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Abstract:

A currency crisis is a speculative attack on the foreign exchange value of a currency, resulting in a sharp depreciation or forcing the authorities to sell foreign exchange reserves and raise domestic interest rates to defend the currency. This article discusses analytical models of the causes of currency and associated crises, presents basic measures of the incidence of crises, evaluates the accuracy of empirical models in predicting crises, and reviews work measuring the consequences of crises on the real economy. Currency crises have large measurable costs on the economy, but our ability to predict the timing and magnitude of crises is limited by our theoretical understanding of the complex interactions between macroeconomic fundamentals, investor expectations and government policy.

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1. Introduction

A currency crisis may be defined as a speculative attack on the foreign exchange value of a currency that either results in a sharp depreciation or forces the authorities to defend the currency by selling foreign exchange reserves or raising domestic interest rates. For an economy with a fixed exchange rate regime, a currency crisis usually refers to a situation in which the economy is under pressure to give up the prevailing exchange rate peg or regime. In a successful attack the currency depreciates, while an unsuccessful attack may leave the exchange rate unchanged, but at the cost of spent foreign exchange reserves or a higher domestic interest rate. A speculative attack often leads to a sharp exchange rate depreciation despite a strong policy response to defend the currency value.

Currency crises have always been a feature of the international monetary system, both during the Bretton Woods system of generalized fixed parities among major industrialized countries in the post-World War II period as well as after its breakdown in the early 1970s. Dramatic episodes of currency crises include the breakdown of the Bretton Woods system in 1971-73, the crisis of the British pound in 1976, the near-breakdown of the European Exchange Rate Mechanism in 1992-93, the Latin American Tequila Crisis following Mexico's peso devaluation in 1994-95, the financial crisis that swept through Asia in 1997-98 and, more recently, the global financial crisis in 2008-09 that forced sharp depreciations in many advanced as well as developing economies (see IMF, 2008 and IMF, 2009a).

2. Causes of Currency Crises

2.1. Currency Crisis Models

Currency crises have been the subject of an extensive economic literature, both theoretical and empirical. Theoretical models of currency crises are often categorized as first-, second-, or third-generation, though many models combine elements of more than one generic form.

The first generation models of, for example, Krugman (1979) focus on inconsistencies between domestic macroeconomic policies, such as an exchange rate commitment and a persistent government budget deficit that eventually must be monetized. The deficit implies that the government must either deplete assets, such as foreign reserves, or borrow to finance the

imbalance. However, it is infeasible for the government to deplete reserves or borrow indefinitely. Therefore, without fiscal reforms, the government must eventually finance the deficit by creating money. Since excess money creation leads to inflation, it is inconsistent with keeping the exchange rate fixed and first-generation models therefore predict that the regime inevitably must collapse.

In second generation models of currency crises, best represented by Obstfeld (1986, 1994), policymakers weigh the cost and benefits of defending the currency and are willing to give up an exchange rate target if the costs of doing so exceed the benefits. In these models doubts about whether the government is willing to maintain its exchange rate target can lead to the existence of multiple equilibria, and a speculative currency attack can take place and succeed even though current policy is not inconsistent with the exchange rate commitment. This is because the policies implemented to defend a particular exchange rate level, such as raising domestic interest rates, may also raise the costs of defense by dampening economic activity and/or raising bank funding costs. The private sector understands the dilemma facing the government, and may question the commitment to fixed exchange rate when other macroeconomic objectives are compromised. In this framework, a speculative attack is more likely to succeed if higher interest rates exacerbating already weak domestic employment or banking sector conditions. Consequently, the timing of the attack—and whether it will occur--cannot be determined, as it is no longer unique.

These different explanations for currency crises are not mutually exclusive. The fundamental imbalances stressed by first-generation models make a country vulnerable to shifts in investor sentiment, but once a crisis does occur, the second-generation models help explain its self-reinforcing features.

Third-generation models are harder to characterize simply but generally focus on how distortions in financial markets and banking systems can lead to currency crises. Different third-generation models offer various mechanisms through which these distortions may lead to a currency crisis. Some models stress how distortions may emerge in the form of credit constraints. Aghion, Bacchetta, and Banerjee (2001), for example, highlight that an initial depreciation of a currency raises the cost of foreign-currency debt obligations of firms and lowers profits, which in turn may limit borrowing capacity when credit is constrained. The subsequent fall in investment

and output associated with these borrowing limitations may lower the demand for domestic currency and trigger a currency crisis.

Other third-generation models highlight how financial liberalization and government guarantees of private sector liabilities can generate moral hazard and unsustainable fiscal deficits that can lead to crises. For example, McKinnon and Pill (1995) suggest that financial liberalization combined with deposit insurance may induce banks to fuel a lending boom involving both foreign and domestic credit expansion that eventually leads to a banking and currency crisis. Chang and Velasco (2002) emphasize the possibility of self-fulfilling international liquidity crises in an open economy with unrestricted capital markets in which banks issue deposits in domestic and foreign assets, but have longer term illiquid investments that cannot be readily converted to cash in event of a bank run. Dooley (2000) and Burnside, Eichenbaum, and Rebelo (2004) argue that implicit or explicit government guarantees to the banking system may give banks an incentive to take on foreign debt, making the banking system vulnerable to attack. The fragile banking sector in turn makes the task of defending the peg by hiking domestic interest rates more difficult and may lead to the eventual collapse of the domestic currency.

2.2. Impossible Trinity

The ability of countries to maintain commitments to particular exchange rate targets became increasingly more difficult with increasing global financial integration and capital mobility over time. According to the principle of the impossible trinity (sometimes referred to as the holy trinity or trilemma) in international economics, when capital is freely mobile, a country cannot simultaneously have (i) a fixed or managed exchange rate, and (ii) an independent domestic monetary policy, i.e., control of domestic interest rates.

When capital mobility is high and a country pegs its exchange rate to another country's currency, its domestic interest rates will be linked to foreign interest rates, which severely limits its ability to pursue an independent domestic monetary policy. For example, a tightening of domestic monetary policy that raises domestic rates above foreign rates also induces capital inflows in response to the cross-border return differential. This dampens the initial rise in domestic interest rates; it also induces lower domestic demand for imported goods, which further dampens the contractionary effects of a higher interest rate.

The constraint imposed by the unholy trinity was put to the test most dramatically by the three major currency crises of the 1990s—the speculative attack on the European Monetary System (EMS) in 1992-93, the Mexican peso crisis of 1994-95, and the Asia crisis of 1997-98.

