ELSEVIER

Journal of International Economics 41 (1996) 351–366

Journal of INTERNATIONAL ECONOMICS

Currency crashes in emerging markets: An empirical treatment

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Received 4 December 1995

Abstract

We use a panel of annual data for over 100 developing countries from 1971 through 1992 to characterize currency crashes. We define a currency crash as a large change of the nominal exchange rate that is also a substantial increase in the rate of change of nominal depreciation. We examine the composition of the debt as well as its level, and a variety of other macroeconomic factors, external and foreign. Crashes tend to occur when: output growth is low; the growth of domestic credit is high; and the level of foreign interest rates are high. A low ratio of FDI to debt is consistently associated with a high likelihood of a crash.

Key words: Exchange rate; Developing; Panel; Data; Debt; Composition; Macroeconomic

JEL classification: F21; F41

1. Introduction

Are currency crashes in developing countries all the result of similar policy mistakes? Or are they instead the result of myriad unfortunate shocks? Can they be predicted ex ante with standard economic indicators? Do different countries ex post react to crashes in similar fashion, or do the policy responses vary by country and over time? In short: Are currency crashes all alike?

The objective of this study is to look at a large sample of developing country experiences, and to arrive at a broad-brush statistical characterization of currency

0022-1996/96/$15.00
PII S0022-1996(96)01441-9

crashes. It is not an attempt to formulate or test specific theories of what causes these crashes. Some may have been caused by idiosyncratic shocks that are better viewed as bad luck than anything else. Others may have resulted from poor fundamentals or poor policy. We examine a variety of potential causes of crashes, especially those that add to a country's vulnerability to a crash. We also look at some effects of currency crashes.

We classify the variables in which we are interested into four categories: (1) foreign variables like northern interest rates and output; (2) domestic macroeconomic indicators, such as output, monetary and fiscal shocks; (3) external variables such as over-valuation, the current account and the level of indebtedness; (4) the composition of the debt. We focus particularly on the last set of variables, as they have attracted increased interest in the aftermath of the 1994 Mexican crash. Our work is non-structural, and takes the form of univariate graphical analysis and multivariate statistical analysis.

In section II, we discuss our definition of a currency crash. We look at the variables to be analyzed in section III. Section IV is the heart of the paper. It analyzes the movements of our variables around the time of currency crashes using both univariate graphical techniques and a multivariate statistical approach.

2. The Definition of a Currency Crash

We define a 'currency crash' as a nominal depreciation of the currency of at least 25% that is also at least a 10% increase in the rate of depreciation. (Santaella (1995) provides a complimentary approach that analyzes the conditions surrounding IMF financial arrangements in developing countries, while Kaminsky and Reinhart (1995) provide related work on the relationships between banking and balance of payments crises.) Four conceptual issues immediately arise. First, should currency crashes be limited to episodes that end in a large fall in the value of the currency? Second, how big a change in the exchange rate is needed to qualify? Third, how should the exchange rate be measured? Fourth, how does one deal with high-inflation countries that routinely undergo large changes in the exchange rate?

Eichengreen et al. (1995) define a currency crisis to include both the large depreciations that we consider here, and also speculative attacks that are successfully warded off by the authorities. They make the idea of an unsuccessful speculative attack operational by searching for sudden falls in reserves and/or increases in interest rates. Since we focus on developing countries in this paper, it is much more difficult to identify successful defenses against speculative attacks. Reserve movements are notoriously noisy measures of exchange market intervention for almost all countries. In addition, few of our countries have market-determined short-term interest rates with long histories. The standard defenses against speculative attacks – interest rate hikes and reserve expenditures – may

also be less relevant in these countries than sudden tightening of reserve requirements, emergency rescue packages from the IMF or other foreign institutions, and especially the imposition of formal or informal controls on capital outflows. It is extremely difficult to measure such policy actions, and we leave this task to future researchers. While extending the analysis to take account of pre-emptive devaluations and successful defenses is important, it may also be of intrinsic interest to look at successful attacks.

We define a currency crash as a decrease in the value of the local currency of at least 25%. This cut-off point is clearly arbitrary. Sensitivity analysis (not reported here) has assured us that the exact figure is not important.

The third question is how the exchange rate should be measured. We use the change in the natural logarithm of the nominal bilateral dollar exchange rate ($\times$ 100). Until the 1970s, devaluations were discrete changes in the exchange rate, which were easily identified ex post. However, developing countries have more recently taken advantage of more flexible exchange rate arrangements, including crawling pegs, target zones, and even gliding bands. This forces us to use a technique that can accommodate a diverse set of underlying exchange rate regimes. Also, many of the countries we consider use the U.S. dollar to define their exchange rate (not only Latin American, but East Asian as well Frankel and Wei (1994). Hence our use of a simple statistical criterion using dollar bilateral rates.

