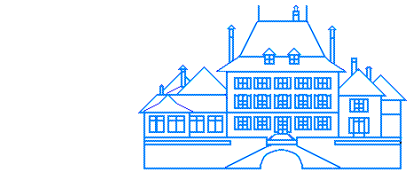

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Understanding Reserve Volatility in Emerging Markets: A Look at the Last Thirty Years

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Abstract

In this paper, we examine external, monetary, and structural determinants of cross-country variation in reserve volatility for 30 emerging market economies from 1973 to 2000. We find that reserve holdings and openness to be the most important determinants of reserve volatility. These results are robust for a range of control variables, including monetary variables, the degree of financial development, and the level of indebtedness. We view these results as establishing interesting stylized facts that may be helpful in evaluating reserve uncertainty as a crisis indicator.

Keywords: Reserve Volatility, Emerging Markets, Openness

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Introduction

The importance of reserve volatility arises frequently in policy discussions of international finance. The buffer stock model first introduced by Frenkel and Jovanovic (1981) and more recently re-examined by Flood and Marion (2001) show that a low weight on reserve volatility reflects an inadequate level of foreign reserve holdings. In a different context, Aizenman and Marion (1999) claim that reserve volatility can reduce international credit if investors become more pessimistic about a country's reserve position. Reserve volatility is also used to identify events or regimes. Kaminsky and Reinhart (1999) construct a index of currency market turbulence measured as a weighted average of exchange rate changes and reserve changes, where reserve volatility enters as a weight for reserve loss. Alternatively, Calvo and Reinhart (2002) and Levy Yeyati and Sturzenegger (1999) rely on reserve volatility to determine whether the official classifications of a country's exchange rate arrangement provides an adequate representation of actual country practice.

Up until now, the recent empirical studies operating with reserve volatility concentrate on the indicator properties of reserve volatility as a signal for identifying future crises episodes. Examples include Aizenman and Marion (1999) and Calvo and Reinhart (2002). The analysis is largely short-run and the focus is frequently on individual countries with a known history of currency crises. Missing in the empirical literature on reserve volatility is a long-run perspective that tries to understand the cross-country differences in reserve volatility.

A plot of the monthly percentage change in foreign exchange reserves of twelve leading emerging market countries in Figure 1 reveals that it is difficult to make generalizations about reserve volatility across countries. The largest fluctuations between 1973-2000 are not always concentrated around the time of well-known episodes such as the Asian Crisis of 1997. Nor is it clear whether the fluctuations have increased or decreased over the three decades. From a cross-country perspective, it is of interest to

learn whether structural factors are responsible for the differing behavior in reserve volatility or whether it is simply noise.[1]

The objective of the paper is to determine the long-run forces determining reserve volatility in a cross-country setup. The focus is on emerging market economies; countries that have experienced large fluctuations in capital flows. A wide range of potential indicators stemming from the currency crisis literature is considered for the 1973-2000 period. In particular, we are interested whether specific groups of variables (i.e., external, monetary or structural) account for the cross-country differences in reserve volatility.

The paper is organized as follows. Section 1 briefly reviews the implications of reserve volatility for emerging market economies. In particular, it discusses theoretical and empirical priors about reserve volatility. Section 2 outlines the empirical strategy: measures of reserve volatility, the economic determinants of reserve volatility, and the empirical methodology. Section 3 presents the main cross-country findings. Section 4 considers alternative specifications and extensions to test the robustness of the empirical findings from section 3. Section 5 concludes.

1. Reserve Volatility and Their Theoretical Priors

While there are an infinite number of channels that can generate fluctuations in reserve holdings, to our knowledge there is no explicit theoretical model that seeks to explain reserve volatility as a macroeconomic policy objective.[2] Moreover, central banks have been quiet as to how reserve volatility should behave. The smoothing or

[1] Several studies including Neely (2000) and Lee (1997) suggest that reserves are an imperfect proxy for foreign exchange interventions or other transactions such as government payment of debt denominated in foreign currency.

[2] The strategic objectives for reserve management are generally defined as maximizing returns subject to the maintenance of sufficient security of the assets and adequate liquidity for meeting the calls on reserves, see Nugée (2000). Studies by Kouri and de Macado (1978), Ben-Bassat (1980), and Dellas and Yoo (1991) have compared the reserve currency preferences of central banks for individual countries to models that minimize the variance of the portfolio return for a given mean rate of return. These studies have a serious shortcoming in that they do not consider important benchmark decisions undertaken by the reserve manager (i.e., the duration of an asset or the reference currency).

minimization of reserve volatility is not regarded to be an objective of central banks.[3] Reserve volatility enters, however, as a contributing factor in various theoretical and empirical models. These are briefly outlined below.

Theoretical Links

One linkage of reserve volatility is to determine the optimal size of a country's international reserves. The buffer stock model of Frenkel and Jovanovic (1981) says that central banks choose an optimal level of reserves to balance the macroeconomic adjustment costs incurred in the absence of reserves with the opportunity cost of holding reserves. In the special case of no reserve drift between stock adjustments, a Taylor-series approximation of optimal reserve holdings with the log transformation yields the following equation for reserves:

$$lnRES_0 = c_0 + 0.5ln\sigma - 0.25lnr, \quad (1)$$

where RES_0 is the optimal starting level for international reserves after restocking, c_0 is a country specific nominal constant, σ is the standard deviation of the Wiener increment in the reserves (time series) process operating between stock adjustments, and r is the opportunity cost of holding reserves. The optimal stock of reserves yields the optimal combination of being able to finance a deficit by drawing on reserves and of having to adjust in the face of a deficit by reducing expenditures relative to income. Higher reserve volatility means that reserves hit their lower bound more frequently. The monetary authority is therefore willing to restock a larger amount of reserves and tolerate greater opportunity costs to incur the adjustment cost less frequently.

An alternative channel involving reserve volatility is through signaling. Moral hazard problems linked with domestic bailouts and credit availability have been cited by Corsetti, Pesenti, and Roubini (1998) and others as an important determinant of the Asian financial crisis. Aizenman and Marion (1999) show that reserve uncertainty can have

[3] Central banks, in rare instances, set guidelines to motivate their demand for reserves. The Guidotti plan, for example, sought to set reserves at a level equivalent to a year's interest payment on foreign debt. See the Report of the Working Group on Transparency and Accountability (1998). www.ustres.gov/press/releases/docs/g22-wg1.htm. Alternatively, the Reserve Bank of New Zealand sets reserves at 10 weeks of imports (see Sherwin, 2000).

nonlinear effects on the supply of credit for an emerging market economy. The authors assume that the private sector believes the domestic authority of an emerging market country will use its international reserves to bailout lenders. When the expected reserve position of an emerging market economy is large relative to the potential bailout in bad states of nature, reserve volatility does not matter. However, the same level of reserve volatility can cause a large reduction in the supply of international credit if the emerging market's foreign debt is large enough or if the collapse of output forces the private sector to downgrade its priors about repayment possibilities.

A further use of reserve volatility is to identify an exchange rate system. Pegged exchange-rate arrangements have been blamed for many of the currency crises in the last decade. Adherents of this view argue that emerging market economies should allow their currency to float freely. To test whether countries are doing what they are professing, Calvo and Reinhart (2002) and Reinhart (2002) analyze the behavior of exchange rates, international reserves and monetary aggregates within a simple open economy model. A symptom of 'fear of floating', (i.e, saying that a country allows their exchange rate to float, but does not,) is identified with high reserve volatility.

Each of the above linkages assume that the monetary authority exercises considerable control over its reserves and reserve volatility. Others such as Lee (1997) argue that the opposite is closer to the truth. Monetary authorities of emerging market economies do not possess the necessary open market instruments to sterilize reserves when inflation or money growth is their policy objective. This is because their financial markets are under developed. Supplementary tools, which include tightening the access of banks at the discount window, adjusting reserve requirements or the placement of government deposits, and using foreign exchange swap facility, yield the same effect as an open market operation. In practice, however, reserves become noisier and their interpretation more difficult.

Empirical Stylized Facts and Considerations

Flood and Marion (2001) and Lane and Burke (2001) offer recent cross-country evidence on reserve holdings that have relevance for the empirical specification of reserve volatility. Both studies consider industrial and non-industrial countries for relatively long

time periods. The first study, restricting itself to the buffer stock framework of Frenkel and Jovanovic (1981), finds that reserve volatility is the only significant variable. Different measures of opportunity cost have little or no explanatory power. The second study does not consider reserve volatility among its list of potential variables and finds that openness is the most important contributing factor for reserve demand. For our purposes, it is of interest to determine whether the combination of openness and reserves unfolds any alternative linkages with reserve volatility.

An alternative channel that needs to be considered is the role of financial development. Recent studies by Goldfajn and Valdes (1997) and Kaminsky and Reinhart (1999) emphasize the interaction between currency crises and banking crises. The "twin crises" arise as a result of an internal or external shock that is amplified and propagated to the rest of the economy by liquidity creating financial intermediaries. The intermediaries generate large capital inflows, and at the same time, augment the risk of large capital outflows. Kaminsky and Reinhart (1999) show empirically that the twin crises have their origin in the deregulation of the financial system. Financial liberalization is followed by a rapid increase in the M2 multiplier and in credit growth. Kaminsky and Reinhart (1999) and Goldfajn and Valdes (1997) also show that this trend in the financial variables reverses abruptly before the outbreak of the currency crisis.

This last linkage underscores the view that the currency crises of the 1990s are fundamentally different from earlier periods. Feldstein (2002), Perrault (2002) and others note the evolution of different banking channels and private capital flows between the 1970s and 1990s. First, private capital flows to the emerging market countries were concentrated in Latin America in the 1970s and the 1980s. During the 1990s, the emerging market economies in Asia and Europe were the new destinations. Second, high expected returns on investment motivated capital flows to emerging market countries. In the 1990s, these flows were boosted by economic and financial liberalization, perceived sound macroeconomic policies and, in some cases, explicit or implicit government guarantees. These recent developments suggest strongly that it is important even in a cross-country context to account for shifts in the potential linkages over time.

