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THE CHOICE OF EXCHANGE RATE REGIME AND MONETARY TARGET IN HIGHLY DOLLARIZED ECONOMIES

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We examine the implications of high degrees of dollarization for the choice of exchange rate regime and the information content of various monetary aggregates in developing countries. We conclude that a high degree of currency substitution argues for a more fixed exchange rate regime, while asset substitution may imply that either more rigid or more flexible regimes may be appropriate. We also ask whether the most informative monetary aggregates include dollar assets. Based on an analysis of five countries, we conclude inter alia that broader aggregates that include dollar assets perform better than those that do not.

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I. Introduction

Dollarization, defined as the holding by residents of foreign currency and foreign currency-denominated deposits at domestic banks, has risen in recent years in many developing countries, notably in Latin America but also in some of the transition economies and in economies as diverse as the

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Philippines, Turkey, and Vietnam.[1] This paper analyzes two important issues posed by this phenomenon. First, how does dollarization affect the choice of the most appropriate exchange rate regime, in particular the choice between fixed and flexible rates? Second, supposing a flexible exchange rate regime, what is the implication of dollarization for the behavior of monetary aggregates; in particular, are aggregates that include dollar-denominated assets more informative indicators of future inflation?[2]

Historically, dollarization has been a response to economic instability and high inflation. In conditions of hyperinflation, in particular, the public typically turns to use a stronger currency to the extent possible. But, remarkably, the increase in dollarization in Latin American countries has continued, in fact accelerated, after those countries achieved substantial inflation control and exchange rate stability over the course of the last decade. Some authors have pointed to ratchet effects in explaining this development (see Guidotti and Rodríguez, 1992).[3] Some data also suggest that the increase in local holdings of dollar assets resulted from the return of capital held by residents abroad as part of the surge in capital flows to developing countries in the 1990s.[4]

It is useful to distinguish between two motives for the demand for foreign currency assets: currency substitution and asset substitution[5]. Currency

[1] The term "dollarization" has also come to mean the establishment of a foreign currency such as the dollar as legal tender in lieu of a distinct domestic currency, as in Panama. That is not our usage here. Berg and Borensztein (2000) discuss full dollarization, that is the adoption of a foreign currency as legal tender.

[2] Baliño et al. (1999) incorporate some of the results of this paper into a broader discussion of the policy implications of partial dollarization.

[3] Kamin and Ericsson (1993) estimate a money demand with "ratchet" effects for Argentina for a period that includes a hyperinflation episode.

[4] Baliño et al. (1999) discusses and interprets these trends. Calvo and Végh (1992, 1996) and Savastano (1992, 1996) also mention capital flows as a driving factor for dollarization.

[5] This distinction is standard in the literature. An early reference is Lamdany and Dorlhiac (1987). See the useful surveys by Calvo and Végh (1996) and Giovannini and Turtelboom (1994). McKinnon (1996) terms the two motives direct currency substitution and indirect currency substitution.

substitution refers to a situation in which foreign assets are used as money (essentially as means of payment and unit of account) while asset substitution occurs when foreign currency assets are demanded as financial assets but without a specific monetary function. Currency substitution typically arises under conditions of high inflation or hyperinflation when the high cost of using domestic currency for transactions prompts the public to look for available alternatives. Once the use of foreign currency in transactions becomes accepted, however, it may not be rapidly abandoned even after stabilization. Asset substitution results from risk and return considerations about domestic and foreign assets. Historically, foreign-currency denominated assets have provided the opportunity of insuring against macroeconomic risks (price instability and prolonged depressions) in many developing countries. Even under conditions of current stability, foreign currency denominated assets may still serve this purpose if agents believe there is even a small chance of inflationary relapse.

Section II analyzes, and also qualifies, the case for adopting a fixed exchange rate under currency substitution. In a simple static stochastic model that assumes nominal rigidities, the exchange rate regime determines the relationship between the pattern of shocks facing the economy and the resulting variance of output, in the spirit of Poole (1970). For example, an economy facing a preponderance of real shocks would have lower output variance in a floating exchange rate regime. Currency substitution may alter these relationships, by changing both the pattern of shocks and the response of the economy to those shocks in the different regimes. In order to investigate how this works, we extend a simple static stochastic macro model based on Obstfeld and Rogoff (1996) to incorporate the phenomenon of currency substitution.

This framework is helpful, but it does not allow us to address many of the key issues associated with partial dollarization that fit more appropriately under the heading of asset substitution. Thus, the second part of section II discusses the implications of asset substitution for exchange rate regime choice, focussing on the risks that devaluations may pose in a dollarized financial system.

Dollarization also raises the issue of the appropriate role of dollar-denominated monetary assets in the conduct of monetary policy in a floating exchange rate regime. In a financial programming exercise, for example, ceilings for domestic credit are based on a specific target for money supply. This requires a choice of a nominal aggregate as (intermediate) target and raises the question of whether this target should include dollar-denominated assets. On the view that money is targeted because it determines the price level through transactions demand for money, currency substitution implies that dollar monetary assets are part of the relevant concept of money while assets substitution implies that they are not. To evaluate this issue, we examine the role of dollar assets in a reduced form inflation equation.[6] Specifically, we use a vector autoregression methodology to examine the strength and stability of the relationship between inflation and lagged changes in various definitions of money in five countries with substantial dollarization. Thus, section III examines the evidence on the usefulness of different monetary aggregates in Argentina, Bolivia, Peru, the Philippines, and Turkey. We find that broad aggregates that include foreign currency deposits are more informative than those that do not, but our measures of dollar currency circulating in the country does not help predict price levels.

II. Exchange Rate Regime

In this section, we look at the implications of dollarization for the choice of exchange rate regime. While the answers are ultimately empirical, an analytical framework can suggest where to look. To organize ideas, it is convenient to consider two polar cases: pure currency substitution and pure asset substitution, covered in subsections A and B below.

[6] A number of recent studies, including Estrella and Mishkin (1996), Friedman and Kuttner (1996), and Feldstein and Stock (1994), have used this type of technique to approach the analogous question of whether any of the domestic money aggregates (money base, M1 or M2) might be useful intermediate targets of US monetary policy.

A. Currency Substitution

Currency substitution will tend to increase exchange rate volatility. The basic cause is the interaction between money supply and the exchange rate. In an economy where both domestic and foreign currency serve as money, changes in the exchange rate have an automatic effect on the money supply: a devaluation increases the value of foreign currency assets in terms of the domestic currency, and the overall money supply increases. The result, derived below, is that the elasticity of substitution between domestic and foreign currency would be high in this case, which makes the exchange rate more sensitive to any expected change in the domestic money supply, or other factors affecting monetary equilibrium. An additional way in which currency substitution may increase monetary volatility is through the possibility for shocks in demand for domestic money relative to foreign money.

Although this increase in volatility suggests a case for adopting a fixed exchange rate under currency substitution,[7] this conclusion is not absolute. The source of shocks still matters (see, for example, Obstfeld and Rogoff, 1996). If shocks mostly originate in money markets, fixed exchange rates provide more stability, but if shocks are mostly real in nature, floating rates are superior in reducing volatility. This principle still holds true in the case of an economy with currency substitution.

