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Exchange Rate Policy and Liability Dollarization: An Empirical Study

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Exchange Rate Policy and Liability Dollarization: An Empirical Study[1]

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Abstract

The paper identifies the contemporaneous relationship between the exchange rate policy and external debt dollarization in a panel of industrial and developing countries. The presence of endogeneity makes the task of empirical identification elusive. The paper uses the method of "identification through heteroskedasticity" developed by Rigobon (2003) to solve the problem of identification in the present context. It finds that, controlling for endogeneity, countries with aggregate liability dollarization tend to be more actively involved in exchange rate stabilization operations, but it finds mixed results for the reverse causality.

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I. INTRODUCTION

We identify the contemporaneous relationship between the exchange rate policy and aggregate liability dollarization in a panel of 90 industrial and developing countries for the period 1970-2003. In particular, we want to explore the two-way link between the central bank's decision to actively intervene in the foreign exchange market to stabilize the nominal exchange rate and the aggregate gross foreign currency liabilities that arise as a consequence of agents' portfolio choices.

The interaction between liability dollarization and exchange rate regime choice has been a long debated topic. There is a widespread belief in the literature and in policy circles that many countries have difficulties letting their exchange rate float, and that many countries that claim to be floaters are actively engaged in exchange rate stabilization operations. This is the so-called "fear of floating" phenomenon discussed in Calvo and Reinhart (2002), which partly puts the blame on the adverse effects of exchange rate fluctuations when countries' liabilities are denominated in foreign currency (i.e., "dollarized").[2] This story takes liability dollarization as given, and focuses on its effects on the exchange rate regime. At the same time, it is quite possible that liability dollarization is also influenced by exchange rate policies as suggested by a set of recent papers. For example, it is conceivable that agents who expect the central bank to maintain a fixed exchange rate vis-à-vis a major currency choose to borrow in that foreign currency to minimize the risk associated with their portfolio choice.

On the one hand, a set of papers, such as Ize and Levy Yeyati (2003), Ize and Parrado (2002) and Moron and Castro (2003) model asset and liability dollarization as a portfolio choice problem given a set of macroeconomic uncertainties and policy choices reflected in the volatility of inflation and real exchange rate. Accordingly, dollarization (real and financial) is higher as the volatility of inflation increases—which increases the volatility of real wages and / or financial returns (costs) --, and lower when the real exchange rate is more volatile. On the other hand, papers including Calvo and Reinhart (2002), Gavin et al. (1999), Calvo (2001), Levy Yeyati, Sturzenegger, and Reggio (2002), and Reinhart, Rogoff and Savastano (2003) argue that if corporate or public sector debts are denominated in foreign currency, central banks may avoid exchange rate flexibility fearing financial instability and bankruptcies.

Despite the abundance of empirical and theoretical studies on the relation between exchange rate policy and liability dollarization, most of the discussion has focused on the one-way causality and has ignored their simultaneous determination. The recent papers by Chang and Velasco (2004) and Chamon and Hausmann (2002) developed models where exchange rate policy and portfolio choices are jointly-determined. On the empirical side, Devereux and Lane (2002) control for endogeneity in estimating bilateral exchange rate volatility. Likewise, Arteta (2002) controls for endogeneity in testing whether flexible exchange rate regimes are associated with lower currency mismatches in the banking sector.

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[2] As in much of the related literature, we use "dollarization" as a short-hand to "foreign currencies".

Our contribution is to use the method of "identification through heteroskedasticity" developed by Rigobon (2003) to obtain unbiased estimates of the effect of liability dollarization on exchange rate and the reverse causality. This methodology relies on the heteroskedasticity found in the data as the means to identify the system of simultaneous equations. It solves the identification problem without using instrumental variables or assuming some exclusion restrictions.

The theoretical underpinnings of this paper are related to Chang and Velasco (2004) who build a model to analyze the endogenous relation where the optimal exchange rate policy chosen by the central bank depends on the severity of liability dollarization. But the latter is determined, in turn, by the optimizing decisions of domestic borrowers, and hence by their expectations of exchange rate policy. If agents expect fixing and arrange their portfolios accordingly, the central bank validates that expectation. If, on the other hand, agents expect floating, the central bank validates that too. Similarly, Chamon and Hausmann (2002) develop a model where the currency denomination choice of individual borrowers and optimal monetary policy are jointly determined. In their model, the monetary authority that cares about the adverse effects of bankruptcy prefers to stabilize the exchange rate rather than the interest rate if liabilities are dollarized. In such cases, there are multiple equilibria in liability dollarization depending on the borrower's expectation regarding the other borrowers' expectations. Even though the two papers are different in their modeling approach, the sequence of events is the same: if private agents expect that the monetary authority will stabilize (float) the currency, then it is optimal to borrow in foreign (domestic) currency. Once, however, the economy ends up with large foreign (domestic) currency debts, the central bank finds it optimal to fix (float) the currency. In a similar vein, Ize (2005) builds a model to explain financial dollarization and shows that policy endogeneity can push the economy to highly dollarized state. In certain situations, however, the portfolio composition is indeterminate, for example, when the exchange rate is pegged and the available asset menu is limited, since both currencies become perfect substitutes (Ize and Parrado, 2002; and Chang and Velasco, 2004).

Despite the strong intuitive appeal of this idea, we still do not have a sense of how strong the empirical link is. The presence of endogeneity makes the task of empirical identification elusive. There are no obvious valid instruments that can be used for estimation, nor exclusion restrictions that can be justified in this setting. To make things even worse, there are possibly additional endogenous variables, for example the volatility of inflation. The volatility of inflation affects debt composition and is also affected by the exchange rate choice.[3]

There are only a few set of empirical papers that acknowledge the presence of endogeneity in this context. Devereux and Lane (2002) consider the endogeneity problem explicitly in estimating bilateral exchange rate volatility. They explain bilateral exchange rate volatility through the stock of external debt in addition to the usual optimum currency area (OCA) factors and use instrumental variables technique (IV). They use two measures of debt liabilities: a- foreign-currency liabilities obtained from Bank of International Settlement (BIS) data; b- sum of the own-currency bank claims and portfolio debt claims (no currency decomposition) obtained from BIS and IMF's International Portfolio Survey. Based on the literature on determinants of

[3] See, for example, Ize and Levy Yeyati (2003), Ize and Parrado (2002), and Chang and Velasco (2004).

bilateral financial relations, their instruments for external financing, trade and symmetry of shocks are: the log of distance and its square, common language dummy, colonial dummy, regional trade agreement dummy, log GDP and its square. Their findings support the fear of floating arguments. They conclude that while external debt, particularly foreign currency denominated debt, is negatively correlated with bilateral exchange rate volatility for developing countries, the OCA parameters are more significant in explaining the exchange rate volatility for developed countries. However, since they get mixed evidence on the issue of the instrument relevance, they caution about the interpretation of IV results (Devereux and Lane, 2002, pp. 22). These instruments are not valid for our purposes, because, we do not try to explain bilateral exchange rate volatility, but rather an aggregate level of exchange rate volatility captured through the intensity of the intervention of the central bank in the foreign exchange markets – effort of central bank to stabilize the currency. Therefore, our paper differs from Devereux and Lane (2002) in two aspects. First, while they focus on bilateral exchange rate volatility, we focus on central banks' effort to stabilize the currency. Second, we explicitly estimate both sides of the two-way relationship between dollarization and exchange rate policy choice. Therefore, we are able to identify not only the effect of dollarized liabilities on exchange rate management, but also the reverse causality.

Arteta (2002) assembles a new database on deposit and credit dollarization in developing and transition economies and finds that floating exchange rate regimes seem to exacerbate, rather than ameliorate, currency mismatches in domestic financial intermediation. He uses land area, terms of trade shocks, and the value of the exchange rate regime in 1974 as instruments for the exchange rate regime. This paper is different from ours not only in the empirical methodology employed, but more importantly, in that it focuses on one-way causality from exchange rate choice to currency mismatches in the financial sector rather than on the two-way causality between exchange rate policy and aggregate liability dollarization. He finds little support for the view that flexible exchange rate regimes reduce currency mismatches in the domestic financial sector. Similarly, we find comparably little evidence that flexible exchange rate regimes reduce aggregate debt dollarization, but we find robust evidence that there is a positive causal link going from aggregate debt dollarization to fixed exchange rate regimes.

We focus on countries' liabilities against the rest of world and answer the question of whether aggregate liability dollarization matters for the exchange rate regime choice. Of course, the governments may care about the domestic distributional effects of its policies. For example, when the local corporate sector borrows from the domestic banking sector in foreign currency or when banking sector has currency mismatches, exchange rate depreciation can cause corporate and / or banking sector instability. Therefore, a central bank that cares about the distributional effects and the cost of instability brought by balance sheet effects might choose to stabilize the exchange rate. This, however, is a different question than ours. Distributional effects, such as banking, corporate or public sector liability dollarization are also important, but the answer critically depends on data availability and it is left for future research.

Our findings support the "fear of floating" argument, but not the presumed reverse positive causality. Countries with high external liability dollarization tend to stabilize their exchange rate. This finding is robust to various proxies for exchange rate management. For the reverse causality, on the other hand, we find in the benchmark regressions that more active intervention in foreign exchange markets (i.e., more fixing) leads to lower liability dollarization. This result is not robust to different normalizations of the external liability dollarization. Although, one may expect that agents have incentives to borrow in domestic currency to minimize the exchange rate risk under floating exchange rate regime, our results may be capturing the indeterminacy in portfolio choice as predicted by Chang and Velasco (2004) and Ize and Parrado (2002). Therefore, we conclude that we find mixed results for the reverse causality. In the following sections, we present our empirical framework and the data, and then we report and discuss the results and robustness checks.

