# Financial Crises in Emerging Markets

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CAMBRIDGE
UNIVERSITY PRESS
Cambridge, U.K. 2001

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# Banking and Currency Crises: How Common Are Twins?

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## 2.1 INTRODUCTION

The joint occurrence of banking and currency crises associated with the recent Asian financial turmoil has drawn renewed attention to the interrelationship between these two phenomena. Banking and currency crises appeared to arise virtually at the same time in Thailand, Indonesia, Malaysia, and Korea in 1997–1998. In fact, the incidence of "twin" crises has been relatively widespread, occurring in such diverse parts of the world as Latin America in the early and mid-1980s and Scandinavia in the early 1990s.

There are good theoretical reasons to expect connections between currency and banking crises, especially because foreign assets and liabilities are a component in commercial banks' balance sheets. In principle, the causality between bank and currency crises may run in either direction. As we discuss in Section 2.2, bank crises may lead to currency crises under some circumstances, while under other conditions currency crises may cause bank crises. Moreover, some recent literature does not distinguish between the two phenomena and regards them as simultaneous manifestations of underlying common factors (Chang and Velasco, 1999).

Most of the empirical literature on currency and banking crises has involved analyzing the determinants of each type of crisis independently of the other. Little empirical work to date has systematically

We thank Mark Peralta, Rasmus Fatum, and Kathleen McDill for research assistance. The views presented in this chapter are those of the authors alone and do not necessarily reflect those of the Federal Reserve Bank of San Francisco or the Board of Governors of the Federal Reserve System. Hutchison's research was supported by The International Centre for the Study of East Asian Development (ICSEAD), the University of California Pacific Rim Research Program, and the Center for Pacific Basin Monetary and Economic Studies at the Federal Reserve Bank of San Francisco.

investigated the association of bank and currency crises. The few exceptions (e.g., Kaminsky and Reinhart, 1999; Rossi, 1999) typically restrict their data sets to a limited number of countries experiencing crises.[1]

In this chapter we empirically investigate the causal linkages between bank and currency crises using a broad country and time-series dataset. Using a broad control group of countries and periods that includes observations with and without crises allows us to draw more general conclusions about the conditions that distinguish crisis from tranquil periods both across countries and across time.

In our empirical analysis, we first provide a detailed statistical overview of the individual and joint ("twin") occurrence of bank and currency crises for 90 industrial and developing countries over the 1975–1997 period. We examine the frequency, regional concentration, association, and relative timing of the onsets of both bank and currency crises. In addition, we assess the value of banking crises in helping to predict future currency crises, and vice versa, using signal-to-noise ratio methodology. We also examine the contemporaneous and lagged relationship of currency and banking crises more formally by estimating the probabilities of the onset of currency and banking crises with probit regressions, using bivariate, multivariate, and simultaneous equation specifications.

We find that the twin crisis phenomenon is concentrated in financially liberalized emerging market economies and is not a general characteristic of either bank or currency crises in a broader set of countries. The linkage between the onset of currency and bank crises in emerging markets is strong, indicating that foreign exchange crises feed into the onset of banking problems and vice versa. This result is robust to model specification and estimation technique. Moreover, only in emerging market economies are banking crises a significant leading indicator of future currency crises. Currency crises do not appear to be a particularly good signal of future banking problems.

The organization of this chapter is as follows: Section 2.2 describes the relevant literature on the possible links between bank and currency crises. Section 2.3 discusses the data used in our empirical analysis. Section 2.4 presents the summary statistical features of the data and signal-to-noise ratio results. Section 2.5 presents the results of probability model (probit) estimates. Section 2.6 concludes the chapter.

[1] An exception is Eichengreen and Rose (1998), who examine the impact of exchange rate regimes and variability on the probability of bank crises in a large sample of developing countries.



## 2.2 LINKAGES BETWEEN CURRENCY AND BANKING CRISES

The association of bank and currency crises and the occurrence of "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. In this section we provide a brief survey of the existing literature concerning the linkages between the onset of bank and currency crises.

### 2.2.1 Causality from Banking Sector Distress to Currency Crises

A number of papers discuss the possibility of causality running from banking problems to currency crises. Obstfeld (1994), for example, argues that a weak banking sector may precipitate a currency crisis if rational speculators anticipate that policymakers will choose inflation over 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. Velasco (1987) and Calvo (1997) argue that a bank run can cause a currency attack if the increased liquidity associated with a government bailout of the banking system is inconsistent with a stable exchange rate. Miller (1999) explicitly considers currency devaluation as one of the logical policy options for a government confronted by a bank run in a fixed exchange rate regime. Gonzalez-Hermosillo (1996) shows that a bank crisis may lead to a currency crisis in a poorly developed financial system where agents may substitute foreign assets for domestic assets.

If banking sector unsoundness can contribute to a currency crisis, what causes a banking crisis? Leading candidate explanations include (a) the well-known "moral hazard" problems in banking associated with financial liberalization and government deposit insurance and (b) large macroeconomic shocks such as a sharp fall in underlying asset values (e.g., "bubble" crash in asset prices). An alternative, "nonfundamentals," explanation is that "bank runs" may occur because of the expectations of individual depositors and creditors (see Diamond and Dybvig, 1983).

### 2.2.2 Causality from Currency Crises to Banking Sector Distress

A possible reverse chain of causality, from currency crises to the onset of banking crises, is also well-recognized. Miller (1996), for example, shows that a speculative attack on a currency can lead to a bank crisis if deposit money is used to speculate in the foreign exchange market and banks are "loaned up." Rojas-Suarez and Weisbrod (1995) and Obstfeld (1994) argue that a currency crisis may lead to problems in a vulnerable banking sector if policymakers respond to the pressure on the exchange

rate by sharply raising interest rates. A common feature of these mechanisms is that banks are already "vulnerable" because of (a) large unhedged foreign liabilities and/or a maturity mismatch between asset and liabilities and (b) a shock arising from the currency market pushes them "over the edge." A currency crisis shock can adversely alter the banking sector directly by causing a deterioration of bank balance sheets if the currency depreciates, or indirectly by causing the central bank to raise interest rates to defend the currency.

If currency crises lead to bank crises, what causes currency crises? Candidate explanations based on fundamentals, usually termed first-generation models of the collapse of fixed exchange rates, include overvalued real exchange rates and other macroeconomic factors such as inflation, budget deficits, and rapid credit expansion (Krugman, 1979). The main alternative explanations allow a role for nonfundamentals, and are frequently termed second-generation models of exchange rate regime collapse (Obstfeld, 1994). This literature focuses on the existence of multiple equilibria and self-fulfilling speculative attacks that can arise from the willingness of policymakers to give up a pegged exchange rate if output, unemployment, or other relevent costs exceed a certain threshold.

#### 2.2.3 Joint Causality

The joint occurrence of "twin crises" may also reflect a response to a common factor. Chang and Velasco (1999), for example, emphasize the role of international illiquidity, defined as a situation in which a country's consolidated financial system has potential short-term obligations that exceed the amount of foreign currency to which it can have access on short notice. They argue that an international liquidity shortfall may be a sufficient, though not necessary, condition to trigger a crisis: "The options left after creditors lose confidence and stop rolling over and demand immediate payment on existing loans – whether to the private sector in Asia or to the government in Mexico and Brazil – are painfully few. The collapse of the currency, of the financial system, or perhaps both is the likely outcome."

Another common factor emphasized in this literature is financial liberalization combined with moral hazard incentives that induce banks to take on particularly risky portfolios, including unhedged foreign currency liabilities. McKinnon and Pill (1996, 1998), for example, emphasize the role of financial liberalization in generating dynamics leading to a twin crisis. Financial liberalization and deposit insurance may fuel a lending boom involving both foreign and domestic credit expansion that eventually leads to a banking and currency crisis.



More generally, Kaminsky and Reinhart (1999) point out that it is possible that "because the seeds of the problems are sown at the same time, which event occurs first is a matter of circumstance." An example they employ to illustrate a twin crisis, jointly caused by common factors, is the "perverse" dynamics of an exchange rate-based inflation stabilization plan, such as that of Mexico in 1987 and the Southern Cone countries in the late 1970s. Reinhart and Vegh (1995) provide empirical evidence that these types of plans have similar dynamics: An early consumption boom is financed by expansion of bank credit and foreign borrowing. The boom is accompanied by real exchange rate appreciation because domestic inflation only converges gradually to the international inflation rate due to inertial effects in wage contracting and price expectations. At some point, the high level of foreign borrowing, reflected in a current account deficit, may be perceived as unsustainable and trigger an attack on the currency. As capital inflows turn to outflows and asset markets crash, the banking sector is affected as well.