The case for fixed exchange rates under currency substitution can be analyzed with the help of a simple model that captures the key effects of currency substitution and focusses on the effect of the exchange rate regime on the variance of output. Suppose that, although there is extensive currency substitution in the economy, practices or institutional restrictions (including

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[7] This is the generally supported view on currency substitution in the literature. See Girton and Roper (1981) -who actually propose competition between currencies instead of fixed rates- Calvo and Végh (1996), and Giovannini and Turtelboom (1994). McKinnon (1996) justifies his recommendation for an international monetary standard and a world monetary authority largely on the volatility of exchange rates under currency substitution.

the legal tender character of the domestic currency) are such that foreign and domestic currency cannot be used interchangeably to settle transactions. The money supply, that is the stock of liquid assets that serves the purpose of medium of payments, is thus a function of the stocks of domestic and foreign money. It would be reasonable to impose some restrictions on this "medium of payments function," such as that it depends positively on its two arguments, and that it is linearly homogeneous. One particularly convenient form of this function is the following:

$$m^s = \alpha m + (1-\alpha)(e+m^*) \qquad (1)$$

where m^s represents the logarithm of the total money supply in the economy, m and m^* denote the logarithms of the domestic and foreign components of money, respectively, and e stands for the logarithm of the exchange rate. One could think of (1) as a production function for means of payment in the economy, requiring both domestic money and foreign money as inputs. The value of $1 - \alpha$, which is equal to the elasticity of money supply with respect to its foreign component, measures the extent of dollarization of payments in the economy. When $1 - \alpha$ is equal to unity, the economy is fully dollarized in the sense that only foreign money serves as medium of payment. While the form of (1) is obviously special, it captures the notion that institutional and customary requirements imply that both domestic and foreign money are needed to execute transactions. This is consistent with the observation that even in hyperinflations the demand for domestic money does not disappear.

It is easiest to think of the aggregate in (1) as pure non-interest bearing money. In this case, if the exchange rate is flexible, the differential return between the domestic and foreign components of money is equal to the rate of depreciation of the exchange rate. One can then postulate, as in Calvo and Rodríguez (1977), that agents would choose to hold a proportion of domestic and foreign money which depends on the expected rate of depreciation of the domestic currency,

$$e_t + m_t^* - m_t = k(E_t(e_{t+1}) - e_t) + \xi_t \qquad (2)$$

where E_t represents the expected value as of time t, and ξ is a random variable representing shifts in preference for domestic and foreign money. The particular form of (2) is convenient because it displays a constant elasticity of substitution between domestic and foreign money, equal to k.

Assuming that money demand, that is the demand for the medium of payments aggregate, has the usual form, equilibrium in the money market would be given by:

$$\alpha m_t + (1-\alpha)(e_t + m_t^*) - p_t = -\eta i_t + \Phi y_t + u_t \qquad (3)$$

where p represents the log of the price level, *i* denotes the interest rate on domestic currency, y stands for the log of GDP, and u represents a random shock to money demand. Using (2), this implies:

$$m_t + (1-\alpha)k(E_t(e_{t+1}) - e_t) - p_t = -\eta i_t + \Phi y_t - (1-\alpha)\xi_t + u_t \qquad (4)$$

Assuming open interest parity and normalizing dollar international interest rates to zero, one obtains:

$$m_t - p_t = -(\eta + (1-\alpha)k)(E_t(e_{t+1}) - e_t) + \Phi y_t + \upsilon_t \qquad (5)$$

where υ represents the consolidated random shock affecting the money market $(u - (1-\alpha)\xi)$. The elasticity of (domestic) money demand is augmented by the product of two terms: the extent of dollarization $(1 - \alpha)$ and the elasticity of substitution between foreign and domestic means of payments (k).

Equation (5) thus displays two special features compared to standard money demand equations in open economies with interest parity. The disturbance term is larger, as it is expanded by the term reflecting shifts in the use of currencies, and the interest elasticity is also higher because it is augmented by the substitutability of domestic and foreign means of payment.

This framework, as shown in the Appendix, yields the following conclusions. In a floating rate regime, the exchange rate of a dollarized economy will be more sensitive to expected changes in the money supply, and to other variables that affect the expected rate of depreciation of the exchange rate.[8] Considering, in addition, that when there is extensive currency substitution it is likely that monetary shocks will be relatively larger in magnitude, as unpredictable shifts between domestic and foreign currency may occur, this would support the desirability of fixing the exchange rate of a highly dollarized economy. However, the principle that an economy is more volatile under floating rates if monetary shocks predominate and less volatile if real shocks predominate still holds in the case of a dollarized economy. The case for a fixed exchange rate under currency substitution is therefore not an absolute one.

B. Asset Substitution

Suppose that domestic residents are allowed to open foreign exchange accounts in domestic banks and that the central bank imposes a 100 percent reserve requirement on those foreign currency accounts. Suppose domestic residents bring into the country $1 million and deposit them with domestic banks. The central bank keeps the foreign currency assets as international reserves in a foreign bank account. What happens? Essentially nothing. Domestic residents hold the same foreign currency net asset position as before and so do the foreign banks. The central bank and the domestic banks have balanced accounts. Without changes in net positions for any agent, there should

[8] As shown in the Appendix, the exchange rate is a function of all the expected future values of the money supply and random shocks, with a discount factor that depends on the interest elasticity of money demand. The higher the elasticity, the more sensitive is the exchange rate to expected future shocks. Note however that, in this model, a high interest elasticity has the opposite effect for *current* shocks to the money market: only small changes in the exchange rate are necessary to generate the adjustment in real money demand necessary to restore equilibrium.

be no meaningful effects on financial markets or aggregate demand. Recorded domestic-currency denominated monetary aggregates should not change, and it would not make sense for the monetary authorities to attempt to offset the increase in deposits with domestic banks.

In practice, however, two things may happen. First, the central bank may not just keep the foreign assets as reserves but would instead use those (gross) foreign reserves as needed in the foreign exchange market. In fact, this could have been the motivation to authorize foreign currency deposits in the first place. Therefore, this capital inflow would either affect the current exchange rate, or help the (short-term) sustainability of an existing exchange rate peg. Second, banks will be able to expand lending through either dollar -or domestic- currency denominated loans. In either case there will be an expansion in aggregate demand and the money supply, as the loan proceeds are spent in goods and some of the foreign currency is sold for domestic currency either by individuals or banks trying to balance their reserves position. (This expansionary effect will take place even if the original dollar deposits are "not money" in the sense of not performing any transactions or liquidity functions for the deposit holders.)

These considerations suggest that dollarization in the form of asset substitutability does not have special implications for monetary policy and exchange rate.[9] Dollarization implies a situation akin to high capital mobility, with low transaction costs to move from foreign-currency to domestic-currency assets, and presumably higher sensitivity to interest differentials. But the basic conditions under which the choice of exchange rate regime is made would only change to the extent that the higher degree capital mobility and substitutability would make sterilization more difficult or costly.

