Unofficial Dollarization in Latin America: Currency Substitution, Network Externalities and Irreversibility

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Abstract:

We examine the extent, causes and consequences of the use of foreign currency as a co-circulating medium of exchange and store of value in Latin America. Using new estimates of the amount of foreign currency in circulation in the form of US dollars, we obtain unique measures of currency substitution, asset substitution, dollarization, and bank credibility for many Latin American countries. We also specify and estimate demand functions for foreign currency in circulation in Argentina in order to examine the dynamic consequences of network externalities for hysteresis and irreversibility.

JEL classification: E4 E5 F3 H26 K42 P2 P3

Keywords: unofficial de facto dollarization, Latin America, currency substitution, asset substitution, foreign currency, network externalities, Argentina, irreversibility, underground economy.

Forthcoming in James W. Dean, Dominick Salvatore and Thomas Willett, eds.,
Dollarizing the Americas, New York: Oxford University Press, 2002

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The current dollarization debate in Latin America [Bogetic, (2000), Calvo (2000, Berg and Borensztein, (2000) and Calvo and Reinhart (2001)] focuses on the normative policy issue of selecting an optimal foreign exchange system for an emerging market economy. At issue, is whether or not Latin American countries should officially dollarize, that is adopt the US dollar de jure as the official legal tender.[2] Advocates suggest that official dollarization enables countries to avoid currency and balance of payment crises by eliminating the temptation of inflationary finance and encourages foreign investment. These effects reduce the level and volatility of interest rates and ultimately stimulate growth. Opponents cite the loss of seigniorage and the loss of an independent monetary policy.

Often overlooked in this normative debate are the positive issues concerning the causes, consequences and extent to which these countries are already "unofficially" (de facto) dollarized. We need to know the degree to which individuals and firms have voluntarily chosen to use a foreign currency as either a transaction substitute or a store of value substitute for the monetary services of the domestic currency, and the implications of such actions. De facto dollarization, involving both currency substitution and asset substitution may be widespread, but since foreign currency use rarely leaves a paper trail, measuring its scope is a particularly elusive task. The absence of empirical estimates of unofficial dollarization makes the outcomes of macroeconomic decisions more difficult to predict. The greater the extent and variability of unofficial dollarization, the weaker is the central bank's knowledge and control over the effective money supply. Unofficial dollarization also reduces the monetary

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[2] A similar discussion is underway in Central and Eastern Europe concerning the possible adoption of the Euro –The Eurization debate.

authority's ability to earn seigniorage from its own currency issue. Finally, unofficial dollarization reflects citizen's perceptions of the stability of the domestic monetary regime, the credibility of monetary policies and the perceived stability of the domestic banking system.

This paper presents new empirical evidence concerning the extent to which the US dollar already serves as the de facto unit of account, store of value and dominant medium of exchange in Latin America. Asset and currency substitution is induced by past inflations, devaluations, and currency confiscations. Often, unofficial dollarization becomes irreversible, due to network externalities that significantly reduce the cost of using dollars once they exceed a threshold level. When de facto dollarization is widespread, the effective money supply is larger than the domestic money supply and is subject to endogenous behavioral responses reflecting currency substitution on the part of the public. Hausmann et al (1999) suggest that under such circumstances, expansionary monetary policy can have pro-cyclical instead of counter-cyclical consequences. Unofficial dollarization will thwart government efforts to employ inflationary finance to impose implicit taxes on domestic monetary assets. Knowledge of the extent of de facto dollarization is therefore an important input into the normative debate since, extensive unofficial dollarization is likely to make domestic monetary policy less effective and active exchange rate intervention more dangerous.

Unofficial dollarization also has fiscal consequences. Foreign cash transactions reduce the costs of tax evasion and participation in the unreported (unofficial) economy. This weakens the government's fiscal ability to command real resources from the private sector and deepens fiscal deficits. The shifting of economic activity toward the underground economy distorts macroeconomic information systems (Feige, 1990, 1997), thereby adding to the difficulty of formulating macroeconomic policy. By obscuring financial transactions, de facto dollarization reduces the cost of enterprise theft, and may facilitate greater corruption and rent seeking. Given these extensive ramifications, informed policy decision-making requires better knowledge of the extent, causes and consequences of unofficial dollarization as well as the specific effects of its components, currency substitution and asset substitution.

The major limitation of any analysis of unofficial dollarization is that the amount of foreign currency in circulation (FCC) is typically unknown. Despite the substantive importance of the issues cited, earlier research has provided no reliable empirical information concerning the actual extent of unofficial dollarization. In their review of the key issues concerning currency substitution, Calvo and Végh (1992) observed:

"In the final analysis, the relevance of currency substitution is an empirical issue…At the empirical level, the study of currency substitution faces a fundamental problem: there is usually no data available on foreign currency circulating in an economy. Therefore the importance of currency substitution is basically unobservable."

There is now a growing body of evidence [Feige, (1994, 1996, 1997) and Porter and Judson (1996)] suggesting that 40-60 percent of US currency is held abroad. This paper presents newly collected data on the location of US currency, specifically, estimates of the amount of US dollars in circulation in Latin America. These data enable us to finally circumvent the fundamental problem of "unobservability" that has plagued the currency substitution literature since its inception, permitting a refinement of definitions and measures of the extent of currency substitution, asset substitution, unofficial dollarization and the credibility of domestic banking institutions.

Once the nature and extent of unofficial dollarization is empirically measurable, it becomes possible to examine the causes of dollarization, and to examine the circumstances under which unofficial dollarization is likely to become persistent and possibly irreversible.[3] Hysteresis and irreversibility will be affected by network externalities associated with the use of foreign currency. We therefore present models of network externalities that seek to determine the conditions under which foreign currency usage is likely to dominate the use of domestic currency by specifying the costs and benefits of the flight from domestic currency. When network externalities in the use of foreign currencies become sufficiently large, countries may decide to officially dollarize their economies, foregoing the flexibility of domestic monetary management in exchange for greater financial stability and an enhanced ability to attract foreign investment. Panama, Ecuador, and most recently El Salvador and Guatemala have chosen to dollarize officially. Argentina attempted to effectively dollarize by pegging the peso to the dollar on a one for one basis; however, the most recent crisis has shown this policy to be unsustainable.

Much of the dollarization literature has focused on the experience of those Latin American countries whose hyperinflationary episodes have induced a flight to dollars. With new estimates of the extent of dollar currency holdings in these countries, we set also out to model the dollarization process. Our empirical models are based on the Argentina experience since Argentina appears to be the most heavily de facto dollarized country in Latin America.

The first section of the paper briefly reviews earlier efforts to measure dollarization by indirect means and defines several new measures of unofficial dollarization that attempt to distinguish between currency and asset substitution. Currency substitution occurs when a foreign currency substitutes as a medium of exchange for the domestic currency, whereas asset substitution refers to the substitution of foreign denominated monetary assets for domestically denominated monetary assets. The next section presents new empirical estimates of the extent of dollarization in Latin America and compares these estimates to earlier proxy measures employed by the International Monetary Fund (IMF). We find that IMF

dollarization measures are highly correlated with our measure of asset substitution but appear to be imprecise measures of currency substitution.

The following section extends the network externality model of currency competition originally presented by Dowd and Greenaway (1993). We analyze the factors that influence individual decisions to use services of different monies showing the motives that lead initially to asset substitution and finally to currency substitution. We show that the choice of exchange rate regime depends on a number of key relationships, such as: the extent to which the broad money supply is covered by foreign exchange reserves, the level of the nominal exchange rate and the sensitivity of the number of agents who use the foreign currency to exchange rate changes, and the impact of exogenous monetary shocks on the exchange rate. As the use of a foreign currency increases, network externalities induce a reduction in the transaction costs associated with the use of the foreign currency. Once these transaction costs are lower than the costs of switching back to the local currency, a threshold of dollarization is achieved, after which currency substitution is likely to become irreversible.