2. Empirical Specifications, Data and Selected Variables

Sample

There is considerable controversy as to what constitutes an emerging market economy. Definitions vary considerably and few studies motivate their selection. Our selection was guided by two considerations that are independent of the occurrence of a crisis episode. The first was data availability that covered the post-Bretton Woods period from 1973 to 2000. This eliminated many of the *so-called* economies in transition, creating a geographical vacuum for Eastern Europe. The second consideration was based on investment opportunities in the non-industrialized world. This is indirectly measured by foreign direct investment (FDI). Our selected sample of emerging market economies was thus defined as the top 30 non-industrialized countries that received FDI from 1973 to 2000. A list of the countries included in the sample can be found in Appendix A1.

Our sample size of 30 countries is set arbitrary. Most empirical studies work with a smaller number of countries. However, because our estimation strategy is cross country with many control variables, we are forced to extend the sample to allow for a reasonable number of degrees of freedom. Figure 2 highlights in black our sample of emerging market economies with respect to (natural log) total FDI from 1973 to 2000.[4] To see whether our selected sample is fairly robust to different standards, Figures 3 and 4 plot the same countries from Figure 2 with respect to (natural log) GDP and (natural log) GDP per capita. The same countries marked in black do not give a unanimous reading. They do, however, suggest that size may be an important criterion.

Econometric Model

We estimate a cross-sectional specification using data averaged over different time periods. The motivation for the estimation strategy rests in investigating whether external, monetary, and structural determinants of cross-country variation are important in explaining reserve volatility. Thus, we intentionally abstract from the cyclical fluctuations in reserves marked by particular episodes in capital flows or speculative

[4] The sample based on FDI is dictated to a large extent by the decade 1991 to 2000. If we consider only the 1990s, only two countries from our sample would not appear.

attacks. The cross-country specification follows Flood and Marion (2001) and Lane and Burke (2001) in their studies for the level of reserves and is defined as

$$Vol(RES_i) = \alpha + \beta Z_i + \varepsilon_i, \quad (2)$$

where $Vol(RES_i)$ is the reserve volatility of country i, Z_i is a set of control variables and ε_i is the error term. Estimation is by OLS with heteroscedasticity using the Newey-West consistent covariances.

The variables in equation (2) are averaged over three periods: 1973-1980, 1981-1990 and 1991-2000. The division into decade averages is motivated by the prevailing view that the currency crises of the 1990s are fundamentally different from earlier periods (see Feldstein 2002). To determine whether this has an impact on reserve volatility, estimates for the three decades are presented in section 3.

Reserve Volatility

The international reserve holdings of a country in this study are defined in terms of foreign exchange. Although it is common to work with the sum of gold, SDRs, foreign exchange, and reserve position in the Fund, the most important variable in terms of size and international following is by far foreign exchange reserves. This variable is denominated in end-of-period U.S. dollars.[5] Hereafter, when we refer to reserves, we mean foreign exchange reserves.

Two measures of reserve volatility based on standard deviations are constructed. The first is the monthly change in reserves, whereas the second is closer to the definition used by Frenkel and Jovanovic (1981) and is the monthly deviation from a Hodrick-Prescott (HP) trend. Individual country holdings of reserves cannot be compared or traced through time unless they are scaled in some way to reflect differences in size. Our choice is to scale reserves by GDP.[6] Thus, we define the two volatilities for country i as $Vol1_i$ =

[5] Preliminary estimates of the individual components of foreign reserves showed large differences with foreign exchange reserves offering the most promising results.

[6] Recently, Flood and Marion (2001) in their empirical study of the buffer stock model investigate several scaling methods. Their results are found to be independent of such transformations.

$In(std.dev(\Delta Res_{i,t})/ave(GDP_i))$ *and* $Vol2_i = In(std.dev(HPtrend_{i,t} - Res_{i,t})/ave(GDP_i))$, where $Res_{i,t}$ denotes reserves and t time (in months).

Table 1 provides descriptive statistics for the level of reserves, standard deviation of the monthly change in reserves, and the standard deviation of the monthly deviation from the HP trend. These natural log transformed variables are not scaled by GDP. Two results stand out. First, the average volatility of reserves (i.e., measured by the standard deviation) for the emerging market sample increased the most over the three decades when compared to the group of industrialized and developing countries. Second, the volatility measures for the emerging market economies do not suffer from excess skewness and kurtosis; a result that underpins our estimation procedure.

Control Variables

The currency crisis literature identifies numerous control variables that may influence reserves and reserve volatility. Because there is no agreement on the theoretical model of reserve volatility, a broad approach is taken by considering a large number of potential empirical determinants. Definitions and sources of the variables are given in Appendix A2.

Our control variables can be grouped into three broad categories: external, monetary, and structural. The classification of the determinants into groups is somewhat vague. Our intention is to determine whether a particular group of variables is more closely associated with reserve volatility. The external determinants are macroeconomic variables that are strongly influenced by foreign developments or shocks from abroad. These variables include the level of reserves, foreign direct investment, the current and capital account, and debt variables. The classification of reserves as external is without contention. There are numerous reasons for holding reserves, yet almost all are related to concerns regarding foreign shocks.

Monetary variables are defined to be instruments that are under the direct control of the monetary authority. These variables include interest rates, exchange rates, and their volatility. Included in this group are capital controls and the IMF's classification of exchange rate systems, both are taken from Cotterelli and Giannini (1997). The impact of

these two policy variables is ambiguous.[7] On the one hand, a flexible exchange rate system or a high level of capital controls may reduce the risk of a speculative attack, reducing the need to hold reserves. On the other hand, capital controls may prevent access to external credit sources, increasing the importance of reserves in financing external transactions. In the case of the exchange rate system, the classification may be unimportant if the monetary authorities are unable to sterilize the purchase of domestic currency due to a weak financial system.

The control variables that fall into the group structural are GDP per capita, population density, openness, corruption, central bank independence, country credit rating, and financial development (i.e. M2/GDP, insurance premium/GDP and insurance premium/population). Structural variables reflect in part institution building (i.e., central bank independence corruption and country credit rating) that are viewed to be important for a country's long-run development. In the same spirit, political stability is captured through the country credit rating.

3. Cross Country Results

This section presents the cross-country estimates of reserve volatility for the periods 1973-1980, 1981-1990, and 1991-2000. Because we are considering a large number of potential determinants of reserve volatility and the sample of emerging market economies is limited to 30 countries, it is necessary to devise an empirical strategy that maintained a respectable number of degrees of freedom. The selection strategy first examined the regressions between reserve volatility and individual determinants. If a variable was not significant at the 5% level (without additional control variables) with reserve volatility, it was thrown out. In many cases this reduced considerably the number of variables. The second phase of the bottom-up strategy looked at whether the variables in consideration remained significant with other control variables. This strategy was

[7] As noted in Lane and Burke (2001) in the case of reserves, the monetary variables may be regarded as endogenous. Yet, we do not believe that the monetary variables are strongly influenced by reserve volatility over the longer horizon.

continued for higher combinations of variables until a satisfactory specification was found.

The search was simplified in that two variables (i.e., reserves and openness) were able to explain a large share of the cross-country differences in reserve volatility. Tables 2-5, which summarize the empirical results, show only the regressions of those variables that were significant with reserve volatility in the first phase of the estimation strategy (i.e., significant variables in a regression for reserve volatility without additional control variables). The constant, which is included in each of the regressions, is not shown in the tables. Because the empirical results are dominated by the inclusion of (the level of) reserves, the discussion of the empirical results is divided into two parts: estimates with and without reserves.

Reserve Volatility and Reserves

Tables 2 and 3 summarize the cross-country results for the two reserve volatility measures *Vol1* and *Vol2* with reserves. The bottom up strategy yielded a parsimonious specification for reserve volatility. The final specifications were dominated by two or three variables. The control variables that were significant in the specification search were correctly signed with the priors, except openness defined by import-GDP ratio for the 1973-1980 period. For this particular period, the import-GDP ratio was found to be negatively correlated with reserve volatility. The Frankel and Romer index was found to be a better proxy for openness for the 1973-1980 period, whereas the opposite applied for the import-GDP ratio when considering the later decades.

The first phase of the specification strategy was dominated by external and structural variables. In particular, openness, FDI, and total debt/GDP were found to be significant for both volatility measures covering all periods. None of the financial development variables and monetary variables has a p-value lower than 0.05 for more than one time period.

The second and final round results for the two volatility measures yield similar findings for the three time periods. The first finding is that the level of reserves dominates all other explanatory variables. Reserves explain between 50% and 70% of the

cross-country differences in reserve volatility. This result says that a country with a high level of reserves is expected to experience greater reserve volatility. The importance of reserves comes as no surprise when comparing the risk minimization model of Ben-Bassat (1980) and the reverse causality results from Flood and Marion (2001) with the buffer stock specification for industrial and non-industrial countries. It thus appears that the interdependence of reserve's first two moments is not specific to emerging market countries.

The second finding is that monetary variables and variables proxying financial development do not enter the final cross-country specification. Monetary variables such as exchange rate volatility and interest rate volatility are never significant with reserve volatility for the three periods. Other variables that demonstrate a weak correlation with reserve volatility (i.e., significant in the first phase for a single decade, but not with other control variables), are central bank independence, financial development (i.e., proxied by M2/GDP and the amount of insurance premias/GDP), short-term debt, population density, and exchange rate arrangement, and country credit ratings.