The most important implications of dollarization in the form of asset substitution for the choice of exchange rate regime may arise from likely increases in foreign exchange risks in the financial markets. When banks expand their assets and liabilities in foreign and domestic currency, they are

[9] This is the same conclusion that Cuddington (1983).

likely to become more vulnerable to exchange rate changes or volatile dollar deposits. Defaults on foreign-currency denominated loans would increase in the event of an exchange rate depreciation, leaving banks (and ultimately, the central bank) in a weakened financial position. In addition, maturity mismatches between bank assets and liabilities in foreign currency would make the banks more vulnerable to volatile dollar deposits.[10] Moreover, capital inflows mediated through the banking system, such as those described above, expand gross reserves with as short run liabilities, in the form of the increase in required reserves of banks. The monetary authorities may use the increase in foreign reserves to support a misaligned exchange rate while increasing short-run liabilities.

The vulnerability of the financial system to exchange rate changes may imply that exchange rate flexibility must be ruled out as a policy tool with which to respond to shocks.[11] Moreover, fixed but adjustable regimes may represent the worst of both worlds, in that they may encourage market participants to assume exchange rate risk based on a (mistaken) confidence in the fixity of the exchange rate. The eventual devaluation would then be particularly costly.[12] For highly dollarized countries, which ultimately cannot hedge fully against exchange rate risk, a hard peg such as a currency board or even full dollarization may be appropriate.[13]

III. Selecting a Money Target

In a floating exchange rate regime, a monetary aggregate may play the role of nominal anchor for monetary policy, perhaps on the grounds that it

[10] See Detragiache (1999).

[11] This argument has been made forcefully in Calvo (1999).

[12] Krugman (1998), *inter alia*, has analyzed the Asian crises of 1997/1998 somewhat along these lines.

[13] Hausmann et al. (1999) argue this case.

determines the price level through transactions demand for money.[14] Dollarization raises the question of what monetary aggregate the central bank should consider.[15] In the frameworks presented in section II, introduction, currency substitution implies that dollar monetary assets are part of the relevant concept of money while assets substitution implies that they are not.

Unfortunately, the empirical literature has shed little light on the distinction between currency substitution and asset substitution in this context. Most work has implicitly or explicitly assumed away assets substitution in testing for currency substitution.[16] The traditional approach has been to attempt to identify currency substitution from the coefficients on the rate of return variables included in money demand functions. Specifically, studies added a variable measuring expected exchange rate depreciation to the usual determinants of domestic money demand and interpreted this variable as measuring the opportunity cost of holding domestic vs foreign *currency*.[17] As Cuddington (1983) pointed out, however, domestic money demand will depend on the rate of exchange rate depreciation even in the absence of currency substitution, because the rate of depreciation affects the yield of foreign assets, which is an opportunity cost to domestic money. Thus, a test to distinguish between currency and asset substitution would include both the rate of return on foreign bonds in domestic currency and the rate of depreciation itself in the money demand regression, with a negative and significant coefficient on the rate of depreciation variable suggesting currency substitution as distinct from asset substitution. Unfortunately, these two rates of return variables are closely correlated, particularly in countries likely to have currency substitution, and their independent effects are essentially impossible to distinguish.

[14] In IMF financial programming, monetary aggregates formally play such a role, though the practice is more flexible. See Mussa and Savastano (1999) for a complete discussion.

[15] Of course, it is not clear that it is advisable to pay much attention to any monetary aggregate at all. We return to this issue below and in the conclusion.

[16] See Savastano (1996) for a useful review of this literature.

[17] See, for example, Miles (1978) and Bordo and Choudri (1982).

In this light, a potentially more fruitful approach would start not with money demand but with the determinants of inflation. Although money demand functions look quite similar to asset demand functions, and the explanatory variables that may distinguish between the two are highly correlated, it is the stock of money, but presumably not of assets, that is closely correlated with the volume of transactions and the rate of inflation. From this point of view, the relevant test of currency substitution is whether foreign monetary assets belong in the monetary aggregate that predicts inflation in the most reliable way.

This line of analysis might suggest the estimation of structural inflation equations and examine the role of various monetary aggregates in the inflation equation.[18] We proceed less ambitiously but more directly here, examining the role of dollar assets in a reduced form inflation equation.[19] Specifically, we use a vector autoregression methodology to examine the strength and stability of the relationship between inflation and lagged changes in various definitions of money in five countries with substantial dollarization. This in turn depends, in part, on which aggregate has the most stable relationship to target variables such as inflation and output.

Before pursuing this question, we emphasize that the question of the usefulness of money targeting *per se* is beyond the scope of this paper. It is worth remembering, though, that it has proven difficult even in comparatively stable and non-dollarized industrial countries to find a clear role for targets on monetary aggregates in the conduct of monetary policy. Thus, since the 1980s, monetary targeting has become less and less common even in these countries. Friedman and Kuttner (1996) provide evidence that the U.S. Federal

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[18] See, for example, Juselius (1992) for Denmark, Metin (1995) for Turkey, and De Brouwer and Ericsson (1995) for Australia. These papers tend not to find an important role for monetary aggregates in explaining inflation, instead pointing to various other factors, such as labor market disequilibria and deviations from PPP.

[19] A number of recent studies, including Estrella and Mishkin (1996), Friedman and Kuttner (1996), and Feldstein and Stock (1994), have used this type of technique to approach the analogous question of whether any of the domestic money aggregates (money base, M1 or M2) might be useful intermediate targets of US monetary policy.

Reserve Board did indeed target monetary aggregates for several years after 1979, but that practice stopped in the mid-1980s, roughly when monetary aggregates ceased having predictive value for future inflation and income. Estrella and Mishkin (1996) also find that the relationship between monetary aggregates and final target variables has been unstable and in particular that there was no causality from monetary aggregates to final targets in the 1980s, both in Germany and the United States. They argue that this suggests that monetary aggregates provide little information about future values of final targets, so that intermediate targets on monetary aggregates are unlikely to be useful. Feldstein and Stock (1994), in contrast, find some evidence of a weak but, they argue, usable relationship between M2 and nominal GDP.[20]

To investigate the relevance of foreign currency deposits and other dollar assets, our strategy is to run a quarterly VAR on prices, a money aggregate, and in some cases the exchange rate for each of five partially dollarized countries. For each of the economies considered, we compare the results for the price equation with different money aggregates along three dimensions. First, if a given aggregate does not Granger cause prices, then it is unlikely to be a good intermediate target.[21] Second, a gauge of the relative information content in the various aggregates is the R^2 statistic for the price equation, which measures how well an equation with that particular aggregate accounts for the variance in prices. Third, an aggregate is more useful if its relationship to prices is stable across time. Thus, we examine the price equation for stability using Chow break-point tests.[22]

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[20] Hendry and Ericsson (1991) among others have found stable money demand functions in these countries. However, they also find that there is little evidence of feedback from deviations in long-run equilibrium in the money market to prices or other variables. They therefore also conclude that targeting of monetary aggregates would not achieve desired targets for final objective variables.

[21] Even this seemingly weak claim may not hold. If, for example, the monetary authorities conducted activist counter cyclical policy with the aggregate in question as intermediate target in the sample, then this would eliminate measured Granger causality.