In the final section we estimate an empirical network externality model of the dollarization process in Argentina developed by Oomes (2001) based on the discrete choice framework with social interactions of Brock and Durlauf (2001). The estimated model permits us to investigate the dynamic circumstances under which Argentina's de facto dollarization occurred as well as the necessary conditions that would be required to reverse unofficial dollarization. The model reveals the difficulty of reversing the process of unofficial dollarization once it has reached a threshold level.

Definitions[4]

In an economy with unofficial dollarization, the *effective* broad money supply (EBM) consists of local currency (cash) in circulation outside the banking system (LCC), foreign currency (cash) in circulation outside the banking system (FCC), local checkable deposits (LCD), foreign currency deposits (FCD) held with domestic banks, and local currency time and savings deposits (LTD). Quasi money (QM) consists of FCD and LTD. Thus, the typical definition of broad money (BM) falls short of the EBM by the unknown amount of FCC. The narrow money supply (NM) is typically defined to include only LCC and LCD. However, in a dollarized economy, the effective narrow money supply (ENM) also includes FCC. [5] Thus,

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[3] For an elaboration of the irreversibility problem see Guidotti and Rodriguez (1992) and Balino, Benett and Borensztein (1999).

[4] This conceptual framework was developed in Feige,et.al 2001.

[5] We ignore those rare institutional circumstances in which transfers between foreign currency deposits are employed for transaction purposes.

(1) EBM ≡ LCC + FCC + LCD + QM ≡ BM + FCC, where:

(2) QM ≡ FCD + LTD

(3) BM ≡ LCC + LCD + QM

(4) NM ≡ LCC + LCD

(5) ENM ≡ NM + FCC

In a regime with unofficial dollarization, the recorded money supply falls short of the effective money supply due to the omission FCC, which is typically unknown and is not directly controllable by the local central bank.

Due to data limitations on measuring the amount of foreign currency in circulation (FCC) cited by Calvo and Végh (1992), research on the currency substitution process has been forced to accept as a proxy for dollarization, the observable amount of foreign currency deposits (FCD). Studies of currency substitution, often associated with the International Monetary Fund (IMF), [Ortiz (1983); Canto (1985); Marquez; (1987); Clements and Schwartz (1992); Sahay and Végh (1995); Ize and Yeyati (1998); Balino, Bennett and Borensztein (1999)] employ the ratio of FCD to broad money as the means of establishing the extent to which countries are dollarized.[6] We denote this common dollarization index:

(6) $(DI_{IMF}) \equiv FCD/BM$.

Unofficial dollarization, in the Latin America context was often a response to hyperinflation. Under such circumstances, a foreign currency may first serve as a unit of account and store of value and only later as a circulating medium of exchange. "Currency substitution" suggests that the foreign currency largely displaces the domestic currency as the medium of exchange. If one is primarily concerned with the extent to which a foreign nation's currency has substituted for local currency primarily as the medium of exchange, it is useful to define an explicit currency substitution index (CSI). When the main impact of dollarization takes the form of asset substitution, it is useful to define an asset substitution index (ASI). Finally, when both asset substitution and currency substitution take place, we define a broader unofficial dollarization index (UDI) that reflects the fraction of the broad effective money supply that is composed of foreign currency and foreign deposits. We use the following definitions throughout the paper:

[6] Balino, et. al. (1999) choose to define highly dollarized countries as those whose ratio of FCD/broad money exceeds 30 percent. The major shortcoming of this definition is that it takes no account of foreign cash in circulation. Further study is required to determine whether there exists a unique value of the dollarization index that represents a threshold effect at which point dollarization is likely to become

Currency substitution occurs when foreign currency is partly or entirely used as a unit of account and medium of exchange. Currency substitution can be official or unofficial.[7] While official cases are still rare, unofficial dollarization is widespread. The most sensitive transaction measure of de facto dollarization is represented by the *currency substitution index (CSI)*, which shows the fraction of a nation's total currency supply held in the form of foreign currency.[8] Thus,

(7) CSI ≡ FCC/(FCC+LCC)

Since domestic transactions are typically settled by debiting and crediting local checkable deposit (LCD) accounts, when institutional circumstances warrant, it may also be useful to modify the CSI and use instead, (CSI_n) defined as the fraction of the effective narrow money supply made up of foreign currency.

(8) CSI_n ≡ FCC/(ENM)

Asset substitution involves the use of foreign denominated monetary assets as substitutes for domestic ones, in their capacity as a store of value. It is measured by the *asset substitution index (ASI)*, defined as the ratio of foreign denominated monetary assets to domestic denominated monetary assets excluding cash outside banks.[9]

(9) ASI ≡ FCD/(LCD+QM)

Dollarization is a summary measure of the use of foreign currency in its capacity to produce all types of money services in the domestic economy. When both asset substitution and currency substitution take place, or when FCD's are used by firms to make transactions with international partners, we define a broader *unofficial dollarization index (UDI)*, which represents the fraction of a nation's broad effective money supply composed of foreign monetary assets. Thus:

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irreversible because of network externalities. Mongardini and Mueller (1999) define the degree of currency substitution as measured by the ratio of FCD to total deposits.

[7] Officially dollarized independent countries include the Marshall Islands, Micronesia, Palau and Panama, Ecuador and El Salvador.

[8] In some countries foreign banknotes may simply be hoarded and treated purely as a store of value. When this part of FCC can be estimated, it should be treated in the capacity of money as the store of value and included in the asset substitution index.

(10) UDI ≡ (FCC+FCD)/EBM

Bank Credibility: The choices individuals make concerning the disposition of monetary assets reflects their perceptions of the credibility of the domestic banking system. Since this perceived credibility is an important factor effecting the ability of the monetary authority to pursue its macroeconomic objectives, it is useful to define a *bank credibility index (BCI)* reflecting the ratio of monetary assets held in the domestic banking system to assets held in the form of currency outside the banking system. Thus,

(11) BCI ≡ (LCD+FCD+LTD)/(LCC+FCC),

where LTD represents time and savings deposits in domestic banks. The higher BCI, the higher is the public's confidence in the domestic banking system.

Each of the foregoing indices depends upon a number of economic variables that reflect the relative incentives to hold the different assets described in both the denominator and numerator of each index. These incentives include relative rates of return as reflected by interest rate differentials, inflation differentials and exchange rate depreciation as well as the relative costs and benefits associated with network externalities, switching costs and risks of banking institutions.

The conventional IMF dollarization index (DI_{IMF}) will be an adequate proxy of de facto dollarization when foreign currency holdings are of marginal importance, or when FCC and FCD are highly complementary. However, if significant amounts of foreign currency circulate for transaction purposes or if FCC and FCD are in fact substitutes, then the IMF dollarization measure is likely to perform poorly as an indicator of unofficial dollarization, understating the true extent of dollarization due to its omission of FCC holdings. Moreover, DI_{IMF} does not permit one to distinguish between the dynamic currency substitution and asset substitution processes that our more refined indicators attempt to capture. In order to examine the adequacy of the IMF index, we first turn to a discussion of our efforts to obtain direct estimates of US currency holdings in Latin America.

Measurement

Direct measurement of FCC

[9] Again, a reader should keep in mind that the definition of ASI also depends upon the particular institutions of a nation. Its quality is high when the amount of FCD and LTD used for transactions purposes is low in comparison to the amount of those deposits used as income earning assets.

US currency is widely used outside of the US. By the end of 2001, 50 percent of the $580 billion of US currency in circulation is believed to have been held abroad.[10] US currency (cash) has many desirable properties. It has a reputation as a stable currency, and is therefore a reliable store of value. It is available in many countries, is widely accepted as a medium of exchange, and protects foreign users against the threat of bank failures, devaluation and inflation. US dollar usage preserves anonymity because it leaves no paper trail of the transaction for which it serves as the means of payment. Indeed the very characteristics that make the US dollar a popular medium of exchange also makes it difficult to determine the exact amount and location of US notes circulating abroad. Nevertheless, there is a direct source of information that can be used to determine the approximate amounts of US cash in circulation in different countries.

