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WORKING PAPER NO. 97-21

DOLLARIZATION HYSTERESIS AND NETWORK EXTERNALITIES: THEORY AND EVIDENCE FROM AN INFORMAL BOLIVIAN CREDIT MARKET

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Abstract

This paper considers network externalities from currency acceptability as a determinant of observed persistence of dollarization in Latin American countries. A model with efficiencies from establishing a network of currency users is constructed. Model implications are then tested using a unique data set of daily loan records from an informal Bolivian credit market. Empirical results are consistent with dollarization hysteresis being driven by network externalities from currency adoption. The results also imply that credible exchange rate stabilization policy alone is not sufficient to achieve dollarization reversal.

JEL F31, F41, E41.

The U.S. dollar has become a primary instrument for saving and transactions in many Latin American countries. This "dollarization" has been a result of political instability and the debt crisis of the early 1980s. Money-financed deficits generated spiraling inflation, loss of confidence in domestic money, and shifts to the relatively stable purchasing power of the U.S. dollar. To reverse dollarization, standard models of exchange- or money- based stabilizations call for macroeconomic reforms. As in the models reviewed in Calvo and Vegh (1990), credible policy to reduce inflation leads to shifts back from dollars to domestic currency.

Experiences of several Latin American countries show that policy credibility alone may not be sufficient for dedollarization. For example, while Argentina, Bolivia, and Peru contained hyperinflations in the mid-1980s, the ratio of dollar to domestic bank deposits, a crude proxy for dollarization, has not declined significantly in these countries. In Bolivia there has been an *increase* in the proxy measure following successful monetary and fiscal reforms in 1985. As shown in Table 1, foreign currency deposits as a percentage of domestic M2 rose from 35 percent in 1986 to 63 percent in 1991.

Of course, true dollar circulation is unobservable, and deposit data measure dollarization only partially. For Bolivia, an alternative to deposit data as a dollarization measure is provided by loan data from informal credit markets. The informal loans, as outlined in Melvin and Ladman (1991) and Melvin and Fenske (1992), are made in competitive and unregulated markets, which frees the loan data from government-induced biases that plague traditional deposit-based dollarization measures. Such biases arise from official investment constraints and foreign exchange confiscations that distort bank deposit measures to a greater degree than informal and unregulated loans. For Bolivia, as with the deposit-based dollarization proxy, informal loan data point to *increased* dollarization following successful policy reforms. Table 1 shows an increase in loan dollarization from 47 percent in 1985 to 84 percent in 1987. At least for policymakers interested in autonomy, it is of interest to determine factors that inhibit returns to domestic currency use following successful stabilizations.

Kamin and Ericsson (1993), in the first extensive empirical study of currency hysteresis, consider macroeconomic factors, such as domestic inflation, that reflect policy. They find, for example, that the maximum past domestic inflation rate for a dollarized country has a statistically significant "ratchet" effect on dollarization. The larger is maximum past inflation, the more likely it is for dollarization to persist. It remains of interest to determine the underlying factors that give rise to such ratcheting. Factors receiving recent theoretical attention are transaction costs and financial adaptation. Guidotti and Rodriguez (1991), for example, construct a transaction cost model with a neutral band for inflation, within which there is no incentive to dedollarize. Switching back to domestic currency following dollarization will occur only if domestic inflation is low enough to overcome a transaction cost differential between use of dollars versus the domestic currency. Sturzenegger (1992) extends the theory by emphasizing scale economies and financial adaptation as forces behind hysteresis effects driven by transactions costs. This paper follows the recent line of transaction cost explanations of dollarization and hysteresis by constructing a transaction cost model with network externalities associated with currency use. Implications of the model are analyzed using data from informal Bolivian markets for dollar and domestic currency loans along with measures of currency network effects.

Section I of the paper presents a transaction cost model of dollarization and empirically tractable implications for decisions to borrow and lend in dollars versus domestic currency.

Section II discusses the informal Bolivian loan market. Section III applies a structural probit estimation procedure to the data. Section IV provides quantitative results. Section V concludes.

I. A transaction cost model of a dollarized economy

Consider a model with a single good and identical multi-member households, each consisting of a financial intermediary, goods seller, and shopper. Each period, shoppers buy goods from sellers using domestic currency (Bolivian in our case) and foreign currency (U.S. dollars) obtained by borrowing from intermediaries. For convenience, Table 2 lists and describes variables used in the model. We use * superscripts to denote variables denominated in dollars. Lower case household decision variables represent quantities demanded while upper case represents quantities supplied. We proceed by describing specific trading opportunities facing the intermediary, seller, and shopper members of a typical household.

I.A. Intermediary

At nominal exchange rate e_t the intermediary divides the household's beginning of period nominal wealth according to:

$$M_t + e_t M^*_t = L_t + e_t L^*_t \qquad \text{<1>}$$

L_t and L^*_t are the domestic and dollar loans made available by the intermediary to shoppers at going interest rates R_t and R^*_t.[1] The intermediary is assumed to incur real transaction costs in making loans. These costs take the form: $\Psi^L(L_t/P_t, T^s_t, POL_t)$ for Bolivian currency loans; and $\Psi^{L*}(L^*_t/P^*_t, T^s_t, POL_t)$ for dollar loans. Transaction costs are increasing in real loan supplies, i.e. $\Psi^L_1>0$, $\Psi^{L*}_1>0$.

T^s_t represents an index of factors that reduce (increase) the marginal transaction cost of lending an extra dollar (Bolivian currency unit), i.e. $\Psi^L_{1,2} \geq 0$, $\Psi^{L*}_{1,2} \leq 0$.[2] We take these factors that influence loan supply costs to arise from externalities present from a network of agents who use dollars in financial markets. If, for example, the partial derivatives of the transaction cost functions just identified are both nonzero, a network of dollar users increases the marginal cost of lending Bolivian currency and decreases the marginal cost of lending dollars. Externality effects from a currency network can be gauged empirically by a number of factors which we discuss in section IV. Note that the loan supply-side factors captured by T^s_t may include variables with inertia, which can generate hysteresis effects of dollar usage.

