CREDIT RATIONING AND EXCHANGE-RATE STABILIZATION: EXAMINING THE RELATION BETWEEN FINANICAL FRICTIONS, EXCHANGE-RATE VOLATILITY, LENDING RATES, AND CAPITAL INFLOWS

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CREDIT RATIONING AND EXCHANGE-RATE STABILIZATION:

Examining the Relation between Financial Frictions, Exchange-Rate Volatility, Lending Rates, and Capital Inflows

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This paper develops and tests a model of the relation between the volatility of the exchange rate, default rates, the *level* of interest rates on loans, and the availability of credit, laying emphasis on frictions in the financial market, specifically foreclosure costs to collecting bad debts. On the assumption that foreign sources of funds are crucial for domestic finance, the paper tests the hypothesis of a high positive relation between the volatility of the exchange rate and the lending rate, and between the volatility of the exchange rate and capital inflows, on a sample of 54 countries over 1980-2000. The paper finds that exchange-rate and macroeconomic volatility are strong predictors of capital inflows (but not of lending rates) and that there may be an important role for financial frictions in the transmission process.

Moreover, the paper finds that episodes of disinflation that rely on a reduction of the rate of depreciation tend to be accompanied by lower exchange rate volatility (in addition to simply lower rates of devaluation). Both effects, but principally the latter through financial frictions, suggest a solution to the lack of connection between the theory and the stylized facts of exchange rate-based stabilizations: ERBS programs may lead to initial booms through should cause a significant rise in the availability of credit, even if the cost of credit does not fall by much.

Keywords: interest rates, exchange rate volatility, financial frictions, creditor rights, exchange rate based stabilization.

JEL codes: E43, E44, E50, F31, F41, G14, E31, E63

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Credit Rationing and Exchange-Rate Stabilization: Examining the Relation between Financial Frictions, Exchange-Rate Volatility, Lending Rates, and Capital Inflows

Gabriel X. Martinez

Does a reduction in exchange rate volatility lead to a lower *level* of interest rates? If so, how? There is much theoretical and empirical work on the relation between exchange rate volatility and interest rate volatility (see Belke et al. (2003)), and a general consensus has not been reached. But the question of this paper (lower exchange rate volatility leads to lower interest-rate levels) has received less attention.

A connected question is the relation between exchange rate volatility and the availability of credit from foreign sources. Again, there's an intuitive connection between exchange-rate stability and capital inflows but it has received little formal theoretical or empirical attention.

This paper explores these questions by developing a model of a financial sector that is dependent on foreign sources of funds, so the behavior (both the average and the standard deviation) of the rate of change of the exchange rate affects the average cost of funds. Following the literature on credit rationing and the financial accelerator, this paper hypothesizes that, in the presence of financial frictions, interest rates are "sticky" but the availability of funds is not (lenders prefer to react to excess demand for loans by restricting the supply of credit rather than by raising interest rates).[1] If this is so, a stabilization of the exchange rate (which increases the expected return to lenders), should cause a drastic increase in the availability of credit and a small change in the lending rate.

This question is very relevant to the study of exchange rate-based stabilization programs (ERBS), which as Hamann (2001) points out, have generated a growing theoretical and empirical literature that is far from closed. One of the main puzzles of this literature (see Sobolev (2000) for a short survey) is the relation between interest rates and aggregate demand in the models. To generate the boom-bust pattern that is typically observed, these models (see Calvo and Végh (1999)) require either that the intertemporal elasticity of substitution be very large or that interest rates fall very significantly. The stylized facts of ERBS indicate that interest rates do fall, but, given the (very low) estimates of the intertemporal elasticity of substitution, the magnitude of the interest-rate fall could not possibly generate the observed post-ERBS boom.

Empirical estimates of the intertemporal elasticity of substitution compare aggregate demand with the *deposit* rate. But if changes in *credit* rather than *savings* are the major source of variation in aggregate demand, then the relevant interest rate should be the *lending* rate (rather than the deposit rate).[2] Deposit rates and lending rates need not move together, or in the same proportion, insofar as

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[1] Zeira (1991) developed an open-economy model where credit markets' imperfections alter basic macroeconomic results through credit rationing and not through interest rates. His model did not include exchange rate behavior.

[2] Indeed, domestic credit is positively correlated to GDP, and lending booms are typically accompany ERBS programs.

the spread between the two is affected by the presence of credit market frictions (and by events such as financial liberalization) or other factors. In this case, the estimated intertemporal elasticity of substitution widely understates the actual relationship between the relevant cost of spending and aggregate demand.

Moreover, there are two shortcomings to most current theoretical models of ERBS: they give no role to the volatility of the exchange rate in financial relations and they give no role to changes in the availability of credit in the determination of aggregate demand.

In existing models, the only effect of ERBS on the interest rate is through an interest parity condition (see, for example Calvo and Végh (1994), equation 18), so there is no place for the volatility of the exchange rate to affect interest rates. But ERBS not only stabilizes the exchange rate (and through it, prices), it also stabilizes the rate of change of these variables. If one allows *both* the rate of devaluation *and* the volatility of this rate to affect the interest rate, one should expect to see a drastic fall in the *market-clearing* lending rate following an ERBS program – or, if one assumes that financial frictions causes equilibrium credit rationing in pre-ERBS economies – one will expect ERBS to lower interest rates by little but to significantly increase the availability of funds.

1. The Mean and the Standard Deviation of the Rate of Change of the Exchange Rate

It is convenient to start by testing the hypothesis that while E(ε), the average appreciation rate,[3] is a policy variable, the standard deviation of the appreciation rate, $stdev(\varepsilon) = \sigma^{\varepsilon}$, is an decreasing function of the average appreciation rate. This is very much consistent with the general experience that high inflation usually means highly variable inflation; insofar as there's a high degree of pass-through (which is the case in most developing economies that would choose the exchange rate as a nominal anchor), high inflation means a high depreciation rate. Then a low appreciation rate (a high depreciation rate) leads to a highly variable appreciation rate.