Over the past two decades, the United States Customs Service has been mandated to collect systematic information on cross border flows of US currency. The Currency and Foreign Transactions Reporting Act (also known as the "Bank Secrecy Act") requires persons or institutions importing or exporting currency or other monetary instruments in amounts exceeding $10,000, to file a Report of International Transportation of Currency or Monetary Instruments. The U.S. Customs Service has collected these reports, commonly known as Currency and Monetary Instrument Reports (CMIR) since 1977. Although the CMIR data system was established with the aim of recording individual instances of cross border inflows and outflows of currency and monetary instruments, its micro records can be usefully aggregated to study the size, origin and destination of cross border currency flows. The CMIR data system consists of more than 2.5 million inbound filings and more than 300,000 outbound filings. The information contained in the millions of accumulated confidential individual CMIR forms have been aggregated in order to fully preserve the confidentiality of individual filer's information. The aggregated data yield time series observations on the gross inflows and outflows of US currency to different destinations. By cumulating the net outflows of US dollars to all destinations, we are able to obtain estimates of the approximate amount of US currency held abroad as well as the location of US currency around the world.[11]

Table 1 presents the available evidence on the actual amounts of US currency in circulation in various Latin American countries. Column (1) contains the author's estimates obtained from aggregated CMIR reports and column (2) is obtained from informal surveys

[10] This "official" estimate, now published by the Bureau of Economic Analysis and the Federal Reserve Board, is based on an adjusted version of the proxy measure proposed by Feige (1994). The official estimate is based on net shipments of $100 bills from the Federal Reserve offices in New York and Los Angles. A more refined proxy measure (Feige, 1998) also includes data from the Miami and San Francisco Federal Reserve offices. The refined proxy suggests that at the end of 2001, 40.9 percent of US currency was held overseas.

conducted by a team of representatives of the Federal Reserve and US Treasury Department (United States Treasury Department, 2000). Both measures suggest that Argentina exhibits the highest per capita holding of US dollars in Latin America.

Table 1- Estimates of Per Capita Holdings of US Currency and Domestic Currency in Latin America			
	(1)*	(2)**	(3)***
Country	Per Capita $FCC	Per capita $FCC	Per capita $LCC
	CMIR Estimates (1997/98)	US Treasury Informal Survey	
	(Dollars)	(Dollars)	(Dollars)
Argentina	1478	698	374
Bolivia	144	NA	49
Brazil	15	6	108
Colombia	NA	52	81
Costa Rica	209	NA	130
Dominican Republic	NA	188	98
Mexico	NA	51	124
Nicaragua	135	NA	25
Panama	NA	648	0
Paraguay	NA	18	85
Peru	67	185	50
Uruguay	762	NA	199
Venezuela	104	NA	93

Sources:

*Author's Calculations: **(United States Treasury Department, 2000): ***International Financial Statistics

Estimates of dollar FCC holdings are then used to calculate the currency substitution, asset substitution, and dollarization indices described in the previous section. Feige, et al. (2002) examined these ratios for a sample of twenty four countries for which data were available and found that the widely used IMF dollarization index is highly correlated with the asset substitution index but appears to be an imprecise measure of currency substitution.

Figure 1 displays a country-by-country comparison of the conventional IMF dollarization proxy ((DI_{IMF}) and our broader dollarization index (DI), which takes explicit account of the estimated amount of FCC in circulation in each nation. The IMF dollarization index understates the true extent of unofficial dollarization due to its omission of FCC. Our estimates suggest that the highest de facto dollarization has occurred in Bolivia, Nicaragua, Uruguay and Argentina, whereas Mexico and Venezuela are the least dollarized Latin American countries in our sample.

[11] Feige, (1997) and Feige, et al. (2002) present greater detail on the collection and processing of CMIR data.