[22] The actual test employed is the breakpoint F-test as described in PC-Give 9.0 (See Hendry

We consider three types of dollar assets: foreign-currency deposits at the domestic banking system (FCD), cross-border deposits held at banks abroad (CBD), and dollar currency in circulation within the domestic economy (DCC). Reliable information is available only for the first category, and most existing studies are based on this measure. The best source of data on CBD are the statistics published by the Bank for International Settlements (BIS), which compiles data on deposits held by nonresidents at all reporting institutions classified by the country of nationality of the depositor. It is likely that CBD are highly underestimated, however, because of the legal and tax-related ramifications of cross-border deposits. For example, residents of one country can transfer assets to a company they set up in a third country, which appears to be the holder of the deposit.[23] Nevertheless, one would expect that the broad trends in the evolution of the BIS measure of CBD are similar to those followed by a more accurate measure. Moreover, the bias has probably been decreasing in recent years because of the tendency to lessen exchange controls in various developing countries. No statistics on DCC exist; a measure of *flows* of U.S. currency to and from other countries can be constructed, however, from U.S. Customs Service data on shipments of currency across the U.S. border. Although this measure has a number of shortcomings, discussed below, it nevertheless provides some indication of the evolution of dollar currency holdings.[24]

These three dollar aggregates plus the usual domestic suspects yield seven

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and Doornik (1996). This tests, at each point t, for a structural break in the estimated equation between the first t observations and the remaining observations. For each t, the model is estimated over the first t observations (as long as t is large enough to permit estimation). Forecasts are then generated for the remaining T - t + 1 observations. A typical statistics is calculated as $[(RSS_T - RSS_{t-1})(t - k - 1)] / [RSS_{t-1}(T - t + 1)]$ and is assumed to be distributed as $F(T - t + 1, t - k - 1)$.

[23] For example, the three top countries of residence of nonbank depositors in the Western Hemisphere are Cayman Islands, Panama, and the Netherlands Antilles.

[24] Baliño et al. (1999) discuss the sources and styled facts for these data in much greater depth.

candidate monetary aggregates. Four exclude estimates of US dollar cash in circulation: base money (MB), currency-in-circulation (CC), M1 (CC plus sight deposits), M2 (M1 plus domestic-currency time deposits), M3 (M2 plus FCD), and in some cases M4 (M3 plus CBD). In addition, where data are available we construct estimates of US dollar cash in circulation (DCC) from Baliño et al. (1999). To this end, we follow the admittedly crude approximation of assuming there was no dollar cash in circulation at the end of 1988, and that the stock in circulation subsequently is equal to the cumulative net flow based on the customs data. This yields three additional aggregates: M1 plus DCC (M1_us), M3 plus DCC (M3_us), and M4 plus DCC (M4_us).

For each country, we estimate bivariate VARs in money and prices, as well as trivariate VARs including the exchange rate. In light of the short time series available, we take an eclectic approach with regard to cointegration. First, we estimate these regressions in first differences, supposing that there is no cointegration.[25] Where we could not reject cointegration of money and prices using a Johansen test, we also add an error correction term to the difference regression, calculated from the cointegrating vector derived from the Johansen procedure. In the trivariate regressions, for those cases where the hypothesis of one cointegrating vector cannot be rejected but two or more can be, we are generally able to plausibly identify the cointegrating vector as comprising money and prices. Where there are two, it is usually plausible to identify the two vectors as a money demand equation and a PPP-type relation between the exchange rate and prices. In these cases, both error correction terms are included in the VARs.[26]

[25] The results of augmented Dickey-Fuller and Phillips-Perron unit root tests suggest that for most countries, prices, money and the exchange rate are I1, though there was some evidence of I2 prices.

[26] The estimated cointegrating vectors generally look like simple money demand equations, in that (with the coefficient on money normalized to 1) the coefficient on prices is close to, though usually significantly lower than, -1. In the trivariate regressions, the two cointegrating vectors can be tentatively identified as a money demand equation with coefficients as in the bivariate cases, and as a PPP-equation, with roughly equal and opposite coefficients on prices and the exchange rate.

In illustration of this procedure, we find for M1 in Peru, for example, that the Johansen procedure indicated that there are two cointegrating vectors, which after normalization are[27]:

$$EC1 = m1 - 0.92\ cpi \tag{6}$$

$$EC2 = e - 0.90\ cpi$$

The estimated price equation is:

$$\underset{}{\Delta p_t} = \underset{(1.29)}{-1.34} + \underset{(0.21)}{0.25}\ \Delta p_{t-1} + \underset{(0.16)}{0.46}\ \Delta e_{t-1} + \underset{(0.15)}{0.45}\ \Delta m_{t-1} - \tag{7}$$

$$- \underset{(0.09)}{0.11}\ EC1 - \underset{(0.09)}{0.50}\ EC2 + \varepsilon_t$$

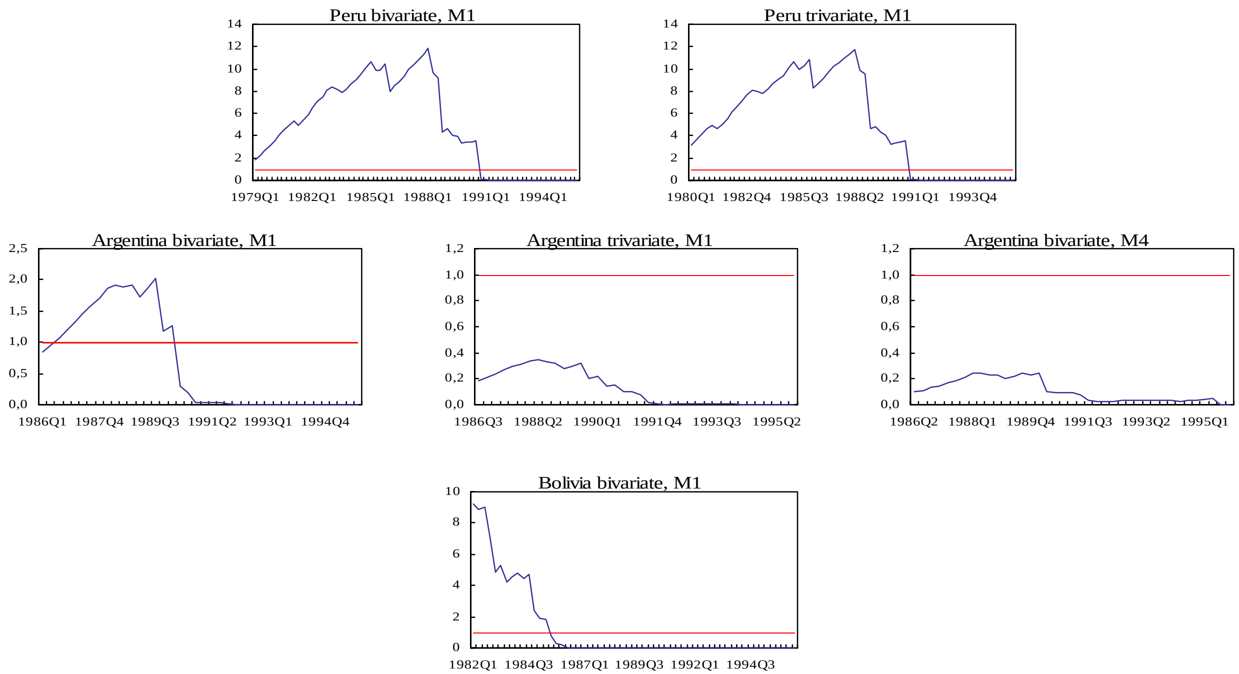
For each country except the Philippines, we estimate the VAR first over the entire sample for which we had data, and then over a more recent sub-sample. This sub-sample is motivated for Argentina and Peru by the concern (buttressed by the Chow tests) that stabilizations in 1990/1991 may have caused a break in the price equations, and for Bolivia and Peru by the desire to include DCC in the regressions (Figure 1 shows the results from some of the Chow tests). The more recent sub-samples are much too short to estimate cointegrating vectors so these regressions were carried out only in first differences.[28 29 30]

[27] We also include a dummy variable equal to 1 during the period when convertibility of dollar deposits was suspended. We do not modify the critical values of the Johansen test to take them into account, on the grounds that the dummy is stationary.