The third finding is that the empirical specifications for the 1990s differs with respect to the earlier periods. Reserves as an explanatory variable do not explain reserve volatility to the same extent as in the earlier decades. The R^2s are lower for the 1990s. Of greater interest is the significance of other variables in the specification for the 1990s. First, openness is significant for both measures of reserve volatility. As expected a higher degree of openness is correlated with higher levels of reserve volatility. Second, total debt, M2/GDP, and country credit ratings are found to be significant for the 1990s in the regressions for *Vol1*.

Reserve Volatility without Reserves

The empirical results in Table 2 to 5 may be criticized on the grounds of reverse causality in equation (1). While we do not have a direct test for the simultaneity problem, two routes are taken to tackle this issue. The first is to offer empirical results without reserves and to determine whether our previous findings still hold. The second is to consider alternative measures of reserve volatility that adjust for reserves and test for the significance of reserves as a control variable.

Tables 4 and 5 present cross-country results without reserves as an economic determinant of reserve volatility. Unlike the earlier regressions summarized by Tables 2 and 3, the regressions without reserves do not yield uniform results for *Vol1* and *Vol2*. Openness is the only variable to enter significantly in all the regressions. In fact for the regressions based on *Vol2*, openness is the only variable that is significant. Instead in the case for *Vol1*, we find that GDP per capita is an important determinant of reserve volatility for the 1981-1990 period and FDI and country credit ratings matter for the 1991-2000 period. Again monetary and financial variables do not enter the final cross-country specification.

An alternative way to understand the influence of reserves in the tables 2 to 5 is to adjust *Vol1* for average reserves i.e., $Vol1^* = \ln(\text{std. dev.}(\Delta RES_i)/\text{ave}(RES_i)\text{ave.}(GDP_i))$ and $Vol1^{**} = \ln(\text{std. dev.}(\Delta RES_i)/\text{ave}(\Delta \ln RES_i)\text{ave.}(GDP_i))$. The two definitions of volatility embed a standard volatility measure with average reserves and their change. The latter definition may be interpreted as an inverse sharp ratio, which attempts to adjust a return by its risk. To see whether the specifications of Table 2 are robust to these alternative measures of reserve volatility, the same regressions were rerun with *Vol1* and Vol1***.[8] The results (not shown) find that reserves remain significant for each of the three sample periods, apart from *Vol1*** for the 1980s. The result that countries with higher reserve levels observe higher reserve volatility holds also for *Vol1** and *Vol1***. The other findings that financial variables and monetary variables do not matter and that the specification for the 1990s differs from the earlier periods holds.

4. Extensions to the Cross Country Results

To determine the robustness of our empirical results in the previous section, several modifications are undertaken. In particular, we explore several channels that attempt to shed light on why the monetary and financial variables are unable to explain reserve volatility when using a long-run framework.

[8] The regression results are available upon request.

Crisis Episodes

An alternative consideration is to give greater weight to financial liberalization and banking crises. Studies by Goldfajn and Valdes (1997) and Kaminsky and Reinhart (1999) stress that intermediation acts as a propagation mechanism stimulating both capital inflows and outflows. While we find little evidence that financial development matters for reserve volatility, the linkages between banking and currency crises and reserve volatility were not explored in section 3. We rely on two sources for our crisis indexes. The first is the Kaminsky-Reinhart index of currency market turbulence, which is based on monthly changes in the exchange rate and in reserves. This index is constructed mechanically such that

$$+1 \text{ when } |I_t - \bar{I}|/\sigma_I > 3 \text{ where } I_t = \Delta e_t/e_{t-1} - \alpha\Delta RES_t/RES_{t-1}$$

$$\text{and } \alpha = \sigma_e/\sigma_{RES},$$

0 otherwise,

where σ denotes the standard deviation, e_t the exchange rate and *RES* reserves.[9] The second source is from Glick and Hutchison (1999). They provide dates of banking, currency and twin crisis for the years 1975 to 1997.

Table 6 presents the results for the crisis indexes with *Vol1*. The control variables are again reserves and openness. Overall, the evidence is weak at best that crisis episodes influence reserve volatility in cross-country regressions. The indexes are almost always insignificant with or without the control variables and the coefficients have no clear pattern. This result holds for all time periods and is independent of the type of index.

Exchange Rate Regimes: de jure versus de facto Classifications

The empirical analysis for exchange rate regimes in section 3 relied on the IMF *de jure* classification based on the regime that governments claim to have. The empirical results were negative with this variable. Many countries, however, in theory follow flexible regimes, but intervene in the foreign exchange rate market to such an extent that in

[9] Kaminsky and Reinhart (1999) filter the data for high inflation periods. Our procedure sets the threshold level for a crisis from 3 to 4 when inflation is more than 150% during a six-month period.

practice makes them indistinguishable from fixed rate regimes. To address this problem we use a *de facto* classification of exchange rate regimes constructed by Levy Yeyati and Sturzenegger (1999). The authors use cluster analysis to group different regimes according to movements in the nominal exchange rate, changes in the nominal exchange rate, and changes in international reserves. The index has four classifications (floating = 1, dirty = 2, crawling peg =3, and fixed = 4) for each year from 1990 to 1998.

The cross-country results with the two exchange rate classifications are given in Table 7. The empirical results show that the index for de facto classifications is possibly an important determinant of reserve volatility, whereas the index for de jure classification is not. The evidence suggests that de facto exchange rate regimes which require more interventions are positively correlated with reserve volatility. The regressions with the IMF (de jure) index, summarized in Table 7a, are insignificant and in almost all cases are incorrectly signed. Moreover the results for reserves and openness are not influenced by the presence of the IMF index. The results with the Levy Yeyati-Sturzenegger (de facto) index, given in Table 7b, show a different picture. This exchange rate index is significant at the 5% level for *Vol1* in each of the regressions, whereas the evidence for *Vol2* is less conclusive. More importantly, the coefficients on the de facto index are all correctly signed, i.e., the greater is the commitment to defend a given value for the exchange; the larger is reserve volatility. Of further note is the observation that openness is no longer significant when the Levy Yeyati-Sturzenegger index enters the cross-country regressions.

Panel Estimation

A further possibility why the financial and monetary variables are insignificant in the cross-country regressions is simply that key episodes get washed out through averaging. Although our primary focus is on identifying the long-run determinants of reserve volatility, we rely on panel estimates to separate better the short- and long-run influences of monetary variables on reserve volatility. Panel estimation allows crises episodes to have a stronger impact on reserve volatility, enabling a comparison with the earlier cross-country estimates. The annual panel uses the same variables from section 3 along with the de facto classifications and the crisis indexes from Tables 6 and 7. The same bottom-up strategy from section 3 is applied to the panel estimates.

The (unbalanced) panel estimates for fixed and random effects are given in Table 8. The table shows only the variables that are significant when no control variables (reserves and openness) are considered. Among the significant variables in the first phase of the estimation strategy are several monetary (i.e., the crisis indexes, interest rate volatility, exchange rate volatility) and financial development (i.e., M2/GDP) variables that were insignificant in the cross-country regressions. These variables are significant at the 5% level both for the fixed effects and random effects specification. Of interest is the observation that the debt variables did not figure in the final specifications. Next, when the significant variables are regressed with the control variables reserves and imports/GDP, we find that all the monetary variables remain significant along with the current account and the country credit rating. The financial development variables are, however, no longer significant in the second estimation phase. This is also true for FDI and the absolute change in exports.

To determine whether a particular monetary variable or a crisis index stands out, individual variables were juxtaposed to those given in equation (10) (i.e., reserves, openness and the Kaminsky - Reinhart index). This specification was found to explain reserve volatility the best. No other contributing determinants were found to be significant in this specification. From this evidence, we conclude that the Kaminsky - Reinhart index is highly correlated with a short-run but not a long-run measure of reserve volatility.

5. Summary and Policy Implications

The importance of reserve volatility has entered in different policy discussions surrounding the Asian crisis. Much of the analysis is primarily short run and centers on the signaling ability of reserve volatility to identify specific episodes. Instead the objective of this paper is to ask whether structural determinants are important in explaining cross-country variation in reserve volatility. The question is of relevance because structural variables such as openness are generally not considered in Levy Yeyati-Sturzenegger

(1999) or Calvo and Reinhart (2000) when making comparative statements about a country's fluctuations in reserves.

While openness is found to be an important structural variable for explaining reserve volatility, three empirical regularities intertwined with this variable emerge from our cross-country estimates. The first is that reserve volatility is largely explained by two variables: the level of reserves and the degree of openness. Both of these long-run variables are positively correlated with reserve volatility and explain between 50% and 70% of the cross -country differences in reserve volatility. These results are indirectly supportive of other cross-country studies seeking to uncover the determinants of the average level of reserves. The buffer stock studies by Frenkel and Jovanovic (1981) and others find that the first and second moment of reserves are highly correlated with each other, whereas Lane and Burke (2001) stress the importance of openness in explaining a country's reserves. The second finding underscores the observation of Feldstein (2002) that the decade of the 1990s is distinct from earlier periods. In particular, we find that long-term debt and the inverse of M2 velocity matter for reserve volatility for the 1990s. The third finding is that we find no strong evidence that monetary variables (i.e., exchange rate volatility, the average interest rate, and capital controls) matter for explaining cross-country differences in reserve volatility. This last finding needs to be qualified in that the role of de facto as opposed to de jure exchange rate classifications is found to be a potential contributor of reserve volatility. For the 1990s, we find evidence for one measure of reserve volatility that de facto and not de jure exchange rate classifications are significant.