As Germany raised its interest rates to fight inflation following reunification in the early 1990s, other European countries who had linked their currencies to the Deutschemark through the EMS—found matching the higher German interest rates onerous for their economies. In 1992 the system was overwhelmed by large speculative flows of capital, and consequently some countries dropped out of the EMS and let their currencies depreciate in order to allow their domestic interest rates to diverge from those in Germany.

In the case of Mexico, policymakers faced capital flight following upward U.S. interest rate movements and Mexican political developments in 1994. Efforts by Mexico's central bank to avoid raising domestic interest rates while also limiting depreciation of the peso proved unsustainable and contributed to the peso crisis in December 1994.

The origins of the Asia crisis of 1997-98 were in part related to the fact that many countries had effectively linked their currencies to the dollar at a time when the dollar appreciated relative to the Japanese yen and Chinese renminbi. With the Thai baht, Indonesia rupiah, and other Asian currencies rising relative to the yen and the renminbi, the products of Thailand, Indonesia, and other Asian countries grew more expensive relative to those of Japan and China. The decline in competitiveness put pressure on their currencies to depreciate. Other important factors also were at work in the Asian crisis, including elements of bank depositor panic and fragile banking systems, attributable to the lack of incentives for effective risk management created by implicit or explicit government guarantees against failure**.**

These examples illustrate how emerging markets as well as industrial countries often have not been able to make credible commitments to fixed exchange rates for an extended period. Although it is technically feasible for a country to maintain a pegged exchange rate as long as its central bank has access to enough foreign exchange reserves to respond to speculative attacks, its central bank also must be willing always to subordinate all the other goals of monetary policy. In practice, this means that it must be willing to raise domestic interest rates high enough to maintain the attractiveness of its currency to speculators.

But, as the examples above show, many countries with pegged exchange rate regimes at some time or another have found forgoing an independent monetary policy to be a price too high

to pay, particularly when high domestic rates adversely affect domestic unemployment or financial sector stability. In other words, countries with pegged or fixed exchange rate regimes are often not prepared to abandon completely the use of monetary policy for stabilization purposes. With their priorities in doubt, they are more likely to become lightning rods for speculative attack and currency crises.

In principle, countries with floating exchange rates should be more resistant to currency crises, since one would expect continuous market adjustment to limit the buildup of pressures leading to extreme currency overvaluation and subsequent large discrete currency declines as may occur under fixed exchange rate regimes. In fact, pegged and intermediate exchange rate regimes –those that maintain relatively rigid exchange rates but do not formally peg to a single anchor currency -- are associated with greater susceptibility to currency crises -- as well as other financial crises, such as debt crises, sudden stops in capital inflows, and banking crises. This has been particularly true for developing and emerging market countries with more open capital accounts (Ghosh, Ostry, and Tsangarides, 2010). Nonetheless, many countries purportedly with floating exchange rates have experienced currency crises. This may be attributable to the fact that countries reporting their currencies as on a floating rate regime are often quite reluctant in fact to allow their currencies to float due to so-called fear of floating behavior (Calvo and Reinhart, 2002)—and de facto follow a pegged exchange rate regime.

3. Association with other Crises

Currency crises are often associated with other types of financial crises, such as banking crises. The occurrence of so-called twin crises may be attributable to a number of channels of causation: a bank crisis leading to a currency crisis, a currency crisis leading to a bank crisis, or joint causality.

A bank run can cause a currency attack if the increased liquidity associated with a government bailout of the troubled banks erodes their ability to maintain the prevailing exchange rate commitment (Velasco, 1987; Calvo, 1997). Or, as discussed above, a weak banking sector may precipitate a currency crisis if speculators anticipate that policymakers would prefer to give up exchange rate stability in order to avoid bankruptcies and further strains on the banking sector rather than endure the costs of defending the domestic currency (Obstfeld, 1994).

A possible reverse chain of causality, from currency crises to the onset of banking crises, is also well recognized. If banks hold significant holdings of unhedged foreign liabilities, a currency crisis shock can adversely alter the banking sector directly by causing a deterioration of bank balance sheets as currency depreciation raises the domestic currency burden of these liabilities.

The joint occurrence of currency and banking may also reflect a response to common factors. Banks and firms are exposed to liquidity shocks if they finance long-term lending and investment with short-term borrowing (Chang and Velasco, 2001). Consequently, an international liquidity crunch may trigger twin crises. The global financial crisis of 2007-08 had similar effects on currency values and banking sector health in many countries. Although started by losses associated with sub-prime mortgage derivative products (e.g. asset-back securities and credit default swaps) in the U.S. and Western Europe, it quickly led to a world-wide deleveraging process where institutions moved to limit their foreign currency exposure. A flight to the U.S. dollar—the global reserve and payments currency—ensued, forcing very large currency devaluations in many advanced and developing countries (see IMF, 2008 and IMF, 2009a).

Currency crises may be associated with other types of financial crises, such as sudden stops of foreign capital inflows, sharp rises in capital outflows, and sovereign debt defaults. Calvo, Izquierdo, and Talvi (2002), for example, provide a sudden-stop interpretation for the 2001-02 financial crisis in Argentina in which international investors lost faith in the country's ability to finance its growing fiscal indebtedness while also maintainig a currency peg to the dollar at a time that the economy was in the midst of a three year- recession. The resulting capital flow reversal prompted a bank run, which in turn forced the end of its currency peg and a sharp currency depreciation. The depreciation significantly worsened the government's already weak fiscal position and led Argentina to default on its public debt.

4. Incidence of Currency Crises

4.1. Crisis Definitions and Measurement Issues

Different definitions of currency crisis have been used in the empirical literature. Some papers use a narrow definition of crisis, i.e. a successful attack that results in a significant depreciation of the exchange rate. For example, Frankel and Rose (1996) define a currency crisis

as a nominal depreciation of 25 percent or greater, which is at least 10 percent greater than the depreciation in the preceding year. To avoid capturing the large exchange rate fluctuations associated with high inflation periods, Milesi-Ferretti and Razin (1998) use a definition that requires, in addition to a 25 percent depreciation, at least a doubling in the rate of depreciation with respect to the previous year *and* a rate of depreciation the previous year below 40 percent. To restrict the sample to episodes in which the exchange rate was relatively stable the previous year, another definition they employ requires a 15 percent minimum rate of depreciation, a minimum 10 percent increase in the rate of depreciation with respect to the previous year, and a rate of depreciation of below 10 percentage points in the previous year.

Other papers use a broader definition that includes episodes of unsuccessful attacks as captured by large changes in an index of exchange market pressure, defined as a weighted average of exchange rate changes and reserve losses.[1] Following convention (see, for example, Eichengreen, Rose, and Wyplosz, 1995; Kaminsky and Reinhart, 1999), the weights attached to the exchange rate and reservation components of the currency pressure index are inversely related to the variance of changes of each component over the sample for each country. The intuition is that if there is an attack on the currency, either the exchange rate would depreciate or the central bank would sell foreign currency to support the exchange rate.