The fourth question is how to deal with countries that meet our first criterion – changes in the exchange rate of 25% or more – year after year. These are countries with high inflation rates and correspondingly high expected rates of depreciation. To ensure that we do not consider each of these depreciations to register as an independent crash, we require that the change in the exchange rate, not only exceed 25%, but exceed the previous year's change in the exchange rate by a margin of at least 10%. We also define a 3-year 'window' around crashes, as explained below.

3. The Variables of Interest

As noted, we group the domestic variables into four categories: internal domestic macroeconomic variables, factors pertaining to the level of international indebtedness and other external variables, those pertaining to the composition of the debt stock, and foreign variables.

3.1. Macroeconomic Indicators

The academic literature on 'speculative attacks' is relevant to our analysis, even though empirical tests are as yet rather meager, and largely limited to currency crises among industrialized countries.

Krugman (1979) is the classic theoretical model of currency crises as speculative attacks. The original paper assumed that the pre-crisis regime was literally a fixed exchange rate, but the model has been extended to crawling pegs (Connolly, 1986) and currency bands (Krugman and Rotemberg, 1991). The speculative attack model delivers several factors that should be important in predicting currency crashes: monetary and fiscal expansions, declining price competitiveness, current account deficits, and losses in international reserves.

While some of the predictions of these models have been borne out empirically, some speculative attacks have taken place without large apparent monetary and fiscal imbalances. The response has been a 'second generation' of multiple-equilibrium models which generate self-fulfilling attacks; Eichengreen et al. (1995) provide a review. These models tend to focus on political factors, such as the political cost of high unemployment or foregone output that result from a tough defense against a speculative attack.

We examine six variables relevant to the speculative attack literature: the rate of growth of domestic credit (a measure of monetary policy), the government budget as a fraction of GDP (a crude measure of fiscal policy), the ratio of reserves to imports, the current account as a percentage of GDP, the growth rate of real output, and the degree of over-valuation.[1]

3.2. External Variables

External variables are critical to our analysis. We use the ratio of debt to GNP as our primary measure for the level of international debt. We also use the ratio of foreign exchange reserves to monthly imports, the ratio of the current account to GDP, and the real exchange rate (which measures competitiveness) as additional measures of vulnerability to external shocks.[2] All have been widely used in the literature

3.3. Debt Composition

The composition of both capital inflows and the stock of debt has received much attention recently. Relevant indicators include Foreign Direct Investment (FDI) vs. portfolio flows, long-term vs. short-term portfolio capital, fixed-rate vs. floating-

[1]We would like to have better measures of political stability, but are hampered by the data. The data also constrain us from including: the unemployment rate; *ex post* changes in the terms of trade; and the *ex ante* variability of export prices.

[2]A variety of other ratios have also been proposed in the literature as proxies for the level of the debt burden. These include: the interest/output ratio; the debt/export ratio; the interest/export ratio; the debt service/export ratio; and the current account/export ratio.

rate borrowing, and domestic-currency vs. foreign-currency denomination. These variables are a central focus of this study.

The hypothesis regarding Foreign Direct Investment is that FDI is a safer way to finance investment than is portfolio investment. One argument is that FDI is directly tied to real investment in plant, equipment and infrastructure; whereas borrowing can go to finance consumption. Borrowing to finance consumption does not help add to the productive capacity necessary to generate export earnings to service the debt in the future. But FDI funds may be fungible; an FDI surplus in the capital account is no guarantee of high investment.

The stronger argument in favor of FDI is that of stability. In the event of a crash, investors can suddenly dump securities and banks can refuse to roll over loans, but multinational corporations cannot quickly pack up their factories and go home. Chuhan et al. (1995) provide empirical analysis supportive of this view. Yet this argument has been questioned. Dooley et al. (1994) have found that a high level of FDI seems to be associated with higher variability in capital flows, not lower. This probably reflects multinational corporations moving money in and out of the country, through transfers between subsidiary and parent, with greater ease than can be done outside the corporate walls. It makes the FDI hypothesis worth testing.

Two relevant aspects of the composition of capital inflows are the fraction of debt which is concessional and the fraction that comes from multilateral development banks. In both cases, the capital is both easier to service and far less likely to depart quickly in times of trouble than is the case for private market-rate debt. Indeed, the inflows from these sources may even increase when there is a crash.