### 2.3 DATA

#### 2.3.1 Defining Currency Crises

Currency crises are typically defined as "large" changes in some indicator of actual or potential currency value. Some studies focus on episodes of large depreciation alone (e.g., Frankel and Rose, 1996), while others include episodes of speculative pressure in which the exchange rate did not always adjust because the authorities successfully defended the currency by intervening in the foreign exchange market or raising domestic interest rates (e.g., Eichengreen, Rose, and Wyplosz, 1995; Moreno, 1995; Kaminsky and Reinhart, 1999). Alternative criteria have been employed in the literature for identifying "large" changes in currency value or pressure relative to what is considered "normal." Some studies employ an exogenous threshold rate of depreciation common to all countries in the analysis (e.g., Frankel and Rose, 1996; Kumar, Moorthy, and Perraudin, 1998), while others define the threshold in terms of country-specific moments (e.g., Kaminsky and Reinhart, 1999; Kaminsky, Lizondo, and Reinhart, 1998; IMF, 1998; Esquivel and Larrain, 1998; Glick and Moreno, 1998; Moreno, 1999).[2]

In this study our indicator of currency crises is constructed from "large" changes in an index of currency pressure, defined as a weighted average of monthly real exchange rate changes and monthly (percent)

[2] Furman and Stiglitz (1998) and Berg and Patillo (1999) evaluate the predictive power of a range of model methodologies and definitions for the 1997 Asia crisis.

reserve losses.[3] The weights are inversely related to the variance of changes of each component over the sample for each country. Our measure presumes that any nominal currency changes associated with exchange rate pressure should affect the purchasing power of the domestic currency – that is, result in a change in the real exchange rate (at least in the short run). This condition excludes some large depreciations that occur during high inflation episodes, but it avoids screening out sizable depreciation events in more moderate inflation periods for countries that have occasionally experienced periods of hyperinflation and extreme devaluation.[4] Large changes in exchange rate pressure are defined as changes in our pressure index that exceed the mean plus two times the country-specific standard deviation, provided it also exceeds five percent.[5,6]

### 2.3.2 Defining Bank Crises

Banking problems are usually difficult to identify empirically because of data limitations. The potential for a bank run is not directly observable and, once either a bank run or large-scale government intervention has occurred, the situation most likely will have been preceded by a protracted deterioration in the quality of assets held by banks. Identifying banking sector distress by the deterioration of bank asset quality is also difficult because direct market indicators of asset value are usually lacking. This is an important limitation because most banking problems in recent years are not associated with bank runs by depositors (affecting the liability side of the bank balance sheet) but with deterioration in asset quality and subsequent government intervention. Moreover, it is often laxity in government analysis of banking fragility, and slow follow-up action once a problem is recognized, that allows the situation to deteriorate to the point of a major bank crisis involving large-scale government intervention.

Given these conceptual and data limitations, most studies have employed a combination of events to identify and date the occurrence of a bank crisis. Institutional events usually include forced closure, merger, or government intervention in the operations of financial institutions, runs on banks, or the extension of large-scale government assistance. Other indicators frequently include measures of nonperforming assets, problem loans, and so on. We have identified and dated episodes of banking sector distress following the criteria of Caprio and Klingebiel (1996, and updated on the World Bank WebPage) and Demirgüç-Kunt and Detragiache (1998a). If an episode of banking distress is identified in either study, it is included in our sample. If there is ambiguity over the timing of the episode, we use the dating scheme of Demirgüç-Kunt and Detragiache (1998a) because it tends to be more specific about the precise start and end of each episode.[7]

### 2.3.3 Determinants of Currency and Banking Crises

The theoretical and empirical literature has identified a vast array of variables potentially associated with currency and banking crises (see Kaminsky, Lizondo, and Reinhart, 1998; Demirgüç-Kunt and Detragiache, 1998a; and Hutchison and McDill, 1999). The choice of explanatory variables in our analysis was determined by the questions we posed earlier, the availability of data, and previous results found in the literature. Our objective is to postulate a "canonical" model of currency and banking crises in order to form a basic starting point to investigate the linkages between currency and banking crises. We postulate quite simple basic models with few explanatory variables. The main source of the macro data is the International Monetary Fund's *International Financial Statistics* (CD-ROM). The data series and sources are described in Appendix 2B.

[3] Our currency pressure measure of crises does not include episodes of defense involving sharp rises in interest rates. Data for market-determined interest rates are not available for much of the sample period in many of the developing countries in our dataset.

[4] This approach differs from that of Kaminsky and Reinhart (1999), for example, who deal with episodes of hyperinflation by separating the nominal exchange rate depreciation observations for each country according to whether or not inflation in the previous 6 months was greater than 150 percent, and they calculate for each subsample separate standard deviation and mean estimates with which to define exchange rate crisis episodes.

[5] Kaminsky and Reinhart (1999) use a three-standard-deviation cutoff. While the choice of cutoff point is somewhat arbitrary, Frankel and Rose (1996) and Kumar, Moorthy, and Perraudin (1998) suggest that the results are not very sensitive to the precise cutoff chosen in selecting crisis episodes.

[6] We have also constructed an alternative measure of currency crises following Esquivel and Larrain (1998) that employs a hybrid condition: The monthly depreciation in the (real) exchange rate either (i) exceeds 15 percent, provided that the depreciation rate is also higher than that in the previous month, or (ii) exceeds the country-specific mean plus 2 standard deviations of the real exchange rate monthly growth rate, provided that it also exceeds 5 percent. The first condition ensures that any large (real) depreciation is counted as a currency crisis, while the second condition attempts to capture changes that are sufficiently large relative to the country-specific monthly change of the (real) exchange rate. The results of our analysis are unaffected by use of this alternative measure.

[7] Demirgüç-Kunt and Detragiache (1998a, 1998b) identify banking sector distress as a situation where one of the following conditions hold: Ratio of nonperforming assets to total assets is greater than 2 percent of GDP; cost of the rescue operation was at least 2 percent of GDP; banking sector problems resulted in a large-scale nationalization of banks; and extensive bank runs took place or emergency measures such as deposit freezes, prolonged bank holidays, or generalized deposit guarantees were enacted by the government in response to the crisis.

The key explanatory variables used in our analysis of currency crises are the degree of real currency overvaluation, export revenue growth, and the M2/foreign reserves ratio. Prior to episodes of sharp depreciation, we expect the real trade-weighted exchange rate to be overvalued. We define overvaluation as deviations from the fitted trend in the real trade-weighted exchange rate, created by taking the trade-weighted sum of the bilateral real exchange rates (defined in terms of CPI indices) against the U.S. dollar, the deutsche mark, and the yen, where the trade weights are based on the average bilateral trade shares in 1980 and 1990 with the United States, Europe, and Japan.

We also expect export growth (in U.S. dollars) to be sluggish, and the growth rate of M2/foreign reserves to be higher, prior to a currency crisis. A slowdown in export growth indicates a decline in foreign exchange earnings that in turn may set up the expectation of – and speculative pressure for – a currency decline. A rise in the M2/foreign reserves ratio implies a decline in the foreign currency backing of the short-term domestic currency liabilities of the banking system. This would make it difficult to stabilize the currency if sentiment shifts against it.

Several other variables were considered in this study but were not included in the reported regressions (for brevity) because they did not increase explanatory power: the current account/GDP ratio, nominal and real M2 growth, nominal and real domestic credit (net of claims on the public sector), the M2/reserve money multiplier (often used as an indicator of the effects of financial liberalization, as in Calvo and Mendoza, 1996), the budget surplus/GDP ratio, and so on.[8]

The determinants of bank crises that we considered in the basic canonical model are real GDP growth, inflation, and financial liberalization. These are found to be significant determinants (or associations) of banking crises by Demirgüç-Kunt and Detragiache (1998a) and Hutchison and McDill (1999). The financial liberalization data is from Demirgüç-Kunt and Detragiache (1998b), supplemented by national and international sources. It is constructed on the basis of the beginning of observed policy changes to liberalize interest rates, taking on a value of unity during the liberalized period of market-determined rates and zero otherwise.

Several other possible determinants of bank crises were considered but were not reported because they did not contribute significantly to the explanatory power of the model. These variables are real credit growth, nominal (and real) interest rate changes, the budget position of

[8] We also do not consider possible contagion effects during currency crises. See Glick and Rose (1999).



the general government, and explicit deposit insurance.[9] An index of stock prices was also considered and this entered significantly in determining the onset of banking crises (see Hutchison and McDill, 1999). However, stock price data was only available for a small sample of countries and was therefore not included in the base regressions.[10]

### 2.3.4 Data Sample and Windows

Our data sample is determined by the availability of data on currency market movements and banking sector health, as well as on the determinants of currency and bank crises, discussed above. We do not confine our analysis to countries experiencing banking or currency crises. We also include developed and developing countries that did not experience either a severe banking problem or currency crisis/speculative attack during the 1975–1997 sample period. Using such a broad control group allows us to make general statements about the conditions distinguishing between countries encountering crises and others managing to avoid crises.

The minimum data requirements to be included in our study are that GDP are available for a minimum of 10 consecutive years over the period 1975–1997. This requirement results in a sample of 90 countries. We group the countries into three categories: industrial countries (21), emerging economies with relatively open capital markets (32), and other developing and transition economies (37).[11] The particular countries included in our dataset are listed in Appendix 2A. For each country-year in our sample, we construct binary measures of currency and bank crises, as defined in Sections 2.3.1 and 2.3.2 (1 = crisis, 0 = no crisis); a currency crisis is deemed to have occurred for a given year if the change in currency pressure for any month in that year satisfies our criterion (i.e., two standard deviations above the mean). The dates of currency and bank crises are reported in Appendix 2B.