Changes in the index above some threshold are deemed to represent crises, defined as a zero-one binary variable, i.e. 1 for crisis and 0 for no crisis. The threshold is usually defined in terms of country-specific moments. For example, Eichengreen, Rose, and Wyplosz (1995) use a one and a half standard deviation threshold, Glick and Hutchison (2000, 2005, 2006) use a 2 standard deviation threshold, while Kaminsky and Reinhart (1999) and Kaminsky, Lizondo, and Reinhart (1998) use a three standard deviation cutoff.[2]

To minimize the chances of capturing the continuation of the same currency crisis episode, it is common to impose windows on the data. That is, after identifying each large change in currency pressure, any large changes in the following fixed-period (e.g. two years) are

[1] Most currency pressure measures of crises for emerging economies do not include episodes of defense involving sharp rises in interest rates because of limited data for market-determined interest rates in many countries.
[2] Some studies use a hybrid condition. For example, Glick and Hutchison (2000, 2005, 2006) define large changes in exchange rate pressure as changes in their pressure index that exceed the mean plus two times the country-specific standard deviation, provided that it also exceeds five percent. The first condition ensures that any large depreciation is counted as a currency crisis, whereas the second condition attempts to screen out changes that are insufficiently large in an economic sense relative to the country-specific monthly change of the exchange rate.

treated as part of the same currency episode and skipped before continuing the identification of new crises.

4.2. Frequency of Currency Crises

Figure 1 shows the incidence of currency crises in the post-Bretton Woods period, 1975-2007 using data from Laeven and Valencia (2008). They define a currency crisis as a nominal depreciation of the currency of at least 30 percent that is also at least a 10 percent increase in the rate of depreciation compared to the year before. For countries that meet the criteria for several continuous years, they use the first year of each 5-year window to identify the crisis. This methodology identifies 201 currency crises over the period.

The figure indicates that currency crises are a common phenomenon, averaging more than five per year since 1975, with relative peaks in the early 1980s at the time of widespread sovereign debt defaults, the early 1990s at the time of the EMS and Tequila crises, and in 1998 at the time of the Asian financial crisis and the Russian debt default..[3] The 3-year period, 2005-07 appears to be a period of relative tranquility. However, the global financial crisis in 2008-09 caused widespread financial market turmoil. As shown in Table 1, twenty-three countries experienced exchange rate depreciations of 25 percent or more during the 9-month period between August 2008 and February 2009, many of which would satisfy the formal definition of currency crisis used above.

The association between currency crises and banking crises is illustrated in Figure 2, which shows the incidence of twin crises by year. Observe that twin crises are much less frequent than currency crises alone. While 1994 experienced 25 currency crises world-wide, only 9 of these episodes coincided with a banking crisis. The 1990s was the peak period of twin crises, abstracting from the 2008-09 global financial crisis for which complete data on banking crises are not yet available.

Table 2 compares the association of currency crises and the cessation of net capital inflows, using results from a study by Hutchison and Noy (2006) of sudden stops in 24 emerging market economies over the period 1975-2002. It shows that currency crises coincide with sudden stops roughly half of the time. Of the 60 currency crises identified in emerging markets

[3] The figure for 1994 is inflated by the devaluation of the 14 African members of the CFA zone against the French franc and the dollar.

during this period, 34 coincided with a sudden stop and 26 did not. On the other hand, there are many more instances of sudden stops that do not coincide with currency crises. Of the 119 sudden stops, 85 did not coincide with a currency crisis..

5. Predicting Currency Crises

The high costs of currency crises in terms of real output losses have prompted efforts to predict them. International financial institutions and central banks have sought to develop so-called early warning systems (EWS) of currency crises for the purpose of improving monitoring of financial conditions. Many private investment banks also have developed such models to enhance foreign exchange trading strategies. Berg et al. (2000), Goldstein et al. (2000), (IMF , 2002a). Edison (2003), and Berg, Borensztein, and Pattillo (2005) provide good surveys of the early warning literature on currency crises.

The design of currency crisis warning systems requires several elements: (i) a crisis definition, discussed in the previous section, (ii) a set of possible explanatory variables, and (iii) a statistical methodology to generate warnings of crises.

5.1. Determinants

The theoretical and empirical literature has identified a vast array of variables potentially associated with currency crises (see, e.g. Frankel and Rose, 1996; Kaminsky et al., 1998; Kaminsky and Reinhart, 1999). These variables include macroeconomic and financial fundamentals such as, money or domestic credit growth, the fiscal deficit, current account deficit, real exchange rate overvaluation, and output growth; as well as variables that gauge a country's vulnerability to attacks, such as measures of the adequacy of international reserves relative to possible short-run liabilities of foreign and domestic origin, foreign financing needs, and the overall soundness of the financial sector. Other possible variables include indicators of market expectations or investors' risk appetite, such as interest rate differentials, and exposure to contagion from crises in other countries. Trade and financial openness may also affect the likelihood of currency crisis.

The intuition for the association of these variables with currency crises is straightforward. The simple monetary model of exchange rate determination, for example, predicts that money growth in excess of the anchor currency's money growth will cause higher inflation that creates

pressure for depreciation of the home currency. If the home country successively resists depreciation for a time, the ultimate fall in the exchange rate may occur as a large discrete movement in the form of a currency crisis. A rise in credit growth similarly may imply possible inflationary pressures as well as a rise in the short-term domestic currency liabilities of the banking system. Greater short-term foreign debt implies a greater burden on the economy in the event of a sudden stop of foreign lending.

Higher foreign reserve holdings imply greater ability to respond to speculative depreciation attacks. The ratio of M2 to reserves captures to what extent the liabilities of the banking system are backed by international reserves. In the event of a currency crisis, bank depositors may rush to convert their domestic currency assets into foreign currency, so that this ratio captures the ability of the central bank to meet those demands and stabilize the currency. The ratio of external debt to foreign reserves measures exposure to the risk that investors chose not to roll over debt to either sovereign or private domestic borrowers.

Relatively large exchange rate overvaluation is expected to be associated with an increased likelihood of a currency crisis because of the negative effects on competitiveness. Adverse performance of the terms of trade because of relatively higher import prices erodes purchasing power and dampens domestic economic activity. Declining real GDP growth may signal worsening economic conditions and undermine investor confidence in home country investment opportunities.

