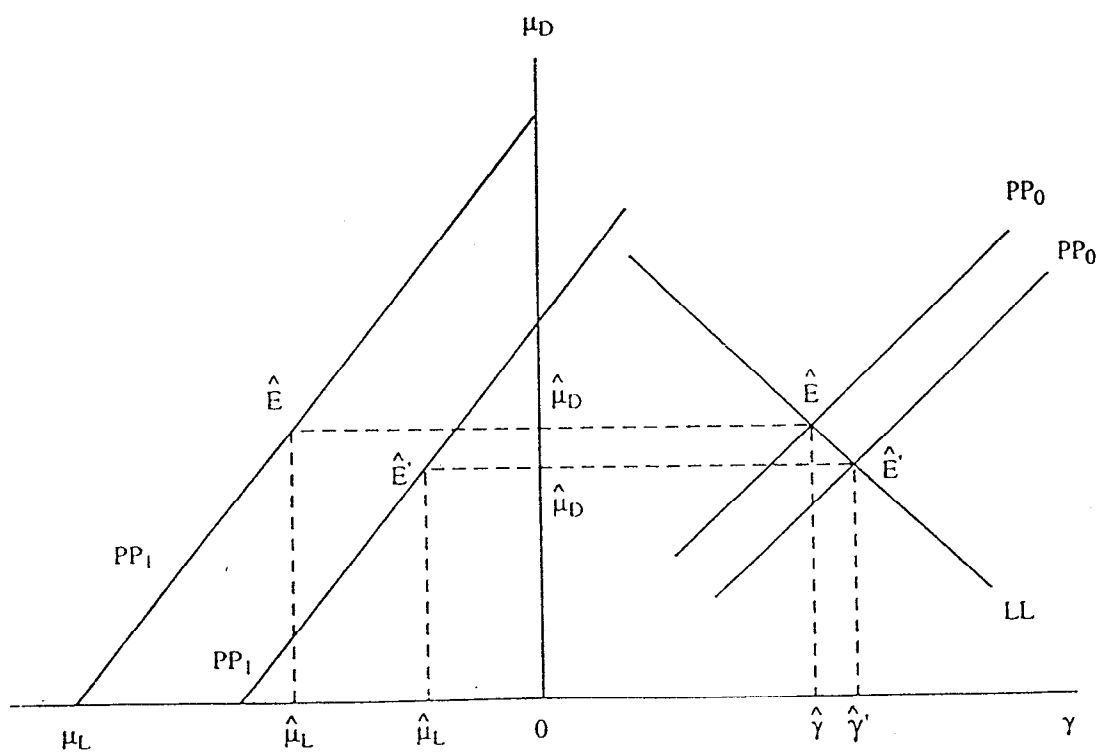


FIGURE A-2
Increase in the Tax Wedge



from which, using (A.45), it can readily be checked that

$$1 - \partial \gamma / \partial x = L' [-h_C + (1-\lambda^*) 2h_L (\partial \mu_L / \partial \gamma)] / G > 0 \quad (\text{A.49})$$

which, combined with (A.44), implies that $\partial \mu_L / \partial x$. Hence, loan dollarization rises, deposit dollarization falls, and financial intermediation expands.⁴⁷

Debt wedge

Consider first the impact of a decline in λ_R keeping ρ constant. The PP_0 curve shifts upward; γ and μ_L rise while μ_D falls. As there is a capital outflow and the supply of loanable funds falls, the average lending rate must rise, indicating that the increase in the home currency rate is not fully offset by a comparable reduction in the local dollar rate.

Consider next the polar opposite case of an increase in ρ with $\mu_R = 0$. The LL shifts upward while the PP_0 moves downward. Again, while γ unambiguously falls, the net effect on loan dollarization can be assessed taking derivatives of (A.37). Differentiating (A.42) implicitly yields

$$\partial \gamma / \partial \rho = \{-L'[(1-\lambda^*) h_L (\partial \mu_L / \partial \rho|_\gamma)] - W/(\rho + \gamma - x)^2\} / G \quad (\text{A.50})$$