This assumption stands to empirical scrutiny. Using 1980-2000 data from the IFS on 54 countries (for details, see below), regression analysis indicates that *low depreciation* rates (that is, *high appreciation* rates) often lead to *low variability* of the appreciation rate.

$$\underset{(0.6600)}{\text{STDAP} = 9.0951} - \underset{(0.0332)}{0.3078}\text{*MAPPR} + [\text{AR(1)}=\underset{(0.0312)}{0.9957}, \text{AR(2)}= -\underset{(0.0304)}{0.2597}]$$

total panel observations = 782 adj-R2 = 0.7223 DWstat = 1.896

[3] The theoretical model of this paper is easier to understand if we define the exchange rate e so that a rise in e (i.e., $\varepsilon > 0$) is interpreted as an appreciation. Over 1980-2000, most countries' currencies depreciated against the U.S. dollar; a rise in ε (an end to high depreciation), then, is a stabilization of the exchange rate.

where STDAP stands for the 5-year standard deviation of the annual appreciation rate and MAPPR stands for the 5-year moving average of the annual appreciation rate.

2. Modeling the Open-Economy Financial Sector

The model modifies Bernanke, Gertler, and Gilchrist (BGG 1998), by adding a role for currency mismatch. This is particularly important for developing countries, as has been increasingly argued since the East Asian crisis of 1997. Borrowers typically earn income or own assets denominated in domestic currency but borrow in foreign currency. Banks avoid currency mismatch on paper because their deposits and loans are both in foreign currency, but a large devaluation causes losses and bankruptcy by causing large default rates (and, often, a deposit outflow).

This paper models this stylized fact with stark simplicity to give centrality to the behavior of the exchange rate. Idiosyncratic shocks are assumed away: the only shock a borrower experiences is a change to the value of the currency. The lenders are assumed to be international banks that can diversify across countries, but they experience loan-default losses if the value of the currency falls (in which case they must pay a foreclosure cost to collect the loan).

Again in the interest of simplicity there is no asymmetric information, but the existence of a foreclosure cost causes both a backward-bending supply of loans and the possibility of credit rationing. Indeed, credit rationing is essential to the broader argument: interest rates fall little (but capital inflows rise much) during ERBS episodes. Even more broadly, it has been argued that the conventional interest-rate channel of the financial accelerator is not consistent with the empirical evidence, but that a credit-rationing-based financial accelerator is (see Boissay (2001)). Financial frictions of this kind suggest a mechanism to explain these stylized facts.

The next two sub-sections discuss the basic framework of financial relations: consumers' demand for loans and the lender returns' function. The following two sub-sections show how credit rationing arises in this model and how the variability of the exchange rate is related to the cost of borrowing.

2.1 Consumers

Consumers (assumed to be identical) live for two periods, during both of which they earn endowment income denominated in domestic currency, denoted y_t. Assume that they cannot lend this endowment, but they can borrow against future income. Denominated in foreign currency, the individual's lifetime endowment is

$$e_1 y_1 + \mathrm{E}(e_2) y_2 \qquad \text{Eq. 1}$$

where e is the foreign currency price of domestic currency. Importantly, e_2 is uncertain; ε is the (gross) *appreciation* rate of the domestic currency and $\mathrm{E}(\varepsilon) = \mathrm{E}(e_2)/e_1$ is the expected appreciation rate. Assume, that consumers use the entirety of their endowment to purchase foreign goods in the first period of their life, which are their only source of utility:

$$U=u(c^*_1).$$

Given this set-up, from standard intertemporal maximization it follows that consumers will maximize their utility by spending the entirety of the net present value of their lifetime endowment on period-1 consumption of foreign goods. Assuming that prices are constant and normalized to 1,

$$c^*_1/e_1 = E(\varepsilon)y_2/(1 + i) + y_1. \qquad \text{Eq. 2}$$

As long as y_1 and y_2 are non-negative, consumers will want to borrow against the second-period endowment to finance this consumption demand. The lifetime endowment will be sufficient as long as $\varepsilon \geq E(\varepsilon)$.

Consumers demand loans[4] to finance the difference between first-period consumption demand and first-period income. They obtain financing from foreign banks. Both the loan amount L and the loan rate i are chosen by the bank (see below).

$$L \leq c^*_1 - e_1y_1 \qquad \text{Eq. 3}$$

In this set up, second-period income is the only source of repayment capacity for the borrower. Then the total value to be repaid (interest plus principal) cannot

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[4] Following New Keynesian models (Greenwald and Stiglitz 1993, Myers and Majluf 1984), informational asymmetries prevent the development of an equity market. For simplicity, assume that borrowers can only borrow from one bank.

be larger (in expectation) than the foreign-currency value of second-period income, $(1 + i)\, L \leq E(e_2)y_2$. It follows that there must be a value of ε, labeled $\hat{\varepsilon}$, such that if $\varepsilon < \hat{\varepsilon}$, the borrower is incapable of paying back the full amount of the loan (because the foreign-currency value of the second-period endowment falls by too much),

$$\hat{\varepsilon}\, e_1 y_2 = (1+i)L \,. \qquad \text{Eq. 4}$$

Notice that, in this model, a depreciation ($\varepsilon < 1$) generally hurts borrowers by increasing the foreign-currency value of their loan commitments (as compared to their domestic-currency denominated income) and makes them more likely to default on loans. In other words, in this simple conception of financial relations, devaluation is always contractionary.[5]

Clearly a higher i raises the threshold below which borrowers are incapable of paying back their loans. (Notice that i is defined in terms of foreign currency units).

BGG assume that the actual outcome of projects is private information, so the lender must pay a monitoring cost. This assumption would be inappropriate in this context, where there are no idiosyncratic shocks and the only uncertainty is macroeconomic (and presumably observable). However, lenders must pay fo-

[5] Unlike Céspedes, Chang, and Velasco (2000) we do not assume that output can be sold internationally, so a devaluation does not have the conventional effect.

reclosure costs (which are formally equivalent to BGG's monitoring costs) on the assumption that borrowers can't freely commit to repaying their loans.