Within portfolio capital, the maturity structure is perhaps the most important of the composition issues, followed closely by the question of variable-rate arrangements. In the high-inflation 1970s, there was a worldwide shift toward shorter maturities and towards nominal interest rates that were indexed to short-term interest rates such as LIBOR to protect creditor. The debt crisis that erupted in 1982 was clearly exacerbated by the fact that so much international debt was tied to short-term nominal interest rates. In the Mexican crash of 1994, the problem took the form of a heavy concentration of short-term debt, which describes the tesobonos as well as the CETES and ajustobonos. This not only raised the cost of borrowing in line with U.S. interest rate increases in 1994, but also resulted in difficulties associated with rolling over the debt later on. In other words, short maturities apparently pose problems of default risk above and beyond those problems of interest rate risk that they share with floating-rate debt; Cole and Kehoe (1995) provide more analysis. Both composition questions, short-term vs. long-term and floating-rate vs. fixed-rate, seem worth investigating.

We are also interested in the distinction between securities sales and commercial bank borrowing. Syndicated commercial bank loans were the preferred vehicle of international finance in the 1970s, but the 1982 crisis changed that. In the 1990s, their place has been largely been taken by portfolio managers and institutional

investors buying stocks and bonds (as was the norm before W.W.II). Some have argued that crashes in the 1990s are likely to be far less costly to the borrowing countries than was the crisis of the 1980s, because countries need no longer deal with banks to the same degree. Also, equities are a more efficient vehicle for risk-sharing than either loans or conventional bonds. With equities, unlike bonds or bank loans, the cost of the obligation does not stay fixed when the ability of the country to earn export revenue falls.

3.4. Foreign Variables

It is critical to look not only at individual country variables, but at the global financial environment as well. Global variables potentially include world economic activity, commodity prices, real interest rates, and other financial market shocks. The debt crisis of 1982, and subsequent debtor devaluations, were to a large extent triggered by the tight northern monetary policy which resulted in high interest rates and a global recession.

It is quite striking that most of the econometric studies that were undertaken in 1993–1994 on the causes of renewed large capital inflows to Latin America and East Asia in the early 1990s concluded that external factors were a major cause, perhaps the major cause. Calvo et al. (1993, pp. 136–137) found that 'foreign factors account for a sizable fraction (about 50%) of the monthly forecast error variance in the real exchange rate...[and]...also account for a sizable fraction of the forecast error variance in monthly reserves.' They warned that 'The importance of external factors suggests that a reversal of those conditions may lead to a future capital outflow.' Chuhan et al. (1994) estimated that U.S. factors explained about half of portfolio flows to Latin America, though they explained less than country factors in the case of East Asia. Fernandez-Arias (1994) found that the fall in U.S. returns was the key cause of the change in capital flows in the 1990s. Dooley et al. (1994), studied the determinants of the increase in secondary debt prices among 18 countries since 1986 and concluded that 'International interest rates are the key underlying factor.' The steep rise in American interest rates during 1994 constituted a test of the warning which most of these studies had carried [explicitly or implicitly], that an adverse shift in world financial conditions could lead to an abrupt halt to the inflows and a new crisis on the order of 1982.

In this paper, we focus on two important foreign variables: short-term northern interest rates and real OECD output growth.[3]

3.5. The Data Set

Most of our data set was extracted from the 1994 World Bank's World Data CD-ROM . It consists of annual observations from 1971 through 1992 for 105

[3]We have added both the level and the percentage change in the IMF's Developing Country Commodity Price Index, but neither is ever significant.

countries.[4] The sample was selected, with respect to choice of both country and time, to maximize data availability. However, numerous observations are missing for individual variables. We checked the data via both simple descriptive statistics and graphical techniques. We have also used exchange rates and interest rates from the IMF's International Financial Statistics CD-ROM, and aggregate real output from the OECD.

We examine seven different characteristics of the composition of capital inflows or the debt. Each is expressed as a percentage of the total stock of external debt. The variables are: (1) the amount of debt lent by commercial banks; (2) the amount that is concessional; (3) the amount that is variable-rate; (4) the amount that is public sector; (5) the amount that is short-term; (6) the amount lent by multilateral development banks (this includes the World Bank and regional development banks, but not the International Monetary Fund; (7) the flow of Foreign Direct Investment (FDI) expressed as a percentage of the debt stock.

As measures of vulnerability to external shocks, we examine: (1) the ratio of total debt to GNP; (2) the ratio of reserves to monthly import values; (3) the current account surplus (+) or deficit (−) expressed as a percentage of domestic output; (4) the degree of overvaluation. We define the latter simply as the deviation from Purchasing Power Parity, and measure the latter as the country-specific average bilateral real exchange rate over the period in question.

For macroeconomic purposes, we examine: (1) the total government budget surplus (+) or deficit (−), again, expressed as a percentage of GDP; (2) the domestic credit growth rate; (3) the growth rate of real GDP per capita.