The empirical findings allow us to make several observations, which are relevant for the policy discussion of currency crises. To understand reserve volatility and its indicator properties one must be careful when making short-run and long-run comparisons. Crisis episodes, whether defined as banking or currency crises, are not found to be a contributing factor for reserve volatility over longer time periods. Panel estimates using annual data show that monetary variables along with several crisis indexes enter as important short-run determinants of reserve volatility. However, the type of de facto exchange rate regime, which has a more permanent fixture, has a stronger influence on

long-run reserve volatility. These issues are important for the arguments put forth by Calvo and Reinhart (2002), Levy Yeyati and Sturzenegger (1999) and others that a country's over reliance of a pegged exchange rate is an explanation for credibility problems specific to emerging market economies that exhibit high reserve volatility. Our empirical results show further that one needs to take into account the size of a country's reserves and the degree of openness regardless when making short and long-run comparisons about a countries exchange rate regime based on reserve volatility.

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Appendix

A1. Country Sample

Emerging Market Countries: Argentina, Bahrain, Brazil, Chile, China, Hongkong, Colombia, Ecuador, Egypt, Hungary, India, Indonesia, Israel, Korea, Malaysia, Mexico, Nigeria, Pakistan, Peru, Philippines, Poland, Romania, Saudi Arabia, Singapore, South Africa, Thailand, Trinidad Tobago, Tunisia, Turkey, Venezuela.

Industrial Countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, UK, USA.

Developing Countries: Bangladesh, Barbados, Belize, Benin, Bolivia, Botswana, Burkina Faso, Burundi, Cambodia, Cameroon, Cap Verde, Central Africa, Chad, Comoros, Congo Republic, Cote d`Ivoire, Cyprus, Dominican Republic, Dominica, El Salvador, Equatorial Guinea, Ethiopia, Fiji, Gabon, Gambia, Ghana, Guatemala, Guinea Bissau, Guyana, Haiti, Honduras, Iran, Jamaica, Jordan, Kenya, Kuwait, Lebanon, Lesotho, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Myanmar, Nepal, Niger, Oman, Panama, Papua New Guinea, Paraguay, Samoa, Senegal, Seychelles, Sierra Leone, Sri Lanka, Sudan, Swaziland, Syrian Arab, Tanzania, Togo, Tonga, United Arab Emirates, Uruguay, Zambia, Zimbabwe.

A2. Control Variables

External Variables

Short-term debt is the natural log of average short-term debt in percent of total debt. (Source World Bank (2001) Global Development Finance CD-Rom).

Total debt is the natural log of average total debt divided by average GNP. (Source World Bank (2001) Global Development Finance CD-Rom).

Foreign direct investment is defined as the natural log of average foreign direct investment divided by average GDP. (Source IMF line 78bed).

Current account is defined as the natural log of average current account divided by average GDP. (Source IMF line 78ald).

Capital account is defined as the natural log of average capital account divided by average GDP. (Source IMF line 78bcd).

Country credit rating is from Institutional Investor for years 1980, 1985, 1990, 1995, 2001.

Export volatility is defined as *ln(std. dev(Δ Exports)/ave(GDP)).* (Source IMF lines 70, 99bc).

Monetary Variables

Interest rate is the average three-month interest rate (i.e., *ln(ave* $i_{i,t}$*)*. The frequency is monthly (Source IMF line 60c).

Interest rate volatility is defined as the natural logarithm of the standard deviation of the monthly change in the three-month interest rate over time (i.e., $ln(std.\ dev(\Delta i_{i,t}))$. (Source IMF line 60c).

Exchange rate volatility is defined as logarithm of the standard deviation of the monthly change in the exchange rate with respect to the U.S. dollar (i.e.$ln(std.\ dev(\Delta s_{i,t}))$. (Source IMF line rf).

Capital controls index is taken from Cottarelli and Giannini (1997). The index is an average over the different periods.

Exchange rate system index is +1 for fixed and 0 for flexible exchange rate systems. The index, which is an average over the different periods, is taken from Cottarelli and Giannini (1997).

Structural Variables

GDP per capita is *ln(ave GDP/ave Population).* (Source IMF line 99b.c, 99z).

Population density is specified as *ln(ave Population/country size).*

Openness is defined in two ways. The first uses the Frankel-Romer index (1999) denoted as Openness (fr) in the tables. This captures the natural level of trade openness by using the sum of the predicted bilateral trade shares from the geographical determinants in a gravity model. The measure is the ratio imports to GDP, which is defined as the natural log of average imports over average GDP. This variable is denoted as Openness (Import/GDP) in the tables. (Source IMF line 71, 99bc).

Financial Development is measured in two ways. The first uses M2/GDP (source IMF line 35, 99b. The second is proxied by the insurance premium density and insurance premium penetration. Economies with a high insurance premium volume are likely to have a rather high level of development. Premium density is defined as premium volume per capita, whereas premium penetration is the premium volume in percentage of GDP. Premium density and penetration are both published yearly by Swiss Re`s research department.

Central bank independence, both indexes for non industrial countries are taken from Cukierman (1992) and Cukierman et al. (1992).

Corruption index, this index is taken from Mauro (1995).