If the entrepreneur does not declare bankruptcy, he pays the lender the amount $\hat{\varepsilon} e_1 y_2$ and keeps the difference between the revenue from the output produced and the loan plus interest (the payment amount is denominated in the same units as the loan amount, that is, the first-period value of the currency). If he does declare bankruptcy, the borrower loses the entirety of the consumer's second-period income, εy_2.

Assume, concretely, that e_2 is i.i.d. across time and firms, whose density function is $w(e)$ and whose continuous and once-differentiable c.d.f. is $\Omega(e)$. Consistent with the evidence presented above, we make the assumption that $stdev(\varepsilon)$ is negatively related to $E(\varepsilon)$.

2.2 *Lenders*

Consumers borrow, for simplicity, from international investors whose opportunity cost of funds is constant at $i^*$and who are perfect competitors so they make zero expected profits. If debtors declare themselves in default, lenders pay the cost $\mu e_2 y_2 = \mu \varepsilon e_1 y_2$, interpreted as foreclosure costs, and take possession of the entire output of the project. Because the foreclosure cost is proportional to the output of the project, it remains significant even as production scale increases.

On the assumption that banks, who can lend to more than one country, are able to diversify country risk away by pooling loans, and using the fact that $d\Omega(e) = w(e)de$, the expected return to the lender must satisfy

$$(1+i^*)(L) = e_1 y_2 \hat{\varepsilon}[1-\Omega(\hat{\varepsilon})] + (1-\mu) e_1 y_2 \int_0^{\hat{\varepsilon}} \varepsilon \, d\Omega(\varepsilon) \qquad \text{Eq. 5}$$

2.3 *The Effect of a Change in* E(ε) *on interest rates*

What determines $\Omega(\hat{\varepsilon})$, the probability that the appreciation rate will fall below $\hat{\varepsilon}$? Suppose ε follows a normal distribution: statistical theory suggests that $\Omega(\hat{\varepsilon})$ depends both on the mean and the standard deviation of ε. Intuitively, a lower standard deviation of the distribution of appreciation rates should expose lenders to less default risk, *other things equal*, because there are fewer states of nature in which the currency's value will be insufficient for repayment. It is easy to illustrate this intuitive claim.

Moreover, a lower standard deviation also increases the typical $(1-\mu)y_2 e_1 \varepsilon$, that is, the amount received by the lender in case of default.

The combination of a lower probability of default and higher default-state payments implies a lower equilibrium interest rate (assuming zero lender returns and no credit rationing).[6] The relation between stdev(ε) and Ω is difficult to show analytically, but it is easy to develop a numerical simulation of this very

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[6] This intuitive claim must be qualified, however, because of the magnitude of the changes in either E(ε) or σ^{ε} during ERBS programs, and the presence of simultaneous programs of financial liberalization, etc., which may contribute to higher interest rates.

simple model to derive values of both Ω and δ for different levels of E(ε) and σ^{ε}. The basic data for income, expenditure, and exchange rates is Ecuadorian data (Ecuador applied an ERBS program in the early 1990s). Two four-year periods are distinguished: 1988-1992, a low-appreciation, pre-ERBS period and 1993-1996, a (comparatively) high-appreciation, ERBS period.

Table 1
Behavior of the Exchange Rate, Ecuador, 1988-1996

	1988-1992	1993-1996
Cumulative appreciation over the period	−72.22%	−49.21%
Average monthly appreciation[7]	−2.57%	−1.39%
Standard deviation of the monthly appreciation rate	3.57%	1.43%

Source: Banco Central del Ecuador, Base de Datos de Estudios
Note: appreciation here is defined as $\varepsilon-1$

Following BGG, we assumed μ, the cost of foreclosure, to be equal to 0.12. The risk-free lender return for lenders, i^*, was set at 6.63, the average U.S. Federal Funds rate of the period. For simplicity (and to concentrate on the changes of the behavior of the exchange rate), we set y_1=y_2 at Ecuador's 1988 nominal GDP (5.2 billion sucres). Then the only changes between scenarios were the average appreciation rate and the standard deviation of this rate.

Table 2
Simulation Results for Ω and default payments d, given historical values of E(ε) and σ^{ε}

	(1)	(2)	(3)

[7] Recall ε is the gross rate of appreciation, so a rise in E(ε) indicates stabilization – a fall in the average rate of depreciation – which characterizes ERBS programs.

	Pre-ERBS	Post-ERBS: only average ε changes.	Post-ERBS: both average ε and σ^{ε} change.
Ω	6.84%	7.77%	0.45%
d	0.113%	0.125%	2.635%

Source: Author's calculations.

Notes: ε = average monthly gross rate of appreciation of the currency.

stdev(ε) = 12-month standard deviation of the monthly gross rate of appreciation of the currency.

Ω = probability of default.

d = $(1-\mu)y_2 e_1 \varepsilon^d / L$, where ε^d is the average default-causing rate of depreciation.

The cutoff-ε below which borrowers default is itself a function of the distribution of ε, so large changes in either mean ε or the standard deviation σ^{ε} change the entire financial relation. Another simulation was run in which the average monthly appreciation rate and the standard deviation were only changed marginally (see Table 3).

The simulations confirm that, indeed, a high appreciation rate and a low variability of the exchange rate are related to lower probabilities of default $\frac{d\Omega(\hat{\varepsilon})}{dE(\varepsilon)} < 0$, and to higher average payments from defaulting borrowers,

$$\left[\frac{d}{dE(\varepsilon)}\right]\left[\frac{\int_0^{\hat{\varepsilon}} \varepsilon \, d\Omega(\varepsilon)}{[1-\Omega(\hat{\varepsilon})]}\right] > 0 .$$

Table 3
Simulation Results for Ω and default payments
for marginal changes in E(*ε*) and σ^{ε}

	(1) Pre-ERBS	(2) Post-ERBS: only average *ε* changes.	(3) Post-ERBS: both average *ε* and σ^{ε} change.
average ε	97.37%	97.39%	97.39%
σ^{ε}	3.66%	3.66%	3.62%
Ω	18.59%	18.09%	12.33%
d	0.082%	0.082%	1.470%

Source: Author's calculations.
Notes: ε = average monthly gross rate of appreciation of the currency.
stdev(ε) = 12-month standard deviation of the monthly gross rate of appreciation of the currency.
Ω = probability of default.
d = $(1-\mu)y_2 e_1 \varepsilon^d / L$, where ε^d is the average default-causing rate of depreciation.