II. Data Description

In order to get a proxy for aggregate liability dollarization, we use two data sets: debt and total external liabilities from Lane and Milesi-Ferretti (2006) and original sin index[4] from Hausmann and Panizza (2003).

We use two series from Lane and Milesi-Ferretti (2006) who have compiled information from various sources on aggregate foreign assets and liabilities for a set of industrial and developing countries.

1. *Gross Foreign Debt (D)* = stock of aggregated foreign debt liabilities.

2. *Gross Foreign Claims* (C) = stock of aggregated foreign total liabilities.

where "aggregate" means that they include the private and public sectors of the economies. The difference between these two measures is that the latter includes foreign direct investment and equity as part of total assets and liabilities, while the former is only debt. We report regression results based on both variables, but our main focus is *D*, which has captured the bulk of the attention in the theoretical literature. The sample consists of a panel data set of 145 countries. The data extends from 1970 to 2003.

Since we are particularly interested in the foreign currency component of these liabilities, we multiply both variables with the "Original Sin" index from Hausmann and Panizza (2003). In particular, we use OSIN3, which is a measure of the proportion of the debt that is contracted in foreign currencies for about 90 countries between 1993 and 2001. This produces a proxy for debt liabilities (total external liabilities[5]) in foreign currency. A full list of countries is available in Appendix I.

Given that Hausmann and Panizza's original sin data is an unbalanced panel – with only one or two years for certain countries – and that for most countries time variation is rather limited, we initially take the average by country.[6] By doing so, we implicitly assume that the currency

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[4] Original sin refers to the fact that most countries have difficulties in borrowing in their of currency.

[5] Since equities and foreign direct investment are very different from debt by nature, we do not put a lot of weight on the results obtained from this variable.

[6] This implies that a single observation in the time span 1970-2003 suffices to have OSIN data for the corresponding country. This allows us to increase data availability considerably. Even though this creates some measurement error,

(continued…)

composition of debt (and claims) remains stable over the sample period. We use this definition as our baseline, but also present the results based on the simple interaction between D and C with OSIN3 without taking the average by country.

In order to make the data comparable across countries, we normalize *D* and *C* by total debt (i.e., debt assets plus debt liabilities) and total claims (i.e., assets plus liabilities) respectively. After this normalization, and the interaction with original sin, D and C become:

3. *GrossD* = gross foreign debt in foreign currency as a share of total debt assets plus debt liabilities

4. *GrossL* = gross foreign claims in foreign currency as a share of total assets plus liabilities

Alternatively, we normalize *D* and *C* (both interacted with OSIN) by the size of the economy (*GDP*). As a first approximation, one could do so by simply dividing the numerator by GDP_t—where "*t*" indexes year. The disadvantage of this procedure is that we can not be sure to what extent the time series variation in the resulting ratio is driven by the numerator or the denominator. This complicates our identification procedure. We deal with this issue by normalizing *D* and *C* by the "*average GDP per capita * population*$_t$". Note that "*average GDP per capita*" is the 1970-2003 period average for each country, so it has *no* time series variation. We multiply by population to achieve a meaningful measure of the size of the economy with some variation. This alternative normalization is conceptually equivalent to dividing the numerator by GDP_t (i.e., normalizing each observation by the size of the economy), but it has the advantage of eliminating the time series variation that is purely associated to changes in *GDP*.[7]

After this alternative normalization, and the interaction with original sin, D and C become:

5. *GrossD_GDP* = gross foreign debt in foreign currency as a share of GDP

6. *GrossL_GDP* = gross foreign claims in foreign currency as a share of GDP

As mentioned earlier, we also exploit the limited time series variation of *OSIN* in the Hausmann and Panizza's dataset by interacting *D* and *C* by $OSIN_t$. This results in four additional variables:

7. *GrossD_OSIN*

8. *GrossL_OSIN*

9. *GrossD_GDP_OSIN*

10. *GrossL_GDP_OSIN*

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we don't think that the bias is too problematic as also suggested by Bordo and Meissner (2005). For most of the developing and small size countries, the index is 1 through out the available years, and slow moving for the others.

[7] Instead we introduce the variation in population, but population has much more stable growth rates than GDP.

which are the same as the previous variables, but by interacting with *$OSIN_t$* rather than *average OSIN*, we do not assume that the currency composition of debt remains stable over time. The disadvantage of this procedure is that we loose a lot of observations (see summary statistics in Table 2) because for most countries we have *OSIN* data only for a couple of years in the 1990's.

Detailed descriptions of how all variables are constructed, along with data sources and methods are available in Appendix II.

The other key variable in our dataset is the exchange rate policy choice. We want a variable that captures the strength of the intervention in foreign exchange markets. We choose intervention in foreign exchange markets (proxied by the volatility of foreign reserves) over direct measures of nominal exchange rate volatility for our benchmark regressions because of various reasons. First, the measurement of the latter can be problematic due to existence of multivariate exchange rate regimes. Second, multiple currency crises that unexpectedly increase the nominal exchange rate volatility create outliers that may extensively distort the standard deviations of our estimates. Third, some countries peg their currency to a basket of currencies rather than to a single anchor, and finally not every country that pegs (or stabilizes the nominal exchange rate) does it always vis-à-vis the same anchor currency. Although there are some problems associated with the use of reserves, such as changes in reserves due to fluctuations in valuation and accrual of interest earning, the outlier problem is less severe with the reserve data.[8]

Our measure for the exchange rate policy choice assumes that countries that intervene more actively in foreign exchange markets (which is reflected in higher volatility of reserves) are de-facto fixers, while actors that are more passive tend to be floaters. For this purpose, we collected monthly data on reserves holdings for the entire sample period for each country in our dataset. We, then, computed the annual volatility of reserves as the standard deviation of monthly changes in reserves for every year. Because a given level of volatility in reserves in countries with low monetization implies a larger relative intervention, we normalized the volatility of reserves using the monetary base (and also a broader monetary aggregate). Finally, we do an innocuous transformation (described in detail in Appendix 2) to aid in the interpretation of the results. The end products are two variables (for two different normalizations) that we use in our regressions:

11. R_M0: reserve volatility as a share of M0.

12. R_M2: reserve volatility as a share of M2.

To make sure that different possible normalizations do not change the results, we also define another measure that takes the standard deviation of the ratio of monthly changes in reserves to money.

13. *$std(R\_M_0)$*: Volatility of the ratio of changes in reserve to money.

[8] See Calvo and Reinhart (2002) for a discussion.

For the robustness checks, we also define four alternative variables that seek to capture the exchange rate volatility more directly. First, we define the volatility of nominal exchange rate (domestic currency vis-à-vis the US dollar) as the standard deviation of monthly changes in the nominal exchange rate [std(NER)]. Alternatively, since countries can potentially borrow in multiple vehicle currencies, we calculate the standard deviation of nominal effective exchange rate [std(NEER)]. This definition is in principle superior to the first one, but it is available for fewer countries. Third, following Eichengreen, Hausmann and Panizza (2003), we compute freedom to float, (FF) defined as the ratio of volatility of nominal exchange rate (and alternatively the nominal effective exchange rate) to the volatility of reserves. Therefore, a higher number implies higher volatility of exchange rate relative to the reserves (i.e., more nominal exchange rate flexibility). Finally, we calculate a variety of the so-called "exchange-market pressure" (ERMP) defined in Eichengreen, Rose and Wyplosz (1996). We take the ratio of volatility of reserves to sum of the volatilities of reserves and the nominal exchange rate (and alternatively the nominal effective exchange rate). This variable quantifies the extent to which central bank chooses to stabilize the exchange rate for a given level of pressure on its currency, where the extent of the pressure on the currency (or the lack of thereof) is captured by the denominator of the ratio.

The other endogenous variable in the system is the volatility of inflation. We collect data for annual inflation rates for all the countries and compute:

14. *Vol(π) = standard deviation of the monthly changes in the Consumer Price Index (CPI).*

Our controls for the first-stage regressions are:

15. *trade openness (trwdi) = Trade / GDP.*

16. *capital account openness (kaopen) = constructed as an on/off indicator of the existence of restrictions to cross-border capital flows using Chinn and Ito (2004).*

17. *country size = ln (real GDP).*

We also use other control variables including, a dummy for currency crisis from Frankel and Wei (2004), sudden stops from Cavallo and Frankel (2004), and US interest rates to control for international liquidity conditions.[9]

Appendix 2 contains a detailed summary of all the variables, a detailed description of their construction, the data sources and all abbreviations. And in Table 1 we provide the most important summary statistics. As we do not have all the data for every variable in every year, the resulting dataset is an unbalanced annual panel of 90 countries.

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[9] For example, Caballero and Krishnamurthy (2001) argues that inelastic supply of external funds during crisis periods can cause fear of floating. This, however, has also an effect on both agents' portfolio choices and the volatility of inflation.