[28] In these subsamples, the Johansen test in some cases could not reject the hypothesis of no cointegrating vectors in these sub-samples and in others implied implausible cointegrating vectors. Given the weaknesses of the Johansen procedure in small samples, only the results for the difference regressions are reported.

[29] As discussed for Peru, we also included several dummy variables, designed as crude attempts to capture breaks in the price, money or exchange rate equations due to major

Figure 1. Breakpoint Chow Tests of Inflation Equation



Notes: The test employed is the breakpoint F-test (see text footnote 22). This tests, at each point t, for a structural break in the estimated equation between the first t observations and the remaining observations. The graphs show the resulting statistic (calculated as $[(RSS_T - RSS_{t-1})(t-k-1)]/[RSS_{t-1}(T-t+1)]$ and assumed to be distributed as F(T-t+1, t-k-1)). The horizontal line represents the 1 percent significance level for this statistic.

The following is an analysis of the results by country. The results for Peru (Table 1) support three conclusions. First, M3 appears to have a stronger relationship to prices than does M2. That is, the inclusion of foreign currency deposits in the broad money aggregate seems to strengthen its explanatory power. The results from the Granger causality tests are the most revealing here, as the R-squared statistics, while consistent with these results, are very similar across the different regressions. In the full sample, neither M2 nor M3 Granger cause inflation, though M3 is slightly more promising. For example, only M3 appears to be cointegrated with prices in the bivariate VARs. But there is strong evidence for structural breaks in the price equations with all the aggregates in 1990, when Peru stabilized a hyperinflation and changed its exchange rate regime. In the more recent sub-sample, M3 performs clearly better than M2, as M3 Granger causing prices but M2 does not. In the trivariate VARs, M3 is the only aggregate that Granger causes inflation.

Second, the inclusion of measures of U.S. dollar cash in circulation does not generally improve the performance of monetary aggregates. (Data are only available for the more recent subperiod.) In one case, with M3 in the trivariate VAR, the inclusion of U.S. dollar cash in circulation eliminates the Granger causality.

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regime changes. Since the estimated equations are in reduced form, the interpretation of these dummies is problematic. However, since they improve the fit of the equations, they may provide a fairer test for the power of money to predict prices during periods of broad stability, at a cost of weakening the test of the ability of aggregates to predict prices across major regime changes. For Argentina, one dummy captures the effects of Plan Bonex stabilization in the second and third quarters of 1989, while the second captures the change in the exchange rate regime from the end of 1989. Two Bolivian dummies capture the effects of suspension of FCD convertibility from 1983 to 1986 and the stabilization plan in 1985. For Peru (full sample), one dummy captures the suspension of FCD convertibility between 1985 and 1988, while another captures the change in monetary policy and exchange rate regime since 1990. One Turkey dummy captures the effects of the exchange rate crisis in 1994. There were no dummies for the Philippines.

[30] The Schwartz criterion determined the lag length for the VARs. Each equation for a given country and time period used the same lag length.

Table 1. Peru

	Monetary Aggregate[1]								
	MB	CC	M1	M1_US	M2	M3	M3_US	M4	M4_US
Full Sample 1975:3-1995:4									
1 lag									
Bivariate[2]									
No cointegration									
Granger Causality[3]	0.0345*	0.0937	0.0553		0.7378	0.3443		0.4678	
R-squared[4]	0.782	0.776	0.78		0.77	0.772		0.771	
With error correction term[5]									
Granger Causality	---	0.0198*	0.0726		---	0.4432		---	
R-squared		0.791	0.784			0.774			
Trivariate[6]									
No cointegration									
Granger Causality[3]	0.0488*	0.1022	0.0688		0.6886	0.4217		0.759	
R-squared[4]	0.783	0.779	0.781		0.772	0.774		0.772	
With error correction term[5]									
Granger Causality	0.0126*	0.0459*	0.0030**		0.0954	0.0873		0.1838	
R-squared	0.841	0.834	0.844		0.83	0.833		0.83	
Stability[7]	Strong evidence of a break in the inflation equation at the end of 1990 for all monetary aggregates and for both bivariate and trivariate specifications.								

Table 1. (Continue) Peru

	Monetary Aggregate[1]								
	MB	CC	M1	M1_US	M2	M3	M3_US	M4	M4_US
Subsample 1991:1-1995:4									
1 lag									
Bivariate									
No cointegration									
Granger Causality	0.0002**	0.0247*	0.0012**	0.0120*	0.0674	0.0000**	0.0051**	0.0000**	0.0042**
R-squared	0.947	0.927	0.942	0.931	0.921	0.961	0.935	0.955	0.936
Trivariate									
No cointegration									
Granger Causality	0.8474	0.9622	0.8709	0.6849	0.7665	0.0445*	0.2997	0.4122	0.4915
R-squared	0.96	0.96	0.96	0.96	0.96	0.968	0.963	0.962	0.961

Notes: [1] Money aggregate definitions:
MB: base money; CC: domestic currency in circulation; M1: CC plus sight deposits.
M2: M1 plus domestic currency time deposits; M3: M2 plus foreign currency deposits; M4: M3 plus cross-border deposits.
M1_US, M2_US, M3_US: domestic aggregate plus dollar cash in circulation.
[2] Quarterly VAR with money and prices
[3] Statistic shown is p-value of hypothesis that no lags of the money variable belong in the price equation.
* implies significance at the 5 percent level, ** at the 1 percent level.
[4] The R^2 for the price equation in the VAR.
[5] Where there is evidence of cointegration, the estimated cointegrating vector (lagged once) is added to the differenced regression.
The Granger causality test includes a zero restriction on the lagged cointegrating vector.
[6] Quarterly VAR with money, prices and the nominal exchange rate (against the US dollar).
[7] Breakpoint F-tests are conducted at each quarter after initial period. See footnote 22 of text and Figure 1 for selected results.

Third, the evidence is mixed regarding the comparison of M3 with the narrow aggregates. In the full-sample VARs, base money and currency-in-circulation appear to perform better. In the full-sample bivariate VAR in differences, only base money, among all the aggregates, Granger causes inflation. Where there is evidence of cointegration, only currency-in-circulation Granger causes inflation. In the trivariate VARs, all the aggregates appear to be cointegrated with prices, but only the three narrower aggregates Granger cause inflation. As mentioned above, there is strong evidence of a structural break in 1990, and in the more recent sub-sample, there is some evidence that M3 is the best predictor of inflation.