Then differentiating equation (5) with respect to E(*ε*) (and remembering lender returns must be zero in equilibrium),

$$0 = \frac{d\hat{\varepsilon}}{dE(\varepsilon)} - \frac{\hat{\varepsilon}}{[1-\Omega(\hat{\varepsilon})]}\frac{d\Omega(\hat{\varepsilon})}{dE(\varepsilon)} + (1-\mu)\frac{d}{dE(\varepsilon)}\left[\frac{\int_0^{\hat{\varepsilon}} \varepsilon \, d\Omega(\varepsilon)}{[1-\Omega(\hat{\varepsilon})]}\right]$$

$$\frac{d\hat{\varepsilon}}{dE(\varepsilon)} = \frac{\hat{\varepsilon}}{[1-\Omega(\hat{\varepsilon})]}\frac{d\Omega(\hat{\varepsilon})}{dE(\varepsilon)} - (1-\mu)\frac{d}{dE(\varepsilon)}\left[\frac{\int_0^{\hat{\varepsilon}} \varepsilon \, d\Omega(\varepsilon)}{[1-\Omega(\hat{\varepsilon})]}\right]$$

the first term of the RHS is negative and the second term is positive, so $\frac{d\hat{\varepsilon}}{dE(\varepsilon)} < 0$. It is therefore obvious from equation (4) and from our assumption that E(*ε*) and *stdev*(*ε*) are negatively related that

$$\frac{di}{dE(\varepsilon)} < 0 \text{ and } \frac{di}{d\,stdev(\varepsilon)} > 0 .$$

The model therefore predicts a fall in interest rates when E(ε) rises, and an even larger fall in *i* when *stdev*(ε) is allowed to fall when E(ε) rises: by lowering the probability of default $\Omega(\hat{\varepsilon})$ and increasing the payments made by defaulting borrowers, a fall in *stdev*(ε) increases the return to the lender, other things equal. Because lenders make no profits in equilibrium, the interest rate paid by borrowers must fall. This is confirmed in simulations.

Table 4
Simulation Results for *i* for marginal changes in E(ε) and σ^{ε}

	(1)	(2)	(3)
	ε=97.37% stdev(ε)=3.66%	ε=97.39% stdev(ε)=3.66%	ε=97.39% stdev(ε)=3.62%
i	3.052%	2.978%	2.035%

Source: Author's calculations.
Notes: ε = average monthly gross rate of appreciation of the currency.
stdev(ε) = 12-month standard deviation of the monthly gross rate of appreciation of the currency.
i = interest rate on loans.

As a preparation for econometric tests, let us derive a simple formula for the determinants of interest rates. In the absence of default, the interest parity condition says that domestic interest rates and foreign interest rates should only differ by the expected change in the exchange rate. *i* was defined above in terms of foreign currency units. Here we redefine it in domestic currency units. Because ε is the gross appreciation rate, the interest parity condition takes the slightly unfamiliar form $\frac{1+i^*}{\varepsilon}=1+i$. Allowing for a positive probability of default on loans, one can simplify equation (5) as

$$(1+i^*)=(1+i)\varepsilon(1-\Omega)+\frac{(1-\delta)}{L}$$

where $1-\delta=(1-\mu)e_1y_2\int_0^{\hat{\varepsilon}}\varepsilon d\Omega(\varepsilon)$. δ should vary from country to country and from period to period, according to things like the effectiveness of domestic courts (which affect μ); the existence and severity of a macroeconomic crisis (which affects y_2); and the variability of the exchange rate (which affects $\int_0^{\hat{\varepsilon}}\varepsilon d\Omega(\varepsilon)$). This formulation allows us to see the determinants of i clearly:

$$\frac{L(1+i^*)-(1-\delta)}{L\varepsilon(1-\Omega)}=(1+i) \qquad \text{Eq. 6}$$

Domestic loan rates should fall as the rate of appreciation rises, as interest parity would predict, but in addition loan rates should be lower if the typical loss from default is smaller; (that is, if creditor rights are enforceable and if the economy is stable); and if the probability of default, which depends on σ^{ε}, is lower. The next section confirms that the loan amount L has ambiguous effects on the interest rate.

2.4 *Credit Rationing*

To see clearly how the presence of financial frictions generates credit rationing, it is useful to start by finding the effect of higher interest rates on lender returns. Using equation (4), we know that $\frac{d\hat{\varepsilon}}{di} = \frac{(c*_1 - e_1 y_1)}{e_1 y_2}$. Then the derivative of the lender's return from loans with respect to the loan rate is

$$
\begin{aligned}
&[1-\Omega(\hat{\varepsilon})] - (1+i)\frac{d[\Omega(\hat{\varepsilon})]}{di} + \frac{(1-\mu)e_1 y_2 \frac{(1+i)L}{e_1 y_2} w(\hat{\varepsilon})\frac{d\varepsilon}{di}}{L} \\
&= [1-\Omega(\hat{\varepsilon})] - (1+i)w(\hat{\varepsilon})\frac{L}{e_1 y_2} + \frac{(1-\mu)(1+i)w(\hat{\varepsilon})L}{e_1 y_2} \\
&= [1-\Omega(\hat{\varepsilon})] - \mu\frac{(1+i)w(\hat{\varepsilon})L}{e_1 y_2}
\end{aligned}
$$

An increase in the interest rate increases the income of the lender in the case of no default, but it also raises the foreclosure costs the lender pays in case of default (by raising $\Omega(\hat{\varepsilon})$). Then the effect of an interest rate rise on lender returns can be positive or negative, depending on the size of the loan (assume foreclosure costs are significant enough).