Finally, we use the percentage growth rate of real OECD output (in American dollars, at 1990 exchange rates and prices) as our measure of northern demand. We construct the 'foreign interest rate' as the weighted average of short-term interest rates for the United States, Germany, Japan, France, the United Kingdom and Switzerland; the weights for the debtor in question are proportional to its fractions of debt denominated in the relevant currencies.[5] There is a good deal of heterogeneity by country (within-year) in foreign interest rates. However, they

[4]The countries we include are: Algeria; Argentina; Bangladesh; Barbados; Belize; Benin; Bhutan; Bolivia; Botswana; Brazil; Burkina Faso; Burundi; Cameroon; Cape Verde; Central African Republic; Chad; Chile; China; Colombia; Comoros; Congo; Costa Rica; Cote d'Ivoire; Djibouti; Dominican Republic; Ecuador; Arab Republic of Egypt; El Salvador; Equatorial Guinea; Ethiopia; Fiji; Gabon; The Gambia; Ghana; Grenada; Guatemala; Guinea; Guinea-Bissau; Guyana; Haiti; Honduras; Hungary; India; Indonesia; Islamic Republic of Iran; Jamaica; Jordan; Kenya; Republic of Korea; Lao People's Democratic Republic; Lebanon; Lesotho; Liberia; Madagascar; Malawi; Malaysia; Maldives; Mali; Malta; Mauritania; Mauritius; Mexico; Morocco; Myanmar; Nepal; Nicaragua; Niger; Nigeria; Oman; Pakistan; Panama; Papua New Guinea; Paraguay; Peru; Philippines; Portugal; Romania; Rwanda; St. Vincent and the Grenadines; Sao Tome and Principe; Senegal; Seychelles; Sierra Leone; Solomon Islands; Somalia; Sri Lanka; Sudan; Swaziland; Syrian Arab Republic; Tanzania; Thailand; Togo; Trinidad and Tobago; Tunisia; Turkey; Uganda; Uruguay; Vanuatu; Venezuela; Western Samoa; Republic of Yemen; Federal Republic of Yugoslavia; Zaire; Zambia; and Zimbabwe.

[5]We use IFS line 60b, money market interest rates. Using lending rates (IFS line 60l) does not change any results.

generally move together, rising in the mid-1970s, the early 1980s and the early 1990s.

4. Results

4.1. Event Study Methodology

We begin our investigation by characterizing the behavior of countries suffering from a currency crash. Our methodology is that used by Eichengreen et al. (1995).

As noted, we define a crash as an observation where the nominal dollar exchange rate increases by at least 25% in a year and has increased by at least 10% more than it did in the previous year. We exclude crashes which occurred within 3 years of each other to avoid counting the same crash twice.

Our definition of a currency crash yields 117 different crashes (74 crashes are deleted because of the 3-year 'windowing'.) These are spread over a large number of countries, but have a slight tendency to be clustered in the early-to-mid 1980s. Thus the observations probably should not be treated as independent observations. The actual crashes are tabulated in an appendix.

Non-crash observations that are not within three years of a crash constitute a sample of 'tranquil' observations (some of these observations occur in countries that never had a crash throughout the sample under study). We use these as a control sample, and compare behavior around crash episodes with behavior during periods of tranquility (Fig. 1).

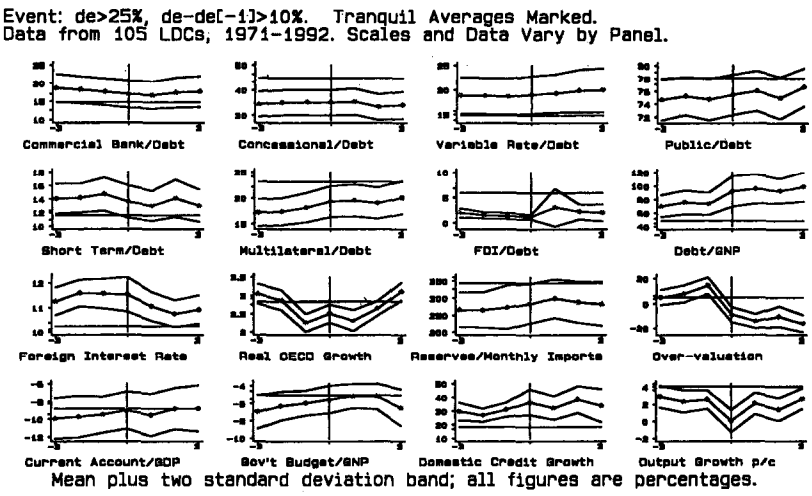

Fig. 1. Movements 3 years before and after crashes.