Figure 1: Comparison of Alternative Dollarization Measures

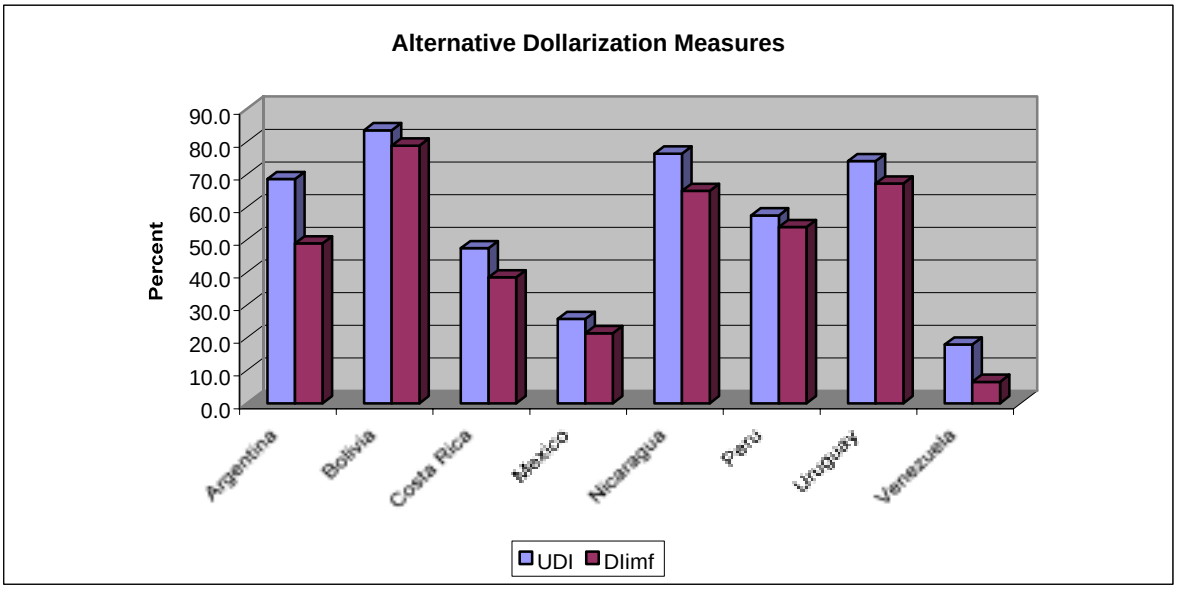


Figure 2: Currency and Asset Substitution Indices for Latin America

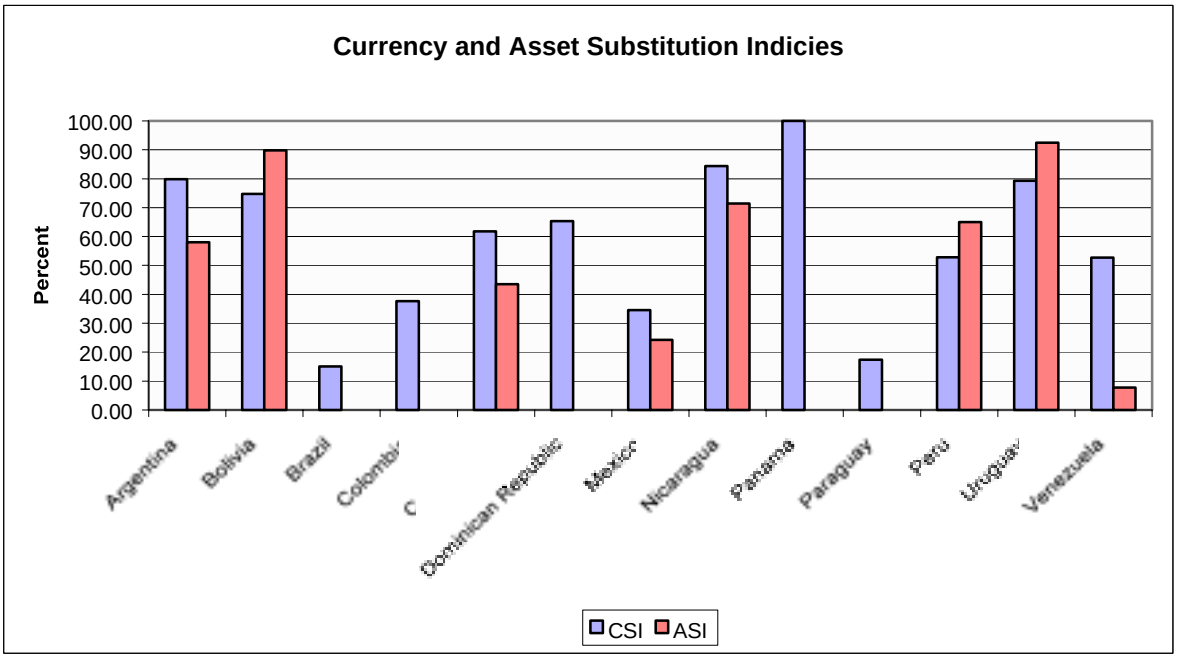


Figure 2 presents our estimates of the degree of currency substitution and asset substitution in Latin American countries. The figure reveals that the patterns of currency substitution and asset substitution are in fact quite different among the countries observed. Bolivia, Peru and Uruguay are notable because asset substitution dominates currency substitution, whereas the other countries display a pattern in which currency substitution dominates.

Network Externalities: Asset and Currency Substitution

Latin American hyperinflations and severe exchange rate depreciations dramatically reduce the rates of return on local domestic currency relative to U S dollars, inducing individuals to flee from weak currencies into stronger ones. Such shifts are initially motivated by asset substitution to avoid the costs of a depreciating store of value. However, currency also represents an important medium of exchange, and the extent of currency substitution depends upon the relative transaction costs of foreign and local currency. These relative transaction costs are, in turn, determined by the network externalities enjoyed by the users of each alternative medium of exchange and the costs of switching between them. For any expected rate of depreciation of the domestic currency, it is more likely that agents will substitute into a foreign currency if other agents already use it as a co-circulating medium of exchange in the domestic economy. When severe exchange rate depreciation induces unofficial dollarization, network externalities tend to reinforce the rewards of holding the stronger currency. Switching costs inhibit a return to the local currency even after a successful stabilization effort. These well know incentive effects give rise to the conjecture that once de facto dollarization has reached a threshold, it may well persist, leading to the observation of dollarization hysteresis.

These considerations have been formalized in the models presented by Farrell and Saloner (1986) and Dowd and Greenaway (1993). Building on these foundations, we consider (N+1) money-using agents with infinite life horizons. They make decisions on the use of currency in time T. Up to time T they used only local currency, but from T onwards they can also use a competing foreign currency. Agent's decisions concerning the use of local currency are based on the following utility function:

$$(12) \qquad u(T) = (a + bn) \int_{T}^{\infty} e^{-r(t-T)} dt = (a + bn)/r$$

where u(T) is utility in time T derived from using the local currency from time T to infinity; t ≥ T are time periods from now (T) onwards; r is the discount factor; n is log of N. If there are no network externalities, the parameter (a) reflects the redemption value of the local currency when no one else uses it, and bn (b>0) reflects the network externality benefit of others using the currency.

Similar logic applies to the utility of using a foreign currency with or without network externalities where an*, denotes values for the foreign currency. Hence, when all agents use local currency,

$$(13) \qquad u(T) = (a+bn)/r \text{ and } u^*(T) = a^*/r$$

Conversely, when all agents use competing foreign currency,

(14) $u(T) = a/r$ and $u^*(T) = (a^*+b^*n^*)/r$

All agents will hold local currency even if it is not used for transactions purposes (hypothetical absence of network externalities), if the utility from holding it for purposes other than settling payments is greater than the utility from using competing foreign currency when all agents are using it minus the cost (s) of switching between the two currencies. Hence all agents will use local currency when,

(15) $a/r > [(a^*+b^*n^*)/r] - s$

Conversely, all agents will switch to competing foreign currency if the utility from using it when no one else switches to its use is higher than the sum of utility derived from use of local currency when everybody uses it including switching costs, that is, when,

(16) $a^*/r > [(a+bn)/r] + s$

These corner solutions define the conditions under which agents use local currency exclusively or foreign currency exclusively. The more interesting intermediate cases consider the range of circumstances under which asset and currency and substitution behaviors induce both currencies to co-circulate simultaneously. These intermediate cases are indeterminate unless agents have a mechanism for determining the gains from asset substitution and a mechanism for forming expectations of whether other agents will switch to the competing currency. If agents knew the redemption values of the two currencies as well as the extent to which others are likely to switch, they would adopt the foreign currency when,

(17) $[(a^*+b^*n^*)/r] - s \geq [(a+bn)/r]$

that is, when the expected present value of asset substitution returns (represented by the parameter a*) and currency substitution returns (network externality returns represented by bn*) of the new currency, minus switching costs exceed the expected present value of asset and currency substitution returns to the local currency. The limitation of the Dowd-Greenaway model is that it provides no behavioral mechanism for trading off the utility derived from asset substitution with that of currency substitution. This requires additional relationships connecting the asset substitution parameters and the currency substitution parameters to observable variables.

Asset Substitution and the Exchange Rate

Recall that the asset substitution parameter (a) depends on the redemption value of the currency. We will assume that this redemption value depends positively upon the extent to which the broad domestic money supply is covered by international reserves that is, by the "coverage ratio", c. The coverage ratio, (expressed in local currency) is defined as,

(18) $c = e_{(BM)}R[BM]^{-1}$

and,

(19) $a = a(c),\ da/dc > 0,$

where R represents central bank's international reserves, e is nominal exchange rate of domestic currency vs. the foreign currency and BM is the domestic broad money supply (BM=LCC+LCD+LTD). As long as the coverage ratio (c) is high, the likelihood of asset substitution is low.

It is interesting to note how this ratio reacts to an exogenous monetary expansion. On one hand, expansionary monetary policy reduces the ratio (c) by increasing denominator of (18). On the other hand, expansionary monetary policy leads to exchange rate depreciation, which increases numerator. Since the asset substitution parameter (a) is a positive function of (c), the net effect of exogenous monetary expansion on the redemption value of the local currency is,

(20) $\partial a/\partial BM = a'_c c'_{BM} = a'_c[e'_{BM}(R/BM) - eR/(BM)^2]$

Equation (20) reveals that expansionary monetary policy has both positive and negative impacts on utility from the use of money, however the second term in the brackets converges to zero so the ratio (R/BM) dominates the outcome. The effect depends on the initial level of coverage i.e. redemption value (R/BM), on the sensitivity of the exchange rate to changes in domestic money supply (e'_{BM}), and on the level of the nominal exchange rate (e). After normalizing e and e'_{BM} to one, we see that the higher the initial coverage, the greater is the impact of domestic monetary expansion on the utility of holding domestic money. Next, higher exchange rate sensitivity increases the utility of holding domestic money (reduces likelihood of asset substitution) because, for a given expansion in BM, higher sensitivity means a greater coverage ratio (c) expressed in domestic currency. For plausible values of reserves, money and the exchange rate sensitivity, there is nothing in the mechanics of the asset substitution component of the model that can turn the utility of holding domestic money negative. Asset substitution will arise earlier if the initial coverage ratio (redemption value of the local currency) is lower, although higher exchange rate sensitivity to money supply can partly alleviate this impact.