Suppose we start with a very low *L*. Because lender returns must be zero, higher interest rates must be compensated by raising *L*. This is equivalent to saying that (at sufficiently low levels of *L*) the loan supply curve is upward sloping.

At sufficiently high levels of *L*, a rise in interest rates reduces lender returns: to keep lender returns equal to zero, *L* must *fall*. In other words, at high enough levels of *L*, lenders respond to higher loan demand by keeping interest rates more or less constant and rationing credit. This is typically illustrated by a backward-bending loan supply curve.

The level of L^c at which borrowers are credit-rationed if market-clearing interest rates are higher than the interest rate that satisfies equation (5), denoted by $\hat{\imath}$, is given by

$$L^c = \frac{[1-\Omega(\hat{\varepsilon})]e_1 y_2}{\mu(1+\hat{\imath})w(\hat{\varepsilon})}. \qquad \text{Eq. 7}$$

Therefore, in the presence of credit rationing, the equilibrium quantity of loans will depend positively on the repayment capability of the borrower (measured by e_1y_2) and the probability of repayment; it will depend negatively on foreclosure costs and interest rates (note, however, that $\hat{\imath}$ is "sticky", which is the cause of credit rationing). Recall that the probability of repayment rises if the exchange rate is stabilized, which implies that the equilibrium quantity of loans ought to rise as well.

3. Testing the Model

Most studies of the stylized facts of ERBS have noted that interest rates actually fall by too *little* and that sometimes (e.g., during heterodox stabilizations or if the stabilization program is accompanied by financial liberalization) they actually rise. Yet our model shows, in simulations, that interest rates ought to fall significantly when E(ε) rises and σ^{ε} falls. Does this theoretical claim hold up to the empirical evidence? Historically, what happens to the cost of borrowing when E(ε) rises? What happens when σ^{ε} falls? The first sub-section tests a version of equation (6) against on a sample of 54 countries over 1980-2000, to see if interest rates are determined empirically in the manner this paper argued theoretically, using σ^{ε} as a proxy for Ω.

We want to test three hypotheses about interest rates:

- That credit market imperfections and macroeconomic instability cause interest rates to be higher.
    - o Besides taking away the effect of APPR on interest rates, the other regressors do not seem to impact interest rates, which is so counterintuitive that it suggests that interest rates are not fully flexible and that therefore there is credit rationing in the international financial markets.
- That the fall in the cost of capital following a reduction in the instability of the exchange rate (a rise in APPR) is too small to justify the existing theoretical models of exchange-rate based stabilization.
    - o Both sets of regressions suggest that, once other factors are included in the regression, the coefficient on APPR remains significant and of the right sign, but it becomes less than one in a statistically significant way. This means that interest rates are "sticky" to changes in APPR once credit market effects are controlled for.
- That the stabilization of the exchange rate affects lending deposit rates by significantly less than it affects deposit rates. As mentioned in the introduction, the relevant cost of spending is arguably the lending rate. If this interest rate changes by little when the exchange rate is stabilized, one

must look for other factors to explain changes in aggregate demand, such as credit market frictions and the availability of capital.

  - Indeed, the coefficient on APPR is much, much smaller in LEND regressions than in DEPRATE regressions.

Then, confronted with the evidence that changes in the volatility of the exchange rate and the macroeconomy seem to have little effect on interest rates, we hypothesize that there is credit rationing –so that interest rates are "sticky" but loan amounts are free to vary in response to improvements in lender returns– and test the hypothesis that capital inflows (which are represented by *L* in the model) are determined according to equation (7) – or rather, by equation (6) solved for *L*. Hence, we hypothesize:

- That capital flows, conventionally assumed to depend on foreign and domestic interest rates, as well as on risk, are also dependent on the interaction between credit market conditions and macroeconomic stability.
  - There is support for the hypothesis that countries were credit rationing is more severe (maybe due to financial market imperfections), the variability of appreciation rates or of output will have a large (negative) impact on capital flows.

To measure credit rationing, we use two measures, one from Galindo and Micco's (2001) study on creditor protection and financial cycles and another from

Tornell and Westermann's (2002) study on the credit channel in middle-income countries.

First, we borrow estimates for (1-μ) from Galindo and Micco (2001), who develop a measure of "effective creditor rights," denoted by CRED, that takes into account both the legal rights of creditors and the application of the rule of law in the country (then 1-CRED indicates greater market imperfections). The table below reports the countries in the data set, selected because Galindo and Micco's measure was available for them.

Table 5
Countries in the data set

Argentina,	Ecuador,	Jamaica,	Philippines,
Australia,	Egypt,	Japan,	Portugal,
Austria,	El Salvador,	Kenya,	Singapore,
Belgium,	Finland,	Korea,	South Africa,
Bolivia,	France,	Malaysia,	Spain,
Brazil,	Germany,	Mexico,	Sri Lanka,
Canada,	Greece,	Netherlands,	Sweden,
Chile,	Guatemala,	New Zealand,	Switzerland,
Hong Kong,	Haiti,	Nicaragua,	Thailand,
Colombia,	India,	Nigeria,	Trinidad and Tobago,
Costa Rica,	Indonesia,	Norway,	United Kingdom,
Denmark,	Ireland,	Paraguay	Uruguay
Dominican Republic	Israel	Peru,	Venezuela,
	Italy,		Zimbabwe

This measure has problems. It combines a measure of creditor rights (derived from La Porta et al. (1998)) with a measure of the rule of law in each country (derived from Kaufmann et al. (1999)). But some of the results are downright odd (see Table A.0): for example, countries like Colombia, Chile, or Portugal (and the United States) are found to have *fewer* effective rights for creditors than Zimbabwe, Pakistan, or Indonesia; France has less effective creditor protection than Haiti; Switzerland has about the same effective creditor rights as Nigeria and less than Turkey or Egypt; Malaysia is found near the top of the list, just better than Denmark and Austria. This suggests that regression coefficients of this measure must be interpreted with caution.