5.2. Statistical Methodology

After a set of useful indicators has been identified, the information contained in the indicators needs to be combined in an objective manner. Three common approaches are event studies (e.g., Kaminsky and Reinhart, 1999), the signaling method (e.g., Kaminsky, Lizondo, and Reinhart, 1998), and the limited dependent variable probit/logit model (e.g., Frankel and Rose, 1996).

Event Study Approach

The event studies approach examines the behavior of individual indicators in the period leading up to crises. For each variable, behavior during pre-crisis periods is compared with behavior during tranquil or non-crisis periods. Figure 3 illustrates the behavior of selected

variables around the time of currency crises, using results from Kaminsky and Reinhart (1999) based on data for 20 emerging market countries over the period 1970 to1995.

The top left hand panel of Figure 3 shows that, on average, the 12-month growth in the domestic credit/GDP ratio is higher than in tranquil times. Growth in domestic credit/GDP remains above normal as the currency crisis nears, consistent with a credit boom. The top right hand panel shows the evolution of the 12-month change in M2/reserves of central banks; this ratio also grows well above its norm prior to crises. The increases are associated with a sharp decline in foreign currency reserves, as authorities seek to stabilize the exchange rate. During the year before currency crises, the real exchange rate shows evidence of being overvalued, appreciating relative to its trend in comparison to tranquil periods. The real exchange-rate appreciation reverses itself rapidly with the devaluation. Crises in the sample are preceded, on average, by a deterioration of the terms of trade. The deterioration of the terms of trade and the overvaluation of the currency are reflected in a marked slowing in economic activity and a decline in output prior to crises.

Signaling Approach

Similarly to the event study approach, the indicator approach also involves monitoring key variables for signs of unusual behavior that signal a future crisis. However, the latter approach involves specifying a particular numeric threshold, beyond which the variable sends a signal of a future crisis. For example, if the country-specific threshold for the ratio of the current account deficit to GDP is 3 percent, a ratio above 3 percent would imply a greater probability of a crisis. When a warning signal is issued, there are two possibilities: (i) a crisis occurs, implying the signal given was accurate, or (ii) a crisis does not occur, implying the signal given was a false alarm. When a warning signal is *not* issued, there are also two possibilities: (i) a crisis occurs, implying the absence of a warning signal was false, or (ii) a crisis does not occur and the signal was correct.

The determination of the optimal threshold level involves striking a balance between failing to predict a crisis that actually occurs (a Type I error) and predicting a crisis that does not actually occur (a Type II error). On the one hand, if the threshold is set too lax, then the indicator will catch all crises, but will give lots of false signals (noise). On the other hand, if the threshold

is too tight, the indicator will never issue a false signal, but it will miss all the crises. Hence, for each variable, the optimal threshold is selected so as to maximize the good signal –to-noise ratio.

The choice of which indicators to focus relatively more attention depends on the loss function of the policymaker and/or analyst. One criterion is to rank the usefulness of indicators in the declining order of their signal-to-noise ratios. Thus, for example, an indicator that displays four times as many good signals as false signals (noise) would be regarded as better than an indicator with a ratio of only two good signals for every false one. Alternatively, if one is concerned less about false alarms and more about failing to predict a crisis, one may focus on indicators that correctly predict a high fraction of actual crises. Thus an indicator that predicts correctly 50 percent of actual crises would be regarded as more useful than one that predicts correctly only 25 percent of crises.[4]

Figure 4 reports a representative application of the signaling approach from Edison (2003). Edison considers 19 different indicator variables, analyzed at a monthly frequency, ranking the indicators based on the signal-to-noise criterion. These results are computed for her sample of 28 countries, over the horizon January 1970 to April 1995. (The sample period is truncated in April 1995 to provide a large enough number of observations to evaluate the predictive capabilities of the model for the 1997-99 crises.) Observe in her analysis that the real exchange rate, measured as the deviation from its trend, is ranked as the top performer; its signal-to-noise ratio is about 4:1. The next best performer is the 12-month percent change in the ratio of short-term debt to reserves, with a 2.5:1 ratio, followed by the M2/reserves ratio.

The signaling approach in its most basic applications does have some shortcomings. First, by evaluating each variable separately, it does not consider how an interrelated set of conditions could make an economy more vulnerable to crisis. In response, some studies aggregate the information from different variables into a single prediction by calculating a composite probability as the weighted sum of the number of indicators that are signaling, where each indicator is weighted by its reliability in predicting crises. A second shortcoming of the signaling

[4] Because of differences in the way these two criteria treat false versus missed signals, they may not give the same ranking, i.e. indicators may be ranked as top performers based on one criterion, but be ranked poorly based on the other. The difference arises because, although both criteria positively value correctly predicted crises, the signal-to-noise ratio criterion penalizes an indicator for giving false alarms. That is, the more false signals an indicator issues, the lower is its signal-to-noise ratio. In contrast, the share-of-crises-predicted correctly criterion penalizes missed signals, i.e., the failure to give an alarm when a crisis subsequently occurs, but does not penalize for false signals, i.e., alarms that are issued prior to a crisis that actually occurs.

approach is that it ignores possible correlations between different indicators. Third, it issues only binary signals, i.e., either an indicator is above its threshold, indicating a signal, or it is below its threshold, indicating no signal about a possible crisis. Consequently, there is no measure of the strength of the signal possibly related to the extent it exceeds its threshold.

Probit and Other Approaches

The probit/logit approach addresses some of the shortcomings of the signaling approach. It estimates a probability relationship where the dependent variable is a discrete measure of crisis (e.g., 1 or 0, if a crisis occurs or does not occur, respectively) by regressing on a set of explanatory variables. A probit regression generates predictions taking into account the correlation among all the predictive variables, and allows testing of the statistical significance of individual variables. It can also show the probability of a future crisis. However, because the probit is a nonlinear model, the contribution of a particular variable depends on the magnitude of all the other variables. This means that the relationship between changes in the variables themselves and changes in their contribution to the crisis prediction is not always transparent.

More recent studies have developed new strategies in an attempt to improve predictive performance (see the references in Berg et al, 2005). These include piecewise-linear generalization in a probit model and refining the crisis variable from a binary to a trinary variable -- crisis periods, post-crisis recovery periods, tranquil periods. Other studies explore more sophisticated econometric techniques, such as autoregressive conditional hazard models and regime switching with time-varying probabilities. Some studies depart from a regression-based setting altogether and use classification rules to identify safety zones for fundamentals under which currency crashes are unlikely to occur, or a binary recursive tree technique to explore possible interactions among time-varying economic determinants and structural variables, such as financial, corporate, and public sector governance, that may not change much over time.

5.3. Assessment of Crisis Prediction Approaches

The variables identified as useful have varied somewhat from study to study, owing to differences in crisis definitions, data sets, and methodologies. Berg and Patillo (1999) and Berg, Andrew, Eduardo Borensztein, and Catherine Patillo (2005) provide comparative evaluations of the accuracy of different methods.