The results for Argentina (Table 2) yield two broad conclusions. First, M2 tends to be inferior to broader aggregates, particularly those that include FCDs, and in some cases dollar cash in circulation and Argentinean deposits abroad. In the full sample, M4 Granger causes inflation, while M2 and M3 do not. Moreover, the only stable bivariate price equation includes M4; the others appear to have a break in 1990. Remarkably, all the trivariate price equations appear stable throughout the estimating period. For the most recent sub-sample, M3 Granger causes inflation with a p-value of .06, while the broader aggregates (and M2) are much less significant. The differences in the R-squared statistics are in the same direction but much smaller. Second, the inclusion of dollar cash in circulation does not substantially improves the performance of monetary aggregates for Argentina. It is not possible from these results to conclude whether the broader aggregates are better than the narrowest aggregates at predicting inflation. For both samples, the narrower aggregates, particularly base money, also tend to Granger cause inflation in both samples. They tend to have slightly higher R-squared statistics.

Two clear conclusions emerge for Turkey (Table 3). First, while all the aggregates Granger cause inflation, the addition of foreign currency deposits to M2 strengthens the relationship between the monetary aggregates in inflation. Removing the time deposits from M2 also strengthens the relationship. That is, the relationship is consistently stronger for M1 and M3

Table 2. Argentina

	Monetary Aggregate[1]								
	MB	CC	M1	M1_US	M2	M3	M3_US	M4	M4_US
Full Sample 1980:3-1995:4									
2 lags									
Bivariate[2]									
No cointegration									
Granger Causality[3]	0.0009**	0.1188	0.1041		0.457	0.2768		0.0000**	
R-squared[4]	0.725	0.68	0.682		0.665	0.671		0.903	
With error correction term[5]									
Granger Causality	---	---	---		---	---		---	
R-squared	---	---	---		---	---		---	
Trivariate[6]									
No cointegration									
Granger Causality[3]	0.0084**	0.552	0.878		0.896	0.966		0.687	
R-squared[4]	0.916	0.903	0.901		0.901	0.901		0.915	
With error correction term[5]									
Granger Causality	0.0124*	0.2547	0.2972		0.3102	0.8068		0.2131	
R-squared	0.921	0.913	0.911		0.913	0.907		0.924	

Table 2. (Continue) Argentina

	Monetary Aggregate[1]								
	MB	CC	M1	M1_US	M2	M3	M3_US	M4	M4_US
Stability[7]	The Breakpoint Chow test detects a break in the inflation equation in 1990 for all monetary aggregates except M4 which has a stable relationship with inflation. All inflation equations are stable when allowing for the exchange rate.								
Subsample 1991:1-1995:4									
1 lag									
Bivariate									
No cointegration									
Granger Causality	0.0319*	0.0823	0.0461*	0.25	0.2134	0.0636	0.7356	0.7172	0.2604
R-squared	0.827	0.814	0.822	0.797	0.799	0.818	0.782	0.782	0.796

Notes: See Table 1 for notes.

Table 3. Turkey

	Monetary Aggregate[1]						
	MB	CC	M1	M1_US	M2	M3	M3_US
Full Sample 1986:4-1996:3							
2 lags							
Bivariate[2]							
No cointegration							
Granger Causality[3]	0.0258*	0.0269*	0.0000**		0.0121*	0.0005**	
R-squared[4]	0.529	0.528	0.695		0.545	0.604	
With error correction term[5]							
Granger Causality	---	0.0091**	0.0000**		0.0107*	0.0017**	
R-squared	---	0.576	0.704		0.572	0.607	
Trivariate[6]							
No cointegration							
Granger Causality[3]	0.0277*	0.0305*	0.0000**		0.0104*	0.0003**	
R-squared[4]	0.534	0.531	0.719		0.556	0.623	
With error correction term[5]							
Granger Causality	---	0.0018**	0.0000**		---	0.0059**	
R-squared	---	0.653	0.759		---	0.632	

Table 3. (Continue) Turkey

	Monetary Aggregate[1]						
	MB	CC	M1	M1_US	M2	M3	M3_US
Stability[7]	The inflation equation exhibits a stable relationship with the monetary aggregates throughout the estimation sample when an impulse dummy that takes a value of 1 in 1994:2 is included.						
Subsample 1991:2-1996:3 2 lags							
Bivariate							
No cointegration							
Granger Causality	0.0438*	0.0554	0.0002**	0.999	0.0231*	0.0012**	0.875
R-squared	0.732	0.723	0.823	0.629	0.745	0.799	0.635
Trivariate							
No cointegration							
Granger Causality	0.0461*	0.0985	0.0001**	0.9701	0.0416*	0.0015**	0.8101
R-squared	0.744	0.724	0.844	0.643	0.749	0.814	0.652

Notes: See Table 1 for notes.

than M2. In the bivariate first-difference regressions over the entire sample, for example, R-squared is 0.55 with M2, 0.60 with M3, and 0.70 with M1. Second, the addition of dollar cash in circulation greatly weakens the relationship between monetary aggregate and prices.

The results for Bolivia (Table 4) do not allow us to tell whether foreign currency deposits should be added to the definition of money; the results for M2 and M3 are very similar. However, some conclusions are possible. First, it would appear that CBD should not be included in money. Second, there is some evidence that the inclusion of dollar cash in circulation strengthens the relationship of money and prices, though this depends on the specifications. In particular, dollar cash in circulation helps only when the exchange rate is excluded from the VAR.

The results for the Philippines (Table 5) also do not shed much light on the question of whether FCDs should be included in money, as both M2 and M3 perform much more poorly than narrower aggregates, particularly currency in circulation. (There are no data on dollar cash in circulation). The price equation is apparently stable for the entire period, no matter which monetary aggregate is included.

To summarize, the results vary substantially from country to country and across sub-samples. Few broad conclusions are possible. We can nonetheless make three important generalizations about the impact of dollarization. First, the superiority of a broad aggregate that includes FCD to one that does not (that is, M3 to M2) appears fairly robust. Second, the inclusion of dollar cash in circulation does not generally improve the performance of the monetary aggregate. Finally, it appears that the narrow aggregates appear to do at least as well as the broader aggregates in most cases.

To interpret the first conclusion, it may help to consider that in general the demands for each of the monetary assets considered will be subject to random shocks. An aggregate may be a better predictor of inflation if random shocks to the demand for that aggregate have smaller variance. In general, broader aggregates might be better or worse predictors of the objective variable (here inflation). If one component of the broader aggregates has a much tighter

Table 4. Bolivia

	Monetary Aggregates[1]								
	MB	CC	M1	M1_US	M2	M3	M3_US	M4	M4_US
Full Sample 1975:4-1996:3									
1 lag									
Bivariate[2]									
No cointegration									
Granger Causality[3]	0.0000**	0.0000**	0.0000**		0.0004**	0.0000**		0.2043	
R-squared[4]	0.794	0.8	0.808		0.781	0.796		0.758	
With error correction term[5]									
Granger Causality	0.0000**	0.0000**	0.0000**		0.0000**	0.0000**		0.0024**	
R-squared	0.786	0.796	0.804		0.766	0.813		0.682	
Trivariate[6]									
No cointegration									
Granger Causality[3]	0.0000**	0.0000**	0.0000**		0.0000**	0.0000**		0.0177*	
R-squared[4]	0.817	0.814	0.829		0.796	0.806		0.771	
With error correction term[5]									
Granger Causality	0.0000**	0.0000**	0.0000**		0.0000**	0.0000**		0.0002**	
R-squared	0.865	0.866	0.879		0.845	0.878		0.849	
Stability[7]	The Breakpoint Chow tests finds a break in all the inflation equations in the middle of 1985.								