The second measure of credit rationing (denoted as CRDRAT) is derived from Tornell and Westermann (2002), who show that, in countries where there is credit rationing, the relative price of non-traded goods to traded goods (proxied here by the real exchange rate) is positively correlated to the rate of growth of real domestic credit. They argue that non-traded goods producers are typically credit constrained (say, because of asymmetric information) while traded goods producers have access to international financial markets. If this is true, a rise in the relative price of non-traded goods should lead to a rise in the availability of credit to this sector. This "credit channel" is not present in countries where there are no credit market imperfections (here, where non-traded goods producers are capable of borrowing from international markets). It follows that a strong and positive correlation between the real exchange rate and the rate of growth of real domestic credit can be taken as a proxy for credit market imperfections. CRDRAT has been defined as a 5-year correlation.

Theory suggests an interaction term between CRED or CRDRAT and macroeconomic conditions. Creditor rights should be harder to enforce during economic downturns and/or exchange rate market disarray; countries with a history of macroeconomic volatility and low growth are likely to have lower effective creditor rights: of two unstable countries, the one with poorer credit markets should experience lower capital flows, and vice versa. CRDRAT is negatively correlated with the average growth rate of real GDP in most regions, and it is positively correlated with the standard deviation of the real growth rate and the appreciation rate. The implication is that faster-growing countries and countries with more macroeconomic stability have lower credit market frictions.

We also include an interaction term between the credit market variables and the standard deviation of the appreciation rate, STDAP, on the assumption that higher exchange-rate variability will reduce capital flows more if the domestic financial system has more frictions.

In addition to μ, we use the US Federal Funds rate as i^*, the opportunity cost of funds for the international lender. We obtained IFS data for the lending rate, the exchange rate, and GDP at 1995 prices, over 1980-2000, for the 54 countries listed in Table 5.[8] Tables A.1 – A.6 at the end of the paper report the results of different versions of an econometric model based on equations (6) and (7).

3.1 Regressions with the Deposit Rate and the Lending Rate as the Dependent Variable

Following interest parity, the domestic lending rate (LEND) and the deposit rate (DEPRATE) should move one-to-one with the opportunity cost of funds

[8] We excluded the hyperinflationary episodes in Argentina and Brazil from the data set as well as outlying observations for the rate of appreciation in Nicaragua (in 1988 and 1991).

(FEDFUNDS, positively) and the appreciation rate (APPR, negatively). Weaker effective creditor rights (1-CRED or CRDRAT, a higher μ) should lead to higher interest rates. A higher σ^{ε} raises the probability of default and so puts upward pressure on domestic interest rates. We've assumed a version of the "original sin" hypothesis by defining STDAP as the standard deviation of the appreciation rate over the previous 5 years, so that expectations about future default rates are based on a recent history of exchange rate volatility. Low volatility of real growth rates (STDGDP), should be accompanied by lower rates of default on loans and therefore lower interest rates.

As can be seen from Tables A.1 - A.4, the coefficient of APPR is significant and has the sign implied by interest parity in all the regressions (both with DEPRATE and LEND as the dependent variables), but the magnitude of the coefficients requires comment. Table 6 (which summarizes the results) suggests that APPR has a much larger effect on the depreciation rate than on the lending rate and that this effect is very sensitive to credit market frictions. In particular, when credit market frictions are measured by Tornell and Westermann's indicator, the APPR coefficient becomes much less than one in both kinds of regressions.

Table 6
Coefficients of APPR in regressions with DEPRATE and LEND as dependent variables and adj-R^2 statistics; with and without credit-market indicators.

Coefficient of APPR	Without credit market variables	With Galindo and Micco's index (average)	With Tornell and Westermann's index (average)
In DEPRATE regressions	-11.2018 (4.8477)	-11.0865 (4.7615)	-0.1486 (0.0595)
In LEND regressions	-1.8846 (0.9961)	-1.4841 (0.6891)	-0.2401 (0.1266)
adj-R^2 Statistic			
In DEPRATE regressions	0.1399	0.1365	0.4929
In LEND regressions	0.2179	0.2388	0.4834

Contrary to intuition, macroeconomic and exchange-rate stability do not seem to affect deposit or lending rates much; the coefficients are generally of the wrong sign and insignificant.

There is weak support for the hypothesis that the effect of stabilization on lending rates is related to financial frictions, as shown in Table 6, and by the fact that the interaction terms in Tables A.1 - A.4 are all of the expected sign and only marginally insignificant. Tornell and Westernmann's indicator seems to be superior to Galindo and Micco's, at least by the adj-R^2 criteria.

In conclusion: consistently with the stylized facts of ERBS, in which a stabilization of the exchange rate (i.e., a rise in E(ε) and a fall in σ^{ε}) have weak effects on interest rates, these regressions find little connection between (macroeconomic and exchange-rate) volatility and interest rates, which is surprising and merits further investigation. There is also evidence to suggest that the effect of a reduction in the rate of depreciation (a rise in APPR) is larger for deposit rates than for lending rates, and that credit market frictions may account for part of this difference.

3.2 *Regressions with Capital Inflows as the Dependent Variable*

Historically, countries that are affected by macroeconomic or exchange rate instability have little access to the international financial market: they are credit-rationed at the prevailing interest rate, and higher interest rates do not reduce the degree of credit rationing. Stabilization, on the other hand (modeled here as a higher E(ε) or a lower σ^{ε}) has often been accompanied to renewed access to international capital markets. Theory suggests that capital inflows should be affected by more or less the same factors that affect the lending rate in our models. We hypothesize that countries were credit rationing is more severe (maybe due to financial market imperfections), the variability of appreciation rates or of output will have a large (negative) impact on capital flows.

Modifying equation (6) to solve for the determinants of L,

$$L = \frac{(1-\delta)}{(1+i^*)-(1+i)\varepsilon(1-\Omega)}$$

we see that L depends negatively on the losses from default (foreclosure costs, macroeconomic instability), on the probability of default (and therefore on the volatility of the exchange rate), and on the opportunity cost of funds; it depends positively on the domestic loan rate and the appreciation rate.