POL_t in the intermediary's cost functions represents an index of Bolivian policy credibility that can influence transactions costs independently from network externality effects. We assume that low credibility reduces (increases) the marginal transactions cost of making dollar (Bolivian currency) loans, i.e. an increase in POL_t is taken to capture a decline in domestic policy credibility and $\Psi^L_{1,3} > 0$, $\Psi^{L*}_{1,3} < 0$.

I.B. Goods seller

A household's goods seller receives an endowment of Y^T_t units of the good and allocates it according to:

$$Y^T_t = Y_t + Y^*_t \qquad \text{<2>}$$

with Y_t (Y^*_t) being sold in the domestic market at domestic currency (dollar) price P_t (P^*_t). For simplicity, we assume the firm does not engage in international trade.

I.C. Shopper

Prior to purchasing goods, a household's shopper borrows l_t (l^*_t) units of domestic currency (dollars) from an intermediary. The domestic balance is used to purchase C_t units of the good at Bolivian currency price P_t. The dollar balance is used to purchase C^*_t units of the good at dollar price P^*_t. In transacting, the shopper incurs the following real transaction costs: $\Psi^C(C_t, l_t/P_t, T^d_t, POL_t)$ for Bolivian currency purchases; and $\Psi^{C*}(C^*_t, l^*_t/P^*_t, T^d_t, POL_t)$ for dollar purchases. The shopper's costs are increasing in volumes of transactions, i.e., $\Psi^C_1>0$, $\Psi^{C*}_1>0$, and decreasing in real balances used to execute a given volume of transactions, i.e., $\Psi^C_2<0$, $\Psi^{C*}_2<0$.

The shopper's costs also depend on currency network externalities from dollar usage. These factors, present here on the demand side of the loan market, are represented by T^d_t. We assume that $\Psi^C_{2,3}\geq0$ and $\Psi^{C*}_{2,3}<0$, so that as T^d_t increases, the increased experience with and adaptation to dollar-denominated transactions will increase consumer benefits by reducing the marginal cost of borrowing and spending dollars. Section IV describes empirical proxies that we use to capture the demand side externality effects.

As with the intermediary, policy credibility enters as POL_t in shoppers' transactions cost functions. We specify that the marginal cost of borrowing in Bolivian currency (dollars) rises (falls or is unchanged), the lower is Bolivian policy credibility, i.e., an increase in POL_t is taken to capture a decline in domestic policy credibility and $\Psi^C_{2,4}>0$, $\Psi^{C*}_{2,4}\leq0$.

I.D. Household budget and choice problem

At the end of each period, household members settle all repayments and regroup to consume goods. A goods seller returns home with Bolivian currency (dollar) receipts P_tY_t ($P^*_tY^*_t$). The shopper brings home l_t-$P_t(C_t+\Psi^C(t))$-$(1+R_t)l_t$ in domestic currency and l^*_t-$P^*_t(C^*_t+\Psi^{C*}(t))$-$(1+R^*_t)l^*_t$ dollars. The intermediary brings home proceeds from extending Bolivian and dollar loans, net of transaction costs. If we add cash positions of all household members, end-of-period domestic and dollar cash balances are:

$$M_{t+1}=(1+R_t)L_t-P_t\Psi^L(t)+P_tY_t+l_t-P_t[C_t+\Psi^C(t)]-(1+R_t)l_t \qquad \text{<3>}$$

$$M^*_{t+1}=(1+R^*_t)L^*_t-P^*_t\Psi^{L^*}(t)+P^*_tY^*_t+l^*_t-P^*_t[C^*_t+\Psi^{C^*}(t)]-(1+R^*_t)l^*_t \qquad \text{<4>}$$

The household orders consumption sequences according to utility measure $U=E_t\Sigma^{\infty}_{0}\beta^j\mu(C_t , C^*_t)$, where E_t is an expectation conditioned on information dated t and earlier. Given beginning money balances M_t and M^*_t, the household maximizes utility subject to <1>-<4> by choosing sequences of consumptions, supply quantities for the seller, and loan balances taking prices, interest rates, exchange rates, and factors T^d_t , T^s_t , POL_t as given. Optimality conditions associated with a typical household's problem include:

$$R_t = \Psi^C{}_2(C_t , l_t/P_t , T^d_t , POL_t) \qquad \text{<5>}$$

$$R^*_t = \Psi^{C*}(C^*_t , l^*_t/P^*_t , T^d_t , POL_t) \qquad \text{<6>}$$

$$E_t(e_t/e_{t+1}) = [1+R^*_t- \Psi^{L*}{}_1(L^*_t/P^*_t , T^s_t , POL_t)]/[1+R_t -\Psi^L{}_1(L_t/P_t , T^s_t ,POL_t)] \qquad \text{<7>}$$

Conditions <5> and <6> indicate that the shopper borrows up to where the marginal transaction value of each currency equals the marginal interest cost. Condition <7>, associated with the intermediary's loan supply, gives interest rate parity in the presence of transactions cost effects. To arrive at relations suitable for estimation, we assume the following cost functional forms:

$$\Psi^C = (C_t)^{\alpha1} (l_t/P_t)^{-\alpha2}(T^e_t)^{-\alpha3}(POL_t)^{-\alpha4} \qquad \text{<8>}$$

$$\Psi^{C*} = (C^*_t)^{\beta1}(l^*_t/P^*_t)^{-\beta2}(T^d_t)^{\beta3}(POL_t)^{\beta4} \qquad \text{<9>}$$

where $\alpha i>0$ for i=1,2,4; $\beta i>0$ for i=1,2,3; $\alpha 3\geq 0$; and $\beta 4\geq 0$. Substituting the relevant derivatives of