Table 4. (Continue) Bolivia

	Monetary Aggregates[1]								
	MB	CC	M1	M1_US	M2	M3	M3_US	M4	M4_US
Subsample 1986:3-1996:3									
1 lag									
Bivariate									
No cointegration									
Granger Causality	0.8281	0.1527	0.3019		0.6691	0.8727		0.9943	
R-squared	0.182	0.223	0.204		0.185	0.182		0.181	
With error correction term[5]									
Granger Causality	---	---	---		---	0.8403		---	
R-squared						0.189			
Trivariate									
No cointegration									
Granger Causality	0.6893	0.0595	0.0907		0.9051	0.9621		0.7264	
R-squared	0.25	0.313	0.301		0.247	0.247		0.249	
With error correction term[5]									
Granger Causality	---	---	0.2977		---	0.0571		---	
R-squared			0.397			0.353			

Table 4. (Continue) Bolivia

	Monetary Aggregates[1]								
	MB	CC	M1	M1_US	M2	M3	M3_US	M4	M4_US
Subsample 1989:4-1996:3									
1 lag									
Bivariate									
No cointegration									
Granger Causality	0.6171	0.0347*	0.071	0.0019**	0.8632	0.9053	0.0178*	0.9919	0.0218*
R-squared	0.066	0.199	0.165	0.318	0.057	0.057	0.23	0.056	0.22
Trivariate									
No cointegration									
Granger Causality	0.7915	0.0066**	0.0078**	0.0686	0.3958	0.6029	0.544	0.5586	0.585
R-squared	0.283	0.45	0.445	0.368	0.302	0.289	0.292	0.291	0.29

Notes: See Table 1 for notes.

Table 5. Philippines

	Monetary Aggregates[1]				
	MB	CC	M1	M2	M3
Full Sample 1987:4-1996:3					
3 lags					
Bivariate[2]					
No cointegration					
Granger Causality[3]	0.0484*	0.0232*	0.0230*	0.1281	0.111
R-squared[4]	0.376	0.402	0.402	0.336	0.342
With error correction term[5]					
Granger Causality	0.0349*	0.0033**	---	---	---
R-squared	0.42	0.492	---	---	---
Trivariate[6]					
No cointegration					
Granger Causality[3]	0.1329	0.0188*	0.0548	0.054	0.1145
R-squared[4]	0.594	0.643	0.618	0.618	0.598
With error correction term[5]					
Granger Causality	0.213	0.0001**	0.0032**	---	---
R-squared	0.61	0.759	0.709	---	---
Stability[7]	The inflation equation exhibits a stable relationship to the monetary aggregates throughout the estimation sample using the Breakpoint Chow test.				

Notes: See Table 1 for notes.

relationship to inflation than the others, then it will perform better in the above tests. If, on the contrary, the components have similar relationships to inflation and the shocks are of similar magnitude, then a broader aggregate will tend to smooth out the shocks and hence perform better. Finally, if the shocks to the different components of the broader aggregates are negatively correlated the case for the broader aggregate would be even stronger.[31]

[31] This effect is captured in the model through the error term in equation (2).

The superiority of both narrower aggregates and M3 to M2 is consistent with the hypothesis that shifts between domestic and foreign assets are important and weaken the relationship between an aggregate that includes just one of these close substitutes (for example, domestic M2) and inflation.

The failure of dollar cash in circulation to improve the performance of monetary aggregates could be taken to imply that it is predominantly a store of value, not a means of exchange. Unfortunately, it may well reflect the substantial measurement error that is undoubtably present in our measure of dollar currency.[32]

Several caveats are in order. First, the simple VAR methodology employed, while it minimized the required assumptions about the structure of the economy, may give misleading results. A maintained assumption is that the nature of the relationship between money and inflation is stable and invariant to changes in the rules for monetary policy. Moreover, important variables have certainly been omitted, because of data limitations and to keep the analysis tractable. More generally, country-specific structural analysis of the price equation would be advisable. Also, the conclusion that M3 would be a better intermediate target than M2 begs the question of whether the monetary authorities can control effectively the foreign component of this broader aggregate. At the least, though, a policy of targeting a domestic aggregate such as M2 should take into account shifts between aggregates, particularly assets denominated in foreign and domestic currency, when evaluating the stance of policy.

IV. Conclusion

The analysis in section II, makes but also qualifies the case for adopting a fixed exchange rate under currency substitution. A floating exchange rate

[32] Kamin and Ericsson (1993) are more successful in using the same measure of dollar currency in estimating a money demand equation for Argentina. One reason for this difference may be our concentration on the role of money in the price equation rather than on the estimation of money demand.

would be highly sensitive to changes in expectations; also, shifts in the demand for (domestic) money would probably be sizable, resulting in higher volatility. A floating exchange rate regime may still be preferable, however, even with currency substitution. If real shocks predominate, for example, a flexible rate would still permit an easier adjustment.[33] Under asset substitution, high capital mobility with limited effectiveness (or high cost) of sterilization might recommend a more flexible exchange rate system. On the other hand, highly dollarized countries that cannot easily hedge exchange rate risk may want to consider eschewing the option to devalue by choosing a currency board or even the adoption of the dollar as legal tender.

Section III analyzes the experience of five developing countries and asks which monetary aggregates seem to have the tightest link to subsequent inflation, and in particular whether those that include various dollar assets perform better. We found that while few broad conclusions are possible, we can nonetheless make three important generalizations about the impact of dollarization. First, the superiority of a broad aggregate that includes FCD to one that does not (that is, M3 to M2 in our terminology) appears to be supported by the data. Second, the inclusion of our measure of dollar cash in circulation does not generally improve the performance of the monetary aggregate. Finally, the narrowest aggregates appear to do at least as well as the broader aggregates in most cases.

We have already stressed above some of the limitations of our approach. First, with regard to the choice of exchange rate regime we have focussed mostly on currency substitution, despite the perhaps more important implications of asset substitution and issues of financial fragility. With regard to the assessment of the usefulness of the different monetary aggregates, perhaps the most important shortcoming is that we assume that the authorities can and should target the money supply so as to hit inflation targets, contrary

[33] Another effect in this direction is that the high interest elasticity of money demand implies that the response of a floating exchange rate to a given *current* money demand shock would be smaller, reducing the real effects of not accommodating this shock.

to most current practice. The choice of a monetary aggregate as intermediate target for policy should be viewed, however, from the broader perspective of finding an aggregate that provides useful summary information on monetary conditions, rather than a target to be strictly pursued independent of the behavior of interest rates, the exchange rate, or other indicators.[34] In this context, it is still to be expected that dollar deposits would play some role within the set of indicators that the central bank would need to watch in assessing monetary conditions.