Figure 1: Monthly Percentage Change in Foreign Exchange Reserves

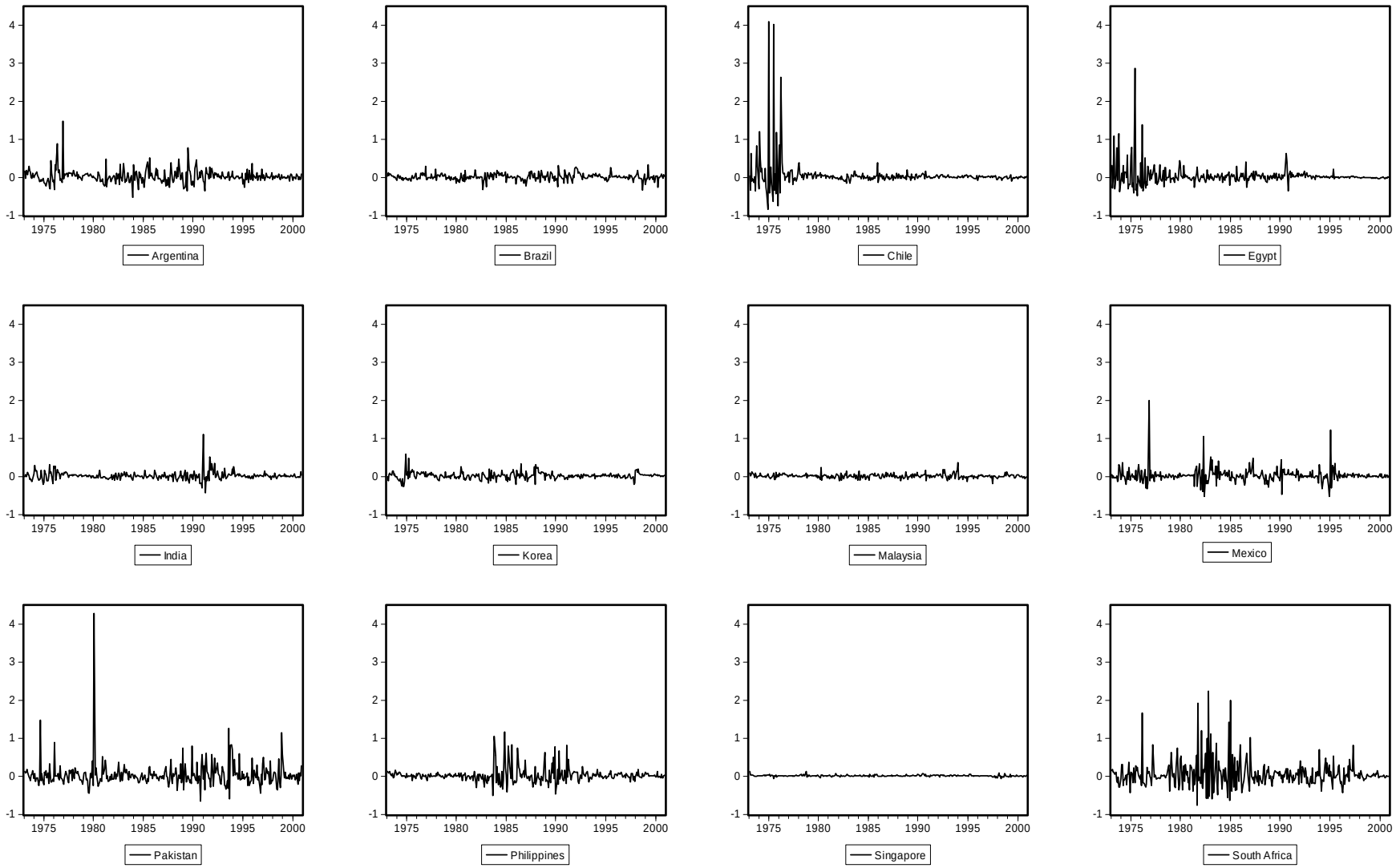

Figure 2: Non Industrialized Countries and Foreign Direct Investment

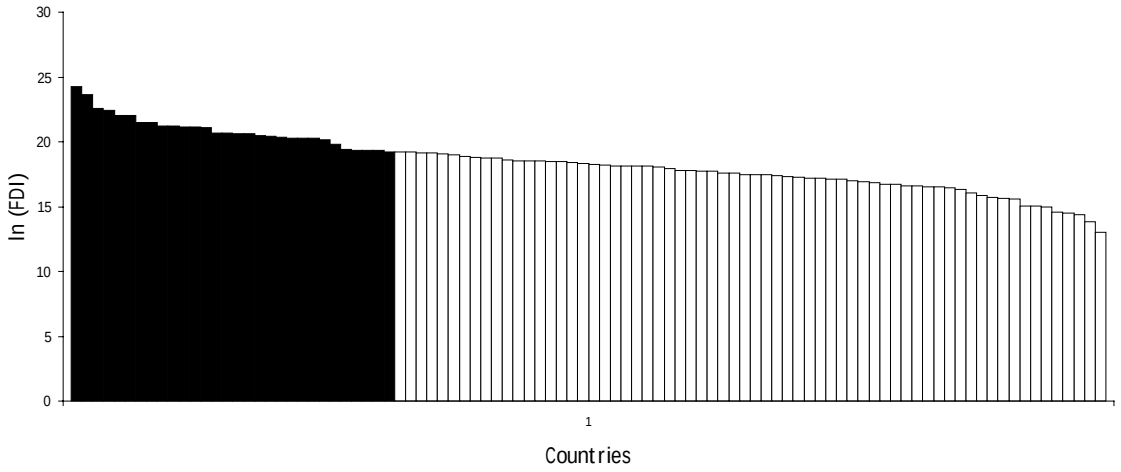

Figure 3: Non Industrialized Countries and GDP

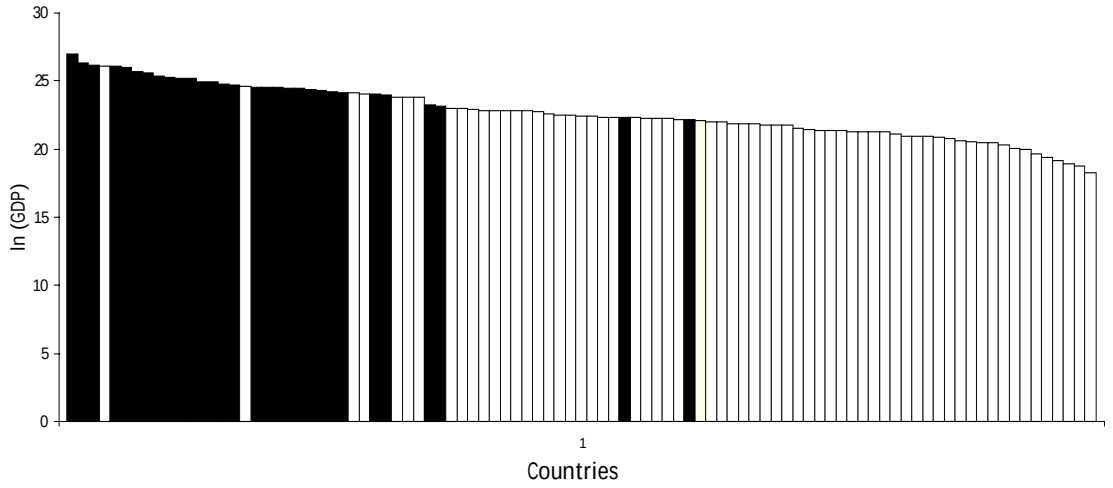

Figure 4: Non Industrialized Countries and GDP per capita

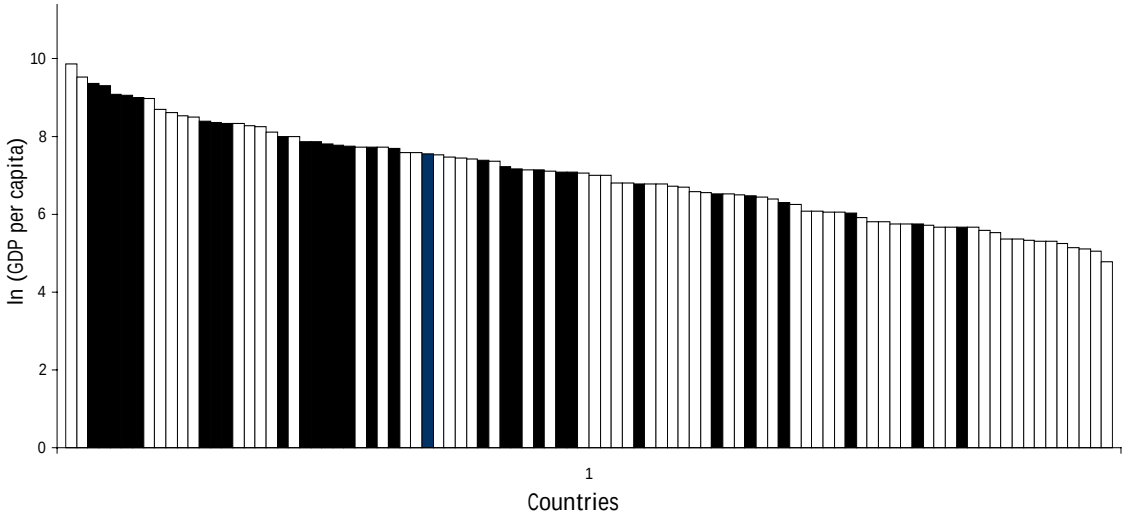

Table 1: Descriptive Statistics of the Dependent Variable

	Emerging Markets			*Industrial Countries*			*Developing Countries*		
Level of Reserves	73-80	81-90	91-00	73-80	81-90	91-00	73-80	81-90	91-00
Mean	21.0921	21.6746	22.9287	21.7293	22.4690	23.2536	18.2053	18.4003	19.4717
Weighted Mean	21.7015	22.1763	23.8348	22.2719	23.6556	24.5463	17.2509	17.1944	18.9412
Maximum	23.5377	23.9247	25.1713	24.1525	24.5638	25.8133	21.0224	21.9934	22.7916
Minimum	19.7031	19.9603	20.0286	18.2827	16.8297	16.9046	15.0999	14.6390	14.7452
Standard Deviation	1.0076	1.0647	1.3344	1.2891	1.7122	1.7983	1.3893	1.6136	1.5604
Skewness	0.3017	0.2377	-0.3795	-0.5268	-1.7262	-2.1651	-0.0924	0.0149	-0.2674
Kurtosis	2.4943	2.2103	2.3983	3.7197	6.4957	8.3159	2.5543	2.6644	3.3193
Observations	27	30	30	22	23	23	68	71	72
Standard Deviation (monthly change in reserves)	73-80	81-90	91-00	73-80	81-90	91-00	73-80	81-90	91-00
Mean	18.7110	19.3228	20.1387	19.4020	20.1691	20.6346	16.2905	16.5714	17.1622
Weighted Mean	19.3671	19.1024	20.9191	20.3055	20.9519	21.5599	15.5971	15.5358	16.8523
Maximum	20.8768	21.1499	21.9578	21.1559	21.4446	22.6708	18.8684	19.5700	22.8050
Minimum	17.3563	17.9887	17.7929	16.1116	17.1156	14.3273	12.9638	14.0276	14.5304
Standard Deviation	0.8207	0.7637	1.0393	1.2062	0.9643	1.6886	1.1824	1.2336	1.4200
Skewness	0.7152	0.2685	-0.3598	-0.7588	-1.2321	-2.5377	-0.4725	-0.0807	0.7094
Kurtosis	3.2150	2.8585	2.6570	3.6405	5.5693	9.9363	3.4920	2.6250	5.3865
Observations	27	29	30	22	22	23	61	65	66
Standard Deviation (monthly deviation from Hodrick-Prescott Trend)	73-80	81-90	91-00	73-80	81-90	91-00	73-80	81-90	91-00
Mean	19.4297	20.0205	20.7795	19.9722	20.7965	21.3656	16.8219	17.1356	17.5601
Weighted Mean	20.1741	20.5332	21.6137	20.9588	21.8928	21.8578	14.6668	15.1334	17.1690
Maximum	21.6706	21.5733	22.6420	21.7732	22.4008	23.3163	19.4574	19.5033	22.4362
Minimum	18.1161	18.3441	18.2396	16.6777	17.2963	17.8656	13.3641	14.3938	14.6982
Standard Deviation	0.9679	0.8445	1.0989	1.2830	1.1412	1.0890	1.1549	1.1357	1.4569
Skewness	0.7890	0.1760	-0.4119	-0.6211	-1.0337	-1.2473	-0.5074	-0.1848	0.2886
Kurtosis	2.6269	2.4150	3.0320	3.1034	5.0901	6.3186	3.8377	2.8814	3.8156
Observations	25	28	30	22	22	22	47	51	64

Note: The variables are in US dollars and are not scaled by GDP.

Countries are listed in the Appendix A1.

Table 2a

Reserve Volatility - *Vol1* (change in monthly reserves) **Estimation: OLS Cross-Country**

Period: 1973-1980	1	2	3	4	5	6	7	8	9	10	11	12
Reserves	0.6162* (0.0929)	0.5710* (0.1008)	0.5864* (0.0780)	0.5662* (0.0949)	0.5077* (0.1757)	0.8437* (0.1593)	0.5874* (0.1903)	0.6445* (0.0859)	0.5880* (0.1300)	0.6307* (0.0843)	0.6500* (0.0921)	0.5829* (0.1243)
Openness (FR)		0.0046 (0.0048)										
Openness (Import/GDP)			-0.2541* (0.0980)									
GDP per capita				0.0963 (0.1016)								
FDI					0.0571 (0.1030)							
Total Debt/GNP						0.3827 (0.2137)						
Capital Account							-36.7184 (27.6831)					
Population Density								-0.0727 (0.0484)				
Capital Control									-0.2417 (0.1827)			
Exchange Rate System										0.5640* (0.1648)		
Country Credit Rating											-0.0059 (0.0042)	
Corruption												-0.0088 (0.0332)
adj. R^2	0.688	0.681	0.736	0.687	0.517	0.624	0.568	0.693	0.631	0.720	0.694	0.574
degrees of freedom	24	23	23	23	15	16	8	23	21	21	23	19

Note: Standard errors are given in parentheses and are corrected for heteroskedasticity using the Newey-West consistent covariances.

*denotes significance at the 5% level.

The regression´s constant is not shown. See Appendix A2 for definition of the variables.