<8> and <9> into <5> and <6> gives loan demands:

$$\left(\frac{l_t}{P_t}\right)=\left[\frac{\alpha 2(C_t)^{\alpha 1}}{R_t(T_t^{\,d})^{\alpha 3}(POL_t)^{\alpha 4}}\right]^{\frac{1}{\alpha 2+1}}$$ <10>

$$\left(\frac{l_t^{\,*}}{P_t^{\,*}}\right)=\left[\frac{\beta 2(C_t^{\,*})^{\beta 1}(T_t^{\,d})^{\beta 3}(POL_t)^{\beta 4}}{R_t^{\,*}}\right]^{\frac{1}{\beta 2+1}}$$ <11>

Bolivian currency (dollar) loan demand is decreasing (increasing) in externality index T^d_t, and is negatively related to the cost of borrowing R_t (R^*_t).

Similarly, we specify the intermediary's transaction cost functions as:

$$\Psi^L = (L_t/P_t)^{\gamma 1}(T^s_t)^{\gamma 2}(POL_t)^{\gamma 3}$$ <12>

$$\Psi^{L*} = (L^*_t/P^*_t)^{\delta 1}(T^s_t)^{-\delta 2}(POL_t)^{-\delta 3}$$ <13>

where $\gamma i>0$ for i=1,3; $\delta i>0$ for i=1,2; $\gamma 2\geq 0$; and $\delta 3\geq 0$. Differentiating and substituting the results into <7> gives dollar loan supply:

$$\frac{L_t^{\,*}}{P_t^{\,*}}=\left(\left[\frac{(T_t^{\,s})^{\delta 2}(POL_t)^{\delta 3}}{\delta 1}\right]\left[1+R_t^{\,*}-E_t\left(\frac{e_t}{e_{t+1}}\right)\right]\left[1+R_t-\delta 1(l_t/P_t)^{\delta 1-1}(T_t^{\,s})^{\delta 2}(POL_t)^{\delta 3}\right]\right)^{\frac{1}{\delta 1-1}}$$ <14>

Given (l_t/P_t), <14> implies that the dollar loan supply is increasing (decreasing) in the dollar (Bolivian) interest rate R^*_t (R_t). Dollar loan supply also is positively related to expected exchange rate depreciation, supply externality index T^s_t, and policy credibility index POL_t.[3]

I.E. Reduced-form loan equation implied by the theory

An empirically tractable loan market relation can be derived from linearizing <14> and imposing loan market equilibrium conditions. Substituting (l_t/P_t) from <10> for (L_t/P_t) in <14> to impose domestic currency loan equilibrium gives relations of the form:

$$(l^*_t/P^*_t) = f(\underset{+}{R^*_t},\ \underset{-}{R_t},\ \underset{+}{E_t(e_{t+1}/e_t)},\ \underset{+}{T^d_t},\ \underset{+}{T_t},\ \underset{-}{C},\ \underset{+}{POL_t})$$

$$(L^*_t/P^*_t) = g(\underset{-}{R^*_t},\ \underset{+}{T^d_t},\ \underset{+}{C^*_t},\ \underset{+}{POL_t})$$

where signs of the partial derivatives are shown below each variable.

To proceed toward estimation, the functional relations governing dollar loan supply (L^*_t/P^*_t) and demand (l^*_t/P^*_t) can be summarized by two linear regressions:

$$\left(\frac{l_t^*}{P_t^*}\right) = a_0^l + a_1^l R_t^* - a_2^l R_t + a_3^l E_t\left(\frac{e_{t+1}}{e_t}\right) + a_4^l T_t^d + a_5^l T_t^s - a_6^l C_t + a_7^l POL_t$$

$$\left(\frac{L_t^*}{P_t^*}\right) = a_0^L - a_1^L R_t^* + a_2^L T_t^d + a_3^L C_t^* + a_4^L POL_t$$

Combining the above regression equations gives the following reduced-form relations:

$$\frac{l_t^*}{P_t^*} = \frac{L_t^*}{P_t^*} = b_0 - b_1 R_t + b_2 E_t\left(\frac{e_{t+1}}{e_t}\right) + b_3 T_t^d + b_4 T_t^s + b_5 POL_t - b_6 C_t + b_7 C_t^*; \qquad \text{<15>}$$

$$pr(L_t^*) = f(\underset{+}{R_t},\ \underset{+}{E_t\left(\frac{e_{t+1}}{e_t}\right)},\ \underset{+}{T_t^d},\ \underset{+}{T_t^s},\ \underset{-}{POL_t}); \qquad \text{<16>}$$

where

$$b_0 = A(a_0^l a_1^L + a_1^l a_0^L);\ b_1 = A(a_2^l a_1^L);\ b_2 = A(a_3^l a_1^L);\ b_3 = A(a_1^l a_2^L + a_4^l a_1^L);\ b_4 = A(a_5^l a_1^L);$$
$$b_5 = A(a_1^l a_4^L + a_7^l a_1^L);\ b_6 = A(a_6^l a_1^L);\ b_7 = A(a_1^l a_3^L);\ A = (a_1^l + a_1^L)$$

Equation <15> provides direction for the empirical modeling of Bolivian loan dollarization. According to <15>, dollar loans increase with a decrease in the Bolivian currency denominated interest rate R_t; an increase in expected Bolivian currency depreciation $E_t(e_{t+1}/e_t)$; a rise in dollar networking factors T^d_t and T^s_t; and a deterioration in Bolivian policy credibility POL_t.[4]

II. Data issues

Agricultural areas in Bolivia have active informal loan markets together with underdeveloped formal financial markets. Data on loans in informal markets are available from records kept by local claims judges. We employ such data here, which were collected in a USAID study by Ladman and Luna (1988). Generally, loans in the informal market are from individual to individual and are denominated in either Bolivian currency or U.S. dollars.[5] Lenders demand registration of loans with claims judges so that legal documentation exists for collection purposes. Hence, one can expect the loan records to adequately represent actual lending practices. The data that we employ are a set of daily loan records for three towns in the Bolivian Upper Cochabamba region. The complete data set contains 8,284 observations from loan records dating January 1, 1980, through July 15, 1987. We exclude, however, loan records from November 1982 through September 1985 when dollar-denominated contracts were illegal.