Appendix. A Simple Model of Exchange Rate Regimes and Shocks in a Highly Dollarized Economy

This appendix develops in detail a simple model to compare the desirability of fixed versus flexible exchange rates in a dollarized economy. The basic structure is taken from Obstfeld and Rogoff (1996), pages 657-58, extended to incorporate the phenomenon of currency substitution.

Recall the assumption that, with currency substitution, the choice between foreign and domestic money depended on the expected rate of depreciation of the domestic currency,

$$e_t + m_t^* - m_t = k\,(E_t(e_{t+1}) - e_t) + \xi_t \tag{8}$$

where we have added a random shock ξ to represent shifts in the preference to use domestic and foreign money. Equilibrium between money supply and money demand (analogous to equation (5)) is now given by:

$$m_t - p_t = -\lambda(E_t(e_{t+1}) - e_t) + \Phi y_t - (1-\alpha)\,\xi_t + u_t \tag{9}$$

[34] It may also be difficult to implement an intermediate target that includes foreign assets. Most obviously, the lack of reliable data on the circulation of dollar currency would make it difficult to do so.

where u represents a random shock to money demand, and we have defined $\lambda = \eta + (1-\alpha)k$. Let υ represent the consolidated random shock affecting the money market $(u - (1-\alpha)\xi)$. It can then be expected that monetary disturbances will be more volatile when dollarization -in the form of currency substitution- is present.

Assume that equilibrium in the goods market is given by:

$$y_t^s = \theta(p_t - E_{t-1}p_t) \tag{10}$$

and

$$y_t^d = \delta(e_t - p_t) + \varepsilon_t \tag{11}$$

where aggregate supply is a Lucas-type price surprise specification and aggregate demand depends on the real exchange rate (the level of foreign prices is normalized to one and assumed fixed) and a random shock ε.

It is straightforward to show that, equating (9) to (10), this goods market setup implies $E_{t-1}p_t = E_{t-1}e_t$. Using this condition to solve for p_t one obtains:

$$p_t = \frac{1}{\delta+\theta}(\delta e_t + \varepsilon_t + \theta E_{t-1}e_t) \tag{12}$$

Inserting the above expression in (8):

$$m_t - \frac{1-\Phi\delta}{\delta+\theta}(\delta e_t + \varepsilon_t + \theta E_{t-1}e_t) = -\lambda(E_t e_{t+1} - e_t) + \Phi(\delta e_t + \varepsilon_t) + \upsilon_t \tag{13}$$

In the case of floating rates, under rational expectations, the solution for the expected exchange rate $E_{t-1}e_t$ will be obtained by solving forward the following equation:

$$E_{t-1}m_t = -\lambda E_{t-1}(e_{t+1} - e_t) + \Phi\delta E_{t-1}e_t + (1-\Phi\delta)E_{t-1}e_t \tag{14}$$

The forward solution of this equation yields:

$$E_{t-1}e_t = \frac{1}{1+\lambda}\sum_{i=0}^{\infty}\left\{\frac{\lambda}{1+\lambda}\right\}^i m_{t+i} + \frac{1}{1+\lambda}\sum_{i=0}^{\infty}\left\{\frac{\lambda}{1+\lambda}\right\}^i \upsilon_{t+i} \tag{15}$$

Equation (14) illustrates why dollarization may result in a higher exchange rate volatility. The discount factor $\lambda/(1+\lambda)$ is higher (closer to one) the higher the degree of dollarization (which implies a higher value for λ). And the higher discount factor implies that the exchange rate will react more sharply to any expected changes in monetary policy, shifts between dollar and domestic currency, or money demand shocks (Recall that the disturbance term represents the sum of shocks to currency substitution and to money demand).

In the case in which the shocks to money demand and to currency substitution are serially uncorrelated and have mean equal to zero, the last term on the right hand side of (14) is equal to zero. Assuming this is the case and that, furthermore, that the monetary authority adopts a rule of keeping the domestic component of money supply constant:

$$m_t^s = \bar{m} \tag{16}$$

the solution for the current exchange rate is simply:

$$E_{t-1}e_t = \bar{m} \tag{17}$$

Using (15) and (16) into (12) one obtains:

$$\bar{m} = \frac{1-\Phi\delta}{\delta+\theta}(\delta e_t + \varepsilon_t + \theta\bar{m}) - \lambda(\bar{m} - e_t) + \Phi(\delta e_t + \varepsilon_t) + \upsilon_t \tag{18}$$

Solving for e_t :

$$e_t = \bar{m} - \frac{\delta+\theta}{(\delta+\theta)\lambda + \delta(1+\theta\Phi)}\upsilon_t - \frac{1+\theta\Phi}{(\delta+\theta)\lambda + \delta(1+\theta\Phi)}\varepsilon_t \tag{19}$$

Using (10), (16), (11), and (18), we can now solve for the level of output

$$y_t = \theta(p_t - \bar{m}) = \frac{\theta\delta}{(\delta+\theta)\lambda+\delta(1+\theta\Phi)}\upsilon_t + \frac{\theta\lambda}{(\delta+\theta)\lambda+\delta(1+\theta\Phi)}\varepsilon_t \qquad (20)$$

The volatility of output will be given by the following expression:

$$\sigma_y^2 = a^2\sigma_\upsilon^2 + b^2\sigma_\varepsilon^2 \qquad (21)$$

where the parameters a and b are defined in a straightforward way from (19). Both real and monetary shocks affect the economy. Recalling that λ equals the interest elasticity of money demand augmented by the degree of dollarization and the substitutability between domestic and foreign currencies, equations (19) and (20) imply that dollarization will tend to increase the impact of real shocks on the economy relative to that of monetary shocks (in addition to its effect on σ_υ^2).

Consider now the case of fixed exchange rates. Fixed exchange rates are implemented in the model by assuming that, through the balance of payments, the money supply adjusts in each period such that the exchange rate remains fixed at the level $\bar{e}$. In this case, the equation analogous to (11), expressing the equilibrium in the goods market is the following:

$$p_t = \frac{1}{\delta+\theta}(\delta\bar{e} + \varepsilon_t + \theta\bar{e}) = \bar{e} + \frac{1}{\delta+\theta}\varepsilon_t \qquad (22)$$

Using (12), equilibrium in the money market is given by the following equation:

$$m_t = (1-\Phi\delta)(\bar{e} + \frac{1}{\delta+\theta}\varepsilon_t) + \Phi(\delta e_t + \varepsilon_t) + \upsilon_t \qquad (23)$$

And output will be given by:

$$y_t = \theta(p_t - \bar{e}) = \theta(\bar{e} + \frac{1}{\delta+\theta}\varepsilon_t - \bar{e}) \qquad (24)$$

Such that the volatility of output in this case equals:

$$\sigma_y^2 = \left\{\frac{\theta}{\delta+\theta}\right\}^2 \sigma_\varepsilon^2 \qquad (25)$$

Equation (24) implies that monetary shocks do not affect the economy under a fixed exchange rate because the balance of payments adjusts instantaneously to any shock in that market. Comparing equation (24) to equations (19) and (20) it can be seen that, even in the presence of dollarization, floating exchange rates are superior to fixed exchange rates as far as real shocks are concerned, as the value of b in (20) is less than the coefficient on the variance of ε in (24).

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