Table 1. Summary statistics by variable

Variable	Obs	Mean	Std. Dev.	Min	Max
GrossD	2024	0.600	0.285	0.000	1
GrossD_GDP	2024	0.498	0.693	0.000	11.943
GrossL	2018	0.552	0.264	0.000	0.972
GrossL_GDP	2018	0.718	1.134	0.000	24.324
GrossD_OSIN	647	0.574	0.278	0.000	0.978
GrossD_GDP_OSIN	647	1.036	1.791	0.000	15.865
GrossL_OSIN	647	0.531	0.253	0.000	0.950
GrossL_GDP_OSIN	647	1.462	2.064	0.000	16.922
LOGR_M0	4638	0.528	2.602	-9.054	8.142
LOGR_M2	4453	-0.741	2.866	-10.820	7.415
ERMP_neer	2214	0.515	0.250	0.020	0.993
Std(NER)	6918	0.063	0.024	0	1.44
FF_NEER	2214	2.087	3.793	0.007	49.09
Vol(π)	4381	0.015	0.024	0.000	0.441
Trwdi	5785	71.741	43.419	1.531	330.596
LnGDP	5997	22.895	2.361	17.080	29.967
Kaopen	4600	-0.012	1.503	-1.725	2.656

III. STRUCTURAL EQUATIONS

As the aggregate liability dollarization (*GrossD or GrossL* or some of the other variants) and the exchange rate policy choice (R_M_0, R_M_2, *ERMP_neer)* affect each other simultaneously, estimating one of the equations without taking the other into account will produce biased results. In addition, both liability dollarization and exchange rate regime choice are endogenous to the volatility of inflation (π).

Our primary interest is in the relationship between the aggregate liability dollarization and the exchange rate policy. Therefore, we want to run the following set of equations:

$$D = \alpha R + \theta_D \pi + \gamma_D x + \eta_D \quad (1)$$

$$R = \beta D + \theta_R \pi + \gamma_R x + \eta_R \quad (2)$$

$$\pi = \kappa D + \theta_\pi R + \gamma_\pi x + \eta_\pi \quad (3)$$

where "*D*" is the abbreviation for one of our measures of dollarization (higher D implies more aggregate liability dollarization), "*R*" is the abbreviation for our measure of exchange rate policy choice, "*x"* is a set of exogenous control variables (common to all four equations) and η_i are structural innovations to each equation. Recall that *R* is a continuous variable that captures the intensity of central banks' intervention in foreign exchange markets through either the volatility of reserves (where higher R implies more fixing), or through "exchange-market pressure" Finally, higher π implies more inflation volatility.

After controlling for the factors that affect all the endogenous variables simultaneously, structural innovations represent the shocks specific to each endogenous variable. For example, a change in foreigners' preference for domestic versus foreign assets or in risk aversion is an independent shock to *D*. An unexpected change in exchange rate policy as a result of a change in central bank's preferences—which is not a response to a change in *D* or the volatility inflation—is an example for a shock to *R*. These structural shocks are possibly uncorrelated with each other. This is, as in much of the related literature, a maintained assumption.

What are the conjectured signs of the coefficients? The literature provides some guidance. Since the emphasis of this paper is on the first two equations and in particular the interrelation between aggregate liability dollarization and exchange rate regime choice (i.e., coefficients α and β), we focus on these two.

• **α can go either way**. The theory would suggest that expectations of fixing will lead agents to borrow in foreign currency, increasing liability dollarization. However, nominal foreign currency and local currency bonds become perfect substitutes under the fix exchange rate regime. If these are the only available type of bonds, then the outcome is not uniquely determined.

• **$\beta > 0$**. Countries with high liability dollarization tend to fix more as suggested by the aforementioned empirical and theoretical literature on "fear of floating".

• **$\theta_D > 0$**. Risk averse agents' loan portfolio choice is affected by inflation volatility to the extent that it has an effect on expected real interest payments. Higher inflation volatility, keeping everything else constant, would increase the volatility of interest payments of domestic currency debt and therefore would encourage liability dollarization (Ize and Levy Yeyati, 2003).

• **$\theta_R > 0$**. In countries where the exchange rate is used as nominal anchor, an increase in inflation volatility may cause more fixing. Alternatively, inflation targeting countries – implying lower volatility of inflation – have to let the exchange rate go if they concurrently opt for open capital markets.

Table 2 shows the simple correlation among the endogenous variables. The first three rows suggest that the correlation between any two versions of the same endogenous variable is high. The last three rows suggest that all the three endogenous variables are positively correlated. However, the direct effects are masked by the endogeneity among the variables. Our contribution in this paper is to disentangle the causality between them.

Table 2. Correlation of Endogenous Variables

Important Correlations	Common Observations	Value	Significance (P-value)
Corr (GrossD & GrossL)	2018	0.971	0.0000
Corr (GrossD & GrossD_OSIN)	481	0.9578	0.0000
Corr (GrossD & GrossD_GDP)	2024	0.1127	0.0000
Corr (GrossD & R_Mo)	1755	0.2625	0.0000
Corr (vol(π) & R_Mo)	3552	0.1896	0.0000
Corr (vol(π) & GrossD)	1783	0.2102	0.0000

Similarly Figures 1 and 2 present the scatter diagram of our two key endogenous variables. While Figure 1 suggests a positive correlation between reserve volatility and aggregate liability dollarization, the message is less clear for the scatter diagram of exchange rate volatility and aggregate dollarization.

Figure 1. Reserve Volatility and Aggregate Liability Dollarization

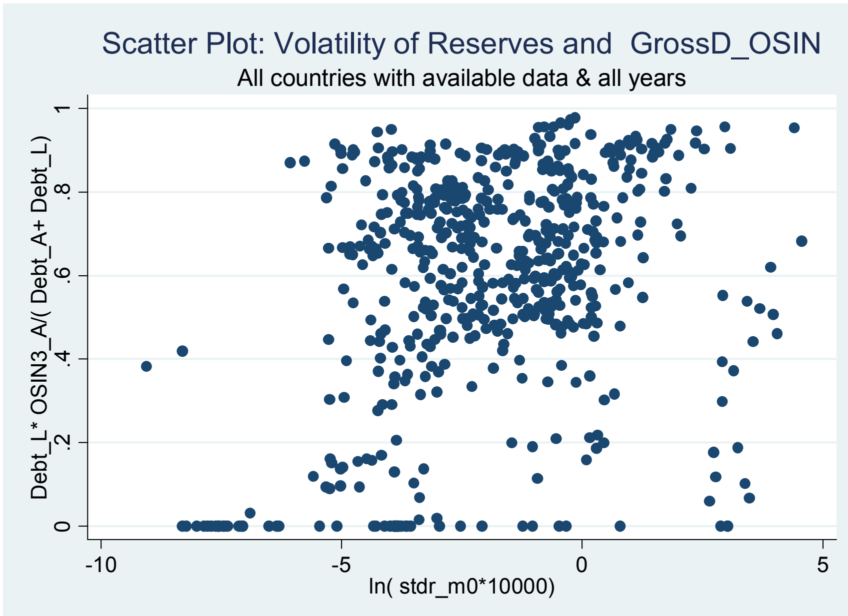
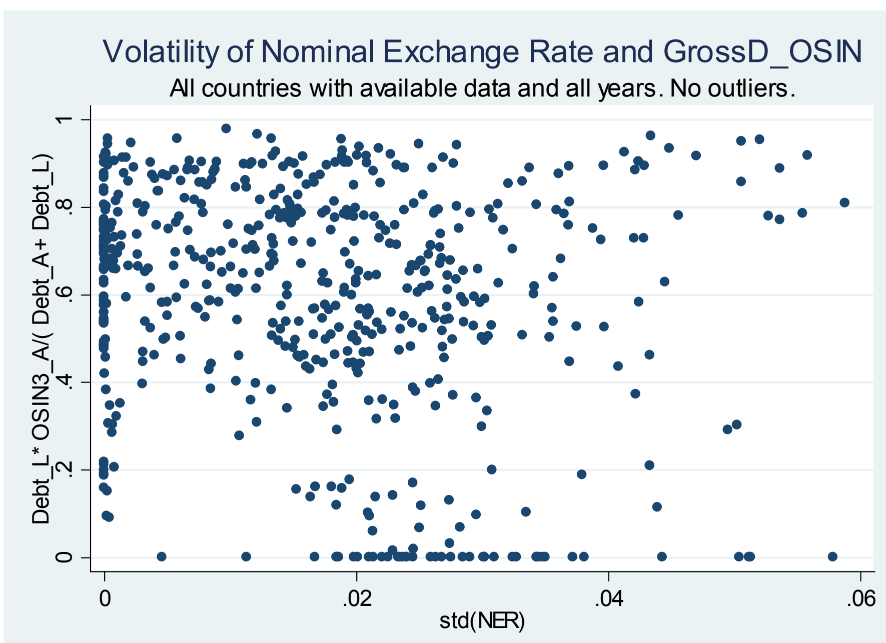


Figure 2. Nominal Exchange Rate Volatility and Aggregate Liability Dollarization



As for the list of common control variables in *x*, for concreteness, we do not discuss the presumed effects of each of them on the endogenous variables, but we discuss why we decided to include each of them:

- **Lags for all endogenous variables**: to account for serial correlation.

- **Country size**: we use the log of *GDP* (*LGDP*) to control for country size. In doing so, we follow Eichengreen, Hausmann and Panizza (2003) who identify "size" as the main determinant of why most countries can not borrow abroad in their own currency (a phenomenon that has been referred to as "original sin"). The bigger countries can borrow in their own domestic currency, because they provide more diversification opportunities to international investors. We need to account for the possibility that original sin is a characteristic of many countries that permeates their ability to conduct monetary policy, stabilize inflation and also constrains agent's choices. Size is also an important factor in the choice of exchange rate regime as emphasized by the optimal currency area literature.[10] Ize and Parrado (2002) argue that small countries, being more exposed to world shocks, are more likely to be dollarized.