To account for factors that influence the choice of currency in a loan, dollarization implications of equation <15> will be cast in terms of a binary choice problem of which currency to use in a loan. Our empirical treatment is to regress the probability of a dollar-denominated loan on variables expected to impact the probability in the same fashion as the explanatory factors for loan choices indicated by <15>. Straightforward probit analysis is not allowed by our data, however, because of the sample selection bias that, whenever a loan is observed in the data, only the interest rate relevant for that particular currency loan is recorded. In the case of a dollar-denominated loan, for example, the related Bolivian currency interest rate prevailing at the time of the loan is not observed. To account for this latent variable, a three-step estimation procedure of Lee (1979) is applied. Lee's procedure supplies consistent estimates of unobserved interest rates.

III. Structural probit analysis

To cast implications from equation <15> into an empirical currency choice setting we record the dependent variable in <15> as $CURR^{DOL}_t=1$ if a loan is denominated in dollars and $CURR^{DOL}_t=0$ otherwise. The structural probit that we estimate, based on <15>, takes the form:

$$\begin{aligned} &PROB(CURR_t^{DOL}) = C_0 + C_1 RBOL^*_t + C_2 DEX_t + C_3 T_t^d + C_4 T_t^s + C_5 POLICY_t \\ &+ C_6 REFORM85_t + C_7 DUMWIN_t + C_8 DUMSPR_t + C_9 DUMSUM_t \end{aligned} \qquad \langle 17 \rangle$$

$RBOL^*$ represents an *estimate* of the Bolivian interest rate in the informal loan market, obtained from Lee's procedure as outlined in the Appendix. DEX is the expected depreciation rate as measured by the realized monthly percentage change in the informal market exchange rate. T^d and T^s are exogenous domestic factors that reflect network externalities from dollar acceptability.

To capture loan-demand side externality factors in T^d we use the following proxies:

CUMLOANS:Cumulative daily dollar to total number of loans recorded in the informal market up to but excluding time t.

CUMVALUE: Cumulative daily dollar to total value of loans recorded up to but excluding time t. The share of prior loans denominated in dollars is taken to serve as a gauge for positive effects on dollar-loan demand of a growing dollar-user network.

To capture loan supply-side externality factors in T^s we use the following proxies:

EXSPREAD: Differential between the black market and official Bolivian currency to dollar exchange rate.

BANKSPREAD: Percentage spread of the average lending over borrowing rate on domestic currency loans in the official Bolivian banking system.

Supply-side network effects from dollar usage, T^s, identify an increased (decreased) incentive for lenders to offer dollar-denominated (Bolivian currency) financial instruments in the informal banking sector. The greater the misalignment of the official exchange rate, i.e., the larger EXSPREAD, the greater the lenders' profit potential from supplying dollars informally. Similarly, the larger the financial risk of Bolivian currency loans in the official banking sector, the greater the propensity for dollar lending in the informal market.

To isolate hysteresis effects on dollarization that are associated with lack of domestic policy credibility from effects associated with network externalities, we include POLICY proxies in <16>. Five POLICY proxies are considered:

BOLINFLVOL: Realized monthly volatility in the Bolivian inflation rate as measured by the consumer price index.

BOLDEPVOL: Realized monthly volatility in the black market depreciation rate.

INFMAX: Past maximum Bolivian inflation rate.

INFVOLMAX: Past maximum Bolivian inflation volatility.

DEPVOLMAX: Past maximum parallel market depreciation volatility.

The first two of the POLICY proxies are used to capture negative monetary policy expectations. The remaining three proxies are “ratchet variables” to capture learning or expectations adjustment periods before domestic agents become convinced that current macroeconomic stability has permanence and inflationary policies will not be repeated. Persistence in agents’ negative policy outlooks can introduce ratchet effects, as in Kamin and Ericsson (1993).

Regression equation <17> also contains dummy variables. REFORM85 captures the Bolivian stabilization policy announced in August 1985 and accounts for the break in the data set. It is set to zero until October 1, 1985 (the first observation following legalization of dollar holdings) and is one thereafter. Dummies are also included for seasonal lending patterns in the largely agricultural Cochabamba region. The harvest period is in the South American fall (March, April, May) and is captured by the constant term. DUMWIN is set to one if a loan occurred in June, July, or August; DUMSPR is one if a loan was in September, October, or November; and DUMSUM is one for loans in December, January, or February.

IV. Probit results

Results from estimating the structural probit in <17> are shown in Tables 3 to 6. To avoid multicollinearity, only one demand-side (T^d_t) and one supply-side (T^s_t) externality proxy is introduced at a time. Two procedures for proxying lack of policy credibility are considered. Initially, only ratchet effects are included in the estimation. Since the ratchet variables INFMAX, INFVOLMAX, and DEPVOLMAX attain maximum values at the time when the break in the data occurs (October 1985) and become constants thereafter, REFORM85 is omitted from the regression. Because of their correlation with REFORM85, however, the ratchet variables may not appropriately reflect underlying rigidities in policy credibility. Thus, a second procedure is employed in which REFORM85 is paired with each of the policy credibility variables BOLINFVOL and BOLDEPVOL. Since the credibility variables are continuous series whose values fluctuate over the entire sample period, this second procedure ensures that the lack-of-credibility effects are clearly isolated from effects associated with the sample break.