The figure is a set of 16 'small multiple' graphics, each an 'event study' of the sort used in finance. Each of the graphics portrays the movement in a variable of interest beginning 3 years before the crash and continuing through the crash (marked by a vertical bar) until 3 years afterwards. Thus, the 'seeds' of crashes can be examined, along with their aftermath. The averages for periods of tranquility are explicitly marked with a horizontal line, making it easy to compare behavior around crashes to that during more 'typical' periods of tranquility.[6] The scales of individual panels are not comparable across variables, nor is the sample size (because of data availability problems). Mean values are provided, along with a band delimiting plus and minus two standard deviations.[7]

A graphical approach like this has disadvantages. The graphs are informal. More importantly, they are intrinsically univariate. They encourage readers to examine individual variables by themselves, whereas the norm in econometrics is to look at the marginal contribution of each variable conditional on the others.

But graphical methods also have advantages. They impose no parametric structure on the data, and impose few of the assumptions that are sometimes necessary for statistical inference or estimation but are frequently untenable. This is especially appropriate in a non-structural exploration of the data. They are often more accessible and informative than tables of coefficient estimates. For these reasons, we use our graphs cautiously. We also verify our ocular analysis with more rigorous statistical techniques, using probit models estimated with maximum likelihood to check our results.

4.2. Graphical Analysis

The results in the figure are essentially as hypothesized. Countries experiencing currency crashes tend to have: high proportions of their debt lent by commercial banks (compared, as always, to tranquil observations), high proportions of their debt on variable-rate terms and in short maturities; and relatively low fractions of debt that are concessional, lent by the multilateral organizations or lent to the public sector. Crash countries tend to experience disproportionately small inflows of FDI (i.e., relatively high 'hot money' portfolio) flows.

Foreign interest rates tend to be high in the period preceding currency crashes, exceeding tranquil foreign interest rates by over one percentage point. This corroborates the commonly-held view that foreign interest rates are an important source of currency crashes. Also, northern growth is much lower in the periods around crashes.

Countries experiencing crashes also tend to have currencies that are over-valued

[6]A $\pm$ 2(confidence interval for the tranquil mean is ticked on the ordinate, centered around the tranquil mean.

[7]These may not represent well-defined confidence intervals, given the issue of potential non-independence.

by over 10%. Unsurprisingly, debt burdens for crashing countries are high and rising. International reserves are also low and falling. Thus, external conditions for crashing countries are generally weak. There is one important exception. While the current account is in deficit, this deficit is small (compared with tranquil observations) and shrinking. Curiously enough, the government budget situation is very similar to that of the current account; small shrinking deficits which do not vary significantly from times of tranquility.

Our negative results on the current account and fiscal side are in striking contrast with the literature. They are especially interesting in light of the strong results we find elsewhere on the domestic macroeconomic side. For instance, domestic credit growth is noticeably high, consistent with the classic speculative attack model.

Most variables (except, trivially, the real exchange rate) tend to move very sluggishly in the years surrounding currency crashes.[8] This leads one to expect that it will be difficult to predict the exact timing of a currency crash with precision. The notable exception is the growth rate of real output per capita, which dips significantly (in both the economic and statistical senses) below the tranquil norm in the year of the crash. Of course, the direction of causality is unclear (especially at the annual frequency) since the crash may be precipitated in part by slow growth, but may also itself induce recession. The flow of FDI varies dramatically across episodes immediately after the crash.

4.3. Regression Analysis

The 'event study' analysis is both naive and intrinsically univariate. More confirmation can be provided by simple regression work. In particular, we estimate probit models linking our binary crash measure to our variables.

We have seven debt-composition regressors, each expressed as a percentage of total debt: (1) commercial bank debt; (2) concessional debt; (3) variable-rate debt; (4) short-term debt; (5) FDI; (6) public sector debt; (7) multilateral debt. Our list of external variables includes: (1) the ratio of international reserves to monthly imports; (2) the current account as a percentage of GDP; (3) the external debt as a percentage of GNP; (4) real exchange rate divergence (over-valuation). As domestic macroeconomic variables, we include: (1) the government budget as a percentage of GDP; (2) the percentage growth rate of domestic credit; (3) the percentage growth rate of real output per capita. We also include the foreign interest rate and the northern growth rate, in percentage points.

We use a multivariate model where all the variables are employed simultaneously. Throughout, we pool all the available data across both countries and time periods, and estimate probit models using maximum likelihood. Combining

[8] Any revaluation effects on trade flows appear to be small.

the effects of the variables together into a single model reduces the sample size dramatically.