Exchange Rate and Currency Substitution

Dowd and Greenaway (1993) showed that decision to switch to competing foreign currency depends on expectations about the behavior of other agents. Assume that agents will form expectations about how many other agents will switch on the basis of nominal exchange rate movements. When the exchange rate depreciates, agents expect the others to switch. Therefore,

(21) $n = n(e), dn/de < 0$

Combining, (13), (20) and (21), the utility function under which all agents use local currency is:

(22) $u(T) = [a_{(c)}c_{(BM))} + bn(e_{(BM)})]r^{-1}$

The consequences of a monetary expansion including both currency and asset substitution effects is now represented by,

(23) $\partial u/\partial BM = [\partial a/\partial BM + dn/dBM]r^{-1} = a'_c[e'_{LM}(R/BM) - eR/(BM)^2] + be'_{LM}n'_e \; r^{--11}$

$dn/dBM < 0$ because: $b>0$; $e'_{BM} > 0$; $n'_e < 0$.

Since the term added to (23) is negative, the conclusion is that the currency substitution effect shortens the period in which expansionary monetary policy can be effective (where effectiveness is measured by its impact on the utility from holding local currency).

Choice of Exchange Rate Regime

Equation (23) provides a formal elaboration of the choice of exchange rate regime on the desirability of dollarization. As long as $\partial u/\partial BM>0$, monetary expansion will not induce unofficial dollarization. However the sign of $\partial u/\partial BM$ is ambiguous, depending upon the sensitivity of the exchange rate to money, the extent to which broad money is covered by foreign reserves, the absolute level of the nominal exchange rate, and the sensitivity of the number of people using the currency to exchange rate changes. In these circumstances, policy makers must be concerned about the consequences of monetary expansion since they are liable to induce switching out of the local currency thereby making monetary expansion ineffective.

If the two sensitivities are high and the coverage ratio is low, policy makers need to consider that a prudent course of action may be to officially dollarize, that is, to either peg the exchange rate to the foreign currency or to adopt the competing currency as legal tender. Otherwise, unofficial dollarization may take its course, with an induced loss of seigniorage and reduced potency of any given monetary action. The costs of these hysteresis effects that

derive from network externalities increase as the de facto dollarization continues and may lead to an irreversibility that precludes a return to the use of domestic currency. In Latin America, with its legacy of high inflation and wage indexation, flexible exchange rate regimens may be unable to capture the potential benefits of monetary interventions. As real exchange rates become less responsive to monetary manipulation, the need for more extreme depreciations increases the dangers of extensive asset substitution.

Further Extensions of Network Externality Models

Oomes (2001) suggests an alternative means of characterizing the consequences of positive network externalities in the use of foreign currencies. Based on the discrete choice framework with social interactions developed by Brock and Durlauf (2001), Oomes demonstrates that network externalities in the demand for currency can explain the observed hysteresis in the unofficial dollarization observed in Russia.

Our extension of the Dowd–Greenaway model shows that network externalities are useful in specifying the determinants and dynamics of the currency substitution process, but it does not produce a readily testable empirical specification. An innovation of the Oomes' framework, is the derivation of a reduced form equation that can be directly estimated empirically and that can be used to explain the dynamics of the currency substitution process.[12]

The model belongs to the class of cash-in-advance models with random matching of buyers and sellers. Buyers and sellers have a choice of conducting a transaction in either domestic (m) or foreign currency (m*). Each agent that is a buyer in one period becomes a seller in the next. The decision problem faced by a given agent *i* is which currency to hold after receiving currency from a random buyer at the beginning of period t and before being matched with a random seller *j* at the end of period t. The currency choice of agent *i* in period *t* is denoted by $m_{i,t} \in \{m,m^*\}$.

The cost of holding domestic currency one period prior to the transaction is the depreciation of the domestic currency (e_t). There are also varieties of different costs associated with transacting in foreign currency. The first type of cost is the "shoe-leather cost" (σ_t), that is, the cost of searching for and transacting at an exchange office. This cost occurs only if there is a mismatch between the currency the buyer decides to hold and the currency choice of the seller. This type of cost can be classified as a transaction cost, or a switching cost in terms of the Dowd-Greenaway model. To the extent that these costs are

[12] The model does not however provide an unambiguous means of empirically discriminating between network externality effects and other potential causes of hysteresis.

used as an explanation for the hysteresis effect, the intuitions guiding the two models are similar.

Since the Oomes model was originally developed for the case of Russia, it also includes a second type of transaction or switching cost, that is, the explicit tax (τ) on the purchase of foreign currency, which was introduced in Russia in 1997. This cost is incurred only if the buyer holds domestic currency and the seller prefers to transact in foreign currency. Finally, there is a variable that captures the institutional barriers to the use of foreign currency for transaction purposes that can be interpreted as the probability of confiscation of the foreign currency involved in the transaction (q).[13] Depending on the actual preferences of the buyer and seller, the costs of alternative choices of agent *i* acting as a buyer conditional on the choice of seller *j* are summarized in Table 2:

Table 2: Cost Matrix for agent *i*. [14]

	$m_{j,t+1}=m$	$m_{j,t+1}=m^*$
$m_{i,t}=m$	e	$e + \sigma + \tau$
$m_{i,t}=m^*$	σ	q

The decision of the representative buyer to hold domestic or foreign currency will also depend on his expectations of sellers' preferences. If the probability, expected by *i*, that any random seller *j* prefers to hold foreign currency in period t+1 is denoted by $\hat{p}_{t+1}$, it can also be interpreted as the expected proportion of buyers holding foreign currency in that period, that is, $\hat{p}_{t+1}$ represents the dollarization ratio expected in period t+1.

The expected costs of holding domestic currency $c(m_t)$, and foreign currency $c(m_t^*)$ can then be derived from Table 2 where,

$$(24) \qquad c(m_t) = \left(1 - \hat{p}_{t+1}\right)\hat{e}_t + \hat{p}_{t+1}\left(\hat{e}_t + \hat{\sigma}_{t+1} + \hat{\tau}_{t+1}\right)$$

and

$$(25) \qquad c(m_t^*) = \left(1 - \hat{p}_{t+1}\right)\hat{\sigma}_{t+1} + \hat{p}_{t+1}\,\hat{q}_{t+1}$$

[13] Oomes assumes that transacting in dollars is illegal, and that the amount of the transaction, which is normalized to unity, can be confiscated with probability q, which then equals the expected total cost associated with confiscation risk.

[14] The explicit assumption made in the table is that the costs of transacting in the foreign currency (q) are smaller than the costs of the buyer and seller choosing to convert the currency twice ($2\sigma + \tau$), that is, that $q < 2\sigma + \tau$. This assumption is made so as to remove the indeterminacy associated with the question as to whether the buyer or the seller will bear the transaction costs.

where (^) denotes expectations. In order to close the model and introduce a stochastic element that allows for non-corner solutions, Oomes introduces the random utility terms $\varepsilon_{i,t}$ and $\varepsilon^*_{i,t}$ (or random disutility terms) that account for unobserved variables effecting the costs or benefits of holding domestic and foreign currency. If φ measures the impact of these terms on the expected total cost, the probability $p_{i,t}$ that a given agent *i* will hold foreign currency can be written as:

$$
\begin{aligned}
& p_{i,t} = \Pr\left\{c(m_t^*) + \varphi\varepsilon^*_{i,t} < c(m_t) + \varphi\varepsilon_{i,t}\right\} \\
(26) \quad & = \Pr\left\{\varepsilon^*_{i,t} - \varepsilon_{i,t} < \frac{1}{\varphi}\left[\hat{e}_t - \hat{\sigma}_{t+1} + \left(2\hat{\sigma}_{t+1} + \hat{\tau}_{t+1} - \hat{q}_{t+1}\right)\hat{p}_{t+1}\right]\right.
\end{aligned}
$$