The estimation results support implications of the theoretical model. Coefficients in the structural equation generally exhibit the theoretically correct signs and are statistically significant. Based on the likelihood ratio test statistics and the percentage of correct 0-1 predictions, the empirical model provides a good fit. According to the empirical results for equation <16>, the probability of a dollar-denominated loan falls significantly with a higher Bolivian interest rate estimate, and there is generally a positive association with the depreciation rate of the domestic currency against the dollar. Also, as the theory predicts, the probability of a dollar loan rises significantly when there is an increase in the network externality variables. Both the T^d_t and T^s_t proxies exhibit statistically significant positive effects on dollarization. This result is robust to the inclusion of different proxies capturing lack of policy credibility.

Considered individually, the ratchet variables raise the probability of a dollar-denominated loan. However, in estimations not reported here it was found that INFMAX, INFVOLMAX, and DEPVOLMAX become insignificant when included with REFORM85 in the same regression. This implies that the ratchet variables may capture more than just lack of policy credibility. They also proxy for the break in the data and, specifically, legalization of dollar contracts after the hyperinflation. To deal with the problem, as identified earlier, REFORM85 is included separately in the regression. Its highly significant positive estimate captures the data break, while macroeconomic policy changes enter separately through BOLINFVOL and BOLDEPVOL. In line with the theory, the results indicate that the larger the monthly inflation and depreciation volatility, the greater the uncertainty about Bolivian macroeconomic policy and, hence, the more likely a switch to dollar loans.

The results also identify seasonalities in the pattern of dollar relative to Bolivian currency loans. Loans made in the South American fall, the main harvest season, are reflected in the constant term. The three dummies for other seasons exhibit negative coefficients, although only DUMSPR is statistically significant. So, relative to the fall season, the probability of a dollar loan is lowest in the South American spring. Winter and summer seasons do not significantly alter the probability of a dollar loan, as observed for the main harvest period.

V. Simulation

Since probit is nonlinear, coefficient estimates do not constitute relevant partial derivatives. Instead, the results must be interpreted at particular values for the independent variables. A common approach is to evaluate probabilities at sample means for all variables that simply serve as controls and to compute effects of a one-standard-deviation increase in a variable of interest. This approach is used in Table 7 to gauge the relative importance of network externality and policy credibility proxies on dollarization. $RBOL^*$, DEX, REFORM85 and seasonal dummies are set at their mean values. Eight simulation results are presented.

Note in Table 7 that the base probability of a dollar loan is higher when the official domestic interest rate differential (BANKSPREAD) is included--panels C and D--than when the Bolivian exchange rate spread (EXSPREAD) is included as a T^s proxy--panels A and B. For instance, by introducing CUMLOANS, BOLINFVOL, and EXSPREAD in the same regression, the sample mean probability of a dollar loan is .6406 as shown in column 1 of panel A. This value rises to .7123 when EXSPREAD is replaced by BANKSPREAD as shown in column 1 of panel C. Similarly, when CUMLOANS and BOLDEPVOL are combined with EXSPREAD and BANKSPREAD, the probability estimates are .5793 and .7291, respectively (third row of column 1, panels A and C).

There is only a slight mean probability difference when CUMLOANS is replaced by CUMVALUE as a demand-side externality proxy. For instance, a combination of CUMVALUE, BOLDEPVOL, and BANKSPREAD produces a probability estimate of .7157 as opposed to .7291 when CUMLOANS is employed (third row of column 1, panels C and D). The largest difference arises in a pairing with EXSPREAD and BOLDEPVOL where, using CUMLOANS, the probability of a dollar loan is .5793 versus .4960 by including CUMVALUE (third row of column 1, panels A and B).

The economic significance of the network externality proxies is seen by calculating probability changes associated with a one-standard-deviation increase in the respective variables. The largest economic impact is from changes in the demand-side proxies. For example, when CUMVALUE, EXSPREAD, and BOLDEPVOL are combined and the cumulative dollar to total loan value increases by one standard deviation, the probability of a dollar-denominated loan rises from .4960 to .5714 (third row of columns 1 and 2, panel B). This probability increase of 7.5 percentage points indicates that CUMVALUE has a significant economic effect on dollarization.

The effect is still positive but somewhat smaller when Bolivian inflation volatility, BOLINFVOL, replaces Bolivian depreciation volatility, BOLDEPVOL, as a policy proxy (first row of columns 1 and 2, panel B) and when CUMLOAN replaces CUMVALUE (first row of columns 1 and 2, panel A).

On the loan supply side, externality effects reflected in changes in the Bolivian bank interest spread have the weakest impact on changes in dollarization. Combining BANKSPREAD with CUMLOANS, the probability of a dollar loan rises by 1 (1.6) percent when BOLINFVOL (BOLDEPVOL) is included and BANKSPREAD increases by one standard deviation (rows 1 and 3, panel C). With the same grouping, but with BANKSPREAD replaced by EXSPREAD, a one-standard-deviation increase in the exchange rate differential is associated with a probability increase of 3 (2.3) percentage points (rows 1 and 3, panel A).

Turning to an isolation of policy effects, note that adjustments in the policy credibility proxies, BOLINFVOL and BOLDEPVOL, do not significantly influence the probability of a dollar loan. When combining CUMVALUE and EXSPREAD, for example, a one-standard-deviation increase in Bolivian inflation volatility (depreciation volatility) raises the probability of a dollar loan by 3.3 (2.4) percent (column 1, panels A and B). The probability increase declines to about 2 percent when EXSPREAD is replaced by BANKSPREAD (column 1, panels C and D). Hence, drastic reductions in inflation variability or depreciation variability would be necessary before any economically significant decline in dollarization is observed.