- **Capital Account Openness**: the degree of capital market openness affects the freedom that central banks have to conduct monetary policy and contain inflation. It also affects agents' portfolio choices. The effectiveness of exchange rate policies highly depends on the degree of capital mobility. The effect is ambiguous depending on central bank's monetary policy choices. As capital mobility increases, central banks may let the exchange rate float if they want to preserve monetary policy independence. However, they may be willing to give-up monetary policy independence like the countries joining to European Union did. Capital market openness also has a direct effect on the ability of a country to borrow from and lend to the rest of the world. Depending on the type of capital controls, the effects are different. If there are capital controls on inflows then the foreign currency liabilities may be lower. If, on the other hand, the outflows are controlled, then the foreign currency assets may be lower.

- **Openness to trade**: countries' exposure to trade might raise trade-related volatility which permeates into other macroeconomic variables. The effect of openness on monetary policy choices is ambiguous. If the country wants to insulate against external shocks it may choose to float the exchange rate, but more open economies might also find it convenient to fix their currency to that of a major trading partner to reduce transaction costs. Ize and Parrado (2002) predict that more open economies should experience higher inflation volatility, and therefore financial dollarization should be higher as well.

- **Other control variables**: We also control for terms of trade volatility, sudden stops, crises and the US interest rates to clean the regressions from the effects of common shocks.

[10] See Mundell (1961).

IV. ESTIMATION

The emphasis of this paper is to estimate coefficients $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ (i.e., the effect of liability dollarization on exchange rate policy and vice-versa) controlling for endogeneity. The problem with the simultaneous equation system (1-3) is that it is unidentified. Since finding good instruments is quite hard, we will use the relatively new technique of identification through heteroskedasticity (IH) proposed by Rigobon (2003). It uses the heteroskedasticity found in the data as the basis for identification. The methodology is similar to "near identification", which employs the assumption that one of the variances of the structural shocks approaches infinity (Wright, 1928). IH, rather than assuming infinite variance, only requires that the relative variances are different across regimes.

In order to explain both the problem and its solution, let us write everything in a compact form, ignoring controls and lags for the time being.

$$\underbrace{\begin{bmatrix} 1 & -\alpha & -\theta_D \\ -\beta & 1 & -\theta_R \\ -\kappa & -\theta_\pi & 1 \end{bmatrix}}_{A}\underbrace{\begin{bmatrix} D \\ R \\ \pi \end{bmatrix}}_{Y}=\underbrace{\begin{bmatrix} \eta_D \\ \eta_R \\ \eta_\pi \end{bmatrix}}_{\eta}, \tag{4}$$

where *A, Y* and η represent the coefficient matrix, endogenous variables and structural shocks, respectively. Note that we normalize by setting the diagonal terms of A to one. In addition, we assume the structural shocks are uncorrelated – which is a common assumption in macroeconomic literature. Consequently, the covariance matrix of the structural shocks has the following form

$$\text{var}(\eta)=\begin{bmatrix} \sigma^2_{\eta_D} & 0 & 0 \\ 0 & \sigma^2_{\eta_R} & 0 \\ 0 & 0 & \sigma^2_{\eta_\pi} \end{bmatrix} \tag{5}$$

This system has nine unknowns; six coefficients and three variances for the structural shocks. What we can estimate with the data, on the other hand, is the reduced form;

$$Y=\underbrace{A^{-1}\eta}_{\varepsilon}, \tag{6}$$

which provides only six moments; three variances and three covariances.

$$Var(Y)=\text{var}(\varepsilon)=A^{-1}\,\text{var}(\eta)A^{-1'}. \tag{7}$$

Therefore, there are not enough equations to estimate the unknowns.

Now, assume that there are two sub-samples, in which the variances of the structural shocks are different. Assume also that the coefficients are the same for both sub-samples. This will produce 12 moments (three variances and three covariances for each sub-sample), which is as many as necessary to solve 12 unknowns (six coefficients and six variances). As long as the relative variances are different across sub-samples, we can achieve identification.

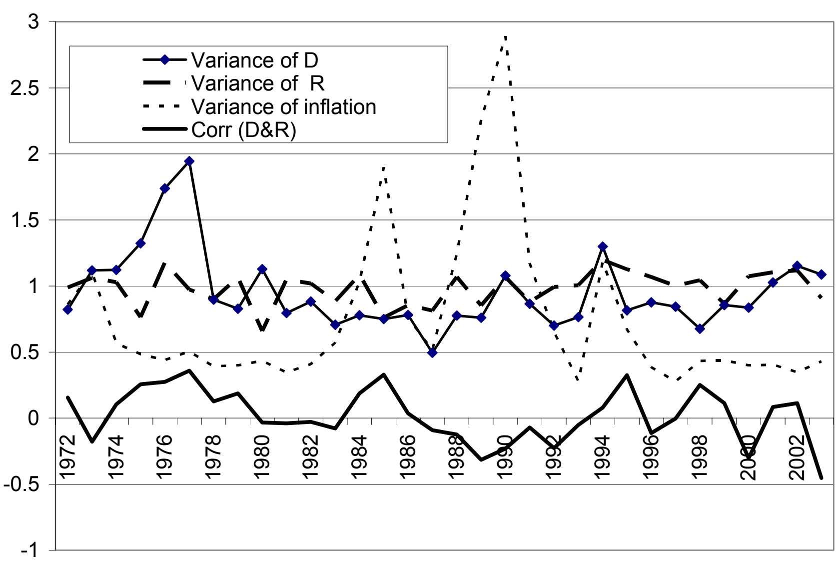
The actual estimation process is as follows. We first estimate a reduced form VAR and recover the residuals.

$$Y = A^{-1}\Phi(L)Y_{t-1} + A^{-1}\Theta(L)X_t + \varepsilon_t\,, \tag{8}$$

where $\varepsilon_t = A^{-1}\eta_t$ are the reduced form residuals, $\Phi(L)$ are the coefficients of lagged endogenous variables and $\Theta(L)$ are the contemporaneous and lagged coefficients of the control variables. As it may take time for net liability dollarization and inflation to react to the changes in the volatility of reserves in previous years, we use two lags to clean the data from serial correlation.[11]

The next step is to define regimes based on the heteroskedasticity of the data. Although there is a considerable cross sectional heteroskedasticity, for simplicity, we will divide our data based on time series heteroskedasticity. As can be seen from the following figure, the relative importance of the variances varies significantly over time. Since the variance of inflation is relatively large, we demeaned the variances to see the relative shifts more clearly. Each variance dominates the others during certain periods, which allows us to achieve identification.

Figure 3. Variances and Correlation of Endogenous Variables



[11] However, we run the regressions with 1 and 3 lags as well in the robustness section.

For the baseline scenario, we will take three years as a regime. However, in the robustness section we will change the regime windows to make sure that does not affect our point estimates. Table 3 presents the relative variance of the structural shocks for each regime. As can be seen from the table relative variances are different across regimes, which is exactly what we need to achieve identification.

Table 3: Relative Variances across Regimes

Regimes	Var(GrossD) /Var(std_R)	Var(GrossD) /Var(π)	Var(std_R) /Var(π)
1972-1974	1.026	1.469	1.431
1975-1977	3.299	14.204	4.305
1978-1980	1.220	4.454	3.652
1971-1983	0.655	2.652	4.048
1984-1986	0.675	0.354	0.525
1987-1989	0.515	0.208	0.403
1990-1992	0.671	0.217	0.323
1993-1995	0.781	1.350	1.728
1996-1998	0.601	3.955	6.577
1999-2001	0.717	3.908	5.453
2002-2003	1.072	7.461	6.960

Even if the regimes are not correctly specified, the estimates are still consistent (Rigobon, 2003). The basic intuition relies on the fact that the covariance matrices of the misspecified regimes will be linear combinations of true covariance matrices, which produces still consistent but less efficient estimates, unless the misspecification is severe enough that the rank condition is violated.

After defining the regimes, we calculate the covariance matrix for each regime. Now we have the covariance matrix of the reduced form residuals shown in (7). When we pre and post multiply these covariance matrices with A, we obtain the covariance matrix of the structural shocks: $A\,\mathrm{var}(\varepsilon)A' = AA^{-1}\,\mathrm{var}(\eta)A^{-1'}A' = \mathrm{var}(\eta)$.

Our identifying assumption is that covariance terms of the structural shocks are zero, which allows us to compute moment conditions for each regime, and then to estimate *A* through GMM by minimizing these moment conditions. We try both weighted and unweighted GMM; the main conclusions remain intact.

Finally, we obtain the distribution of the estimates by bootstrapping. We create normally distributed random numbers, N (0,1), of the size of each regime. We impose the covariance structure of the underlying data for the relevant regime to the randomly created numbers, and estimate the coefficients again 600 times. The results are presented at the following section.

V. Results

In this section, we apply the IH methodology to our estimation problem. We are interested in estimating the relationships between gross debt dollarization (GrossD and other variants), the exchange rate policy choice (R_M_0 and other variants), and the volatility of inflation vol(π). Our system includes these as endogenous variables and three exogenous variables (country size, capital account openness and trade openness). The structural model is described by:

$$AY = \Phi(L)Y_{t-1} + \Theta(L)X_t + \eta_t \qquad (9)$$

Before reporting the results, we make some additional clarifications about the model:

1. *Endogenous variables*: as discussed in the data section, there are several possible normalizations for every variable. With respect to the liability dollarization, we report in this section the results for *GrossD*, and *GrossD_OSIN*. With respect to the stance of monetary policy, we report the results for R_M_0. We leave the other definitions for robustness checks and report the results in the next section.