The final reduced form for estimating the model is derived employing the following additional assumptions: 1) confiscation risk is assumed to be constant over the whole period, q_t=q; 2) the "shoe-leather" costs are assumed to decrease with the dollarization ratio because as dollarization increases, more exchange offices emerge: $\sigma_t=\gamma_1-\gamma_2 p_{t-1}$, where $\sigma_t > 1$; 3) agents expect the depreciation rate to remain the same with some probability α, but will equal the maximum past depreciation rate with probability (1-α). Thus, expectation formation is assumed to be a linear combination of perfect foresight and the ratchet effect (the maximum depreciation from the recent past).

$$
(27) \qquad \hat{e}_t = \alpha e_t + (1-\alpha)e_t^{\max}
$$

The structural form of the model is linearized by the means of the logarithmic transformation, and the final reduced form for the model can be written as:

$$
(28) \qquad \ln\left(\frac{1-p_t}{p_t}\right) = \frac{\gamma_1}{\varphi} - \frac{\alpha}{\varphi}e_t - \frac{1-\alpha}{\varphi}e_t^{\max} - \frac{2\gamma_1 + \gamma_2 + \tau - q}{\varphi}p_{t-1} + \frac{\gamma_2}{\varphi}p_{t-1}^2 + \xi_t
$$

and is estimated by OLS as:

$$
(29) \quad \ln\left(\frac{1-p_t}{p_t}\right) = \delta_0 + \delta_1\left(e_t - e_t^{\max}\right) + \delta_2 e_t^{\max} + \delta_3 p_{t-1} + \delta_4 p_{t-1}^2 + \xi_t
$$

where, $\delta_0 = \frac{\gamma_1}{\varphi}$; $\delta_1 = -\frac{\alpha}{\varphi}$; $\delta_2 = -\frac{1}{\varphi}$; $\delta_3 = -\frac{2\gamma_1 + \gamma_2 + \tau - q}{\varphi}$; $\delta_4 = \frac{2\gamma_2}{\varphi}$.

Empirical Evidence of Hysteresis and Irreversibility

The Latin American country that has the highest per capita holdings of US dollars is Argentina as evidenced by available CMIR data. Our new estimates of dollar holdings in Argentina permit us to test the currency substitution and "irreversibility hypothesis" directly, by estimating demand functions for the observed accumulation of dollar holdings in Argentina. Kamin and Ericsson (1993), indirectly examined currency substitution by estimating "the flip side of the demand for dollars: the demand for domestic currency assets".

Our first effort to model the Argentinean currency substitution phenomenon employs the familiar partial adjustment model applied to the dollarization index LUDI, logarithmically transformed so that the fitted dependent variable fall within the interval between 0 and 1.[15]

(32) LUDI = -Ln(1-UDI/UDI)

The explanatory variables of the dollarization process are those typically employed to specify the demand for money in situations where foreign currency and foreign currency deposits are available substitutes for domestic money. In particular, we employ as regressors the lagged value of the dependent variable, the expected depreciation of the exchange rate (dlex), a banking crisis dummy variable (crisis)[16] and a ratchet variable (Ratchet) to capture the hysteresis effects that have been observed in dollarized countries when network externalities produce incentives for the continued use of a foreign currency even after inflation or exchange depreciation effects have moderated. Specifically, the equation estimated for Argentina is:

(33) LUDI = c(1) + c(2)*LUDI(-1) + c(3)*dlex(+1) + c(4)*ratchet + c(5)*crisis

The ratchet variable takes the form of the highest previously attained rate of depreciation of the exchange rate.[17] The results of the OLS estimate obtained for Argentina are reported in Table 3. All of the coefficients have the expected signs and all are significant at the 5 percent level. Table 4 presents the corresponding long run estimate of the key coefficients of the model presented above.

[15] Mongardini and Mueller (1999) employ a similar model and the same transformation.
[16] Andy Berg of the IMF generously provided the bank crisis variable.
[17] A number of ratchet variables were tested including the past peak inflation rate, depreciation rate and currency substitution index. All were highly significant and the past peak depreciation rate was chosen to simplify the simulation.

Table 3

Regression Results –Argentina -1979-1998

	LUDI
const	-0.5839 (-4.1018)
LUDI(-1)	0.81197 (19.0302)
dlex(+1)	0.13781 (2.23524)
Ratchet	0.25687 (4.0945)
Crisis	1.67477 (4.56825)
R-squared	0.97744
Adjusted R-squared	0.97624
Durbin-Watson stat	2.51075

*t- statistics are reported in parentheses.

Table 4

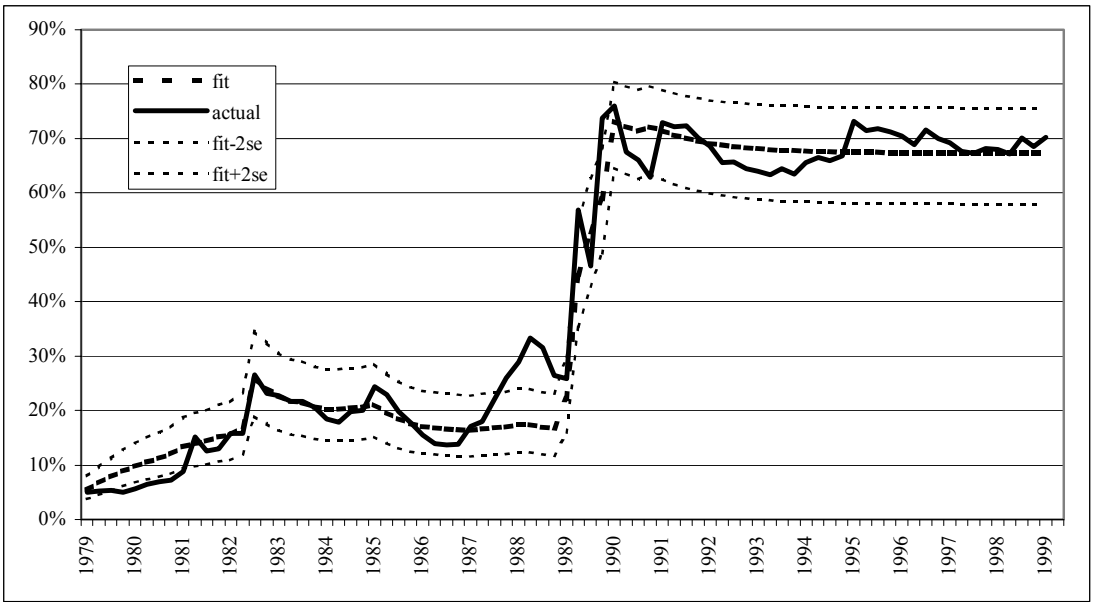
Estimated Long Run Coefficients

Dependent Variable	LUDI
dlex(+1)	0.73
Ratchet	1.37
Crisis	8.91

Figure 3 displays the actual and simulated values of UDI ratio for Argentina for the period 1978 – 1999 based on the estimated equation presented in Table 3. Figure 3 reveals that dollarization in Argentina began in the early 1980's and then accelerated dramatically during the period 1989-1990 as a result of a severe hyperinflation. Despite subsequent successful stabilization efforts, the unofficial dollarization index remained stubbornly around 70 percent. Argentina appears to represent an economy in which unofficial dollarization reached a threshold, after which, network externalities in the use of the foreign currency made the process of unofficial dollarization irreversible.

Figure 3

Actual and Simulated UDI for the Argentina



The Dynamics of Dollarization

Empirical estimation of the Oomes model presented above permits a more detailed examination of the dynamics of de facto dollarization. Assuming a zero tax rate, equation (29) was estimated for the Argentina data and the results are presented in Table 5 with the Goodness of Fit and Residual Tests presented in Table 6.