Several studies (IMF, 2002a; Berg, Borensztein, and Pattillo, 2005) conclude that market views, or analysts' views, as expressed in bond spreads, credit ratings, and exchange rate expectation measures have been unreliable predictors of currency crises, particularly in the 1990s. However, some indicators, such as real exchange rate overvaluation, reserve adequacy (relative to short-term debt or broad money), domestic credit growth, current account, export growth, and reserves growth have tended to perform well in some studies.

Berg, Borensztein, and Pattillo (2005) evaluate the performance of signal and probit models, with particular emphasis on the importance of out-of-sample forecasting in model evaluation, as well as the trade-off between missing crises and generating false alarms. They find that over the Asia crisis period, the best early warning system (EWS) models did dramatically better than non-model-based predictors, such as spreads, ratings, and assessments of informed analysts. Over a more recent period that included the Argentine and Turkish crises in 2001, the performance of some of these alternative predictors improved somewhat, so that the relative superiority of the models declined. This suggests that recent crises were not the surprises that the Asia crises were, either because they were easier to predict or because analysts' sensitivity was improved.

Overall, the consensus is that EWS models have some value in providing early warning about which individual countries are most vulnerable to crisis. However, they generate a lot of false alarms, i.e. even if an EWS gives a signal, a crisis may not occur. In addition, they are less successful at predicting the timing of crises.

5.4. Globalization, Capital Controls, and Currency Crises

Trade openness is another determinant that is generally accepted to play a role in the determination of currency crises. Several studies find that greater trade integration reduces a country's financial fragility and the likelihood of a currency crisis by increasing both the ability and willingness to service external obligations (IMF, 2002b). A greater export ratio decreases the likelihood of sharp reversals of capital flows, as the country is more able to service its foreign currency– denominated debt. In addition, trade openness serves as an incentive to meet external obligations by making a country more vulnerable to creditors' sanctions in case of default. Hence, higher trade integration tends to reduce the frequency of external financial crises. This is

supported by Figure 5, which shows that currency crises over the period 1975-1999 were more frequent in countries that are less integrated into the global trading system.

Findings about the role of capital openness on currency crises are more mixed. This is an important issue in light of the dramatic rise in global financial integration, particularly among the advanced and emerging market economies, over the past three decades. As shown in Figure 6, financial integration, measured as the sum of a country's external assets and liabilities relative to GDP, has risen more than sixfold since 1970 (Lane and Milesi-Ferretti, 2007). Increased financial integration in turn has sparked a broad and vigorous discussion among academics and policymakers on the risk to currency stability. Recent work on the 2008-09 financial crisis suggests that emerging markets with greater total external liabilities relative to the size of the economy experienced greater exchange rate depreciations and losses of reserves.

This raises the issue of the desirability and feasibility of limiting the volume and composition of capital inflows and outflows and, in particular, the effectiveness of imposing legal restrictions on cross-border financial transactions, one of the few tools at the disposal of policymakers to influence capital flows, i.e. capital controls. The sharp rise in financial integration has gone hand in hand with a dramatic *decrease* in countries' de jure restrictions on capital flows, although almost no economy has completely eliminated capital controls, and in many cases they remain substantial, with officials frequently increasing the intensity of controls during episodes of financial disruption. However, despite the frequent use of capital controls as a policy tool, there is no general consensus on critical questions regarding their efficacy. Existing research on the effects of capital controls on capital flows is relatively sparse and the results often ambiguous; while a number of individual country studies exist, there is relatively little cross-country research on this topic. Glick and Hutchison (2005) and Glick et al. (2006) focus on the effect of capital controls on exchange rate stability and currency crises. They find no evidence that capital controls have been effective in insulating countries from currency crises, even when taking into account the likelihood that countries with relative weak economic fundamentals and financial systems are more likely to impose capital controls (and hence present an issue of dual causality and feedback between capital controls and currency crises).

6. Effects of Currency Crises

There are several ways in which a currency crisis may affect economic activity. On the one hand, a depreciation of the domestic currency that occurs in a successful currency attack, may expand the tradable goods sector and spur growth by correcting an overvalued currency or by making the exchange rate more competitive. On the other hand, a depreciation may be contractionary by increasing the repayment costs of external debts denominated in foreign currencies, particularly in dollars. In addition, sudden stops or the reversal of capital inflows during a crisis can slow down growth by lowering investment activity, while a rise in the external debt burden from devaluation in the presence of liability dollarization can lower investment activity and growth.

Until the currency crashes of the 1990s, the mainstream view had been that any negative effects from a currency depreciation were ultimately offset by the positive effect of stimulus to net exports, leading to an the overall expansionary effect of a depreciation on output. However, recent literature emphasizes the contractionary effects of depreciations, particularly in developing countries. Gupta, Mishra, and Sahay (2003), for example, analyze the behavior of output for a sample of 195 currency crisis episodes in developing countries during 1970-98. They find that more than three-fifths of the crises in the sample were contractionary, and that output contraction was more likely greater in large and more developing economies than in small and less developing economies, and crises in countries preceded by large capital inflows were more likely to be associated with contraction during crises. Hutchison and Noy (2005, 2006) investigate the output effects of currency and banking crises in emerging markets during 1975-97 and find that currency crises are very costly, reducing output by about 5 to–8 percent over a 2 to4 year period. They also show that currency crises accompanied by sudden stops have especially severe economic consequences, as the abrupt reversal in foreign credit inflows in conjunction with a realignment of the exchange rate typically cause a sharp drop in domestic investment, domestic production, and employment.

An analysis of currency (and banking) crises by the IMF (2009b) calculates the output losses over time associated with currency crises in emerging markets from the early 1970s to 2002. Figure 7, reports the average decline in output relative to trend following currency crises (the analysis also reports the effects of banking crises) and indicates that the medium-term output losses following crises are substantial. On average, output falls steadily below its pre-crisis trend

until the second or third year after the crisis and does not fully recover to its pre-crisis trend. Thus currency crises can have adverse long-term effects. However, countries that are more open to trade are likely to experience less dramatic drops in real growth and much quicker rebounds in the aftermath of a currency crisis (Milesi-Ferretti and Razin, 1998; Gupta, Deepak, and Sahay, 2000; IMF, 2002b). For example, rapid export growth helped bring Asian economies out of recession following the 1997–98 crisis.