2. *Lag structure*: We include lags in our model, as explained before, because our endogenous variables are slow moving processes. We choose two lags for our main specification, and we change the number of lags to perform robustness checks.

3. *Control variables*: Plausible common-shocks are: trade-related shocks (i.e., for example terms-of-trade fluctuations) that we seek to account for with the openness term;[12] the degree of capital account openness, which may alter the impact and frequency of financial account shocks (i.e., sudden stops in capital flows or currency crises) and have effects on monetary policy;[13] and structural country characteristics that might reduce the freedom of choice of countries with respect to the currency denomination of the debts (which Hausmann and Panizza (2003) show to be robustly correlated to country size).[14]

4. *Fixed effects:* In order to avoid omitted variable bias, we use fixed effects at the first stage of the estimation.

To facilitate the evaluation of the quantitative significance of the estimated coefficients, we normalize each variable by its standard deviation in the whole sample. In Table 4 we present the results from the main specification. Let's begin with the first panel where we report matrix A. The table is organized as follows: each row is an equation, which is a function of the other two endogenous variables (i.e., the columns).[15] Thus, for example, the first row shows the determination of *GrossD* as a function of the volatility of reserves, (R_M_0), and the volatility of

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[12] Ideally we would have liked to include the terms-of-trade volatility itself in the regressions, but we do not have sufficient data.

[13] The presence of capital controls changes the monetary policy options in the aftermath of external shocks.

[14] Crisis and interest rates in the United States – as a proxy for international liquidity – are other factors that may have an impact on all of the endogenous variables simultaneously. Therefore, we also included these two variables in our control variables. They did not change the results.

[15] Each endogenous variable is also a function of the exogenous variables, but we choose not to report them because they are not the main focus of this paper.

inflation, vol(π), while the second row shows the determination of the volatility of reserves as a function of the other two endogenous variables.[16] The second panel of Table 4 reports the *amplification effects* of the structural shocks, which are given by the coefficients of the inverse of matrix A (i.e., A^{-1}) as shown in the reduced form model, (8). The parameters of the reduced-form model capture both direct as well as indirect linkages across endogenous variables. By indirect linkages we mean spillovers of shocks that occur via the other endogenous variables in the system. Thus, the terms of the matrix A^{-1} show the amplification effect of the structural shocks to each equation. Each row is an equation, which is affected by all the structural shocks identified on the columns of the table. Finally, below the corresponding point estimates, we report the percentage of the observations from the 600 repetitions of the bootstrapping that fall below zero. In order to make the interpretation easier, we put a stars next to the coefficient if it is statistically significant.[17]

Table 4. Baseline with *Gross D*

Matrix A: point estimates of contemporaneous coefficients

		effect of:		
		GrossD	R_M_0	Vol(π)
Effect on:	GrossD		-0.109** 97%	-0.030 1.8%
	R_M_0	0.142*** 0.2%		-0.09 0.7%
	Vol(π)	-0.003 58.3%	0.101** 2.3%	

Matrix A^{-1}: amplification effects of the structural shocks

		structural shock to:		
		GrossD	R_M_0	Vol(π)
Effect on:	GrossD	0.985*** 0.7%	-0.109** 97%	-0.020 2%
	R_M_0	0.139*** 1%	0.975*** 0.5%	-0.094 1%
	Vol(π)	0.011 15.7%	0.098** 2.8%	0.991*** 0%

We start with the interpretation of the coefficients in matrix A. The results reported in the first panel of Table 4, indicate that a one standard deviation increase in the volatility of reserves, *decreases GrossD* by 0.109 standard deviations. The result is statistically significant at standard confidence levels since 97% of the 600 bootstrap repetitions fall below zero. In other words, we find that countries that seek to stabilize the nominal exchange rate via more active intervention in the foreign exchange markets (i.e., more reserve volatility) have *less* dollarized gross debts. This result might be counterintuitive to many, but it is consistent with some of the existing theoretical work. In particular, Chang and Velasco (2005) show that the choice of the currency composition

[16] The coefficients in the table are the coefficients of the A matrix multiplied by -1 to account for the fact that A is on the left hand side.

[17] *: significant at ten percent, **: significant at five percent, and ***: significant at one percent.

of debt is indeterminate under fixed exchange rate regimes when there are limited portfolio options.[18]

The presumed positive linkage between the endogenous variables is identified here through the positive feedback of *GrossD* and the volatility of reserves (R_M_0). A one standard deviation increase in the former raises the latter by 0.142 standard deviations. This result is statistically significant at the 99% level, as only 0.2% of the repetitions form the bootstrap have the opposite sign. As suggested by the "fear of floating" literature, economies with more aggregate foreign currency debt tend to fix more.

The volatility of inflation affects the system in the following way: a one standard deviation increase in *vol(π)* results in a 0.030 standard deviations decrease in GrossD and a -0.09 standard deviations decrease in R_M_0. Neither result is statistically significant at standard confidence levels. In turn, we find that a one standard deviation increase in R_M_0 leads to an increase in of 0.101 standard deviations in *vol(π)*. This result is statistically significant, implying that countries that choose to target the nominal exchange rate face more inflation volatility. Finally, *GrossD* does not appear to have any statistically significant effects on the volatility of inflation.

On the second panel of Table 4, we trace the overall effects of any given structural shock on the variables in our model, after accounting for all the spillovers through our system of equations. The results, which are the amplification effects of the structural shocks, are very similar to those reported for the direct effects in terms of both magnitude and sign. Gross debt dollarization is negatively affected by shocks to the volatility of reserves and negatively affected by shocks to the volatility of inflation although the latter is not statistically significant. Also, just as before, the volatility of reserves is positively affected by gross debt dollarization and negatively affected by the volatility of inflation, with only the first effect being statistically significant. Finally *GrossD* does not appear to have any significant effects on *vol(π)* even after all the indirect effects are accounted for, while the volatility of reserves has a positive and statistically significant effect on *vol(π)*.

In Table 5 we check if our results are driven by the assumption that "original sin" is constant for each country. To do so, we construct a dependent variable (*GrossD_OSIN*) that uses the limited time series variation in *OSIN*. As shown in Table 5, the results for our main dependent variables are similar to those reported in Table 4. In particular, it is still the case that more dollarized debt leads to higher reserves volatility (i.e., more fixing). The reduction in the sample size driven by the use of this alternative variable does not appear to affect our results.

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[18] To test the plausibility of this hypothesis, we tried eliminating from our sample the "hard-peggers" as defined by Levy-Yeyati and Sturzenegger (2003) in the de-facto exchange rate classification, but our results don't change. However, this is not sufficient to prove the hypothesis wrong because we don't have data on the available portfolio options.

Table 5. Baseline with *GrossD_OSIN*

Matrix A: point estimates of contemporaneous coefficients

		effect of: GrossD_OSIN	effect of: R_M0	effect of: Vol(π)
Effect on:	GrossD_OSIN		-0.207** 95.7%	-0.009 65.2%
	R_M0	0.230*** 0%		0.05 67.8%
	Vol(π)	-0.004 32.5%	0.015 93.5%	

Matrix A^{-1}: amplification effects of the structural shocks

		structural shock to: GrossD_OSIN	structural shock to: R_M0	structural shock to: Vol(π)
Effect on:	GrossD_OSIN	0.955*** 0.2%	-0.198** 98.2%	-0.019 61.8%
	R_M0	0.220* 5.2%	0.955** 1.5%	0.047 70.3%
	Vol(π)	-0.001 65.8%	0.015 93.3%	1.001** 1.8%

VI. Robustness Checks

In this section we perform a set of robustness checks: we use alternative definitions for our main dependent variables, we change the regime window for our main regressions, we use other control variables and we change the lag structure.[19]

In Tables 6 to 11 we show that out results are robust when we use alternative definitions for the stance of monetary policy. In Table 6, we use a broader monetary aggregate to normalize the volatility of reserves. In Table 7 we use a different normalization altogether. In Tables 8 and 9 we use the "exchange rate market pressure index". In Table 10 we use the "freedom to float" variable, and in Table 11 we use the standard deviation of the nominal exchange rate.

The results in Table 6 are highly consistent with the benchmark results from Table 4. Here, we use a broader monetary measure (i.e. M_2) to normalize the volatility of reserves. Reassuringly, neither the signs of the coefficients, nor its statistical significance change.

[19] For concreteness, we only report a subset of all the robustness checks, but any other tables are available from the authors upon request.

Table 6. Robustness with *R_M_2*

Matrix A: point estimates of contemporaneous coefficients

		effect of:		
		GrossD	R_M_2	Vol(π)
Effect on:	GrossD		-0.092** 96%	-0.032 2.8%
	R_M_2	0.113*** 0%		-0.08 1.3%
	Vol(π)	-0.002 65.8%	0.132*** 3.8%	

Matrix A^{-1}: amplification effects of the structural shocks

		structural shock to:		
		GrossD	R_M_2	Vol(π)
Effect on:	GrossD	0.989*** 0.7%	-0.094** 97.5%	-0.025 3.7%
	R_M_2	0.110** 2.7%	0.980** 1.2%	-0.078 0.8%
	Vol(π)	0.012 21.8%	0.129** 4.7%	0.990*** 0.7%

Table 7 tests whether a different normalization of the volatility of the reserves changes the results or not. Here we calculate the volatility of the change in reserves to monetary base ratios. The results are also robust to this normalization.