[9] Data on the existence of explicit deposit insurance come from the survey by Kyei (1995). We constructed a dummy variable that took on a value of unity if the country, at the time in question, had a formal system of deposit guarantee arrangements in place, and zero otherwise. In the Kyei study, 47 explicit arrangements were identified, as against 55 arrangements implicitly guaranteeing government support for deposits.

[10] External conditions may also matter, but they were not considered in our analysis. Eichengreen and Rose (1998) find evidence that higher interest rates and slower growth in industrial countries contribute to bank crises in emerging markets.

[11] Our emerging economy sample accords roughly with Furman and Stiglitz's variant (1998) of that used by Sachs, Tornell, and Velasco (1996), augmented to include Hong Kong and Uruguay but excluding China, Israel, the Ivory Coast, and Taiwan. The full developing country sample excludes major oil-exporting countries. The United States is excluded from the sample as well.

Of the 90 countries in our sample, 72 countries had banking problems, and 79 countries experienced at least one currency crisis at some point during the sample period. Several countries had multiple occurrences of banking crisis and most had multiple currency crises.

In most of our analysis we are concerned with predicting the onset of currency and banking crises and their relative timing. To reduce the chances of capturing the continuation of the same currency or banking episode, we impose windows on our data. In the case of currency crises, after identifying each "large" monthly change in currency pressure, we treat any large changes in the following 24-month window as a part of the same currency episode and omit the year of that change before continuing the identification of new crises. In the case of multiyear banking crises, we use only the first year in a spell of banking distress – that is, the year of the banking crisis "onset." The duration of banking sector distress was greater than one year in most episodes.

We use annual crisis observations in our study. Attempting to date banking crises by month (as in Kaminsky and Reinhart, 1999) or by quarter seems arbitrary. We employ monthly data for our (real) exchange rate pressure index to identify currency crises and date each by the year in which it occurs. Of course, annual data may obscure or limit some insights about the relative timing of the onset of currency and banking crises, because it does not enable us to distinguish the lead and lag timing of crises to the extent that crises occur at different points of the same year. However, we do not believe that it is possible to date banking crises with such precision as monthly data presumes. Moreover, using annual data enables inclusion of a relatively large number of countries in the analysis (Kaminsky and Reinhart focus on a sample of only 20 countries).

## 2.4 THE INCIDENCE OF BANKING AND CURRENCY CRISES

Table 2.1 summarizes the number and frequency of bank and currency crises according to our definitions and disaggregates them by 5-year time intervals and country development categories.[12] The table also reports the incidence of "twin" crises, defined as instances in which a bank crisis is accompanied by a currency crisis in either the previous, current, or following year.[13] The data for the developing countries are also disaggregated by geographic region.

[12] These figures refer to observations for which data for both bank and currency crises are available; that is, we exclude observations where banking crisis data are available while currency crisis data are not, and vice versa.

[13] A larger window would obviously increase the number of "twins" identified. For example, Kaminsky and Reinhart (1999), who define twin crises as bank crises followed by a currency crisis within four years, identify 19 twin crises over the period 1970–95

**Table 2.1.** Bank and Currency Crises

| | Time Distribution | | | | | |
|---|---|---|---|---|---|---|
| | 1975–1997 | 1975–1979 | 1980–1984 | 1985–1989 | 1990–1994 | 1995–1997 |
| Bank crises | | | | | | |
| Number | 90 | 6 | 16 | 21 | 30 | 17 |
| Frequency[a] | 5.0 | 1.6 | 4.2 | 5.3 | 7.2 | 6.8 |
| Currency crises | | | | | | |
| Number | 202 | 39 | 45 | 50 | 48 | 20 |
| Frequency[a] | 11.3 | 11.0 | 12.0 | 12.6 | 11.6 | 8.0 |
| "Twin" crises | | | | | | |
| Number | 37 | 3 | 5 | 8 | 11 | 10 |
| Frequency[a] | 2.1 | 0.8 | 1.3 | 2.0 | 2.6 | 4.0 |

| | Developmental and Geographic Distribution | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | Developing | | | |
| | Industrial | Developing | Emerging | Africa | Asia | Latin America | Other[b] |
| Bank crises | | | | | | | |
| Number | 19 | 71 | 46 | 21 | 15 | 26 | 9 |
| Frequency[a] | 4.4 | 5.2 | 6.6 | 5.8 | 5.0 | 5.1 | 4.8 |
| Currency crises | | | | | | | |
| Number | 42 | 160 | 78 | 59 | 29 | 53 | 19 |
| Frequency[a] | 9.6 | 11.8 | 11.2 | 16.5 | 9.6 | 10.4 | 10.2 |
| "Twin" crises | | | | | | | |
| Number | 7 | 30 | 23 | 11 | 7 | 8 | 4 |
| Frequency[a] | 1.6 | 2.2 | 3.3 | 3.1 | 2.3 | 1.6 | 2.2 |

*Note:* "Twin" crises are defined as banking crises accompanied by a currency crisis in previous, current, or following year.

[a] Number of crises divided by sum of country-years with and without crises during time interval, in percent.

[b] Includes Eastern Europe and the Middle East.

| | Currency crisis$_t$ | No currency crisis$_t$ |
|---|---|---|
| Bank crisis$_t$ | $A_{t,t}$ | $B_{t,t}$ |
| No bank crisis$_t$ | $C_{t,t}$ | $D_{t,t}$ |

Figure 2.1. Bank and currency crises matrix. *Note*: $A_{t,t}(B_{t,t})$ denotes the number of instances in which a bank crisis occurs in a particular year $t$, and it is (or is not) accompanied by a currency crisis in year $t$. $C_{t,t}(D_{t,t})$ denotes the number of instances in which there was no bank crisis in a particular year $t$, but it is (or is not) accompanied by a currency crisis in year $t$.

Our sample includes 90 banking crisis episodes and 202 currency crises; thus currency crises have been twice as common as bank crises.[14] Of the 90 bank crises, 37, (i.e., 41 percent) have been twins.

Observe that (the onset of) banking crises has increased over time: Bank crises have risen steadily both in number and frequency over our sample period and were four times as frequent in the 1990s as in the 1970s. However, the incidence of currency crises has been relatively constant. In fact, the number and frequency of currency crises were higher in the 1980s than in the 1990s. The frequency of twin crises appears to have risen in step with that of bank crises: In comparison to the 1975–1979 period, they were more than three times as frequent in 1990–1994 and were more than four times as frequent in 1995–1997.

Table 2.1 also indicates that individual banking and currency crises as well as twin crises have been more frequent in developing and emerging markets than in industrial countries. Banking and twin crises have been particularly evident in emerging markets. Among developing countries, the frequency of individual and twin crises has been highest in Africa.

Tables 2.2 and 2.3 present summary nonparametric indicators of the extent to which the onset of banking and currency crises are correlated with each other, using frequency statistics and signal-to-noise measures. Following the methodology of Kaminsky and Reinhart (1999) and Berg and Patillo (1999), consider the association of bank and currency crises in terms of Figure 2.1.

with their sample of 20 countries; we identify 37 such crises – less than twice as many – in a sample roughly four times as large. We implicitly consider a larger window for classifying twin crises when exploring lag relationships up to two years in length between bank and currency crises in the probit analysis in Section 2.5.

[14] With our alternative definition of currency crises [see footnote 6], we identify 94 banking crises and 210 currency crises.



**Table 2.2a.** Bank Crises and Frequency of Currency Crises (in percent)

| | Number of Bank Crises | Frequency of Accompanying Currency Crisis[a] | | | Cumulative Frequency of Accompanying Currency Crisis[b] |
|---|---|---|---|---|---|
| | | $t-1$ | $t$ | $t+1$ | |
| All countries | 90 | 11 | 16 | 15 | 41 |
| Developing countries | 71 | 10 | 18 | 15 | 42 |
| Emerging markets | 46 | 9 | 24 | 20 | 50 |

[a] Frequency with which onset of bank crisis in year $t$ is accompanied by currency crisis in year $t-1$, $t$, or $t+1$.
[b] Total of currency crises in years $t-1$, $t$, and $t+1$ divided by banking crises in year $t$.

**Table 2.2b.** Currency Crises and Frequency of Bank Crises (in percent)

| | Number of Currency Crises | Frequency of Accompanying Bank Crisis[a] | | | Cumulative Frequency of Accompanying Bank Crisis[b] |
|---|---|---|---|---|---|
| | | $t-1$ | $t$ | $t+1$ | |
| All countries | 202 | 7 | 7 | 5 | 18 |
| Developing countries | 160 | 7 | 8 | 5 | 19 |
| Emerging markets | 78 | 11 | 14 | 6 | 29 |

[a] Frequency with which currency crisis in year $t$ is accompanied by onset of bank crisis in year $t-1$, $t$, or $t+1$.
[b] Total of bank crisis onsets in years $t-1$, $t$, and $t+1$ divided by currency crises in year $t$.