Tables and Figures

Table 1. Currency Depreciation against U.S. Dollar, August 2008 – February 2009
Currencies with 25% depreciation or greater

Country	% Depreciation
Zambia	60.0
Hungary	58.1
Russia	52.3
Brazil	51.6
Korea	51.6
Romania	50.0
Sweden	49.5
Mexico	48.4
Australia	46.2
Turkey	45.7
Czech Republic	45.0
New Zealand	44.8
Iceland	42.4
United Kingdom	40.0
Swaziland	37.1
South Africa	37.1
Norway	36.8
Indonesia	31.4
Mauritius	28.8
Paraguay	27.7
Uzbekistan	25.9
Ghana	25.2
Kazakhstan	25.0

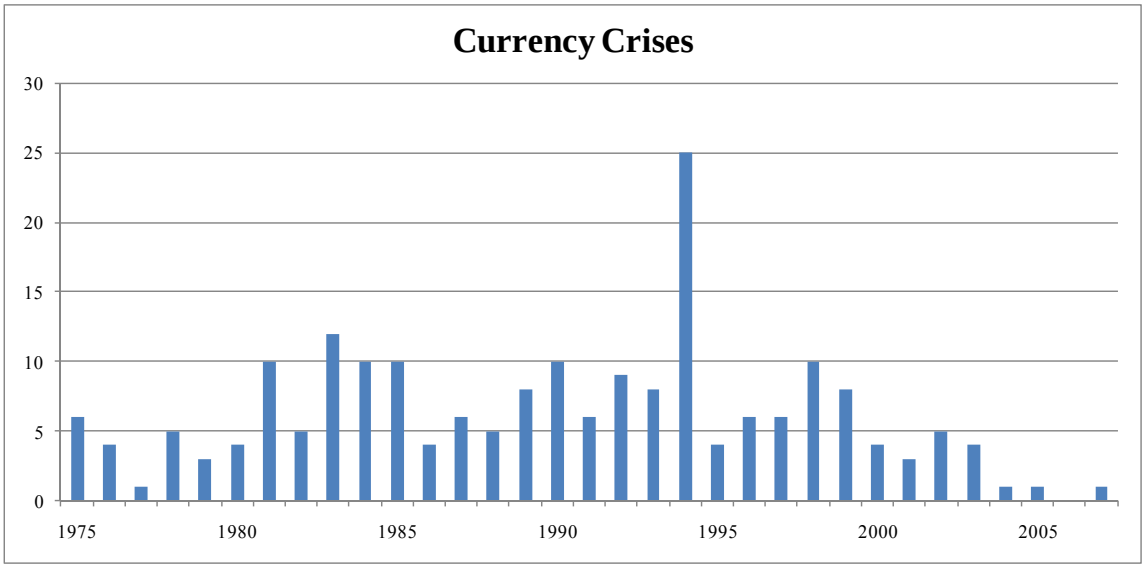
Source: Authors' calculations.

Table 2. Currency Crises and Sudden Stops

	Currency Crisis	No Crisis
A. Normal Crises and Sudden Stops		
Sudden Stop	34 (6%)	85 (16%)
No Sudden Stop	26 (5%)	389 (73%)
B. Major Crises and Major Sudden Stops		
	Currency Crisis	No Crisis
Major Sudden Stop	26 (5%)	49 (9%)
No Major Sudden Stop	23 (4%)	436 (82%)

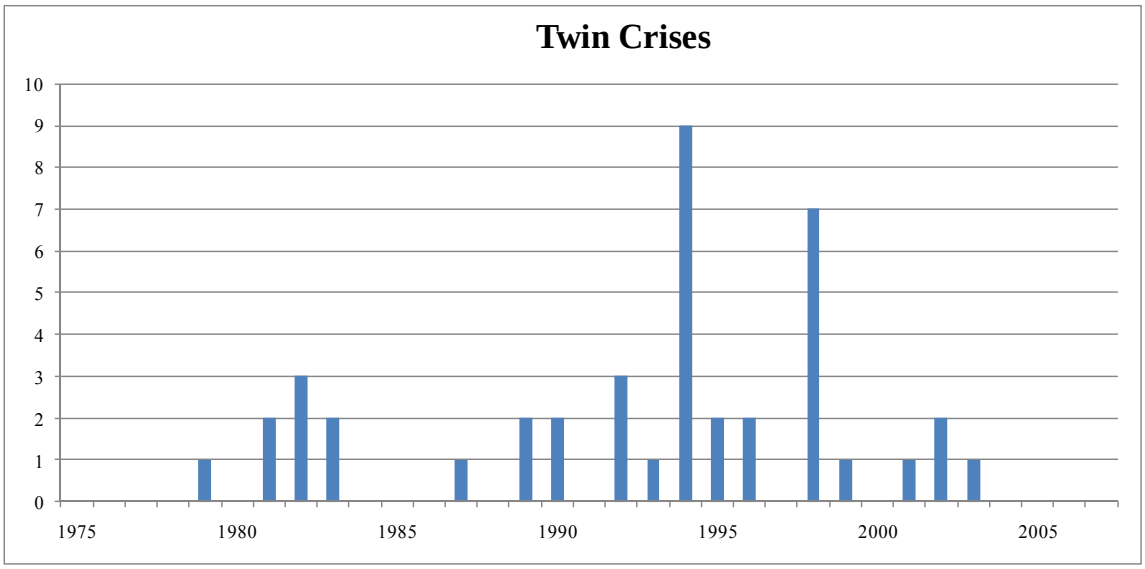
Note: The table reports the number of currency crises or instances of no crises in 24 emerging markets over the period 1975-2002. The figures in parentheses express these numbers as a percent of available country-year observations. A normal (major) currency crisis is defined as the deviation in a currency pressure index of more than 2 (3) standard deviations from the country-specific mean. A (major) sudden stop is defined as a positive change in the current account to GDP ratio of more than 3 (5) percentage points.
Source: Hutchison and Noy (2006).