Our benchmark results are tabulated in the middle of Table 1. Since probit coefficients are not easily interpretable, we report the effects of one-unit changes

Table 1
Probit estimates

	Default		Predictive	
	$\delta F(x)/\delta x$	|z|	$\delta F(x)/\delta x$	|z|
Commercial Bank/Debt	−0.07	0.57	0.03	0.21
Concessional	−0.10	1.74	**−0.14**	2.10
Variable Rate	0.03	0.21	−0.03	0.22
Short Term	0.04	0.34	0.23	1.97
FDI/Debt	**−0.33**	2.88	**−0.31**	2.47
Public Sector/Debt	0.11	1.32	**0.19**	2.18
Multilateral/Debt	−0.03	0.46	−0.06	0.81
Debt/GNP	0.03	1.33	−0.04	1.71
Reserves/Imports	**−0.01**	1.99	**−0.01**	3.39
Current Account	0.10	1.03	0.02	0.22
Over-Valuation	0.05	1.51	**0.08**	2.53
Government Budget	0.27	1.90	0.16	1.06
Domestic Credit	**0.13**	4.78	**0.10**	3.24
Growth Rate	**−0.38**	3.13	−0.16	1.29
Northern Growth	0.55	0.98	−0.85	1.50
Foreign Interest	**1.27**	4.50	**0.80**	2.60
Sample Size	803		780	
Pseudo-R2	0.20	P-Val	0.17	P-Val
Ho: Slopes = 0; $\chi 2(16)$	93.6	0.00	81.2	0.00
Ho: Debt Effects = 0; $\chi 2(7)$	14.2	0.05	25.5	0.00
Ho: External Effects = 0; $\chi 2(4)$	8.8	0.07	16.5	0.00
Ho: Macro Effects = 0; $\chi 2(3)$	32.9	0.00	12.3	0.01
Ho: Foreign Effects-0; $\chi 2(2)$	21.5	0.00	15.4	0.00

Default model: Goodness of fit

	Tranquility	Crash	Total
Predicted tranquility	727	65	792
Predicted crash	6	5	11
Total	733	70	803

Predictive model: Goodness of fit

	Tranquility	Crash	Total
Predicted tranquility	707	64	771
Predicted crash	4	5	9
Total	711	69	780

Probit slope derivatives (× 100, to convert into percentages) and associated z-statistics (for hypothesis of no effect). Slopes significantly different from zero at the 0.05 value in bold.Model estimated with a constant, by maximum likelihood.Predictive Model lags all regressors 1 year.

in regressors on the probability of crash (expressed in percentage points), evaluated at the mean of the data. We also tabulate the associated z-statistics which test the null hypothesis of no effect. Diagnostic statistics follow at the bottom of the table, including actual and predicted crash cross-tabulations, and joint hypothesis tests for the significance of debt composition, external, macroeconomic, and all effects.

Most of the debt composition variables do not have statistically significant coefficients, though some (like the concessional variable) are close to significant. The somewhat weak results are probably the result of multicollinearity among our long list of different debt characteristics.[9] The coefficients for commercial bank and public sector proportions of debt are inappropriately, though insignificantly signed. We also note that the proportion of short-term debt has an insignificant effect on crash incidence. On the other hand, the proportion of external debt accounted for by FDI is consistently strongly and significantly associated with crash incidence; a fall in FDI inflows by one percent of the debt is associated with an increase in the probability of a crash by.3%. The debt composition variables have a weak but non-negligible effect on crash incidence overall.

Interestingly, neither the current account nor the budget deficit has the predicted sign, though neither effect is statistically significant at conventional levels (consistent with the graphical results). But the external effects exert a strong and sensible influence on the likelihood of crash incidence. Higher debt, lower reserves, and a more over-valued real exchange rate all seem to raise the odds of crash incidence. Each of these effects have marginally significant individual effects that are jointly significant.

The domestic macroeconomic effects are quite strong. High domestic credit growth and a recession both coincide with an increased probability of a crash.

Finally, increases in northern interest rates increase the likelihood of a crash by an amount that is both statistically and economically significant. A one percentage point increase in the foreign interest rate raises the probability of a crash by over one percent, holding all other influences constant. But Northern real output growth has little effect on crash likelihood, once other effects have been taken into account.

On the right-hand side of Table 1, we tabulate analogous results in which all the regressors are lagged. This amounts to a crude test of the ability of the regressors to predict crashes, precisely 1 year in advance.[10]

Interestingly enough, the results are mostly stronger than those in the contemporaneous regression. The joint effects of debt composition, external, and internal effects are now all significant. Low fractions of debt which is either concessional or accounted for by FDI or a high fraction which is public-sector, all raise the

[9]We have experimented with factor analysis, and found that a single factor accounts for much variation in the debt composition variables.

[10]A more satisfying way to examine the predictive power of the model would be to examine the intensity of the future expectations of a crash.

probability of a future crash. Low reserves and over-valuation are also crash predictors, as are high foreign interest rates or high domestic credit growth.