The cell $A_{t,t}$ represents the number of instances in which a bank crisis occurring in a particular year $t$ was accompanied by a currency crisis in year $t$ (i.e., a bank crisis provides a "good signal" about the occurrence of currency crises); $B_{t,t}$ is the number of instances in which a banking crisis was not accompanied by currency crisis (i.e., a bank crisis provides a "bad signal" or "noise" about the occurrence of currency crises); $C_{t,t}$ is the number of instances in which banking performance failed to provide a good signal about a currency crisis that occurred; and $D_{t,t}$ is the number of instances in which neither a banking or currency crisis occurred. An analogous matrix can be constructed indicating the number of instances in which a banking crisis in year $t$ was preceded (followed) by a currency crisis in year $t-1$ ($t+1$), denoted by $A_{t,t-1}$ ($A_{t,t+1}$), etc.

Table 2.2 presents information about the association of the onset of banking and currency crises contemporaneously, one period before, and one period ahead for our sample. Table 2.2a shows the frequency with

which the onset of a bank crisis in year $t$ was accompanied by a currency crisis in either year $t, t-1$, or $t+1$ – that is, $A_{t,t-1} / (A_{t,t-1} + B_{t,t-1})$, $A_{t,t} / (A_{t,t} + B_{t,t})$, $A_{t,t+1} / (A_{t,t+1} + B_{t,t+1})$. The last column shows the *cumulative* frequency with which a bank crisis onset in year $t$ is accompanied by currency crises in years $t-1, t$, or $t+1$ – that is, $(A_{t,t-1} + A_{t,t} + A_{t,t+1}) / (A_{t,t} + B_{t,t})$. Table 2.2b shows the analogous measures of the frequency with which a currency crisis at time $t$ was accompanied by the onset of a bank crisis at either $t-1, t$, or $t+1$.

We calculate these frequencies for three different country data samples – all available industrial and developing countries (90 countries), developing countries (79 countries), and emerging markets only (32 countries). We are concerned here with the onset of either a banking or currency crisis. We do not use windows in this exercise to exclude observations immediately following or preceding the onset of a crisis; that is, the onset of a crisis is coded as unity and all other observations are coded as zero.

Comparing Tables 2.2a and 2.2b, observe that the frequency of banking crises associated with currency crises is higher than the frequency of currency crises associated with banking crises. The cumulative frequency with which the onset of a banking crisis is accompanied by a currency crisis within one year before or after is 40 percent or higher. Correspondingly, the onset of a currency crisis is accompanied by a banking crisis within one year by less than 20 percent of the time for the full and developing country samples, though the frequency rises to 29 percent for the emerging market sample.

Comparing the figures for the frequency of banking crises accompanied by currency crises in years $t-1$ and $t+1$ in Table 2.2a provides weak evidence that the frequency of currency crises accompanying banking crises is higher in year $t+1$ than in year $t-1$. This suggests that currency crises tend to lag banking crises or, equivalently, that banking crises tend to lead currency crises. This result is strongest for emerging market countries, where 20 percent of banking crises in year $t$ are accompanied by a currency crisis in year $t+1$, but only 9 percent at $t-1$.

Table 2.3 calculates the signal-to-noise association of banking and currency crises. Table 2.3a reports the signal-to-noise performance of banking crises as a lagging $(t-1)$, contemporaneous $(t)$, and leading $(t+1)$ indicator of currency crises. For the contemporaneous indicator, this is defined as the number of times a banking crisis is accompanied by a currency crisis (i.e., banking crises are good signals of currency crises) as a share of total currency crises (i.e., $A_{t,t} / (A_{t,t} + C_{t,t})$), all divided by the number of times a banking crisis is *not* accompanied by a currency crisis (i.e., banking crises are "noise" or bad signals of currency crises) as a share of all bank crises (i.e., $B_{t,t} / (A_{t,t} + B_{t,t})$). A signal-to-noise greater



**Table 2.3a.** Performance of Bank Crises as a Signal of Currency Crises

| | Good Signal/Noise Ratio of Currency Crises[a] | | |
|---|---|---|---|
| | $t-1$ | $t$ | $t+1$ |
| All countries | 0.98 | 1.44 | 1.42 |
| Developing countries | 0.82 | 1.66 | 1.35 |
| Emerging markets | 0.77 | 2.46 | 1.96 |

[a] Number of years in which the onset of a bank crisis in year $t$ is accompanied by a currency crisis in year $t-1, t$, or $t+1$ (i.e., bank crises are good signals) as a proportion of possible instances in which a currency crisis could have occurred, divided by the number of years a bank crisis in year $t$ is *not* accompanied by a currency crisis in year $t-1, t$, or $t+1$ (i.e., banking crises are "bad" signals) as a proportion of all bank crises.

**Table 2.3b.** Performance of Currency Crises as a Signal of Bank Crises

| | Good Signal/Noise Ratio of Bank Crises[a] | | |
|---|---|---|---|
| | $t-1$ | $t$ | $t+1$ |
| All countries | 1.38 | 1.40 | 0.98 |
| Developing countries | 1.32 | 1.59 | 0.82 |
| Emerging markets | 1.87 | 2.30 | 0.78 |

[a] Number of years a currency crisis in year $t$ is accompanied by a bank crisis onset in year $t-1, t$, or $t+1$ (i.e., currency crises are good signals) as a proportion of possible instances in which a bank crisis could have occurred, divided by the number of years a currency crisis in year $t$ is *not* accompanied by a bank crisis in year $t-1, t$, or $t+1$ (i.e., currency crises are "bad" signals) as a proportion of all currency crises.

than 1 implies that when banking crises occur, currency crises are more likely than not. Table 2.3b reports the corresponding signal-to-noise measures for currency crises as an indicator of banking crises.

Observe that for the full sample the signal-to-noise ratio of banking crises is higher for currency crises at time $t$ and $t+1$ than at time $t-1$. This is more pronounced for our developing country and emerging market samples. This suggests that banking crises tend to be contemporaneous and/or leading, rather than lagging, indicators of currency crises.

## 2.5 PROBIT EQUATION RESULTS

This section presents probit estimates involving currency and banking crises alone as well as with various macroeconomic and institutional determinants of currency and banking crises. Our use of probit models allows us to go beyond the bivariate relationship to focus on the joint contribution of macroeconomic and institutional variables to currency and banking crises.

We estimate the probability of either currency or banking sector crises using a multivariate probit model on an unbalanced panel dataset for both developing and developed countries over the 1975–1997 period (or years available). We observe that either a country at a particular time (observation $t$) is experiencing the onset of a crisis (i.e., the binary dependent variable, say $y_t$, takes on a value of unity) or it is not ($y_t = 0$). The probability that a crisis will occur, $\Pr(y_t = 1)$, is hypothesized to be a function of a vector of characteristics associated with observation $t$, $x_t$, and the parameter vector $\beta$. The likelihood function of the probit model is constructed across the $n$ observations (the number of countries times the number of observations for each country), and the log of the function is then maximized with respect to the unknown parameters using nonlinear maximum likelihood

$$\ln L = \sum_{t=1}^{n} [y_t \ln F(\beta' x_t) + (1 - y_t) \ln(1 - F(\beta' x_t))].$$

The function $F(\cdot)$ is the standardized normal distribution.

In these equations we employ windows following the onset of either a currency or a banking crisis, as discussed in Section 2.3.4. In the currency crisis equation, a 24-month window following the onset of a crisis (or episode of exchange rate pressure) was employed and we eliminated from the dataset these observations. Banking crises are not as frequent as currency crises, so overlapping observations are not a major problem, but the duration of banking crises is often quite long. We employ a window in these cases such that every year of a continuing banking crisis, except the initial or onset year, was eliminated from the dataset.

### 2.5.1 Bivariate Probits

We start with a discussion of the probit estimates for the currency and banking crisis onsets alone – that is, without controlling for macroeconomic variables. These results are reported in Tables 2.4a and 2.4b. Tables 2.5a and 2.5b report results with macroeconomic and other control variables included.[15]

[15] All probit equations are estimated by maximum likelihood using LIMDEP Windows version 7.0.