Taking derivatives of (A.37) gives

$$\partial \mu_L / \partial \rho|_\gamma = -[h_D (1-\lambda^*) \kappa - h_D \tilde{t} (1-\gamma + x)] / \kappa^2, \quad (\text{A.51})$$

and replacing $\partial \mu_L / \partial \gamma$ and $\partial \mu_L / \partial \rho|_\gamma$ from (A.43) and (A.51), it can be shown that

$$\partial \mu_L / \partial \rho = \partial \mu_L / \partial \rho|_\gamma + (\partial \mu_L / \partial \gamma) (\partial \gamma / \partial \rho) > 0 \quad (\text{A.52})$$

In turn, from (A.33), $\partial \mu_D / \partial \rho < 0$. Hence, as ρ increases, there is a capital inflow, deposit dollarization declines and loan dollarization rises. In addition, the average lending rate rises and financial intermediation contracts.

Tax wedge

Consider finally the impact of lowering the remuneration of reserve requirements on FCD relative to the remuneration of reserve requirements on HCD. To abstract from the effect of such a change on the level of implicit taxation on financial intermediation, we focus on the impact of increase in \tilde{t} , keeping the average tax t constant.⁴⁸ As both the LL and PP_0

⁴⁷The reader can check that, from (A-33), $\partial \mu_D / \partial x = -(h_L / h_D) \partial \mu_L / \partial x < 0$.

⁴⁸From (A-42), it is easy to check that the opposite case of a reduction of the average tax rate, (continued...)

schedules shift downward, it is clear that μ_L declines. To check how μ_D is affected, notice that with (A.33), (A.41) may be rewritten:

$$W(1-\gamma+x)/(\rho+\gamma-x) = L[E(r^c) + t + h_c(1-\gamma) - (1-\lambda^*)h_D\mu_D] \quad (A.53)$$

(A.33), (A.34) and (A.53) form an alternative representation of the model with an upward sloping PP schedule in the (γ, μ_D) space and a downward sloping LL schedule (Figure A.2). In this alternative representation, an increase in the tax wedge shifts the PP₀ schedule rightward but does not affect the LL schedule. Hence, γ rises while μ_D falls.

C. Effectiveness of Tax-based Measures

It is readily apparent from (A.34) that the direct impact of \tilde{r} on μ_D is proportional to $1/h$. Thus, a weakening of the demand for dollar hedging, that reduces h_D and h_L (hence h), should increase the impact of \tilde{r} on μ_D . At the same time, (A.53) indicates that around MVP, μ_D does not directly depend on \tilde{r} . Instead, the impact of \tilde{r} on r_L is transmitted through the μ_D term. It increases as h falls, but declines as λ^* increases. Hence, a change in \tilde{r} should be more effective when h has fallen due to progress in stabilization but dollarization remains high due to the fact that inflation volatility remains higher than real exchange rate volatility.

This reasoning can be formalized as follows. The cost-effectiveness of tax-based (or regulatory) measures to reduce dollarization can be assessed by calculating the ratios $d\mu_D/dr_L$ that result from a change in \tilde{r} . Defining

$$F = W a(\gamma) - L(r_L) = 0 \quad (A.54)$$

where

$$a(\gamma) = (1-\gamma+x)/(\rho+\gamma-x), \quad (A.55)$$

we obtain

$$dF = W a' d\gamma - L' dr_L = 0 \quad (A.56)$$

In turn, from (A.53),

$$dr_L = -h_c d\gamma - h_D (1-\lambda^*) d\mu_D \quad (A.57)$$

which, combined with (A.56), yields

⁴⁸(...continued)

with no change in the tax wedge, has a similar impact on dollarization to that of a reduction in country risk or the foreign rate of interest.

$$d\mu_D/dr_L = - [1 + (h_C L')/(a'W)]/[(1 - \lambda^*)h_D] \quad (A.58)$$

Hence, cost-effectiveness increases as h_D declines, i.e., when the demand for dollar hedging by depositors becomes less intense, which should occur as a result of macroeconomic stabilization. However, from (8) and (14), note that

$$(1 - \lambda^*)h_D = c_D [V(s) + Cov(\pi, s)] \quad (A.59)$$

Hence, cost-effectiveness is higher when the real exchange rate is not expected to fluctuate much and its correlation with the rate of inflation is modest.

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