Table 7. Robustness with Std(ΔR/M0)

Matrix A: point estimates of contemporaneous coefficients

		effect of:		
		GrossD	Std($\Delta R/M_0$)	Vol(π)
Effect on:	GrossD		-0.109 65.2%	-0.030** 95.5%
	Std($\Delta R/M_0$)	0.142*** 1%		-0.09* 93%
	Vol(π)	-0.003 45%	0.101** 4.7%	

Matrix A^{-1}: amplification effects of the structural shocks

		structural shock to:		
		GrossD	Std($\Delta R/M_0$)	Vol(π)
Effect on:	GrossD	0.985** 1.7%	-0.109 89.3%	-0.020* 95%
	Std($\Delta R/M_0$)	0.139 10.5%	0.975* 5.2%	-0.094** 96.8%
	Vol(π)	-0.011 33.8%	0.098* 5.5%	0.991** 4.2%

Table 8 reports the results obtained from exchange market pressure – calculated by using the exchange rate vis-à-vis the US dollar. A higher number indicates that for a given level pressure, the monetary authority tries to stabilize the exchange rate more than it lets it go. This specification produces the same results as our baseline model.

Table 8. Robustness with *ERMP_NER*

Matrix A: point estimates of contemporaneous coefficients

		effect of:		
		GrossD	ERMP_NER	Vol(π)
Effect on:	GrossD		-0.225** 97%	-0.081 89%
	ERMP_NER	0.279*** 0%		-0.09 16.5%
	Vol(π)	0.026 61.8%	-0.088 2.3%	

Matrix A^{-1}: amplification effects of the structural shocks

		structural shock to:		
		GrossD	ERMP_NER	Vol(π)
Effect on:	GrossD	0.941*** 0.5%	-0. 207** 97.8%	-0.058* 92.2%
	ERMP_NER	0.262** 2.8%	0.950*** 0.7%	-0.102 19.8%
	Vol(π)	0.001* 4.8%	-0.089 1.7%	1.008*** 0.5%

Countries can trade in different vehicle currencies and a number of central banks might stabilize the domestic currency vis-à-vis a basket of currencies, and not just vis-à-vis a single anchor currency. Therefore, in Table 9 we present the results for exchange market pressure based on the nominal effective exchange rate. The results do not change the main story; higher liability dollarization increases the exchange rate stabilization efforts.

Table 9. Robustness with *ERMP_NEER*

Matrix A: point estimates of contemporaneous coefficients

		effect of:		
		GrossD	ERMP_NEER	Vol(π)
Effect on:	GrossD		0.010 58%	0.012 26.5%
	ERMP_NEER	0.028*** 0.2%		-0.10 26.3%
	Vol(π)	0.018 25.8%	-0.093 74.5%	

Matrix A^{-1}: amplification effects of the structural shocks

		structural shock to:		
		GrossD	ERMP_NEER	Vol(π)
Effect on:	GrossD	1.000*** 0.2%	0.009 61.3%	0.011 26.8%
	ERMP_NEER	0.026** 4.2%	1.009*** 0.3%	-0.098 25%
	Vol(π)	0.016 25.8%	-0.094 75.7%	1.009*** 1.3%

An alternative measure of monetary authorities' stance towards exchange rate is the relative volatility of the exchange to the volatility of reserves. Eichengreen, Hausmann and Panizza (2003) refer this ratio as the "freedom to float" (FF). A higher ratio implies that monetary authority prefers to let the exchange rate go rather than intervening intensively. The results are presented in Table 10. For concreteness, we only report the results based on the nominal effective exchange rate.[20] The results are consistent with those of the benchmark regressions. In particular, it is shown that countries with more aggregate dollarized debt exhibit fear of floating. The results for the reverse causality suggest that countries that float more have more debt in foreign currencies, but the coefficient is not statistically significant.

[20] The results based on the nominal exchange rate are reassuringly similar. The table is available from the authors upon request.

Table 10. Robustness with *FF_NEER*

Matrix A: point estimates of contemporaneous coefficients

		effect of:		
		GrossD	*FF_NEER*	Vol(π)
Effect on:	GrossD		0.052 21.5%	-0.009 68.5%
	FF_NEER	-0.059*** 100%		0.34 86%
	Vol(π)	0.016 31.8%	0.003 93.7%	

Matrix A^{-1}: amplification effects of the structural shocks

		structural shock to:		
		GrossD	*FF_NEER*	Vol(π)
Effect on:	GrossD	0.997** 1.8%	0.052 16.8%	0.008 71.2%
	FF_NEER	-0.053** 95.7%	0.998** 2.3%	0.338 82.7%
	Vol(π)	0.016 20.3%	0.004 92.7%	1.001** 2%

Next, we switch to exchange rate volatility measures. For concreteness we report the results based on the volatility of nominal exchange rate, but the results based on the volatility of the nominal effective exchange rate are reassuringly similar.[21] Table 11 presents our findings. Now higher volatility of exchange rate implies floating—the reverse to the interpretation of the volatility of reserves. In line with our previous findings, higher gross debt dollarization implies lower exchange rate volatility in a statistically significant way. The results for the reverse causality are also similar to those of the benchmark regressions – higher volatility of exchange rate increases gross debt dollarization.

[21] Table available from the authors upon request.

Table 11. Robustness with *Std(NER)*

Matrix A: point estimates of contemporaneous coefficients

		effect of: GrossD	*Std(NER)*	Vol(π)
Effect on:	GrossD		0.094** 2.5%	-0.114 55.8%
	Std(NER)	-0.061*** 100%		0.30* 8.5%
	Vol(π)	0.022 12.7%	0.391** 3.2%	

Matrix A^{-1}: amplification effects of the structural shocks

		structural shock to: GrossD	*Std(NER)*	Vol(π)
Effect on:	GrossD	0.994** 0.7%	0.056** 0.7%	-0.097 42.5%
	Std(NER)	-0.061** 96.5%	1.129** 1.2%	0.345* 9%
	Vol(π)	-0.002 46.3%	0.442** 3.8%	1.133*** 0.7%

In Table 12 we report the results when we use "total liabilities" rather than simply debt liabilities. As explained in the data description section and in the appendix, total claims include equity and foreign direct investment as part of the countries' liabilities. The results imply that the central bank's response to total liability dollarization is similar to its response to debt liability dollarization.

Table 12. Robustness with *GrossL*

Matrix A: point estimates of contemporaneous coefficients

		effect of: GrossL	R_M_0	Vol(π)
Effect on:	GrossL		-0.090* 94.5%	-0.039 5.5%
	R_M_0	0.139*** 0%		0.0001 2.3%
	Vol(π)	0.022 21.7%	0.031** 2.2%	

Matrix A^{-1}: amplification effects of the structural shocks

		structural shock to: GrossL	R_M_0	Vol(π)
Effect on:	GrossL	0.987*** 0.5%	-0.090** 96%	-0.039 11.3%
	R_M_0	0.137* 6.3%	0.987** 4%	-0.005 6.5%
	Vol(π)	0.026* 8.8%	0.029* 6.5%	0.999** 4%

In Tables 13 and 14 we check if our results are robust to the changes in the regime windows. Rigobon (2003) shows that the IH estimates are consistent even though the regimes might be misspecified as long as the misspecification is not so large that the system fails the rank condition. In our benchmark regressions we define each heteroskedastic regime every 3 years. In Table 13 we narrow the window to 2 years.

Table 13. Robustness with *2 years per regime*

Matrix A: point estimates of contemporaneous coefficients

		effect of:		
		GrossD	R_M_0	Vol(π)
Effect on:	GrossD		-0.100* 90%	-0.042 2.8%
	R_M_0	0.133** 4.5%		-0.02*** 99.8%
	Vol(π)	0.014 97.5%	0.037** 0.2%	

Matrix A^{-1}: amplification effects of the structural shocks

		structural shock to:		
		GrossD	R_M_0	Vol(π)
Effect on:	GrossD	0.986*** 0%	-0.100 71.2%	-0.039 3.2%
	R_M_0	0.131** 1.8%	0.986*** 0%	-0.024*** 99.8%
	Vol(π)	0.018 97%	0.035*** 0.2%	0.999** 0%

Table 14 we expand it to 16 years. The results are qualitatively very similar to those of the benchmark regressions.

Table 14. Baseline with *Gross D* 16 years per regime

Matrix A: point estimates of contemporaneous coefficients

		effect of:		
		GrossD	R_M_0	Vol(π)
Effect on:	GrossD		-0.250*** 99.7%	-0.002 50.5%
	R_M_0	0.264*** 0.5%		-0.15* 9.3%
	Vol(π)	-0.034 26.8%	-0.086 80.8%	

Matrix A^{-1}: amplification effects of the structural shocks

		structural shock to:		
		GrossD	R_M_0	Vol(π)
Effect on:	GrossD	0.938*** 0%	-0.232** 99.7%	-0.036 74.3%
	R_M_0	0.249*** 0.2%	0.926*** 0%	0.136* 9%
	Vol(π)	0.011 42%	-0.087 80.8%	0.987*** 0%

Table 15. Baseline with *GrossD_GDP*

Matrix A: point estimates of contemporaneous coefficients

		effect of:		
		GrossD_GDP	R_M_0	Vol(π)
Effect on:	GrossD_GDP		0.001 99.2%	-0.007 1.7%
	R_M_0	1.30E-34* 5.8%		-0.06 0.7%
	Vol(π)	-0.003 10.8%	0.096** 3.2%	

Matrix A^{-1}: amplification effects of the structural shocks

		structural shock to:		
		GrossD_GDP	R_M_0	Vol(π)
Effect on:	GrossD_GDP	1.000*** 0%	0.001 99.8%	-0.007 4.5%
	R_M_0	0.0002* 7.7%	0.994*** 0.3%	-0.063 0%
	Vol(π)	-0.003 9.3%	0.096** 2.5%	0.994** 0%

In Table 15, we report the results using GrossD_GDP. Changing the normalization only affects the size of the estimated coefficient that captures the effect of liability dollarization on the exchange rate choice, but not its sign nor its statistical significance. Instead, for the reverse causality, the sign if now positive (i.e., more reserve volatility leads to more liability dollarization) but the coefficient is not statistically significant. This change in sign and the loss of statistical significance for this coefficient suggests that our previous results for the reverse causality are not robust to the change in variable normalization.