4.4. Sensitivity Analysis

Table 2 performs a variety of robustness checks. The first reports the results of weighted estimation, where the weights are proportional to real output per capita. Using weights proportional to the actual exchange rate jump does not significantly change our benchmark results, The second performs the estimation only on Latin countries; the third analyzes only post-1982 data. Our reports are somewhat sensitive to the exact way in which the data are used for estimation. But our most important results come through relatively clearly. Low FDI flows, high domestic credit growth, low output growth and high foreign interest rates are all associated with currency crashes. Current account and budget deficits remain insignificant determinants of crash incidence.

Table 2
Robustness

	Weighted		Latin		Post 1982	
	$\delta F(x)/\delta x$	$\|z\|$	$\delta F(x)/\delta x$	$\|z\|$	$\delta F(x)/\delta x$	$\|z\|$
Commercial Bank/Debt	0.21	1.71	0.03	0.14	0.03	0.13
Concessional	0.03	0.47	−0.09	0.49	−0.16	1.68
Variable Rate	0.07	0.49	0.15	0.62	−0.16	0.73
Short Term	**0.77**	5.43	**−0.50**	2.20	0.20	0.99
FDI/Debt	**−0.90**	3.57	−0.68	1.52	**−1.36**	2.47
Public Sector/Debt	**0.84**	8.08	0.26	1.77	0.21	1.29
Multilateral/Debt	**−0.26**	2.78	−0.27	1.53	−0.02	0.22
Debt/GNP	**−0.13**	4.55	−0.01	0.19	−0.05	**1.41**
Reserves/Imports	**−0.02**	5.90	−0.00	0.14	−0.00	0.26
Current Account	−0.13	1.22	0.35	1.18	−0.05	0.26
Over-Valuation	0.03	0.92	−0.06	0.68	0.10	2.01
Government Budget	−0.17	0.87	0.42	1.15	0.42	1.54
Domestic Credit	−0.03	1.13	**0.13**	2.92	**0.23**	4.50
Growth Rate	−0.16	1.30	**−0.68**	2.73	**−0.72**	3.52
Northern Growth	**0.90**	2.78	−0.41	0.42	−0.41	0.32
Foreign Interest	**0.72**	3.12	**1.35**	2.32	1.48	1.65
Sample Size	803		198		369	
Pseudo-R2	0.43	P-Val	0.40	P-Val	0.25	P-Val
Ho: Slopes = 0; $\chi 2(16)$	229.7	0.00	63.1	0.00	63.5	0.00
Ho: Debt Effects = 0; $\chi 2(7)$	87.2	0.00	13.4	0.06	11.1	0.13
Ho: External Effects = 0; $\chi 2(4)$	39.2	0.00	4.9	0.30	5.2	0.27
Ho: Macro Effects = 0; $\chi 2(3)$	3.5	0.33	17.4	0.00	29.9	0.00
Ho: Foreign Effects-0; $\chi 2(2)$	14.9	0.00	6.8	0.03	2.7	0.26

Probit slope derivatives (× 100, to convert into percentages) and associated z-statistics (for hypothesis of no effect).Model estimated with a constant, by maximum likelihood.Slopes significantly different from zero at the 0.05 value are in bold.

Table 3 provides more sensitivity analysis. Three perturbations of the model are examined. The first replaces the foreign interest with interactive effects between the level of foreign interest rates and such domestic variables as the debt/output ratio, the variable-rate proportion of debt, and the short-term proportion of debt. Only the product of the interest rate with the debt/GDP ratio is statistically significant. Its effect seems sensible: it is the combination of high indebtedness and an increase in world interest rates that is particularly lethal.

A second perturbation involves adding a variable to reflect the 'currency exposure' of debtors to fluctuations in the exchange rates among the dollar, yen, franc and other major currencies. We defined the currency exposure variable for a