Table 2b

Reserve Volatility - *Vol1* (change in monthly reserves) **Estimation: OLS Cross-Country**

Period: 1981-1990	1	2	3	4	5	6	7	8	9	10	11
Reserves	0.5435* (0.0755)	0.4618* (0.0772)	0.4071* (0.0695)	0.3943* (0.0673)	0.3843* (0.1378)	0.3994* (0.1210)	0.4790* (0.1426)	0.4184* (0.0653)	0.4172* (0.0621)	0.4543* (0.0823)	0.3955* (0.1034)
Openness (Import/GDP)		0.1771 (0.1607)		0.0394 (0.1368)	-0.0715 (0.1375)	0.1875 (0.1500)	0.0131 (0.2874)	0.0070 (0.1358)	0.0771 (0.1445)	-0.0477 (0.1518)	0.0405 (0.1599)
GDP per capita			0.2362* (0.0825)	0.2270* (0.0896)	0.1969 (0.1072)	0.2190 (0.1083)	0.0423 (0.1458)	0.1588 (0.1091)	0.2348* (0.0874)	0.2324 (0.1193)	0.1599 (0.3308)
FDI					0.0817 (0.0453)						
Total Debt/GNP						0.1801 (0.1130)					
Capital Account							1.6300 (2.3451)				
Exchange Rate System								0.2005 (0.2033)			
Country Credit Rating									-0.0052 (0.0057)		
Corruption										-0.0291 (0.0385)	
Premium Density											0.0266 (0.1707)
adj. R^2	0.659	0.665	0.734	0.724	0.691	0.670	0.712	0.719	0.731	0.678	0.634
degrees of freedom	27	26	26	25	20	19	9	20	24	18	18

Note: Standard errors are given in parentheses and are corrected for heteroskedasticity using the Newey-West consistent covariances.

*denotes significance at the 5% level.

The regression´s constant is not shown. See Appendix A2 for definition of the variables.

Table 2c

Reserve Volatility - *Vol1* (change in monthly reserves) **Estimation: OLS Cross-Country**

Period: 1991-2000	1	2	3	4	5	6	7	8	9	10
Reserves	0.4811* (0.0766)	0.2542* (0.1135)	0.2397 (0.1345)	0.1879 (0.1205)	0.2181* (0.0789)	0.1683 (0.1051)	0.2226* (0.0911)	0.2211* (0.0883)	0.2236* (0.0829)	0.3518* (0.1077)
Openness (Import/GDP)		0.3732* (0.1295)	0.3560* (0.1231)	0.3407* (0.1298)	0.4043* (0.1580)	0.5017* (0.1434)	0.4061* (0.1642)	0.4181* (0.1711)	0.3991* (0.1655)	0.4714* (0.1266)
GDP per capita			0.0349 (0.0717)							
FDI				0.1094 (0.1059)						
Total Debt/GNP					0.3896* (0.1147)	0.3769* (0.1174)	0.3856* (0.1199)	0.3941* (0.1150)	0.3852* (0.1166)	
Population Density						-0.1109 (0.0685)				
Country Credit Rating							-0.0005 (0.0041)			
Interest Rate								0.0598 (0.0867)		
Current Account									-0.9481 (2.5677)	
M2										-0.2779* (0.0927)
adj.R^2	0.504	0.610	0.599	0.620	0.615	0.639	0.596	0.594	0.598	0.672
degrees of freedom	28	27	26	26	21	20	20	19	20	26

Note: Standard errors are given in parentheses and are corrected for heteroskedasticity using the Newey-West consistent covariances.

*denotes significance at the 5% level.

The regression´s constant is not shown. See Appendix A2 for definition of the variables.

Tabele 3a

Reserve Volatility - *Vol2* (deviation from Hodrick Prescott trend) **Estimation: OLS Cross-Country**

Period: 1973-1980	1	2	4	3	5	6	7	8	9	10
Reserves	0.6282* (0.1103)	0.6358* (0.1301)	0.6208* (0.0972)	0.5884* (0.1561)	0.5163* (0.1870)	0.7620* (0.2133)	0.4425* (0.1364)	0.6847* (0.0931)	0.6424* (0.1224)	0.5383* (0.1049)
Openness (FR)		-0.0007 (0.0063)								
Openness (Import/GDP)			-0.2098 (0.1159)							
GDP per capita				0.0653 (0.1282)						
FDI					-0.1461 (0.1226)					
Total Debt/GNP						0.3148 (0.3783)				
Capital Account							3.4873 (15.9470)			
Population Density								-0.1294* (0.0460)		
Exchange Rate System									0.1783 (0.2153)	
Central Bank Independence										1.7174 (1.0496)
adj. R^2	0.616	0.598	0.642	0.604	0.394	0.424	0.541	0.664	0.568	0.549
degrees of freedom	22	21	21	21	14	15	7	21	20	17

Note: Standard errors are given in parentheses and are corrected for heteroskedasticity using the Newey-West consistent covariances.

*denotes significance at the 5% level.

The regression´s constant is not shown. See Appendix A2 for definition of the variables.

Table 3b

Reserve Volatility - *Vol2* (deviation from Hodrick Prescott trend) **Estimation: OLS Cross-Country**

Period: 1981-1990	1	2	3	4	5	6	7	8	9	10	11
Reserves	0.5225* (0.0898)	0.4657* (0.1158)	0.4752* (0.1171)	0.4361* (0.1224)	0.4407* (0.0972)	0.4011* (0.1621)	0.4636* (0.0906)	0.5532* (0.0911)	0.5687* (0.0968)	0.5702* (0.1047)	0.5221* (0.0926)
Openness (FR)		0.0053 (0.0051)									
Openness (Import/GDP)			0.0998 (0.2002)								
GDP per capita				0.1557 (0.1220)							
FDI					-0.0025 (0.0599)						
Total Debt/GNP						0.2339 (0.1726)					
Capital Account							3.8589* (1.6588)				
Population Density								-0.0758 (0.0499)			
Capital Control									0.0496 (0.1762)		
Exchange Rate System										-0.0991 (0.2876)	
Current Account											0.4134 (2.5967)
adj. R^2	0.527	0.520	0.514	0.544	0.461	0.299	0.674	0.532	0.563	0.565	0.509
degrees of freedom	26	25	25	25	21	20	10	25	21	21	25

Note: Standard errors are given in parentheses and are corrected for heteroskedasticity using the Newey-West consistent covariances.

*denotes significance at the 5% level.

The regression´s constant is not shown. See Appendix A2 for definition of the variables.

Table 3c

Reserve Volatility - *Vol2* (deviation from Hodrick Prescott trend) **Estimation: OLS Cross-Country**

Period: 1991-2000	1	2	3	4	5	6	7	8	9
Reserves	0.4884* (0.5235)	0.2075 (0.1085)	0.4633* (0.1018)	0.1469 (0.1087)	0.2070 (0.1159)	0.2361 (0.1177)	0.2714* (0.1008)	0.2309* (0.1065)	0.2719* (0.1106)
Openness (Import/GDP)		0.4620* (0.1345)		0.4323* (0.1377)	0.5863* (0.1518)	0.4775* (0.1330)	0.4300* (0.1201)	0.4740* (0.1414)	0.5269* (0.1318)
GDP per capita			0.0349 (0.0730)						
FDI				0.1001 (0.0629)					
Population Density					-0.0805 (0.0506)				
Country Credit Rating						-0.0029 (0.0044)			
Interest Rate							0.0735 (0.0594)		
Current Account								-1.0379 (1.6634)	
M2									-0.1836 (0.1013)
adj.R^2	0.507	0.674	0.492	0.682	0.692	0.668	0.693	0.667	0.695
degrees of freedom	28	27	27	26	26	26	25	26	26

Note: Standard errors are given in parentheses and are corrected for heteroskedasticity using the Newey-West consistent covariances.

*denotes significance at the 5% level.

The regression´s constant is not shown. See Appendix A2 for definition of the variables.

Table 4a

Reserve Volatility - *Vol1* (change in monthly reserves) **Estimation: OLS Cross-Country**

Period: 1973-1980	1	2	3	4	5	6	7	8	9
Openness (FR)	0.0171* (0.0076)	0.0221 (0.0112)	0.0679* (0.0211)	0.0513* (0.0128)	0.0342* (0.0084)	0.0231* (0.0064)	0.0239* (0.0060)	0.0271* (0.0074)	0.0300* (0.0132)
Openness (Import/GDP)									
GDP per capita	0.2287 (0.1625)								
FDI		0.0786 (0.1321)							
Total Debt/GNP			0.0288 (0.2276)						
Capital Account				-144.7937* (46.2171)					
Population Density					-0.1813 (0.0886)				
Capital Control						-0.3282 (0.2858)			
Exchange Rate System							0.4282 (0.2453)		
Country Credit Rating								-0.0043 (0.0069)	
Corruption									-0.0330 (0.0457)
adj. R^2	0.327	0.261	0.413	0.665	0.349	0.329	0.346	0.273	0.199
degrees of freedom	23	15	16	8	23	21	21	23	19

Note: Standard errors are given in parentheses and are corrected for heteroskedasticity using the Newey-West consistent covariances.

*denotes significance at the 5% level.

The regression´s constant is not shown. See Appendix A2 for definition of the variables.

Table 4b

Reserve Volatility - *Vol1* (change in monthly reserves) **Estimation: OLS Cross-Country**

Period: 1981-1990	1	2	3	4	5	6	7	8
Openness (FR)								
Openness (Import/GDP)	0.3381* (0.1317)	0.1486 (0.1137)	0.3628* (0.1539)	0.5379 (0.2514)	0.3053* (0.1265)	0.3573* (0.1502)	0.2927* (0.1376)	0.3283* (0.1533)
GDP per capita	0.3324* (0.0980)	0.3346* (0.0821)	0.3088* (0.1298)	0.1455 (0.2147)	0.2882* (0.1238)	0.3373* (0.1016)	0.3772* (0.1288)	0.4331 (0.4615)
FDI		0.1418 (0.0688)						
Total Debt/GNP			0.2292 (0.1121)					
Capital Account				2.3225 (2.9923)				
Exchange Rate System					0.3343 (0.2831)			
Country Credit Rating						-0.0018 (0.0066)		
Corruption							-0.0277 (0.0501)	
Premium Density								-0.0785 (0.2725)
adj.R^2	0.546	0.598	0.483	0.463	0.547	0.530	0.439	0.456
degrees of freedom	26	21	20	10	21	25	19	19

Note: Standard errors are given in parentheses and are corrected for heteroskedasticity using the Newey-West consistent covariances.
*denotes significance at the 5% level.
The regression´s constant is not shown. See Appendix A2 for definition of the variables.