These results indicate that once externality effects from dollar usage are in place, it is difficult for policymakers to achieve economically significant reductions in dollarization. The implementation of new goods pricing and financial market structures to accommodate dollar usage has led to significant reductions in transaction costs of dollar usage relative to Bolivian currency usage. To achieve widespread dedollarization, large incentives would have to be provided to overcome the transactions cost savings. One such incentive could be in the form of significant reductions in domestic relative to U.S. inflation or its variability. Our results suggest, however, that small-scale fiscal and monetary policy restrictions, even if successful, may not be sufficient to overcome dollarization.

VI. Conclusion

This paper identifies network externalities from currency acceptability as a key determinant of observed currency hysteresis. Network externality effects on domestic versus U.S. dollar usage in loan markets in Bolivia are quantified using macroeconomic observations together with data from informal loan markets. The probability of observing a dollar-denominated loan in a particular region of Bolivia is shown to be positively related to various proxies capturing positive network effects to agents from dollar usage. The statistical significance of these network proxies is robust to inclusion of macroeconomic policy-credibility variables. The results suggest that even credible and successful policy reforms may not be sufficient to overcome dollarization once network benefits from dollar usage become embedded in transactions.

APPENDIX

Applying Lee's procedure to our context involves three steps. In the first step, a "reduced- form" probit is estimated for the probability of a dollar-denominated loan, based on <17>, where the Bolivian interest rate is replaced by its exogenous determinants. This probit regression is then used to construct an inverse Mills ratio for each sample observation. The inverse Mills ratio is $\lambda = h(\theta' X)/H(\theta' X)$, where θ is a vector of probit coefficients and X is a matrix of all independent variables from the reduced-form equation. $h(\cdot)$ and $H(\cdot)$ are the normal and cumulative density functions, respectively. λ accounts for the truncation in the probability distribution when the Bolivian interest rate is unobservable. The second step of the procedure is to enter the estimated inverse Mills-ratio value into an OLS subsample regression where Bolivian interest rate observations form the dependent variable. The third step substitutes the fitted interest rate values into a "structural" probit model of equation <17>, which is estimated over the entire sample. Results from the third-step structural probit are in section III of the text.

The reduced-form probit that we estimate in the first step of Lee's procedure is:

$$\begin{aligned} &PROB(CURR_t^{DOL}) = A_0 + A_1 AMOUNT_t + A_2 TERM_t + A_3 COLL_t \\ &+ A_4 BOLINFL_{t+1} + A_5 DEX_t + A_6 T_t^{\,d} + A_7 T_t^{\,s} + A_8 POLICY_t \qquad <A1> \\ &+ A_9 REFORM85_t + A_{10} DUMWIN_t + A_{11} DUMSPR_t + A_{12} DUMSUM_t \end{aligned}$$

The exogenous determinants of the Bolivian interest rates are:

AMOUNT: Loans are made in either U.S. dollars or Bolivian currency. Over the sample period used, there were 4,269 domestic and 1,492 dollar loans registered. The mean loan size of $588 and maximum loan of $16,320 imply a small economic scale of loan activity.

TERM: The mean loan maturity is three months. The longest loan spanned 60 months. The short nature of the loans is characteristic of cyclical liquidity needs in the agricultural sector.

COLL: This variable is coded 1 if collateral has been offered to secure a loan, 0 otherwise. Collateral includes agricultural goods, personal co-signors, or real property.

BOLINFL: The expected future Bolivian inflation rate is expected to be a key determinant of the nominal domestic interest rate in the informal market. The inflation expectation is proxied by the realized monthly percent change in the consumer price index.

The remaining variables in <A1> are identified in the text. For the second step of Lee's procedure, an OLS interest rate regression is necessary to derive RBOL*. The same exogenous interest rate determinants and seasonal dummies are employed as those in <A1>. The resulting specification is:

$$
\begin{aligned}
RBOL^{*}_{t} = {} & B_0 + B_1 AMOUNT_t + B_2 TERM_t + B_3 COLL_t + B_4 BOLINFL_{t+1} \\
& + B_5 DUMWIN_t + B_6 DUMSPR_t + B_7 DUMSUM_t + B_8 REFORM85_t + B_9 \lambda_t
\end{aligned}
$$

where λ_t is the inverse Mills ratio.

In estimating the above equations we found strong selection bias in the left tail of the Bolivian interest rate distribution, as indicated by a statistically significant negative coefficient on λ_t. This finding reinforces the appropriateness of Lee's three-step censoring adjustment procedure that we apply in this study.

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FOOTNOTES

1. Extending the model to also include dollar deposits held by Bolivians abroad would not change our key results.
2. Whether the experience with dollar network factors alters the marginal transactions cost of lending Bolivian pesos will determine whether $\Psi^{L}_{1,2}$ is positive or zero.
3. An analogous relation can be derived for the domestic loan supply.
4. We abstract from the consumption effects for empirical purposes because there are no appropriate consumption proxies at the daily periodicity that loans are observed.
5. Pesos were the official Bolivian currency prior to January 1987. Thereafter, Bolivianos became legal tender. The conversion rate is 1 Boliviano = 1 million pesos.