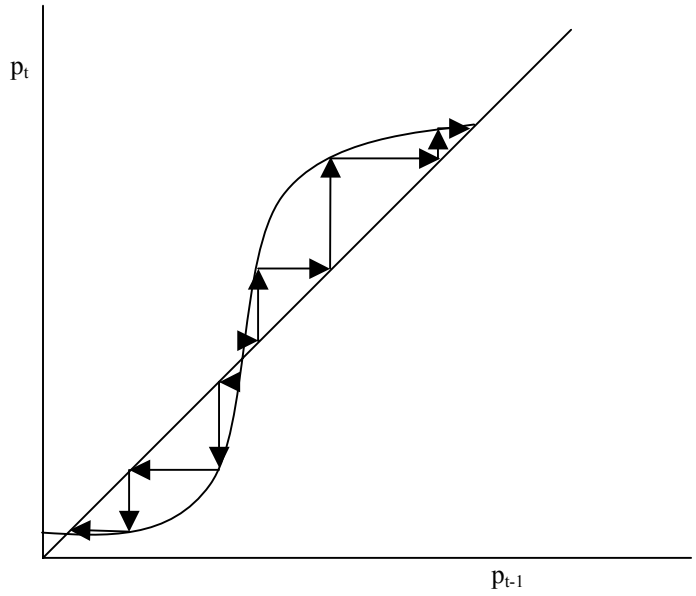
Table 5: **OLS Regression Estimates**

Variable	Coefficient	Std. Error	t-Statistic
δ_0	3.218	0.110	29.20
δ_1	-0.460	0.077	-5.96
δ_2	-0.539	0.084	-6.43
δ_3	-8.891	0.606	-14.67
δ_4	5.003	0.869	5.76

Table 6: Goodness of Fit and Residual Tests

R-squared	0.98	Adjusted R-squared	0.98
Jarque-Bera normality test	244.244	Probability	0.000
Serial correlation LM (4) test	2.814	Probability	0.031
Serial correlation LM (8) test	2.714	Probability	0.012
White heteroskedasticity test	32.183	Probability	0.000

Figure 4: Phase Diagram

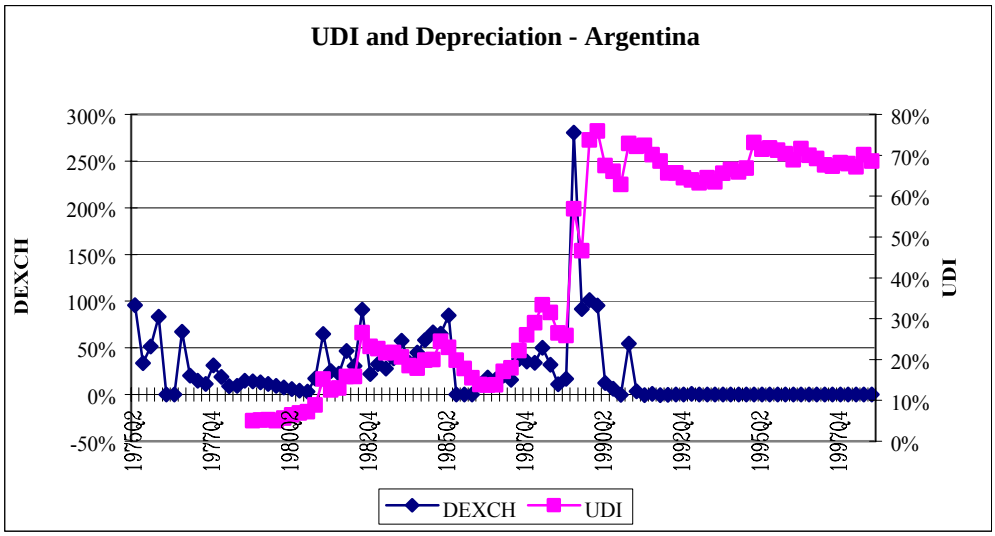


The dynamics of de facto dollarization can be illustrated with the use of the phase diagram derived from the estimated model. Figure 4 reveals that intersections of the 45^o line with a generic phase diagram (showing the structural dependence of this period's dollarization outcome on the outcome of the last period) represent possible equilibrium points. A stable equilibrium occurs when the phase diagram cuts the 45^o line from above and an unstable equilibrium occurs when the phase diagram intersects the 45^o line from below. The diagram indicates that stable steady states exist at either very low or very high dollarization ratios.

In order to explain the dynamic adjustment of the dollarization process in Argentina, Figure 5 displays the unofficial dollarization index and the exchange rate depreciation history. De facto dollarization of Argentina gained momentum during the early 1980's reaching approximately 25 percent but declined in the aftermath of the 1985 Austral Stabilization Plan. As depreciation rates rose once again, dollarization also increased, but this trend was again reversed in the immediate aftermath of the Primavera Plan instituted in August 1988. This experience suggests that there are conditions under which the dollarization process may be reversed. However, as depreciation rates began to rise once again, the dollarization process accelerated in the second quarter of 1989, and then exploded as a consequence of the huge depreciation that occurred in the last half of 1989. By the first quarter of 1990, the unofficial dollarization index reached a high of 76 percent with 90 percent of the value of the nation's currency supply held in the form of US dollars. Despite the success of the subsequent stabilization programs and the sustained period of exchange rate stability, the dollarization process was never reversed, giving rise to the fundamental question raised about the

Argentina experience, namely, how can one account for the persistence and apparent irreversibility of the dollarization process?

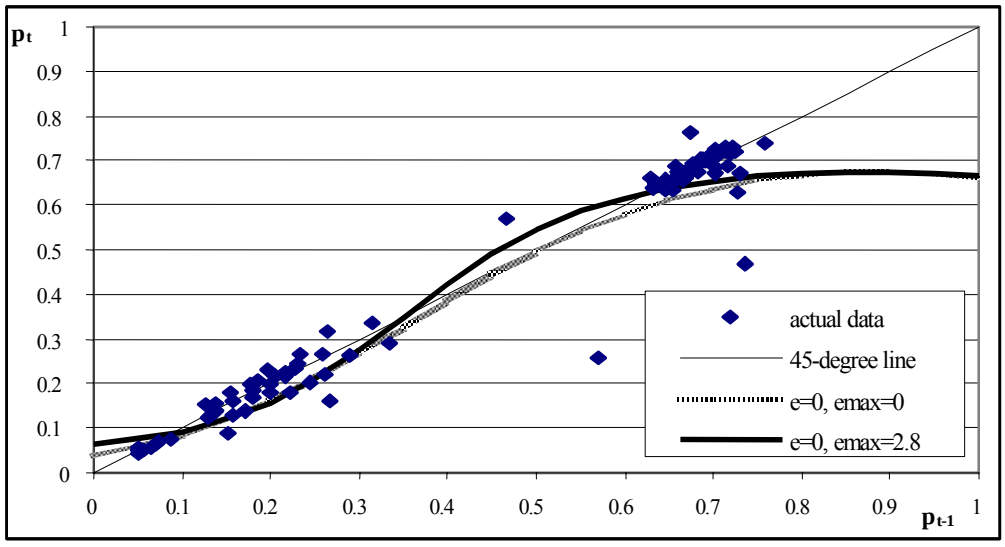
Figure 5: Dollarization and Exchange Rate Depreciation



The explanation offered here is the effect of network externalities. Once de facto dollarization had reached a particular threshold, the transactions costs of using dollars had fallen below the costs of switching back to the local currency. The dynamics of this process can be understood by examining the phase diagrams estimated for the above model.

Figure 6 displays two positions of the phase diagram derived from the estimates of equation (29).

Figure 6- Phase diagram before and after a hyperinflation episode.