We use the almost the same data and model as in the previous subsection, but replacing the lending rate with the ratio of the Financial Account to GDP as a measure of capital flows, where the data are obtained from the IFS for the same set of countries as in the regressions above, excepting France, Germany, Japan, and the United Kingdom, whose capital flows are several orders of magnitude above the rest of the sample; Belgium was excluded because it did not report Financial Account figures for during the sample period. We also add the deposit rate as the one of the explanatory variables as one of the determinants of capital flows. On the hypothesis that interest rates are relatively sticky, we expect them to be statistically insignificant. The results are reported in Tables A.4 - A.5.

The regressions find mixed support for the hypotheses, yet the results are robust to changes in the specification of the model. Once the other variables are accounted for, neither the opportunity cost of funds (measured by the Fed Funds rate) nor the domestic deposit rates are significant predictors of capital inflows. As this paper's model predicts, the appreciation rate is a strong predictor of inflows (funds are attracted by higher APPR, i.e., lower depreciation rates, which may indicate a stabilization of the currency).

STDAP is always of the expected sign and more significant when including the interaction with CRED (but not when interacted with CRDRAT); STDAP loses significance marginally when the interaction term of the standard deviation of GDP with CRDRAT is present.

STDGDP is always of the expected sign and strongly significant when by itself or when interacted with CRDRAT: it becomes marginally insignificant when an interaction with CRED is included (but it keeps the expected sign). This suggests, in a manner consistent with the theoretical model of this paper, that (even if lending rates are relatively insensitive to exchange-rate stabilization) capital inflows are attracted by economic stability *and that financial frictions are important* in determining the response of capital flows to exchange-rate stabilization.

CRDRAT is always of the expected sign and it is statistically significant (unless the interaction with STDAP is included). STDAP*CRDRAT is always of the expected sign, although insignificant at conventional levels. One can tentatively infer that credit-market frictions may have an effect on how the behavior of the exchange rate affects the financial market.

On the other hand, CRED is a poor predictor of capital inflows, both by itself and interacted with STDGDP or with STDAP. All CRED coefficients, by themselves and interacted, have the wrong sign. This would imply that countries with *stronger* effective creditor rights (that is, countries where (1-CRED) is lower) would suffer larger capital outflows, and that this effect increases if STDAP or STDGDP increased, compared to countries with weaker effective creditor rights. The model suggests that these countries would experience *outflows* in the wake of stabilization. This is especially puzzling since it was found that countries that have more exchange-rate volatility tend to have weaker creditor rights. Given the problems with the CRED measure mentioned above, one is tempted to discard this result as an aberration.

For the reasons mentioned above, CRED is unlikely to be a perfect measure of creditor rights. Tornell and Westermann's CRDRAT does relatively better, but its performance is not stellar. Work in developing a better measure is still needed.

It is also clear that capital inflows (rather lending rates) change with changes in the expected profitability of lending, which is determined, in turn, by macroeconomic stability, exchange rate stabilization, and efficient credit markets. This is consistent with they hypothesis that credit market imperfections cause interest rates to be sticky (although this conclusion is by no means inescapable).

We ran additional regressions (with the same variables) on restricted samples, focusing on Latin American, Asian, European, and African countries, and a final set of regressions on the sample excluding European and African countries. Most variables were fairly insignificant in the African and European samples: other explanations must be found for capital flows to these countries. The results discussed above held up in the Latin American and Asian samples, and on the common Latin American-Asian sample.

4. Conclusion

This paper has given theoretical and empirical support to the hypothesis that a) a stabilization of the exchange rate should lead to a reduction in both the average rate of depreciation and its standard deviation; b) that these factors may reduce the cost of credit in the absence of credit rationing; c) that these factors may reduce the incidence of credit rationing if present.

The theoretical model was based on canonical studies of the financial sector, in the spirit of Bernanke, Gertler, and Gilchrist (BGG 1998), simplified to draw attention to the role of currency mismatch: foreign-currency denominated loans and domestic-currency denominated income, which gives centrality to the behavior of the exchange rate. Given the fact that a volatility of the exchange rate should cause more defaults in the model, it was argued that exchange-rate stabilization should lower interest rates –or, in the presence of credit rationing, increase the availability of credit.

This was then tested using Tornell and Westermann's (2001) hypothesized measure of credit market frictions and Galindo and Micco's (2001) measure of creditor rights as proxies for financial frictions and financial data from a large sample of countries. The regressions gave some support to the theoretical model: the standard deviation of the appreciation rate does affect capital inflows (much more significantly than it affects lending rates, which in turn are affected more than deposit rates), which is consistent with the hypothesis that credit market imperfections cause international lending rates to be sticky. This effect was found to be affected by the presence of financial frictions.

An immediate implication of these findings is that ERBS programs are likely to affect aggregate demand not by reducing the cost of credit (which, empirically, does not fall by much after ERBS programs are instituted, even if deposit rates do fall) but by increasing the availability of funds. Because this relationship is due to frictions in the credit market, an ERBS program that is accompanied by a reform of the financial sector aimed at reducing frictions (e.g., improving the quality of information, of banking regulation, of bankruptcy courts, etc.) should lead to an even larger initial expansion of credit and of aggregate demand.

The results of this paper are not, however, indisputable. More work is necessary to find and test better proxies for financial frictions and for different ways in which a stabilization of the exchange rate may affect financial relations. Better and more abundant data on liability dollarization would improve the empirical tests.

An additional test of these hypotheses, also left for further work, is to limit the period of study and the selection of countries to ERBS episodes, focusing on whether financial reform accompanied this program. Of particular importance is whether this financial reform increased financial frictions (say, by increasing moral hazard) or reduced them (say, by implementing better accounting standards).