Finally, in Table 16 we check the robustness of the results using an alternative measure: *GrossD* is calculated by using the time-varying original sin data and normalized with our constructed GDP variable. Once again, our results are robust to this definition as well.

Table 16. Robustness with *GrossD_GDP_OSIN*

Matrix A: point estimates of contemporaneous coefficients

		effect of:		
		GrossD_GDP_OSIN	R_M_0	Vol(π)
Effect on:	GrossD_GDP_OSIN		0.003 97.7%	0.038* 8.8%
	R_M_0	8.86E-35** 3.8%		0.05 98%
	Vol(π)	-0.067 88.3%	0.008 94.5%	

Matrix A^{-1}: amplification effects of the structural shocks

		structural shock to:		
		GrossD_GDP_OSIN	R_M_0	Vol(π)
Effect on:	GrossD_GDP_OSIN	0.997*** 0.5%	0.003 99.3%	0.038* 6.3%
	R_M_0	-0.003 4.3%	1.000*** 0.5%	0.049 97.3%
	Vol(π)	-0.067 89.3%	0.008 94%	0.998*** 1%

We also tried other robustness checks, such as changing the lag structure from two lags, to one and three, including additional controls such as sudden stops, currency crises, the US interest rates and splitting the sample between developing and developed countries, but since the results are similar, we do not report these tables.[22]

VII. Conclusions

This paper provides novel empirical content to a topic which has been dominated by theoretical work with a strong intuitive appeal in policy circles. Our main purpose is to estimate the causal relation between liability dollarization and exchange rate policy choice. In particular, we want to estimate how severe is the presumed "fear of floating" exhibited by many countries, and to what extent domestic agents choose the currency composition of their debts based on the incentives provided by the central bank through the exchange rate choice. The main hurdle we have to overcome to provide reliable empirical estimates is the problem of endogeneity between these variables.

[22] Available from the authors upon request.

We use identification through heteroskedasticity to deal with the inherent endogeneity problem. Our results provide support to the "fear of floating" argument: countries with high aggregate liability dollarization tend to stabilize the exchange rate. On the other hand, the evidence on the reverse causality is somewhat counterintuitive. Our results suggest that more fixing decreases liability dollarization (although the results are not strongly robust). This may be the result of limited portfolio choice as it has been recently suggested by a strand of the related theoretical literature. In any case, this result warrants further research and more detailed analysis. At the very least, our results suggest that the move towards more flexible exchange rates in not, in-and-of-itself, sufficient to promote de-dollarization. This is consistent with, for example, Ize and Levy-Yeyati (2005) who suggest that an active, market-driven, de-dollarization policy agenda should cover several fronts and is not just the outcome of the exchange rate choice.

This paper focuses on the aggregate liability dollarization. The next step is to explore the response function on a more disaggregated level. For example, monetary policy may react to liability dollarization in government borrowing, or alternatively only in private sector debt. However, it is clear that in both cases, one needs to control for endogeneity, and the methodology of identification through heteroskedasticity offers a concise way of doing so. We plan to explore these additional topics in subsequent work contingent to the availability of the data.

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Appendix I. Country List

Country	Industrial	Developing
Algeria		X
Argentina		X
Aruba		X
Australia	x	
Austria	x	
Bahamas, The		x
Bahrain		x
Barbados		x
Belgium	x	
Bolivia		x
Brazil		x
Bulgaria		x
Canada	x	
Chile		x
China		x
Colombia		x
Costa Rica		x
Cyprus		x
Czech Republic		x
Denmark	x	
Dominican Republic		x
Ecuador		x
Egypt, Arab Rep.		x
El Salvador		x
Estonia		x
Finland	x	
France	x	
Germany	x	
Ghana		x
Greece	x	
Guatemala		x
Hong Kong, China		x
Hungary		x
Iceland	x	
India		x
Indonesia		x
Ireland	x	
Israel	x	
Italy	x	
Jamaica		x
Japan	x	

Country	Industrial	Developing
Jordan		x
Kazakhstan		x
Korea, Rep.		x
Latvia		x
Lebanon		x
Lithuania		x
Luxembourg	x	
Malaysia		x
Malta		x
Mauritius		x
Mexico		x
Moldova		x
Morocco		x
Netherlands	x	
Netherlands Antilles		x
New Zealand	x	
Nicaragua		x
Norway		
Oman		x
Pakistan		x
Panama		x
Papua New Guinea		x
Peru		x
Philippines		x
Poland		x
Portugal	x	
Qatar		x
Romania		x
Russian Federation		x
Singapore		x
Slovak Republic		x
Slovenia		x
South Africa		x
Spain	x	
Sri Lanka		x
Suriname		x
Sweden	x	
Switzerland	x	
Taiwan		x
Thailand		x
Trinidad and Tobago		x

Country	Industrial	Developing
Tunisia		x
Turkey		x
Ukraine		x
United Kingdom	x	
United States	x	
Uruguay		x
Venezuela		x
Zimbabwe		X

Appendix II. List of Variables, Abbreviations, and Data Sources

Variable Abbrev. / Name	Frequency	Variable Formula	Definitions	Observations	Source
GrossD Gross Foreign Debt in Foreign Currency as a share of total debt assets plus debt liabilities	Annual, 1970-2003	$\frac{D_L \times OSIN}{D_A + D_L}$	**D_A** = Debt Assets = portfolio debt plus other investments. **D_L** = Debt Liabilities = portfolio debt plus other investments. $OSIN = \max\left\{1 - \frac{\text{securities in currency}_i}{\text{securities issued by country}_i}, 0\right\}$	Data on D_A and D_L [from Milesi-Ferreti and Lane (2004)] does not specify the currency composition of debt. To proxy the foreign currency portion of debt shares, we interact D_L by OSIN [from Hausmann and Panizza (2003)], which is a measure of the proportion of the debt that is borrowed in foreign currency.	(1) D_A and D_L: Lane and Milesi-Ferretti (2004). (2) OSIN: Hausmann and Panizza (2003)

Variable Abbrev. / Name	Frequency	Variable Formula	Definitions	Observations	Source
GrossD_GDP Gross Foreign Debt in Foreign Currency as a share of average GDP per capita	Annual, 1970-2003	$\frac{D_L \times OSIN}{avg(GDPpc) * pop}$	**D_A** = Debt Assets = portfolio debt plus other investments. **D_L** = Debt Liabilities = portfolio debt plus other investments. $OSIN = \max\left\{1 - \frac{\text{securities in currency}_i}{\text{securities issued by country}_i}, 0\right\}$ $avg(GDPpc) * pop = \frac{1}{T}\sum_{t=1970}^{2003}\left[\frac{GDP_t}{pop_t}\right] * pop_t$		(1) D_A and D_L: Lane and Milesi-Ferretti (2001). (2) OSIN: Hausmann and Panizza (2003) (3) GDPpc: GDP in U$S [from Lane and Milesi-Ferretti (2004)] / Population [IFS line 99z]
GrossL Gross Foreign Liabilities in Foreign Currency as a share of total assets plus liabilities	Annual, 1970-2003	$\frac{L \times OSIN}{L + A}$	**A** = Assets = Total Assets **L** = Liabilities = Total Liabilities $OSIN = \max\left\{1 - \frac{\text{securities in currency}_i}{\text{securities issued by country}_i}, 0\right\}$	Data on A and L [from Milesi-Ferreti and Lane (2004)] does not specify the currency composition. To proxy the foreign currency portion of debt shares, we interact L by OSIN [from Hausmann and Panizza (2003)], which is a measure of the proportion of the debt that is borrowed in foreign currency.	(1) A and L: Lane and Milesi-Ferretti (2004). (2) OSIN: Hausmann and Panizza (2003)

Variable Abbrev. / Name	Frequency	Variable Formula	Definitions	Observations	Source
GrossL_GDP Gross Foreign Liabilities in Foreign Currency as a share of average GDP per capita	Annual, 1970-2003	$\frac{L \times OSIN}{avg(GDPpc) * pop}$	**A** = Assets = Total Assets **L** = Liabilities = Total Liabilities $OSIN = \max\left\{1 - \frac{\text{securities in currency}_i}{\text{securities issued by country}_i}, 0\right\}$ $avg(GDPpc) * pop = \frac{1}{T}\sum_{t=1970}^{2003}\left[\frac{GDP_t}{pop_t}\right] * pop_t$		(1) A and L: Lane and Milesi-Ferretti (2004). (2) OSIN: Hausmann and Panizza (2003) (3) GDPpc: GDP in U$S [Lane and Milesi-Ferretti (2004)] / Population [IFS line 99z]