Table 1

Bolivian Macroeconomic Data Following the 1985 Stabilization Program

	1985	1986	1987	1988	1989	1990	1991
Inflation (%)	11,750	276	15	16	15	17	21
Exchange Rate (Bol./$)	1.69	1.92	2.21	2.47	2.98	3.40	3.75
Fiscal Deficit (-) or Surplus	-1,182	-6	67	-79	-184	-262	-13
Dollar Loans/ Total Loans (Informal)	.47	.77	.84	na	na	na	na
Foreign Currency Deposits/M2 (Banks)	.13	.35	.32	.41	.57	.58	.63

Table 2

Variable	Description
M_t	Beginning of period domestic cash balance
M_t^*	Beginning of period dollar cash balance
e_t	Nominal exchange rate (Bolivian currency per U.S. dollar)
L_t	Domestic currency loan supply of an intermediary
L_t^*	Dollar loan supply of an intermediary
R_t	Net nominal interest rate on domestic currency loan
R_t^*	Net nominal interest rate on dollar loan
P_t	Bolivian currency price per unit of the good
P_t^*	Dollar price per unit of the good
T^s_t	Index of loan supply externality factors
POL_t	Index of Bolivian policy credibility
Y_t^T	Total household endowment of the good
Y_t	Goods supplied in domestic market at domestic currency price
Y_t^*	Goods supplied in domestic market at dollar price
l_t	Domestic currency loan demand of shopper
l^*_t	Dollar loan demand of shopper
T^d_t	Index of loan demand externality factors
C_t	Shopper's goods purchases at domestic currency price
C^*_t	Shopper's goods purchases at dollar price

Table 3

Coefficient Estimates for Structural Probit <17>; T^d_t=CUMLOANS, T^s_t=EXSPREAD

Regression Number	**1**	**2**	**3**	**4**	**5**
CONSTANT	-1.45*** (-3.89)	-2.36*** (-7.00)	-1.65*** (-4.88)	-1.68*** (-4.48)	1.46*** (-3.98)
RBOL	.005 (1.24)	-.029*** (-4.09)	-.019*** (-2.75)	.005 (0.26)	.007 (0.34)
DEX	-.710 (-1.63)	.278* (1.88)	-.622 (-1.00)	-.473 (-1.25)	.733** (2.03)
CUMLOANS	2.19*** (3.34)	4.34*** (7.59)	5.20*** (9.32)	1.02 (1.48)	2.22*** (3.39)
EXSPREAD	.00002* (1.76)	.00001*** (2.94)	.00001*** (4.27)	.00001** (2.58)	.00001** (1.99)
DUMWIN	.0052 (0.07)	-.027 (-0.34)	-.023 (-0.29)	-.003 (-0.04)	-.0022 (-0.03)
DUMSPR	-.304*** (-3.70)	-.347*** (-4.23)	-.378*** (-4.69)	-.260*** (-3.12)	-.312*** (-3.80)
DUMSUM	-.026 (-0.31)	-.097 (-1.17)	-.166** (-2.01)	-.015 (-0.18)	-.030 (-0.37)
INFMAX	.0013*** (3.53)	-----	-----	-----	-----
INFVOLMAX	-----	.00005*** (18.03)	-----	-----	-----
DEPVOLMAX	-----	-----	2.96*** (17.10)	-----	-----
REFORM85	-----	-----	-----	2.83*** (4.92)	2.52*** (3.50)
BOLINFVOL	-----	-----	-----	.00001** (3.92)	-----
BOLDEPVOL	-----	-----	-----	-----	1.43* (1.77)
-2LogL	4129	4022	3988	4130	4131
% CORRECT PREDICT.	0.9189	0.9221	0.9221	0.9217	0.9186

Based on 5761 observations: 1-1-80 to 10-31-82; 10-1-85 to 6-30-87. T-statistics in parentheses.
* (**) [***] denotes significance at the 10% (5%) [1%] level.

Table 4

Coefficient Estimates for Structural Probit <17>; T^d_t=CUMVALUE, T^s_t=EXSPREAD

Regression Number	**1**	**2**	**3**	**4**	**5**
CONSTANT	-1.50*** (-4.03)	-2.42*** (-7.21)	-1.75*** (-5.18)	-1.71*** (-4.55)	-1.51*** (-4.12)
RBOL	-.005 (-1.26)	-.028*** (-3.91)	-.017** (-2.57)	.004 (0.24)	-.008 (-1.37)
DEX	.678 (1.25)	.302 (0.96)	-.563* (-1.81)	-.457 (-1.22)	-.703** (-1.96)
CUMVALUE	1.66*** (3.39)	3.33*** (7.95)	3.98*** (9.76)	.764 (1.47)	1.69*** (3.44)
EXSPREAD	.00001* (1.71)	.00001*** (3.03)	.00001*** (4.33)	.00003** (2.56)	.00001** (1.94)
DUMWIN	.004 (0.05)	-.028 (-0.35)	-.024 (-0.31)	-.004 (-0.05)	-.004 (-0.05)
DUMSPR	-.298*** (-3.60)	-.324*** (-3.94)	-.351*** (-4.33)	-.258*** (-3.08)	-.305*** (-3.70)
DUMSUM	-.017 (-0.20)	-.788 (-0.95)	-.142 (-1.73)	.019 (0.22)	-.021 (-0.26)
INFMAX	.0013*** (3.45)	-----	-----	-----	-----
INFVOLMAX	-----	.00001*** (17.14)	-----	-----	-----
DEPVOLMAX	-----	-----	2.86*** (16.19)	-----	-----
REFORM85	-----	-----	-----	2.83*** (4.89)	2.47*** (3.40)
BOLINFVOL	-----	-----	-----	.00004** (3.88)	-----
BOLDEPVOL	-----	-----	-----	-----	1.44* (1.88)
-2LogL	4129	4028	3997	4144	4132
% CORRECT PREDICT.	0.9188	0.9221	0.9221	0.9219	0.9186

Based on 5761 observations: 1-1-80 to 10-31-82; 10-1-85 to 6-30-87. T-statistics in parentheses.
* (**) [***] denotes significance at the 10% (5%) [1%] level.