Table 4c

Reserve Volatility - *Vol1* (change in monthly reserves)						**Estimation: OLS Cross-Country**		
Period: 1991-2000	1	2	3	4	5	6	7	8
Openness (FR)								
Openness (Import/GDP)	0.5212* (0.1069)	0.5878* (0.1261)	0.5536* (0.1785)	0.8264* (0.1603)	0.6459* (0.1307)	0.7560* (0.1304)	0.6927* (0.1257)	0.6781* (0.1244)
GDP per capita	0.0733 (0.0607)							
FDI		0.2965* (0.1147)						
Total Debt/GNP			0.2248 (0.3090)					
Population Density				-0.0016 (0.0812)				
Country Credit Rating					0.0132* (0.0056)			
Interest Rate						-0.1709 (0.1218)		
Current Account							4.3533* (1.6038)	
M2								-0.1485 (0.1026)
adj.R^2	0.549	0.560	0.187	0.464	0.534	0.512	0.517	0.557
degrees of freedom	27	27	22	27	27	26	27	27

Note: Standard errors are given in parentheses and are corrected for heteroskedasticity using the Newey-West consistent covariances.
*denotes significance at the 5% level.
The regression´s constant is not shown. See Appendix A2 for definition of the variables.

Table 5a

Reserve Volatility - *Vol2* (deviation from Hodrick Prescott trend) **Estimation: OLS Cross-Country**

Period: 1973-1980	1	2	3	4	5	6	7
Openness (FR)	0.0131 (0.0083)	0.0200 (0.0110)	0.0406 (0.0253)	0.0312* (0.0108)	0.0323* (0.0072)	0.0199* (0.0049)	0.0195* (0.0078)
Openness (Import/GDP)							
GDP per capita	0.2437 (0.1695)						
FDI		-0.1439 (0.1526)					
Total Debt/GNP			-0.0178 (0.4029)				
Capital Account				-60.5179 (29.3965)			
Population Density					-0.2233* (0.0922)		
Exchange Rate System						-0.0617 (0.2646)	
Central Bank Independence I							2.4344 (1.3181)
adj. R^2	0.257	0.096	-0.019	0.224	0.321	0.155	0.149
degrees of freedom	21	14	15	7	21	20	17

Note: Standard errors are given in parentheses and are corrected for heteroskedasticity using the Newey-West consistent covariances.
*denotes significance at the 5% level.
The regression´s constant is not shown. See Appendix A2 for definition of the variables.

Table 5b

Reserve Volatility - *Vol2* (deviation from Hodrick Prescott trend) **Estimation: OLS Cross-Country**

Period: 1981-1990	1	2	3	4	5	6	7	8
Openness (FR)								
Openness (Import/GDP)	0.3389* (0.1585)	0.3624* (0.1345)	0.4138 (0.2494)	0.5592* (0.1360)	0.7869* (0.1573)	0.4619* (0.1823)	0.5159* (0.1510)	0.5965* (0.1721)
GDP per capita	0.2535* (0.1211)							
FDI		0.0702 (0.0691)						
Total Debt/GNP			0.2751 (0.1448)					
Capital Account				5.9427* (1.3473)				
Population Density					-0.1888* (0.0749)			
Capital Control						-0.2545 (0.2684)		
Exchange Rate System							0.1333 (0.4040)	
Current Account								-3.1359 (4.2633)
adj. R^2	0.337	0.231	0.235	0.450	0.358	0.236	0.220	0.267
degrees of freedom	25	21	20	10	25	21	21	25

Note: Standard errors are given in parentheses and are corrected for heteroskedasticity using the Newey-West consistent covariances.
*denotes significance at the 5% level.
The regression´s constant is not shown. See Appendix A2 for definition of the variables.

Table 5c

Reserve Volatility - *Vol2* (deviation from Hodrick Prescott trend) **Estimation: OLS Cross-Country**

91-00	1	2	3	4	5	6	7
Openness (FR)							
Openness (Import/GDP)	0.6301* (0.1199)	0.5186* (0.1135)	0.7574* (0.1090)	0.6300* (0.1172)	0.6351* (0.1005)	0.6340* (0.1238)	0.6866* (0.1184)
GDP per capita	0.0034 (0.0547)						
FDI		0.1436 (0.0704)					
Population Density			-0.0808 (0.0500)				
Country Credit Rating				0.0002 (0.0035)			
Interest Rate					0.0271 (0.0470)		
Current Account						-0.0326 (1.5946)	
M2							-0.0835 (0.1059)
adj. R^2	0.623	0.673	0.653	0.623	0.622	0.623	0.631
degrees of freedom	27	27	27	27	26	27	27

Note: Standard errors are given in parentheses and are corrected for heteroskedasticity using the Newey-West consistent covariances.
*denotes significance at the 5% level.
The regression´s constant is not shown. See Appendix A2 for definition of the variables.

Table 6a

Reserve Volatility - *Vol1* (change in monthly reserves) **Estimation: OLS Cross-Country**

Period: 1973-1980	1	2	3	4	5	6	7	8	9	10
Reserves		0.5966* (0.1056)	0.5775* (0.0910)				0.6090* (0.1309)	0.5720* (0.0973)		
Openness (Import/GDP)			-0.2472* (0.1026)	-0.3298 (0.2168)				-0.2533* (0.1004)	-0.3941 (0.2203)	
Openness (FR)					0.0269* (0.0083)					0.0360* (0.0135)
(KR) Index	1.2559 (1.8105)	-0.0433 (1.0424)	-0.1245 (0.8820)	1.0923 (1.6270)	-1.5577 (1.9270)					
(GH) Currency Crisis Index						-1.0656 (1.3484)	0.7179 (0.6786)	0.6913 (0.5187)	-0.9386 (0.9288)	-0.5663 (1.2907)
(GH) Banking Crisis Index										
(GH) Twin Crisis Index										
adj. R^2	-0.023	0.637	0.687	0.047	0.267	-0.252	0.617	0.668	0.091	0.241
degrees of freedom	23	22	21	22	22	19	18	17	18	18

Note: Standard errors are given in parentheses and are corrected for heteroskedasticity using the Newey-West consistent covariances.
*denotes significance at the 5% level.
The regression´s constant is not shown. See Appendix A2 for definition of the variables.

Table 6a (Cont.)

Reserve Volatility - *Vol1* (change in monthly reserves) **Estimation: OLS Cross-Country**

Period: 1973-1980	11	12	13	14	15	16	17	18	19	20
Reserves		0.5835* (0.1162)	0.5479* (0.0881)				0.6408* (0.0970)	0.6101* (0.0789)		
Openness (Import/GDP)			-0.2503* (0.1059)	-0.3967 (0.2275)				-0.2491* (0.1021)	-0.3944 (0.2187)	
Openness (FR)					0.0406* (0.0148)					0.0265* (0.0059)
(KR) Index										
(GH) Currency Crisis Index										
(GH) Banking Crisis Index	1.5938 (1.1060)	1.5930 (0.7858)	1.5511* (0.6045)	1.5274 (1.3565)	2.4460* (0.8169)					
(GH) Twin Crisis Index						-0.3116 (0.9533)	0.8089 (0.4757)	0.7609 (0.4574)	-0.3028 (0.9219)	0.5774 (0.8770)
adj. R^2	-0.008	0.653	0.704	0.112	0.341	-0.038	0.696	0.744	0.069	0.274
degrees of freedom	19	18	17	18	18	24	23	22	23	23

Note: Standard errors are given in parentheses and are corrected for heteroskedasticity using the Newey-West consistent covariances.

*denotes significance at the 5% level.

The regression´s constant is not shown. See Appendix A2 for definition of the variables.

Table 6b

Reserve Volatility - *Vol1* (change in monthly reserves) **Estimation: OLS Cross-Country**

Period: 1981-1990	1	2	3	4	5	6	7	8	9	10
Reserves		0.5558*	0.4579*				0.5015*	0.4042*		
		(0.0726)	(0.0738)				(0.0831)	(0.0810)		
Openness (Import/GDP)			0.2161	0.6758*				0.2456	0.6247*	
			(0.1473)	(0.1298)				(0.1655)	(0.1431)	
Openness (FR)					0.0245*					0.0394*
					(0.0041)					(0.0099)
(KR) Index	0.3684	0.7379	0.8381	0.8853	0.2789					
	(0.7988)	(0.5145)	(0.5660)	(0.6838)	(0.6269)					
(GH) Currency Crisis Index						0.2979	0.6096	0.8448	1.0500*	1.1423*
						(0.5446)	(0.4202)	(0.4685)	(0.4430)	(0.5228)
(GH) Banking Crisis Index										
(GH) Twin Crisis Index										
adj. R^2	-0.029	0.679	0.695	0.430	0.356	-0.038	0.622	0.650	0.377	0.400
degrees of freedom	27	26	25	26	26	21	20	19	20	20

Note: Standard errors are given in parentheses and are corrected for heteroskedasticity using the Newey-West consistent covariances.

*denotes significance at the 5% level.

The regression´s constant is not shown. See Appendix A2 for definition of the variables.

Table 6b (Cont.)