**Table 2.4a.** Probit Regression Estimates for Currency Crises

| Variable | All Countries | | | Developing Countries | | | Emerging Markets | | |
|---|---|---|---|---|---|---|---|---|---|
| Bank crisis$_t$ | 4.89 | 5.38 | 5.60 | 6.64* | 7.00* | 7.16* | 11.35*** | 12.26*** | 12.98*** |
| | (1.38) | (1.51) | (1.56) | (1.67) | (1.77) | (1.81) | (2.52) | (2.78) | (2.96) |
| Bank crisis$_{t-1}$ | | 4.71 | | | 4.58 | | | 10.58** | |
| | | (1.29) | | | (1.06) | | | (2.14) | |
| Bank crisis$_{t-1}$ or $_{t-2}$ | | | 4.48 | | | 3.86 | | | 11.03*** |
| | | | (1.63) | | | (1.19) | | | (2.98) |
| **Summary Statistics** | | | | | | | | | |
| Number of crises | 202 | 193 | 193 | 160 | 152 | 152 | 78 | 73 | 73 |
| Number of observations | 1,587 | 1,520 | 1,520 | 1,196 | 1,147 | 1,147 | 615 | 589 | 589 |
| Log likelihood | –604.0 | –576.7 | –576.2 | –469.3 | –446.7 | –446.6 | –230.9 | –215.3 | –213.3 |
| Pseudo-$R^2$ | 0.28 | 0.28 | 0.28 | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 | 0.30 |
| Quadratic probability score | 0.22 | 0.22 | 0.22 | 0.23 | 0.23 | 0.23 | 0.22 | 0.21 | 0.21 |
| Log probability score | 0.38 | 0.38 | 0.38 | 0.39 | 0.39 | 0.39 | 0.38 | 0.37 | 0.36 |
| **Goodness-of-Fit (25% Cutoff)[a]** | | | | | | | | | |
| Percentage of observations correctly called | 87 | 87 | 87 | 87 | 87 | 87 | 84 | 84 | 84 |
| Percentage of crises correctly called | 0 | 0 | 0 | 0 | 0 | 0 | 14 | 15 | 15 |
| Percentage of noncrises correctly called | 100 | 100 | 100 | 100 | 100 | 100 | 94 | 94 | 94 |
| **Goodness-of-Fit (10% Cutoff)[a]** | | | | | | | | | |
| Percentage of observations correctly called | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 12 | 78 |
| Percentage of crises correctly called | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 36 |
| Percentage of noncrises correctly called | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 84 |

*Note*: The table reports the change in the probability of a crisis in response to a 1 unit change in the variable evaluated at the mean of all variables (×100, to convert into percentages) with associated $z$-statistic (for hypothesis of no effect) in parentheses below. Significance at 10 percent level is denoted by *; at the 5 percent level by **; at the 1 percent level by ***. Constant included, but not reported.

[a] Goodness-of-fit statistics defined respectively as $(A + D) / (A + B + C + D)$, $A / (A + C)$, and $D / (B + D)$, where $A$ ($C$) denote number of crises with predictions of crises above (below) probability cutoff and $B$ ($D$) denote number of corresponding noncrises with predictions of crises above (below) the cutoff.

**Table 2.4b.** Probit Regression Estimates for Bank Crises Onsets

| Variable | All Countries | | | Developing Countries | | | Emerging Markets | | |
|---|---|---|---|---|---|---|---|---|---|
| Currency crisis$_t$ | 2.70 | 2.85 | 3.21* | 3.80* | 3.88* | 4.31** | 9.72*** | 10.97*** | 11.26*** |
| | (1.54) | (1.52) | (1.78) | (1.94) | (1.82) | (2.10) | (3.15) | (3.29) | (3.40) |
| Currency crisis$_{t-1}$ | | 1.06 | | | 0.28 | | | 1.44 | |
| | | (0.53) | | | (0.11) | | | (0.34) | |
| Currency crisis$_{t-1}$ or $_{t-2}$ | | | 2.16 | | | 1.61 | | | 2.71 |
| | | | (1.49) | | | (0.92) | | | (0.89) |
| **Summary Statistics** | | | | | | | | | |
| Number of crises | 90 | 87 | 89 | 71 | 69 | 71 | 46 | 46 | 46 |
| Number of observations | 1,537 | 1,443 | 1,470 | 1,152 | 1,079 | 1,103 | 562 | 530 | 536 |
| Log likelihood | –341.6 | –327.5 | –333.5 | –264.8 | –254.9 | –261.1 | –154.5 | –151.3 | –151.4 |
| Pseudo-$R^2$ | 0.20 | 0.20 | 0.21 | 0.21 | 0.21 | 0.21 | 0.25 | 0.26 | 0.26 |
| Quadratic probability score | 0.11 | 0.11 | 0.11 | 0.12 | 0.12 | 0.12 | 0.15 | 0.15 | 0.15 |
| Log probability score | 0.22 | 0.23 | 0.23 | 0.23 | 0.24 | 0.24 | 0.27 | 0.29 | 0.28 |
| **Goodness-of-Fit (25% Cutoff)[a]** | | | | | | | | | |
| Percentage of observations correctly called | 94 | 94 | 94 | 94 | 94 | 94 | 92 | 91 | 92 |
| Percentage of crises correctly called | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Percentage of noncrises correctly called | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| **Goodness-of-Fit (10% Cutoff)[a]** | | | | | | | | | |
| Percentage of observations correctly called | 94 | 94 | 93 | 85 | 85 | 85 | 86 | 86 | 87 |
| Percentage of crises correctly called | 0 | 0 | 2 | 18 | 17 | 18 | 24 | 24 | 24 |
| Percentage of noncrises correctly called | 100 | 100 | 99 | 89 | 90 | 90 | 92 | 92 | 92 |

*Note*: See Table 2.4a.



**Table 2.5a.** Probit Regression Estimates for Currency Crises

| Variable | All Countries | | | Developing Countries | | | Emerging Markets | | |
|---|---|---|---|---|---|---|---|---|---|
| Overvaluation$_{t-1}$ | 0.26*** | 0.25*** | 0.24*** | 0.23*** | 0.22*** | 0.21*** | 0.22*** | 0.21*** | 0.18*** |
| | (6.83) | (6.76) | (6.26) | (5.81) | (5.74) | (5.31) | (4.23) | (4.08) | (3.54) |
| Ln (M2/reserves)$_{t-1}$ | 0.96 | 0.96 | 1.11 | 1.58* | 1.59* | 1.62* | 3.19*** | 3.19*** | 3.11*** |
| | (1.23) | (1.26) | (1.42) | (1.80) | (1.81) | (1.82) | (2.64) | (2.68) | (2.61) |
| Export growth$_{t-1}$ | –0.05 | –0.05 | –0.05 | –0.05 | –0.05 | –0.06 | –0.16** | –0.16** | –0.17** |
| | (1.16) | (1.20) | (1.06) | (1.14) | (1.19) | (1.22) | (2.03) | (2.00) | (2.11) |
| Bank crisis onset$_t$ | | 4.26 | 4.76 | | 5.01 | 5.72 | | 8.82** | 10.51** |
| | | (1.22) | (1.35) | | (1.30) | (1.48) | | (2.10) | (2.54) |
| Bank crisis onset$_{t-1}$ or $_{t-2}$ | | | 2.60 | | | 3.65 | | | 8.69** |
| | | | (0.92) | | | (1.16) | | | (2.40) |
| **Summary Statistics** | | | | | | | | | |
| Number of crises | 183 | 183 | 174 | 151 | 151 | 143 | 78 | 78 | 73 |
| Number of observations | 1,471 | 1,471 | 1,408 | 1,145 | 1,145 | 1,097 | 601 | 601 | 575 |
| Log likelihood | –522.5 | –521.8 | –499.0 | –421.3 | –420.5 | –400.8 | –213.1 | –211.0 | –196.9 |
| Pseudo-$R^2$ | 0.32 | 0.32 | 0.31 | 0.32 | 0.32 | 0.32 | 0.34 | 0.35 | 0.35 |
| Quadratic probability score | 0.21 | 0.21 | 0.21 | 0.22 | 0.22 | 0.22 | 0.21 | 0.21 | 0.20 |
| Log probability score | 0.36 | 0.35 | 0.35 | 0.37 | 0.37 | 0.37 | 0.35 | 0.35 | 0.34 |
| **Goodness-of-Fit (25% Cutoff)[a]** | | | | | | | | | |
| Percentage of observations correctly called | 87 | 86 | 86 | 86 | 86 | 85 | 86 | 86 | 86 |
| Percentage of crises correctly called | 13 | 12 | 11 | 15 | 15 | 13 | 21 | 23 | 30 |
| Percentage of noncrises correctly called | 97 | 97 | 97 | 96 | 96 | 96 | 96 | 95 | 94 |
| **Goodness-of-Fit (10% Cutoff)[a]** | | | | | | | | | |
| Percentage of observations correctly called | 46 | 47 | 47 | 44 | 45 | 47 | 53 | 56 | 58 |
| Percentage of crises correctly called | 79 | 79 | 79 | 79 | 78 | 79 | 82 | 82 | 81 |
| Percentage of noncrises correctly called | 41 | 43 | 42 | 39 | 40 | 42 | 48 | 52 | 55 |

*Note*: See Table 2.4a.