Table 5

Coefficient Estimates for Structural Probit <17>; T^d_t=CUMLOANS, T^s_t=BANKSPREAD

Regression Number	1	2	3	4	5
CONSTANT	-1.25*** (-3.39)	-3.52*** (-9.84)	-3.25*** (-8.52)	-1.54*** (-3.94)	-1.27*** (-3.43)
RBOL	-.029* (-1.78)	-.052** (-6.72)	-.051*** (-6.58)	-.024 (-1.46)	-.028* (-1.75)
DEX	-.066 (-1.42)	1.03*** (3.18)	.429 (1.31)	-.426 (-1.13)	.668* (1.88)
CUMLOANS	2.14*** (3.83)	2.58*** (4.88)	2.56*** (4.79)	1.61*** (2.75)	2.26*** (3.95)
BANKSPREAD	.189* (1.84)	.835*** (7.78)	1.09*** (10.19)	.108** (1.89)	.154** (1.93)
DUMWIN	-.0003 (-0.003)	-.091 (-1.14)	-.123 (-1.52)	-.017 (-0.21)	-.007 (-0.09)
DUMSPR	-.245*** (-2.98)	-.391*** (-4.82)	-.452*** (-5.60)	-.215*** (-2.60)	-.253*** (-3.07)
DUMSUM	-.063 (-0.79)	-.047 (-0.61)	-.093 (-1.21)	-.059 (-0.75)	-.069 (-0.39)
INFMAX	.002*** (5.95)	-----	-----	-----	-----
INFVOLMAX	-----	.00001*** (12.89)	-----	-----	-----
DEPVOLMAX	-----	-----	3.45*** (10.65)	-----	-----
REFORM85	-----	-----	-----	3.48*** (7.00)	3.04*** (5.85)
BOLINFVOL	-----	-----	-----	.00001*** (2.98)	-----
BOLDEPVOL	-----	-----	-----	-----	.930* (1.99)
-2LogL	4131	4074	4073	4141	4132
% CORRECT PREDICT.	0.9222	0.9222	0.9222	0.9219	0.9222

Based on 5761 observations: 1-1-80 to 10-31-82; 10-1-85 to 6-30-87. T-statistics in parentheses.
* (**) [***] denotes significance at the 10% (5%) [1%] level.

Table 6

Coefficient Estimates for Structural Probit <17>; T^d_t=CUMVALUE, T^s_t=BANKSPREAD

Regression Number	**1**	**2**	**3**	**4**	**5**
CONSTANT	-1.30*** (-3.49)	-3.54*** (-9.92)	-3.27*** (-8.89)	-1.56*** (-3.99)	-1.32*** (-3.54)
RBOL	-.027 (-1.39)	-.051*** (-6.50)	-.050*** (-6.37)	-.023* (-1.92)	-.026* (-2.09)
DEX	-.631* (-1.77)	1.04*** (3.21)	.442 (1.35)	-.415 (-1.09)	.645* (1.82)
CUMVALUE	1.62*** (3.90)	1.95*** (4.96)	1.93*** (4.86)	1.21*** (2.77)	1.71*** (4.02)
BANKSPREAD	-.200 (-1.38)	.809*** (7.46)	1.06*** (9.80)	-.118 (-0.80)	.166** (2.05)
DUMWIN	-.0002 (-0.03)	-.090 (-1.12)	-.120 (-1.49)	-.017 (-0.21)	-.007 (-0.09)
DUMSPR	-.239*** (-2.90)	-.380*** (-4.67)	-.440*** (-5.43)	-.211*** (-2.54)	-.246*** (-2.98)
DUMSUM	-.053 (-0.66)	-.380 (-0.42)	-.078 (-1.02)	-.028 (-0.52)	-.058 (-0.73)
INFMAX	.002*** (5.73)	-----	-----	-----	-----
INFVOLMAX	-----	.00001*** (11.46)	-----	-----	-----
DEPVOLMAX	-----	-----	3.42*** (12.84)	-----	-----
REFORM85	-----	-----	-----	2.94*** (6.82)	2.96*** (5.65)
BOLINFVOL	-----	-----	-----	.00002** (2.93)	-----
BOLDEPVOL	-----	-----	-----	-----	.918* (1.92)
-2LogL	4131	4075	4073	4141	4132
% CORRECT PREDICT.	0.9222	0.9222	0.9222	0.9219	0.9222

Based on 5761 observations: 1-1-80 to 10-31-82; 10-1-85 to 6-30-87. T-statistics in parentheses.
* (**) [***] denotes significance at the 10% (5%) [1%] level.

Table 7

Predicted Values for the Probability of Observing a Dollar-Denominated Loan

PANEL A	1 CUMLOANS, EXSPREAD	2 δCUMLOANS, EXSPREAD	3 CUMLOANS, δEXSPREAD
BOLINFVOL	0.6406	0.6700	0.6700
δBOLINFVOL	0.6736	--------	--------
BOLDEPVOL	0.5793	0.6443	0.6026
δBOLDEPVOL	0.6026	--------	--------
PANEL B	**1 CUMVALUE, EXSPREAD**	**2 δCUMVALUE, EXSPREAD**	**3 CUMVALUE, δEXSPREAD**
BOLINFVOL	0.6480	0.6808	0.6808
δBOLINFVOL	0.6844	--------	--------
BOLDEPVOL	0.4960	0.5714	0.5199
δBOLDEPVOL	0.5199	--------	--------
PANEL C	**1 CUMLOANS, BANKSPREAD**	**2 δCUMLOANS, BANKSPREAD**	**3 CUMLOANS, δBANKSPREAD**
BOLINFVOL	0.7123	0.7517	0.7224
δBOLINFVOL	0.7324	--------	--------
BOLDEPVOL	0.7291	0.7823	0.7454
δBOLDEPVOL	0.7422	--------	--------
PANEL D	**1 CUMVALUE, BANKSPREAD**	**2 δCUMVALUE, BANKSPREAD**	**3 CUMVALUE, δBANKSPREAD**
BOLINFVOL	0.7123	0.7580	0.7257
δBOLINFVOL	0.7324	--------	--------
BOLDEPVOL	0.7157	0.7764	0.7357
δBOLDEPVOL	0.7291	--------	--------

δ(.) denotes a one standard deviation increase in variable (.) above its mean. Variables not preceded by **δ** are evaluated at their sample means.