Reserve Volatility - *Vol1* (change in monthly reserves) **Estimation: OLS Cross-Country**

Period: 1981-1990	11	12	13	14	15	16	17	18	19	20
Reserves		0.4684* (0.0688)	0.3808* (0.0684)				0.5482* (0.0738)	0.4335* (0.0795)		
Openness (Import/GDP)			0.1958 (0.1664)	0.5455* (0.1372)				0.2529 (0.1684)	0.7052* (0.1406)	
Openness (FR)					0.0348* (0.0065)					0.0293* (0.0043)
(KR) Index										
(GH) Currency Crisis Index										
(GH) Banking Crisis Index	0.5446 (0.3972)	0.2919 (0.2305)	0.3778 (0.2465)	0.6524* (0.2934)	0.7270* (0.2507)					
(GH) Twin Crisis Index						0.2059 (0.3866)	0.2861 (0.2020)	0.3925 (0.2119)	0.5494* (0.2656)	0.7034* (0.2787)
adj. R^2	0.043	0.606	0.617	0.398	0.434	-0.026	0.669	0.693	0.463	0.474
degrees of freedom	21	20	19	20	20	27	26	25	26	26

Note: Standard errors are given in parentheses and are corrected for heteroskedasticity using the Newey-West consistent covariances.

*denotes significance at the 5% level.

The regression´s constant is not shown. See Appendix A2 for definition of the variables.

Table 6c

Reserve Volatility - *Vol1* (change in monthly reserves) **Estimation: OLS Cross-Country**

Period: 1991-2000	1	2	3	4	5	6	7	8	9	10
Reserves		0.4823*	0.2453				0.5629*	0.3503*		
		(0.0773)	(0.1240)				(0.0871)	(0.1274)		
Openness (Import/GDP)			0.3822*	0.5861*				0.3344*	0.6052*	
			(0.1339)	(0.0894)				(0.1201)	(0.0908)	
Openness (FR)					0.0182*					0.0371*
					(0.0068)					(0.0058)
(KR) Index	-0.2375	0.0563	-0.1684	-0.3608	0.3510					
	(0.6821)	(0.4576)	(0.3885)	(0.3718)	(0.6176)					
(GH) Currency Crisis Index						-0.6039	0.7457	0.8405	0.4900	0.4308
						(0.9853)	(0.5228)	(0.4986)	(0.6288)	(0.5429)
(GH) Banking Crisis Index										
(GH) Twin Crisis Index										
adj.R^2	-0.031	0.486	0.597	0.543	0.238	-0.032	0.584	0.667	0.552	0.486
degrees of freedom	28	27	26	27	27	22	21	20	21	21

Note: Standard errors are given in parentheses and are corrected for heteroskedasticity using the Newey-West consistent covariances.

*denotes significance at the 5% level.

The regression´s constant is not shown. See Appendix A2 for definition of the variables.

Table 6c (Cont.)

Reserve Volatility - *Vol1* (change in monthly reserves)							**Estimation: OLS Cross-Country**			
Period: 1991-2000	11	12	13	14	15	16	17	18	19	20
Reserves		0.5871* (0.0784)	0.3727* (0.1085)				0.5213* (0.0926)	0.2870* (0.1138)		
Openness (Import/GDP)			0.3405* (0.1226)	0.6196* (0.1034)				0.4063* (0.1181)	0.6291* (0.0919)	
Openness (FR)					0.0358* (0.0060)					0.0176* (0.0067)
(KR) Index										
(GH) Currency Crisis Index										
(GH) Banking Crisis Index	-0.2373 (0.4083)	0.3784 (0.2245)	0.4196* (0.1933)	0.2469 (0.2828)	-0.0814 (0.2736)					
(GH) Twin Crisis Index						-0.2237 (0.3843)	0.4086 (0.3194)	0.5375 (0.2739)	0.4160 (0.2925)	0.1028 (0.2924)
adj.R^2	-0.029	0.603	0.690	0.560	0.482	-0.026	0.515	0.646	0.562	0.231
degrees of freedom	22	21	20	21	21	28	27	26	27	27

Note: Standard errors are given in parentheses and are corrected for heteroskedasticity using the Newey-West consistent covariances.

*denotes significance at the 5% level.

The regression´s constant is not shown. See Appendix A2 for definition of the variables.

Table 7a

De jure versus de facto Exchange Rate Regimes **Estimation: OLS Cross-Country**

Period: 1991-2000	**Vol 1**				**Vol 2**			
Reserves		0.4516* (0.0865)	0.2767* (0.1243)			0.4449* (0.0882)	0.2252 (0.1218)	
Openness (Import/GDP)			0.3077* (0.1435)				0.3866* (0.1508)	
Openness (FR)				0.0143* (0.0055)				0.0142* (0.0052)
IMF Classification (de jure)	0.0662 (0.2052)	-0.0444 (0.1342)	-0.0140 (0.1274)	-0.1030 (0.2000)	-0.0610 (0.2219)	-0.1699 (0.1448)	-0.1317 (0.1210)	-0.2284 (0.2269)
adj. R^2	-0.040	0.459	0.539	0.152	-0.041	0.439	0.577	0.145
degrees of freedom	23	22	21	22	23	22	21	22

Note: Standard errors are given in parentheses and are corrected for heteroskedasticity using the Newey-West consistent covariances.
*denotes significance at the 5% level.
The regression´s constant is not shown. See Appendix A2 for definition of the variables.

Table 7b

De jure versus de facto Exchange Rate Regimes **Estimation: OLS Cross-Country**

Period: 1991-2000	**Vol 1**				**Vol 2**			
Reserves		0.5053* (0.0815)	0.4199* (0.0932)			0.5797* (0.0987)	0.4025* (0.0844)	
Openness (Import/GDP)			0.1364 (0.1348)				0.2831 (0.1526)	
Openness (FR)				0.0086 (0.0051)				0.0099 (0.0063)
Levy Yeyati-Sturzenegger Classification (de facto)	0.2634* (0.0995)	0.2361* (0.0505)	0.2077* (0.0588)	0.2099* (0.0906)	0.2024 (0.1203)	0.1711* (0.0523)	0.1121 (0.0604)	0.1410 (0.1051)
adj. R^2	0.208	0.713	0.712	0.243	0.087	0.684	0.723	0.130
degrees of freedom	21	20	19	20	21	20	19	20

Note: Standard errors are given in parentheses and are corrected for heteroskedasticity using the Newey-West consistent covariances.
*denotes significance at the 5% level.
The regression´s constant is not shown. See Appendix A2 for definition of the variables.

Table 8a

Reserve Volatility - *Vol1* (change in monthly reserves)

Fixed Effects **Estimation: Panel**

Period: 1973-2000	1	2	3	4	5	6	7	8	9
Reserves	0.2270* (0.0346)	0.2514* (0.0411)	0.2230* (0.0391)	0.2547* (0.0354)	0.2244* (0.0614)	0.1191* (0.0400)	0.0184 (0.0872)	0.1954* (0.0386)	0.2425* (0.0423)
Openness (Import/GDP)	0.2659* (0.0773)	0.4301* (0.0881)	0.4924* (0.0896)	0.3670* (0.0804)	0.4383* (0.1313)	0.3953* (0.0815)	0.5670* (0.1807)	0.4684* (0.0914)	0.3555* (0.0988)
(KR) Currency Crisis	0.2818* (0.0453)								
(GH) Currency Crisis Index		0.3115* (0.0535)							
(GH) Banking Crisis Index			0.1701* (0.0497)						
(GH) Twin Crisis Index				0.2345* (0.0453)					
Interest Rate Volatility					0.0812* (0.0202)				
Exchange Rate Volatility						0.0278* (0.0054)			
Levy Yeyati-Sturzenegger Exchange Rate Classification							0.0713* (0.0310)		
Current Account								1.1212* (0.2994)	
Country Credit Rating									-0.0090* (0.0029)
adj. R^2	0.598	0.592	0.580	0.612	0.674	0.580	0.525	0.600	0.587
degrees of freedom	710	504	504	632	338	587	160	656	549

Note: Standard errors are given in parentheses and are corrected for heteroskedasticity using the Newey-West consistent covariances.

*denotes significance at the 5% level.

The regression´s constant is not shown. See Appendix A2 for definition of the variables.

Table 8b

Reserve Volatility - *Vol1* (change in monthly reserves)

Random Effects **Estimation: Panel**

Period: 1973-2000	1	2	3	4	5	6	7	8	9
Reserves	0.2367* (0.0307)	0.2621* (0.0354)	0.2352* (0.0358)	0.2665* (0.0325)	0.2255* (0.0515)	0.1417* (0.0357)	0.1584* (0.0729)	0.2086* (0.0343)	0.2575* (0.0367)
Openness (Import/GDP)	0.2796* (0.0619)	0.3823* (0.0692)	0.4281* (0.0693)	0.3524* (0.0615)	0.4456* (0.0987)	0.3804* (0.0674)	0.4296* (0.1098)	0.4274* (0.0713)	0.3809* (0.0737)
(KR) Currency Crisis	0.2777* (0.0439)								
(GH) Currency Crisis Index		0.3232* (0.0595)							
(GH) Banking Crisis Index			0.1797* (0.0504)						
(GH) Twin Crisis Index				0.2400* (0.0461)					
Interest Rate Volatility					0.0796* (0.0161)				
Exchange Rate Volatility						0.0232* (0.0053)			
Levy Yeyati-Sturzenegger Exchange Rate Classification							0.0880* (0.0315)		
Current Account								1.0330* (0.3051)	
Country Credit Rating									-0.0097* (0.0023)
adj. R^2	0.613	0.608	0.596	0.627	0.689	0.598	0.556	0.616	0.606
degrees of freedom	709	503	503	631	337	586	159	655	548

Note: Standard errors are given in parentheses and are corrected for heteroskedasticity using the Newey-West consistent covariances.

*denotes significance at the 5% level.

The regression´s constant is not shown. See Appendix A2 for definition of the variables.