**Table 2.5b.** Probit Regression Estimates for Bank Crisis Onsets

| Variable | All Countries | | | Developing Countries | | | Emerging Markets | | |
|---|---|---|---|---|---|---|---|---|---|
| Inflation$_t$ | 0.02* | 0.02* | 0.02* | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.01 |
| | (1.88) | (1.68) | (1.74) | (0.61) | (0.41) | (0.56) | (0.23) | (0.07) | (0.26) |
| Output growth$_t$ | −0.56*** | −0.54*** | −0.58*** | −0.65*** | −0.60*** | −0.68*** | −1.42*** | −1.20*** | −1.43*** |
| | (3.64) | (3.30) | (3.40) | (3.56) | (3.22) | (3.40) | (4.08) | (3.53) | (3.80) |
| Financial liberalization$_t$ | 7.74*** | 7.96*** | 7.99*** | 9.82*** | 9.82*** | 10.11*** | 6.13* | 6.96** | 5.68 |
| | (5.28) | (5.26) | (4.91) | (5.18) | (5.18) | (4.97) | (1.84) | (2.16) | (1.63) |
| Currency crisis$_t$ | | 4.26** | 4.41** | | 6.04** | 6.09** | | 11.26*** | 11.03*** |
| | | (2.26) | (2.21) | | (2.53) | (2.38) | | (3.06) | (2.77) |
| Currency crisis$_{t-1}$ or $_{t-2}$ | | | 0.08 | | | −1.12 | | | −2.22 |
| | | | (0.04) | | | (0.47) | | | (0.54) |
| **Summary Statistics** | | | | | | | | | |
| Number of crises | 60 | 58 | 57 | 43 | 42 | 42 | 33 | 33 | 33 |
| Number of observations | 960 | 903 | 862 | 560 | 545 | 521 | 336 | 335 | 320 |
| Log likelihood | −200.8 | −190.4 | −186.3 | −131.1 | −124.4 | −123.2 | −92.9 | −87.9 | −85.7 |
| Pseudo-$R^2$ | 0.32 | 0.33 | 0.33 | 0.36 | 0.37 | 0.38 | 0.35 | 0.38 | 0.39 |
| Quadratic probability score | 0.11 | 0.11 | 0.11 | 0.13 | 0.12 | 0.13 | 0.16 | 0.15 | 0.15 |
| Log probability score | 0.21 | 0.21 | 0.22 | 0.23 | 0.23 | 0.24 | 0.28 | 0.26 | 0.27 |
| **Goodness-of-Fit (25% Cutoff)**[a] | | | | | | | | | |
| Percentage of observations correctly called | 94 | 94 | 94 | 92 | 90 | 90 | 89 | 89 | 88 |
| Percentage of crises correctly called | 7 | 12 | 12 | 14 | 19 | 19 | 21 | 33 | 33 |
| Percentage of noncrises correctly called | 99 | 99 | 99 | 98 | 96 | 96 | 96 | 95 | 94 |
| **Goodness-of-Fit (10% Cutoff)**[a] | | | | | | | | | |
| Percentage of observations correctly called | 85 | 85 | 85 | 72 | 78 | 77 | 74 | 76 | 76 |
| Percentage of crises correctly called | 50 | 48 | 49 | 77 | 76 | 74 | 70 | 76 | 79 |
| Percentage of noncrises correctly called | 87 | 87 | 87 | 71 | 78 | 77 | 75 | 76 | 75 |

*Note*: See Table 2.4a.



In each table we report the effect of a one-unit change in each regressor on the probability of a crisis (expressed in percentage points so that 0.01 = 1%), evaluated at the mean of the data. We include the associated $z$-statistics in parentheses; these test the null of no effect. Note that the sample size of the multivariate probit analysis varies depending on the set of variables considered.

We also report various diagnostic measures. The in-sample probability forecasts are evaluated with "pseudo" $R^2$ statistics and analogs of a mean squared error measure, the quadratic probability score (QPS), and the log probability score (LPS), which evaluate the accuracy of probability forecasts. The QPS ranges from zero to 2, and the LPS ranges from zero to infinity, with a score of zero corresponding to perfect accuracy for both.[16] For dependent binary variables, it is natural to ask what fraction of the observations are "correctly called," where, for example, a crisis episode is correctly called when the estimated probability of crisis is above a given cutoff level and a crisis occurs. Such "goodness-of-fit" statistics are shown for two probability cutoffs: 25 percent and 10 percent.

Table 2.4a shows the simple bivariate link between the onset of currency and banking crises. In addition to contemporaneous links, we consider a simple one-year lagged effect of bank crisis onsets as well as a composite lag if a bank crisis began in either of the two previous years. It is apparent from these tables that currency crises are contemporaneously and significantly correlated with bank crises for the emerging market and developing country samples, but not for the full sample of countries. Lagged banking crises, occurring within the past two years, also help to predict the onset of currency crises in emerging markets. Past banking crises, however, do not help predict the onset of currency crises in either the developing country sample or the full set of countries.

Table 2.4b reports the corresponding bivariate results for probit regressions of currency crises on the onset of banking crises. Contemporaneous, but not lagged, currency crises help explain bank crises in the developing and emerging market samples. The contemporaneous link is

[16] For each of the methods we can generate $n$ probability forecasts where $P_t$ is the probability of a crisis in the period $t$, $0 \le P_t \le 1$. $R_t$ is the actual times series of observations; $R_t = 1$ if a crisis occurs at time $t$ and equals zero otherwise. The analog to the mean squared error for probability forecasts is the QPS:

$$\text{QPS} = \frac{1}{n}\sum_{t=1}^{n} 2(P_t - R_t)^2$$

Large errors are penalized more heavily under the LPS, given by

$$\text{LPS} = \frac{1}{n}\sum_{t=1}^{n} [(1 - R_t)\ln(1 - P_t) + R_t \ln(P_t)]$$

weaker for the full sample of countries; that is, it is statistically significant at the 10 percent level in only one formulation of the model. Thus lagged banking crises help predict currency crises in the emerging markets sample, but not vice versa. This asymmetric result, albeit for a different and smaller sample of countries, is consistent with the findings of Kaminsky and Reinhart (1999).[17]

### 2.5.2 Multivariate Probits

Table 2.5a reports the results where the onset of currency crises are explained by both the onset of banking crises and a parsimonious set of (lagged) macroeconomic variables – that is, our canonical model. These results are generally consistent with our priors. That is, the probability of a currency crisis generally rises with greater real overvaluation, higher ratio of the log of M2-reserves ratio, and lower export growth. Overvaluation and the M2-reserves are generally significant for all of our three country samples; export growth is significant only for the emerging country sample.

The bank crisis variable, as an additional explanatory factor, is only significant for the emerging country sample. As with the bivariate results, lagged as well as contemporaneous bank crises help to predict future currency crises.[18]

Analogous probit equations for the onset of bank crises with contemporaneous macro and institutional control variables are reported in Table 2.5b.[19] A decline in output growth and greater financial liberalization, as measured by a "liberalized" interest rate structure, are each highly correlated with the onset of banking sector distress. Inflation is only correlated with the onset of banking sector distress in the full sample, apparently proxying for the developing economies (developing economies have a higher probability of having a banking crisis and also tend to have higher inflation than industrialized economies). It is noteworthy that the macroeconomic variables do not generally help predict the onset of a future banking crisis; that is, results (unreported) with lagged values of the macroeconomic variables are insignificant.

It is apparent that the onset of banking sector distress is highly correlated with currency crises, as indicated by the contemporaneous association reported in Table 2.5b. In contrast with the results in the previous table, the significance levels for the contemporaneous correlation between the onset of banking crises and currency crises range from 1 to 5 percent in all three groups of countries; that is, the correlation holds not just in the emerging market sample, but also in the developing country and full country samples. Once again we find no future predictive power associated with currency crises: Lagged currency crises are not significant in explaining the onset of bank crises onsets in any of our samples. Lagged banking crises help predict currency crises in the emerging markets sample, but not vice versa.

[17] In contrast, Eichengreen and Rose (1998) find that neither contemporaneous nor lagged currency "crashes" are significant in explaining bank crises for a large sample of developing countries.

[18] These results are robust to excluding all 1997 observations, including the recent Asia crisis episodes, from the dataset.

[19] Fewer observations are available for the bank crisis equations than for the currency crisis equations, primarily because of limited availability of financial liberalization data.



### 2.5.3 Simultaneous Equation Probits

We have found significant contemporaneous correlation between banking and currency crises with single equation probit estimation procedures. Table 2.6 shows the model estimates based on simultaneous equation estimates of both the banking sector onset and currency crisis equations.[20] As the table indicates, the basic results for the emerging markets sample are robust. There is clear joint causality between the onset of currency and banking crises in the emerging markets sample. However, no contemporaneous association is seen in the developing country sample (in contrast with Tables 2.4a, 2.4b, and 2.5b) or in the full group of countries (in contrast with Tables 2.4b and 2.5b).

In summary, these results suggest a very strong and robust contemporaneous correlation among the onset of banking and currency crises in emerging market countries, even when controlling for simultaneity bias and a multitude of other explanatory factors such as financial liberalization, export growth, real GDP growth, and so on. There is weaker evidence of this contemporaneous link with a broader sample of developing countries and for the full sample of countries. The other strong result that emerges is that banking crises are a statistically significant leading indicator of currency crises in emerging markets.