Variable Abbrev. / Name	Frequency	Variable Formula	Definitions	Observations	Source
GrossD_OSIN Gross Foreign Debt in Foreign Currency as a share of total debt assets plus debt liabilities	Annual, 1970-2003	$\frac{D_L \times OSIN_t}{D_A + D_L}$	**D_A** = Debt Assets = portfolio debt plus other investments. **D_L** = Debt Liabilities = portfolio debt plus other investments. $OSIN = \max\left\{1 - \frac{\text{securities in currency}_i}{\text{securities issued by country}_i}, 0\right\}$	Data on D_A and D_L [from Milesi-Ferreti and Lane (2004)] does not specify the currency composition of debt. To proxy the foreign currency portion of debt shares, we interact D_L by $OSIN_t$ [from Hausmann and Panizza (2003)], which is a measure of the proportion of the debt that is borrowed in foreign currency. But instead of taking the average OSIN by country (to increase sample size, as in GrossD), here we use the very limited time series variation of OSIN.	(1) D_A and D_L: Lane and Milesi-Ferretti (2004). (2) OSIN: Hausmann and Panizza (2003)

Variable Abbrev. / Name	Frequency	Variable Formula	Definitions	Observations	Source
GrossD_GDP_OSIN Gross Foreign Debt in Foreign Currency as a share of average GDP per capita	Annual, 1970-2003	$\frac{D_L \times OSIN_t}{avg(GDPpc) * pop}$	**D_A** = Debt Assets = portfolio debt plus other investments. **D_L** = Debt Liabilities = portfolio debt plus other investments. $OSIN = \max\left\{1 - \frac{\text{securities in currency}_i}{\text{securities issued by country}_i}, 0\right\}$ $avg(GDPpc) * pop = \frac{1}{T}\sum_{t=1970}^{2003}\left[\frac{GDP_t}{pop_t}\right] * pop_t$	Same as GrossD_GDP, but instead of taking the average OSIN by country, here we use the very limited time series variation of OSIN.	(1) D_A and D_L: Lane and Milesi-Ferretti (2001). (2) OSIN: Hausmann and Panizza (2003) (3) GDPpc: GDP in U$S [from Lane and Milesi-Ferretti (2004)] / Population [IFS line 99z]

Variable Abbrev. / Name	Frequency	Variable Formula	Definitions	Observations	Source
GrossL_OSIN Gross Foreign Liabilities in Foreign Currency as a share of total assets plus liabilities	Annual, 1970-2003	$\frac{L \times OSIN_t}{L + A}$	**A** = Assets = Total Assets **L** = Liabilities = Total Liabilities $OSIN = \max\left\{1 - \frac{\text{securities in currency}_i}{\text{securities issued by country}_i}, 0\right\}$	Data on A and L [from Milesi-Ferreti and Lane (2004)] does not specify the currency composition. To proxy the foreign currency portion of debt shares, we interact L by $OSIN_t$ [from Hausmann and Panizza (2003)], which is a measure of the proportion of the debt that is borrowed in foreign currency. But instead of taking the average OSIN by country (as in GrossL), here we use the very limited time series variation of OSIN.	(1) A and L: Lane and Milesi-Ferretti (2004). (2) OSIN: Hausmann and Panizza (2003)

Variable Abbrev. / Name	Frequency	Variable Formula	Definitions	Observations	Source
GrossL_GDP_ OSIN Gross Foreign Liabilities in Foreign Currency as a share of average GDP per capita	Annual, 1970-2003	$\frac{L \times OSIN_t}{avg(GDPpc) * pop}$	**A** = Assets = Total Assets **L** = Liabilities = Total Liabilities $OSIN = \max\left\{1 - \frac{\text{securities in currency}_i}{\text{securities issued by country}_i}, 0\right\}$ $avg(GDPpc) * pop = \frac{1}{T}\sum_{t=1970}^{2003}\left[\frac{GDP_t}{pop_t}\right] * pop_t$	Same as GrossL_GDP, but instead of taking the average OSIN by country, here we use the very limited time series variation of OSIN.	(1) A and L: Lane and Milesi-Ferretti (2004). (2) OSIN: Hausmann and Panizza (2003) (3) GDPpc: GDP in U$S [from Lane and Milesi-Ferretti (2004)] / Population [IFS line 99z]

Variable Abbrev. / Name	Frequency	Variable Formula	Definitions	Observations	Source
R_M₀ Reserve Volatility as a share of M_0	Annual, 1960-2003	$Ln\left(\frac{std\,(\Delta RES)}{M_0} * 10000\right)$	**std (ΔRES)** = the standard deviation of *monthly* changes in "total reserves minus gold" (reserves is US$) $\mathbf{M_0}$ = Reserve money, converted to US$	To generate an annual series of $\mathbf{M_0}$ in dollars, we begin by converting the monthly data of M_0 in local currency by dividing each observation by the end of period bilateral nominal exchange rate vis-à-vis the US$. We then take the 12 month average of the converted numbers to get yearly observations.	(1) Total Reserves minus Gold: IFS line 1L.DZF (2) Reserve Money: IFS Line 14.ZF (3) Nominal Exchange Rate: IFS Line AE.ZF

Variable Abbrev. / Name	Frequency	Variable Formula	Definitions	Observations	Source
Std(R_M0) Volatility of the ratio of changes in reserve to money	Annual, 1960-2003	$std\left(\frac{\Delta RES}{M_0}\right)$ $std\left(\frac{\Delta RES}{M_0}\right)$	The standard deviation of the *monthly* changes in total reserves minus gold as a share of M_0	The difference between R_M_0 and *Std(R_M0)* is that in the latter we take the standard deviation of the ratio of changes in reserves as a share of money, while in the former we use M_0 to normalize the standard deviation of changes in reserves. To generate a monthly series of $\mathbf{M_0}$ in dollars, we convert the monthly data of M_0 in local currency by dividing each observation by the end of period bilateral nominal exchange rate vis-à-vis the US$.	(1) Total Reserves minus Gold: IFS line 1L.DZF (2) Reserve Money: IFS Line 14.ZF (3) Nominal Exchange Rate: IFS Line AE.ZF

Variable Abbrev. / Name	Frequency	Variable Formula	Definitions	Observations	Source
R_M₂ Reserve Volatility as a share of M_2	Annual, 1960-2003	$Ln\left(\frac{std(\Delta RES)}{M_2}*10000\right)$	**std (ΔRES)** = idem above **M_2** = Money + Quasi-Money, converted to US$	To generate an annual series of **M_2** in dollars, we begin by converting the monthly data of **M_1** in local currency by dividing each observation by the end of period bilateral nominal exchange rate vis-à-vis the US$. We do the same thing for **Quasi-Money**. Next, we add Money and Quasi-Money. Finally, we take the 12 month average of the converted numbers to get yearly observations.	(1) Total Reserves minus Gold: IFS line IL.DZF (2) Money: IFS Line 34.ZF (3) Quasi-Money: IFS Line 35.ZF (4) Nominal Exchange Rate: IFS Line AE.ZF
Std_NER Nominal Exchange Rate Volatility	Annual, 1960-2003	$std(\Delta NER)$	**std(ΔNER) =** the standard deviation of *monthly* changes in nominal exchange rate (local currency per U.S. dollar)		Nominal Exchange Rate: IFS Line AE.ZF

Variable Abbrev. / Name	Frequency	Variable Formula	Definitions	Observations	Source
ERMP_NER Exchange-Market Pressure	Annual, 1960-2003	$\frac{\frac{std(\Delta RES)}{M_0}}{\left(\frac{std(\Delta RES)}{M_0}+std(\Delta NER)\right)}$	As above	This variable is defines and used in Eichengreen, Rose and Wyplosz (1996)	As above
ERMP_NEER Exchange-Market Pressure	Annual, 1960-2003	$\frac{\frac{std(\Delta RES)}{M_0}}{\left(\frac{std(\Delta RES)}{M_0}+std(\Delta NEER)\right)}$	As above	As above	As above.

Variable Abbrev. / Name	Frequency	Variable Formula	Definitions	Observations	Source
FF_NEER Freedom to Float	Annual, 1960-2003	$\frac{std(\Delta NEER)}{\frac{std(\Delta RES)}{M_0}}$	**std(ΔNEER) =** the standard deviation of *monthly* changes in nominal effective exchange rate **std (ΔRES)** = the standard deviation of *monthly* changes in "total reserves minus gold" (reserves is US$) **$M_0$** = Reserve money, converted to US$	This variable is constructed and used in Eichengreen, Hausmann and Panizza (2003). The difference is that we use the nominal *effective* exchange rate.	(1) Nominal Effective Exchange Rate: IFS Lines NECZF and NEUZF. (2) Total Reserves minus Gold: IFS line 1L.DZF (3) Reserve Money: IFS Line 14.ZF
Vol(π) Inflation	Annual 1970-2003	std (Δπ)	std(Δπ) **=** the standard deviation of *monthly* changes in the CPI.	Changes in consumer prices (CPI). Percent per annum	IFS Line 64.XZF
trwdi Trade to GDP ratio	Annual, 1960-2003	$\frac{X+M}{GDP}$			WDI CD-ROM

Variable Abbrev. / Name	Frequency	Variable Formula	Definitions	Observations	Source
KAopen Index of Capital Account openness	Annual 1970-2004		KAOPEN is an index to measure a country's degree of capital account openness. It is based on the binary dummy variables that codify the tabulation of restrictions on cross-border financial transactions reported in the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER).		Chinn-Ito (2005)
csize Country size	Annual, 1960-2003	Ln (Real GDP)	Real GDP = GDP in constant (2000) US$		WDI CD-ROM.