Figure 1. Currency Crises



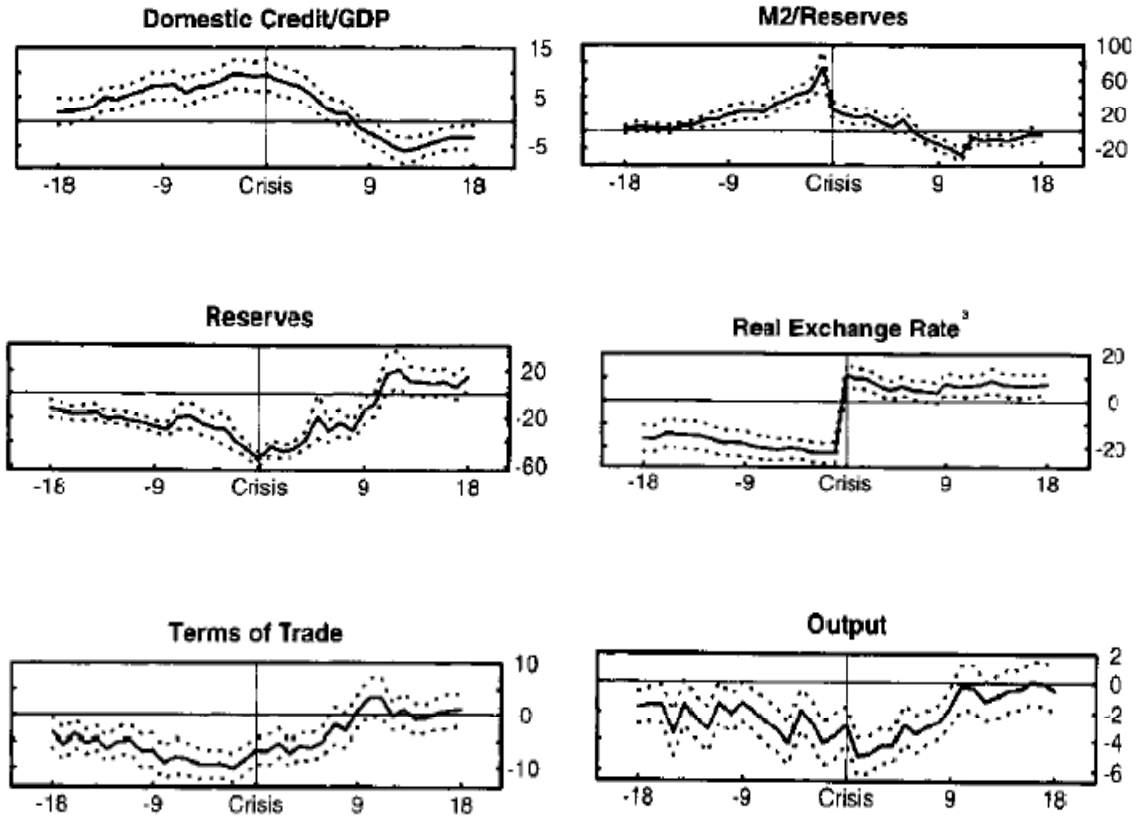
Note: Currency crisis is defined as a nominal depreciation of the currency of at least 30 percent that is also at least a 10 percent increase in the rate of depreciation compared to the year before. Five-year exclusion windows employed. The figure for 1994 is inflated by the devaluation of the 14 African members of the CFA zone against the French franc and the dollar.
Source: Laeven and Valencia (2008).

Figure 2. Twin Crises



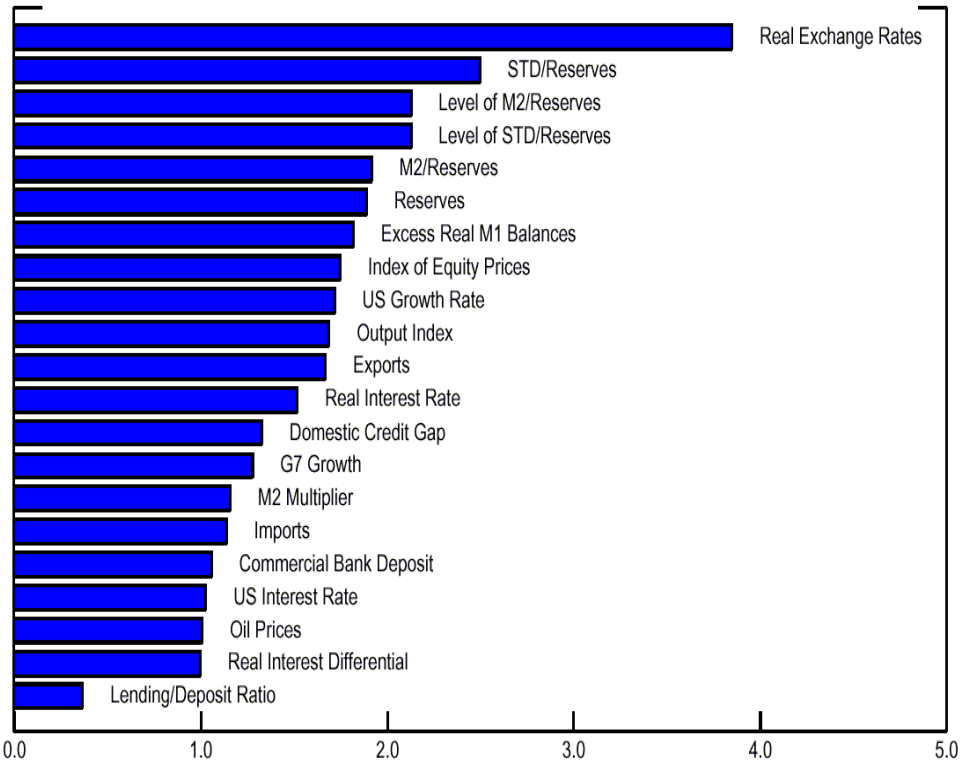
Note: A twin crisis is defined as currency crisis that is accompanied by a banking crisis in the preceding, same, or following year.
Source: Laeven and Valencia (2008).