5. Appendix: Data and Regression Results

Notes: LEND is the country's lending rate, reported in the International Financial Statistics Online database of the International Monetary Fund, measured in percentage points per annum. KINFG is the ratio of the country's financial account to nominal GDP measured in dollars (calculated by multiplying nominal GDP in national currency by the exchange rate defined as U.S. dollars per units of national currency). Financial account, nominal GDP, and exchange rate figures are drawn from the IFS, measured in millions of US dollars. FEDFUNDS is the US Federal Funds rate, obtained from the Federal Reserve website, and measured in percentage points per annum. APPR is the annual change of the exchange rate, defined as units of foreign currency per unit of domestic currency, measured in percentage points. 1 - CRED is a redefinition of Galindo and Micco's (2001) *effective credit rights*, which take values between 0 and 1: higher values of 1-CRED indicate lower effective creditor rights. CRDRAT is constructed following Tornell and Westermann (2001) suggestion that credit-market imperfections can be measured by the correlation between the real exchange rate and the rate of growth of real domestic credit: a higher value of this correlation indicates greater credit-market imperfections. 5-year correlations were used. STDAP is the standard deviation of APPR between t and t-5, measured in percentage points. STDGDP is the standard deviation of GDPbetween t and t-5.

Table A.0
Galindo and Micco's (2001) measure of Effective Creditor Rights (CRED).

All figures between 0 and 1	Creditor Rights	Rule of Law	Effective Creditor Rights
Argentina	0.25	0.58	0.14
Australia	0.25	0.9	0.22
Austria	0.75	0.95	0.71
Belgium	0.5	0.7	0.35
Belize	0.5	0.52	0.26
Bolivia	0.5	0.41	0.21
Brazil	0.25	0.44	0.11
Canada	0.25	0.89	0.22
Chile	0.25	0.77	0.19
China,P.R.: Hong Kong	1	0.83	0.83
Colombia	0	0.3	0
Costa Rica	0.25	0.64	0.16
Denmark	0.75	0.92	0.69
Dominican Republic	0.25	0.59	0.15
Ecuador	0.25	0.32	0.08
Egypt	1	0.53	0.53
El Salvador	0.5	0.34	0.17
Finland	0.25	0.93	0.23
France	0	0.77	0
Germany	0.75	0.87	0.65
Greece	0.25	0.62	0.16
Guatemala	0.25	0.22	0.06
Haiti	0.5	0.13	0.06

India	1	0.54	0.54
Indonesia	1	0.27	0.27
Ireland	0.25	0.85	0.21
Israel	1	0.74	0.74
Italy	0.5	0.72	0.36
Jamaica	0.25	0.32	0.08
Japan	0.5	0.86	0.43
Kenya	1	0.19	0.19
Korea	1	0.41	0.41
Malaysia	1	0.71	0.71
Mexico	0	0.38	0
Netherlands	0.5	0.9	0.45
New Zealand	0.75	0.96	0.72
Nicaragua	0.5	0.32	0.16
Nigeria	1	0.23	0.23
Norway	0.5	0.96	0.48
Pakistan	1	0.31	0.31
Panama	0.75	0.4	0.3
Paraguay	0.25	0.33	0.08
Peru	0	0.37	0
Philippines	0	0.48	0
Portugal	0.25	0.77	0.19
Singapore	0.75	0.98	0.74
South Africa	0.75	0.74	0.55
Spain	0.5	0.76	0.38
Sri Lanka	0.75	0.41	0.31
Sweden	0.5	0.91	0.45
Switzerland	0.25	1	0.25
Taiwan	0.5	0.73	0.37
Thailand	0.75	0.6	0.45
Trinidad and Tobago	0.75	0.63	0.47
Turkey	0.5	0.5	0.25
United Kingdom	1	0.92	0.92
United States	0.25	0.81	0.2
Uruguay	0.25	0.57	0.14
Venezuela	0.5	0.33	0.17
Zimbabwe	1	0.46	0.46

References (incomplete)

Belke, Ansgar, Kai Geisslreither, and Daniel Gros. 2003. *On the Relationship Between Exchange Rates and Interest Rates: Evidence from the Southern Cone*. Diskussionsbeiträge Aus Dem Institute Für Volkswirtschaftslehre, Universität Hohenheim, No. 232/2003.

Bernanke, Ben S., Mark Gertler, and Simon Gilchrist. 1998. "The Financial Accelerator in a Quantitative Business Cycle Framework." National Bureau of Economic Research.

Boissay, Frédéric. 2001. *Credit Rationing, Output Gap, and Business Cycles*. European Central Bank Working Paper, No. 87.

Calvo, Guillermo A. and Carlos A. Végh. 1994. "Stabilization Dynamics and Backward-Looking Contracts." *Journal of Development Economics*, 43, pp. 59-84.

Calvo, Guillermo A. and Carlos A. Végh. 1999. "Inflation Stabilization and BOP Crises in Developing Countries." National Bureau of Economic Research.

Céspedes, Luis Felipe, Roberto Chang, and Andrés Velasco. 2000. *Balance Sheets and Exchange Rate Policy*. NBER Working Paper, 7840.

Galindo, Arturo and Alejandro Micco. 2001. "Creditor Protection and Financial Cycles." Inter-American Development Bank.

Greenwald, Bruce C. and Joseph E. Stiglitz. 1993. "Financial Market Imperfections and Business Cycles." *Quarterly Journal of Economics*, 108:1, pp. 77-114.

Hamann, A. Javier. 2001. "Exchange-Rate-Based Stabilization: A Critical Look at the Stylized Facts." *IMF Staff Papers*, 48:1, pp. 111-38.

Kaufmann, Daniel, Aart Kraay, and Pablo Zoido-Lobatón. 1999. *Aggregating Governance Indicators*. World Bank Working Paper, 2195.

La Porta, Rafael, Florencio Lopez-de-Silanes, Andrei Shleifer, and Robert Vishny. 1998. "Law and Finance." *Journal of Political Economy*, 106:6, pp. 1113-55.

Myers, Stewart C. and Nicholas S. Majluf. 1984. "Corporate Financing and Investment Decisions When Firms Have Information That Investors Do Not Have." *Journal of Financial Economics*, 13, pp. 187-221.

Sobolev, Yuri V. 2000. *Exchange-Rate-Based Stabilization: A Model of Financial Fragility*. IMF Working Paper, WP/00/122.