### 2.5.4 Predicted Crisis Probabilities

To further illustrate the magnitude of the links between currency and bank crises, we examine how this association affects predicted crisis probabilities. Figure 2.2 reports crisis probabilities implied by the single-

[20] Our simultaneous equation methodology follows Maddala (1983, pp. 246–247), which describes the procedure for estimating the structural coefficients and standard errors in a two-equation system where both dependent binary variables (in a probit context) are endogenous. The two-step procedure involves first estimating the reduced forms for each endogenous crisis variable as a function of all exogenous and predetermined variables by probit, then calculating the fitted values of the endogenous variables implied by the reduced forms, and lastly using these fitted values as independent variables in the structural probit equations. The covariance matrices are calculated as in Maddala (1983, p. 247). We do not use lags of our endogenously determined crisis variables in these calculations. We assume that all other explanatory variables are exogenous.

**Table 2.6.** Simultaneous Probit Regression Estimates

| Variable | All Countries | | Developing Countries | | Emerging Markets | |
|---|---|---|---|---|---|---|
| | Currency Crisis | Bank Crisis | Currency Crisis | Bank Crisis | Currency Crisis | Bank Crisis |
| Overvaluation$_{t-1}$ | 0.24*** | | 0.16*** | | 0.16* | |
| | (4.46) | | (2.58) | | (1.84) | |
| Ln (M2/reserves)$_{t-1}$ | 1.88 | | 4.11** | | 4.08* | |
| | (1.51) | | (2.28) | | (1.84) | |
| Export growth$_{t-1}$ | –0.05 | | –0.06 | | –0.18 | |
| | (0.68) | | (0.76) | | (1.52) | |
| Bank crisis onset$_t$ | 1.82 | | 4.16 | | 7.44*** | |
| | (0.74) | | (1.53) | | (2.64) | |
| Inflation$_t$ | | 0.02 | | 0.00 | | –0.00 |
| | | (1.44) | | (0.14) | | (0.18) |
| Output growth$_t$ | | –0.38** | | –0.48** | | –0.74* |
| | | (2.09) | | (2.02) | | (1.66) |
| Fin. liberalization$_t$ | | 7.98*** | | 11.18*** | | 9.61** |
| | | (3.54) | | (4.00) | | (2.18) |
| Currency crisis$_t$ | | 3.48 | | 5.04 | | 8.43** |
| | | (1.26) | | (1.44) | | (2.30) |
| **Summary Statistics** | | | | | | |
| Number of crises | 83 | 47 | 58 | 39 | 35 | 32 |
| Number of observations | 730 | 730 | 463 | 463 | 303 | 303 |
| Log likelihood | –242.3 | –158.0 | –160.4 | –116.4 | –92.6 | –84.8 |
| Pseudo-$R^2$ | 0.31 | 0.30 | 0.34 | 0.36 | 0.38 | 0.40 |
| Quadratic probability score | 0.18 | 0.20 | 0.20 | 0.21 | 0.18 | 0.19 |
| Log probability score | 0.32 | 0.38 | 0.34 | 0.41 | 0.31 | 0.33 |
| **Goodness-of-Fit (25% Cutoff)** | | | | | | |
| Percentage of observations correctly called | 88 | 94 | 87 | 91 | 86 | 87 |
| Percentage of crises correctly called | 12 | 13 | 19 | 18 | 34 | 34 |
| Percentage of noncrises correctly called | 98 | 99 | 97 | 98 | 93 | 94 |
| **Goodness-of-Fit (10% Cutoff)** | | | | | | |
| Percentage of observations correctly called | 55 | 85 | 55 | 68 | 66 | 70 |
| Percentage of crises correctly called | 80 | 45 | 83 | 74 | 77 | 72 |
| Percentage of noncrises correctly called | 52 | 88 | 51 | 68 | 64 | 69 |

*Note*: See Table 4.2a.

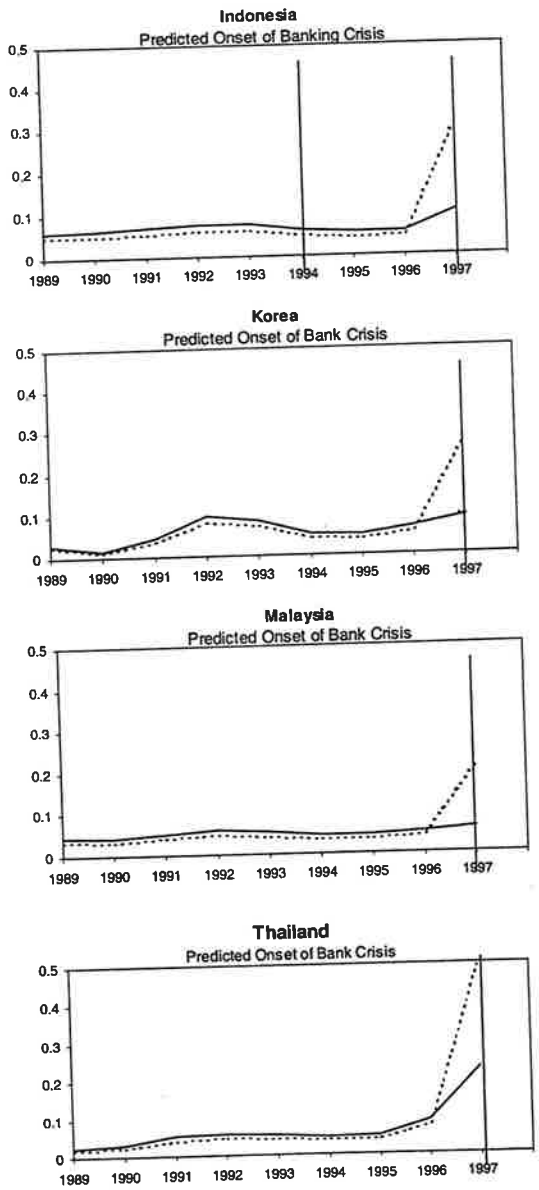


Figure 2.2. Crisis probability predictions. *Note*: Solid lines indicate currency (bank) crisis probabilities implied by benchmark probit equations. Dashed lines indicate currency (bank) crisis probabilities implied by probit equations augmented to include the contemporaneous and composite lagged occurrence of bank (currency) crises. Vertical lines denote the actual occurrence of a crisis.



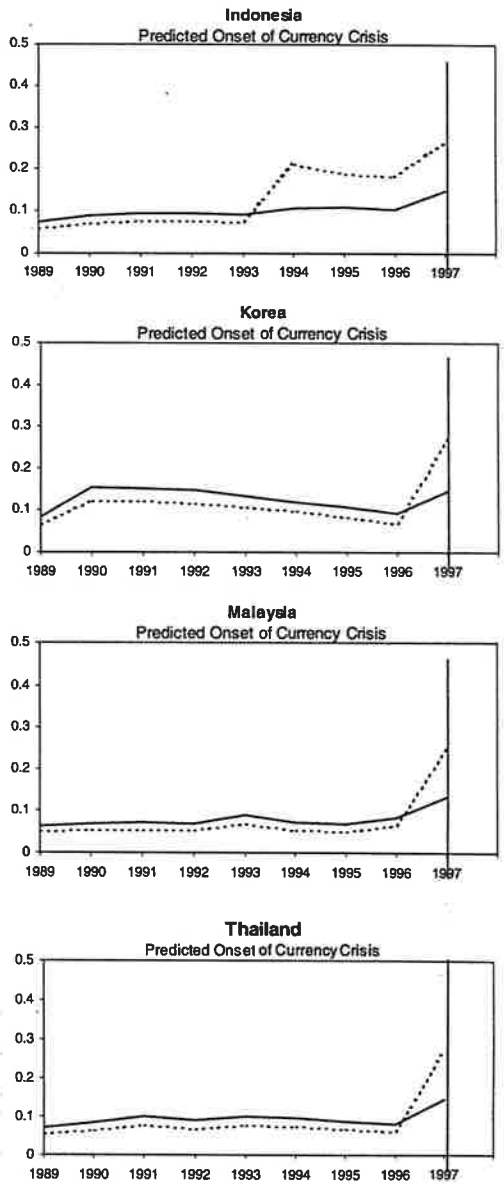


Figure 2.2 (*continued*)

equation probit estimates in Tables 2.5a and 2.5b for four East Asian emerging market economies – Korea, Malaysia, Indonesia, and Thailand – for the period 1989 to 1997. Two graphs are shown for each country: One depicts the probability predictions for the onset of banking sector distress, while the second depicts the onset of currency crises. Two prediction lines are plotted in each graph: The solid line plots the predicted crisis probabilities implied by the benchmark "canonical" probit estimates based only on macroeconomic and institutional variables, while the dashed line plots the predicted probabilities for currency (bank) crises implied by augmenting the benchmark canonical model to include the occurrence of contemporaneous and lagged bank (currency) crises. Vertical lines indicate the actual occurrence of a crisis.

Observe that the predicted probabilities of both currency and bank crises based on the benchmark model increase in all four countries at the time of the 1997 Asian crisis. Including information about the occurrence of other crises causes the predicted probabilities to increase even more sharply. (The occurrence of a banking crisis in Korea in 1994 causes the predicted probability of a currency crisis to rise even earlier.)