Table 3
Sensitivity Analysis

	$\delta F(x)/\delta x$	$\|z\|$	$\delta F(x)/\delta x$	$\|z\|$	$\delta F(x)/\delta x$	$\|z\|$
Commercial Bank/Debt	−0.08	0.56	−0.09	0.76	−0.02	0.19
Concessional	−0.11	1.94	−0.09	1.58	−0.06	1.31
Variable Rate	−0.10	0.54	0.06	0.48	0.00	0.13
Short Term	0.23	1.04	0.07	0.62	0.05	0.53
FDI/Debt	**−0.31**	2.79	**−0.30**	2.85	**−0.22**	2.81
Public Sector/Debt	0.13	1.48	0.11	1.37	0.08	1.20
Multilateral/Debt	0.00	0.05	−0.03	0.53	−0.02	0.53
Debt/GNP	**−0.16**	2.86	0.03	1.43	0.02	1.13
Reserves/Imports	**−0.01**	2.02	−0.01	1.73	−0.00	1.28
Current Account	0.14	1.38	0.10	1.01	0.09	1.24
Over-Valuation	0.05	1.45	0.04	1.30	0.04	1.58
Government Budget	**0.42**	2.83	0.24	1.84	0.17	1.72
Domestic Credit	**0.14**	5.09	**0.12**	4.61	**0.09**	4.52
Growth Rate	**−0.40**	3.21	**−0.41**	3.54	**−0.26**	2.97
Northern Growth	0.42	0.75	0.47	0.90	0.30	0.76
Foreign Interest			**0.66**	2.25	**0.88**	4.33
Foreign Interest*Short Term	−0.02	0.91				
Foreign Interest*Variable Rate	0.01	0.90				
Foreign Interest*Debt/GNP	**0.02**	3.77				
Currency Exposure			**0.62**	3.95		
Africa					**91**	5.55
Asia					**95**	5.16
Latin America					**98**	5.13
Sample Size	803		803		803	
Pseudo-R2	0.21	P-Val	0.23	P-Val	0.21	P-Val
Ho: Slopes = 0; $\chi 2(16)$	101.3	0.00	110.4	0.00	60.1	0.00
Ho: Debt Effects = 0; $\chi 2(7)$	13.4	0.06	28.6	0.00	13.2	0.07
Ho: External Effects = 0; $\chi 2(4)$	13.0	0.01	7.5	0.11	7.3	0.12
Ho: Macro Effects = 0; $\chi 2(3)$	37.3	0.00	33.9	0.00	28.9	0.00
Ho: Foreign Effects-0; $\chi 2(2)$	25.8	0.00	5.1	0.08	20.4	0.00

Probit slope derivatives (× 100, to convert into percentages) and associated z-statistics (for hypothesis of no effect). Slopes significantly different from zero at 0.05 in bold.Model estimated with a constant, by maximum likelihood.

given debtor to be a weighted average of the changes in the dollar exchange rates of the major currencies, where the weights were the shares of that debtor's liabilities denominated in the currencies in question. Thus a country with a heavy share of yen-denominated debt would show a high vulnerability in a year when the yen appreciated sharply against the dollar. The currency exposure variable enters the regression with high statistical significance, but the wrong sign. This result is dominated by the yen/dollar exchange rate: countries with a lot of debt denominated in the ever-appreciating yen did better in the sample than others. East Asian countries have the heavy share of yen debt, and have probably done well for other reasons, so our finding may be spurious.

A third check adds continent dummy variables. None of the important results is affected.

To sum up: our major results appear not to depend strongly on the exact econometric methodology we employ.

5. Summary and Conclusion

Much of the literature on speculative attacks focuses on a few episodes. In this paper we search for the stylized facts associated with currency crashes – large currency depreciations – in a broad group of emerging markets. We use annual data from over 100 developing countries and over two decades.

Our empirical results stem from a non-structural investigation of the data, and mostly come from a grossly over-parameterized statistical model. Thus we eschew structural interpretations. Nevertheless, we find that currency crashes can be characterized in what appears to be a sensible way. Crashes tend to occur when FDI inflows dry up, when reserves are low, when domestic credit growth is high, when northern interest rates rise, and when the real exchange rate shows overvaluation. They also tend to be associated with sharp recessions, though the causal linkages are very unclear. Curiously, neither current account nor government budget deficits appear to play an important role in a typical crash.

We think of this as an encouraging starting point for future research.

Acknowledgments

Frankel is Professor of Economics in the Economics Department at the University of California, Berkeley, and Director of the NBER's International Finance and Macroeconomics program. Rose is Professor and Chair of Economic Analysis and Policy in the Haas School of Business at the University of California, Berkeley, a Research Associate of the NBER, and a Research Fellow of the CEPR. For comments, we thank: Andrew Atkeson, Marvin Goodfriend, Enrique Mendoza, John Rogers, Julio Santaella, Ralph Tryon, Carlos Vegh, seminar participants

at the International Finance Division of the Board of Governors of the Federal Reserve System, conference participants at the Center for International Economics Conference on Speculative Attacks in the Global Economy and two anonymous referees. We also thank Bill Easterly, Barry Eichengreen, Jon Faust, and Alan Stockman for discussion and encouragement. This work is part of a project for the International Finance Division of the International Economics Department of the World Bank, whom we thank for research support. The STATA 4.0 data set and programs are available upon receipt of two formatted 3.5" inch diskettes and a self-addressed, stamped mailer in the year after publication.

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