Figure 3. Empirical Regularities of Selected Variables before Currency Crises



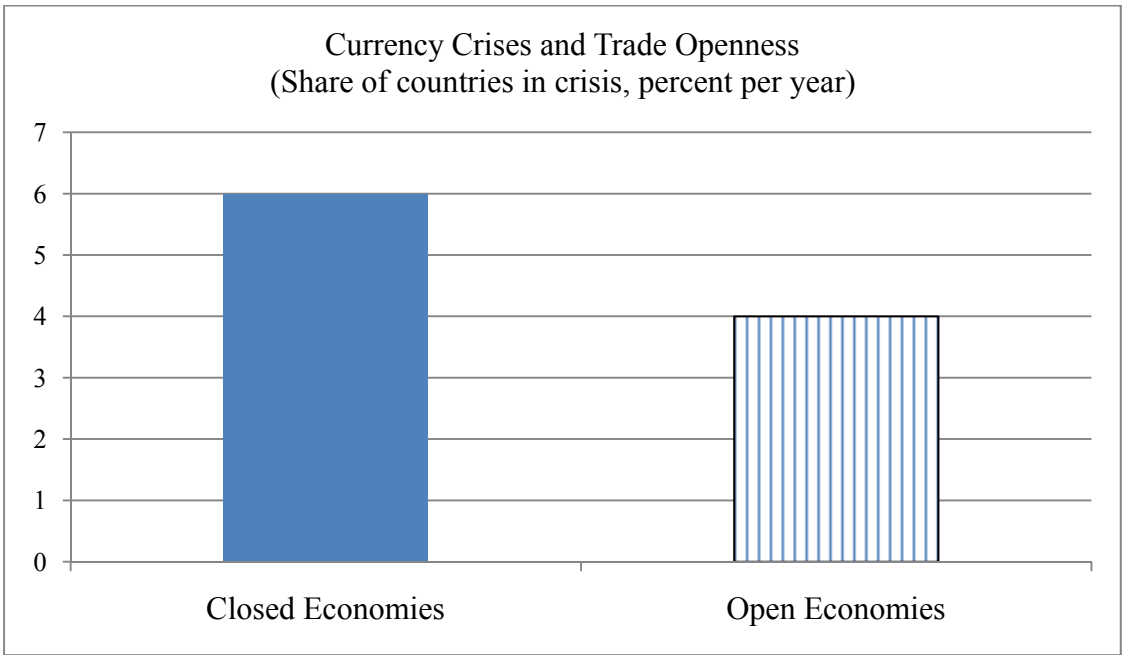
Note: The horizontal axes represent the number of months before (with a negative sign) and after a crisis. Vertical axis reports level of variables reported as 12-month changes, in percent, relative to "tranquil" times, except for the real exchange rate which is defined as deviations from trend, in percent, relative to "tranquil" times. An increase in the real exchange-rate index denotes a depreciation. The sample consists of 20 small open economies countries experiencing currency crises during the period 1970–mid-1995. Currency crises are defined as changes in a weighted average of the change in the nominal exchange rate and of reserves that exceed three standard deviations from the mean (separate sample characteristics are used for countries experiencing hyperinflations).
Source: Kaminsky and Reinhart (1999).

Figure 4. Relative Indicator Performance, ranked by Signal-to-Noise Ratio



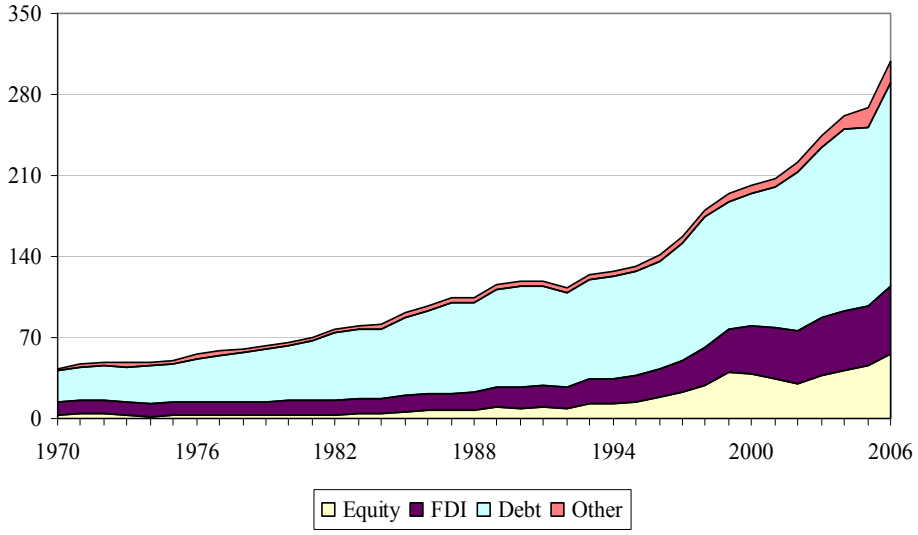
Notes: Table reports the signal-to noise-ratio of indicators during 24 months prior to crisis. These results are computed for a sample of 28 countries, over the horizon January 1970 to April 1995.
Source: Edison (2003).

Figure 5: Currency Crises and Trade Openness in Developing Economies, 1975-1999



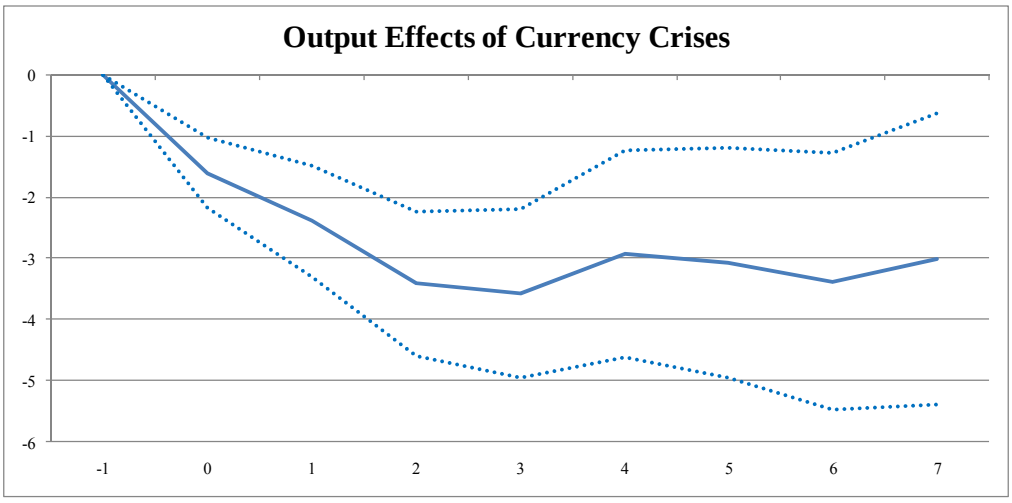
Note: A currency crisis is defined as an exchange rate depreciation vis-à-vis the U.S. dollar of at least 25 percent and at least double the rate of depreciation in the previous year, as long as the latter is less than 40 percent—to exclude hyperinflationary episodes (see Milesi-Ferretti and Razin, 1998). Open economies are those with trade openness –exports plus imports over GDP-- greater than the median.
Source: Constructed from data in IMF (2002b)

Figure 6: International Financial Integration (in percent of GDP)



Note: The figure depicts the sum of countries' total equity, foreign direct investment FDI), external debt and other assets and liabilities relative to total GDP.
Source: Lane and Milesi-Ferretti (2007), updated through 2006.

Figure 7. Output Effects of Currency Crises



Notes: Figure plots output level decline as percent of pre-crisis trend, for year t= -1, first year of crisis at t = 0, and subsequent years on x-axis. 90% confidence bands indicated by dashed lines. The sample includes countries experiencing crises in period from early 1970s to 2002. Currency crises are identified based on the methodology of Milesi-Ferretti and Razin (1998): a 15 percent minimum rate of nominal depreciation against the U.S. dollar, a minimum 10 percent increase in the rate of depreciation with respect to the previous year, and a rate of depreciation of below 10 percentage points in the previous year.
Source: IMF (2009, Figure 4.4).

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