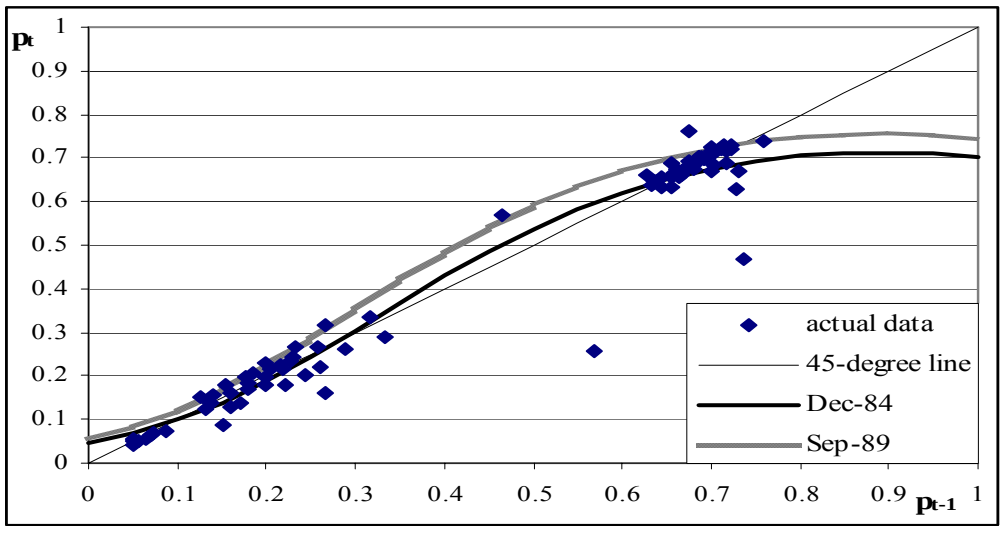
The lower curve's position is specified under the assumption of exchange rate stability and no previous inflationary experience. The equilibrium occurs at the low dollarization equilibrium,

which is a stable equilibrium. The higher curve is positioned so as to reflect exchange rate stability in the aftermath of the second quarter 1989 deflation experience where emax=2.8. Under these conditions the phase diagram intersects the 45^{o} line at the high equilibrium position, representing steady state equilibrium with the approximately 65 percent dollarization.

The dynamic adjustment to the high steady state equilibrium can be inferred from Figure 7, which presents the estimated phase diagram for two historic time periods, December 1984 and September 1989. For a sufficiently high depreciation rate, the lower and middle equilibria disappear and only the high dollarization steady state remains. The estimated functions for those periods reveal that the transition from the low to the high steady state occurred only in late 1989.

It appears that after the 1984 crisis, rapid stabilization reduced the rates of depreciation within two or three quarters, thereby preventing the full adjustment to the higher dollarization level. A similar process occurred in the immediate aftermath of the Primavera Plan. The model suggests that dollarization levels reached the unstable mid equilibrium from which they could still return toward the low stable equilibrium. However, with sufficiently high devaluation, the dollarization index jumped to the high stable equilibrium from which it has not retreated, despite the subsequent long-term stabilization.

Figure 7: **Phase Diagrams for Argentina: December 1984; September 1989**



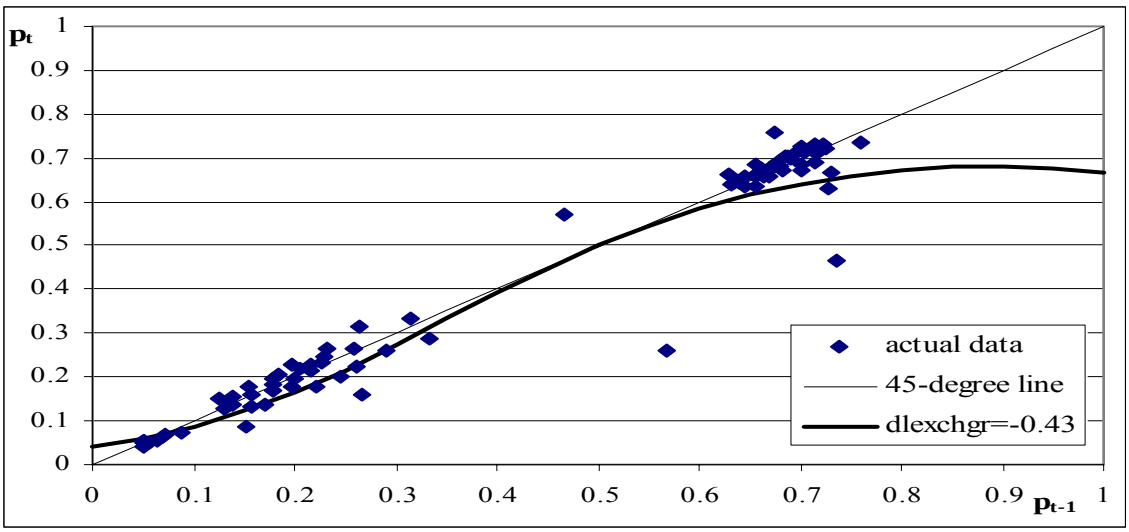
The structural parameters estimated from the model imply that $\alpha = \delta_1 / \delta_2 = .85$ suggesting that there is an .85 probability that any given agent correctly predicts the depreciation rate. The confiscation risk parameter q= .08 suggests that agents perceived that

holding dollars either in the form of cash or foreign currency deposits entailed a risk of eight percent that either their dollars may be counterfeit or their bank accounts might be confiscated. Although this estimated perceived risk premium appears very high, it has been justified by recent events in Argentina.

Irreversibility

A final issue that can be addressed by the estimated model is to inquire under what conditions, if any, would it be possible to reverse the de facto dollarization process? One way of reduce dollarization would be to appreciate the domestic currency. Appreciation would shift the phase diagram downwards until eventually; only one stable steady state would emerge, corresponding to the low dollarization equilibrium. However, the requisite downward shift in the phase diagram estimated for Argentina requires the exchange rate to appreciate by 35 percent. The impact of a 35 percent appreciation (given the present value of emax) producing the requisite downward shift is displayed in Figure 8. The appreciation would have to be sustained for a sufficiently long time so as to allow the actual level of dollarization to fall below the middle equilibrium, finally coming to rest at the low equilibrium steady state.

Figure 8: Necessary Condition for Dollarization Reversibility



Summary and Conclusions

This paper addresses the positive issue of determining the extent and implications of de facto dollarization in Latin America. In an effort to overcome the 'unobservability' problem that has plagued the currency substitution literature, we present direct estimates of the amounts of US dollar foreign currency in circulation in various Latin American countries.

Traditional measures of dollarization employed in earlier literature largely relied on foreign currency deposits as an indicator of currency substitution because actual measures of foreign currency in circulation were unavailable. Employing aggregated data derived from Currency and Monetary Instrument Reports on dollars inflows and outflows to and from the US, we estimate the amounts of US dollars in circulation in various Latin American countries. These new estimates of the location of US currency held overseas permit a refinement of definitions and indicators of currency and asset substitution as well as the development of more accurate indices of the extent of unofficial dollarization. We find that traditional measures of dollarization tend to be indicative of asset substitution but perform poorly as measures of currency substitution.

Argentina appears to be the Latin American country with the highest level of de facto dollarization. Moreover, we find that Argentina's residents have maintained high levels of dollar holdings despite almost a decade of successful stabilization efforts. Argentina therefore represents a classic case of hysteresis, suggesting that once a threshold level of dollarization is attained, it may be maintained, producing what is known as dollarization "irreversibility". In order to explain this phenomenon, we present models of network externalities, which suggest that transaction costs associated with dollar usage fall sufficiently beyond some threshold usage of dollars so that switching back to the domestic currency becomes prohibitively expensive.

Estimates of the network externality model reveal that the threshold level of dollarization appears to be in the neighborhood of 35 percent. The dynamics of the model reveals that stable steady states exist at both low and high dollarization levels. The intermediate equilibrium is unstable, suggesting that de facto dollarization can take place rapidly in the aftermath of a monetary crisis, and once attained may be very difficult to reverse. Interestingly, the model also estimates that the perceived risk of confiscation in Argentina remained high, despite a prolonged period of economic stability. This perception has been borne out by the most recent financial and banking crisis in Argentina.

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