It should be emphasized that these plots are intended not to show the predictive power of our model, but rather to illustrate the statistical importance of linkages between banking and currency crises.[21]

## 2.6 CONCLUSIONS

This chapter investigates the relative timing of the occurrence of banking and currency crises over the 1975–1997 period. For our sample of 90 countries, 72 had at least one case of a serious banking problem and 79 experienced at least one currency crisis at some point during the sample period. Several countries experienced multiple occurrences of banking crisis, and most had multiple currency crises. A total of 90 banking crisis episodes, 202 currency crises, and 37 twin crises were identified. While the relative frequency of individual banking and twin crises has increased over time, the frequency of currency crises has been relatively constant. Developing and emerging market countries suffered both banking and currency crises more often than industrial countries.

The twin crisis phenomenon, however, is mainly concentrated in a limited set of countries, namely, financially liberalized emerging-market economies. Summary statistics indicate an association between crises in broader country groupings (including lesser developed and industrial countries), but we find a robust link only in emerging markets. In emerging markets, banking crises (currency crises) have been associated with currency crises (banking crises) almost 50 percent (30 percent) of the time. This result holds up to a variety of tests: signal-to-noise ratios, bivariate probit regressions, multivariate probit equations, and simultaneous probit estimates. A strong causal, joint feedback, link between banking and currency crises appears only in this group of countries.

This result implies that, at least in financially liberalized emerging-market economies, policy measures taken to help avoid a banking crisis (currency crisis) have the additional benefit of lowering the probability of a currency (banking) crisis. Thus, measures to limit the exposure of balance sheets and enhance confidence in the banking sector may reduce the incentives for capital flight and currency runs. Similarly, policies designed to promote exchange rate stability appear capable of fostering broader stability in domestic banking institutions.

Our analysis also provides evidence that banking crises provide some leading information about the possibility of future foreign exchange instability, though again only for our emerging markets group. Currency crises, by contrast, were not a good leading indicator of impending banking problems. The power of banking crises to predict future currency instability does not appear to be due to a common experience with financial liberalization (or other factors) because this is explicitly taken into account by other variables in our estimation procedure. Instead, it might reflect the footloose nature of capital flows into emerging markets, where the onset of banking problems can quickly lead to capital flight and both current and future currency crises.

[21] It should be noted that these are in-sample probability predictions. An alternative approach is to generate out-of-sample probabilities for 1997 based on estimates generated from data through 1996.



### APPENDIXES

**Appendix 2A.** Countries Included in Dataset

| Industrial Countries | Emerging Markets | Other Developing Countries |
|---|---|---|
| Austria | Argentina | Belize |
| Belgium | Bangladesh | Bolivia |
| Canada | Botswana | Burundi |
| Denmark | Brazil | Cameroon |
| Finland | Chile | Costa Rica |
| France | Colombia | Cyprus |
| Germany | Ecuador | Dominican Republic |
| Greece | Egypt | El Salvador |
| Iceland | Hong Kong | Equatorial Guinea |
| Ireland | Ghana | Ethiopia |
| Italy | India | Fiji |
| Japan | Indonesia | Grenada |
| Luxembourg | Jordan | Guatemala |

(continued)

**Appendix 2A** (*continued*)

| Industrial Countries | Emerging Markets | Other Developing Countries |
|---|---|---|
| Netherlands | Kenya | Guinea-Bissau |
| New Zealand | Korea | Guyana |
| Norway | Malaysia | Haiti |
| Portugal | Mauritius | Honduras |
| Spain | Mexico | Hungary |
| Sweden | Morocco | Jamaica |
| Switzerland | Pakistan | Lao P.D. Republic |
| United Kingdom | Peru | Madagascar |
| | Philippines | Malawi |
| | Singapore | Mali |
| | South Africa | Malta |
| | Sri Lanka | Mozambique |
| | Thailand | Myanmar |
| | Trinidad and Tobago | Nepal |
| | Tunisia | Nicaragua |
| | Turkey | Nigeria |
| | Uruguay | Panama |
| | Venezuela | Paraguay |
| | Zimbabwe | Romania |
| | | Sierra Leone |
| | | Swaziland |
| | | Syrian Arab Republic |
| | | Uganda |
| | | Zambia |

*Note*: The "All Country" sample includes "Industrial Countries," "Emerging Markets," and "Other Developing Countries"; the "Developing Country" sample includes "Emerging Markets" and "Other Developing Countries."

**Appendix 2B.** Occurrences of Banking and Currency Crises

| | Banking Crises[a] | Currency Crises[b] | Financial Liberalization[c] |
|---|---|---|---|
| United Kingdom | 1975–1976, 1984 | 1976, 1979, 1982, 1986, 1992 | 1975–1997 |
| Austria | | | 1975–1997 |
| Belgium | | 1982 | 1986–1997 |
| Denmark | 1987–1992 | | 1981–1997 |
| France | 1994–1995 | 1982 | 1975–1997 |
| Germany | 1978–1979 | | 1975–1997 |
| Italy | 1990–1995 | 1976, 1992, 1995 | 1975–1997 |
| Luxembourg | | | NA |
| Netherlands | | | 1975–1997 |



| | Banking Crises[a] | Currency Crises[b] | Financial Liberalization[c] |
|---|---|---|---|
| Norway | 1987–1993 | 1978, 1986, 1992 | 1984–1997 |
| Sweden | 1990–1993 | 1977, 1981, 1992 | 1980–1997 |
| Switzerland | | 1978 | 1989–1997 |
| Canada | 1983–1985 | 1976, 1992 | 1975–1997 |
| Japan | 1992–1997 | 1979, 1989 | 1985–1997 |
| Finland | 1991–1994 | 1977, 1982, 1991 | 1986–1997 |
| Greece | 1991–1995 | 1980, 1982, 1985 | 1975–1997 |
| Iceland | 1985–1986, 1993 | 1983, 1988, 1992 | NA |
| Ireland | | | 1985–1997 |
| Malta | | 1992, 1997 | NA |
| Portugal | 1986–1989 | 1976, 1978, 1982, 1993 | 1984–1997 |
| Spain | 1977–1985 | 1976, 1983, 1992 | 1975–1997 |
| Turkey | 1982–1985, 1991, 1994–1995 | 1978, 1994 | 1980–1982, 1984–1997 |
| New Zealand | 1987–1990 | 1975, 1983, 1988, 1991 | 1980, 1984–1997 |
| South Africa | 1977, 1985, 1989 | 1975, 1978, 1984, 1996 | NA |
| Argentina | 1980–1982, 1989–1990, 1995–1997 | 1975, 1982, 1989 | 1977–1997 |
| Bolivia | 1986–1987, 1994–1997 | 1981, 1983, 1988, 1991 | 1985–1997 |
| Brazil | 1990, 1994–1997 | 1982, 1987, 1990, 1995 | 1975–1997 |
| Chile | 1976, 1981–1983 | 1985 | 1975–1997 |
| Colombia | 1982–1987 | 1985 | 1980–1997 |
| Costa Rica | 1987, 1994–1997 | 1981 | NA |
| Dominican Republic | | 1985, 1987, 1990 | NA |
| Ecuador | 1980–1982, 1996–1997 | 1982, 1985, 1988 | 1986–1987, 1992–1997 |
| El Salvador | 1989 | 1986, 1990 | 1991–1997 |
| Guatemala | 1991–1992 | 1986, 1989 | 1989–1997 |
| Haiti | | 1977, 1991 | NA |
| Honduras | | 1990 | 1990–1997 |
| Mexico | 1981–1991, 1995–1997 | 1976, 1982, 1985, 1994 | 1989–1997 |
| Nicaragua | 1988–1996 | 1993 | NA |
| Panama | 1988–1989 | | NA |
| Paraguay | 1995–1997 | 1984, 1986, 1988, 1992 | 1990–1997 |

(continued)

**Appendix 2B** (*continued*)

| | Banking Crises[a] | Currency Crises[b] | Financial Liberalization[c] |
|---|---|---|---|
| Peru | 1983–1990 | 1976, 1979, 1987 | 1980–1984, 1990–1997 |
| Uruguay | 1981–1984 | 1982 | 1976–1997 |
| Venezuela | 1978–1986, 1994–1997 | 1984, 1986, 1989, 1994 | 1981–1983, 1989–1997 |
| Grenada | | 1978 | NA |
| Guyana | 1993–1995 | 1978, 1989 | 1991–1997 |
| Belize | | | NA |
| Jamaica | 1994–1997 | 1978, 1983, 1990 | 1991–1997 |
| Trinidad & Tobago | 1982–1993 | 1985, 1988, 1993 | NA |
| Cyprus | | | NA |
| Jordan | 1989–1990 | 1983, 1987, 1989, 1992 | 1988–1997 |
| Syrian Arab Republic | | 1977, 1982, 1988 | No liberalization |
| Egypt | 1980–1985, 1991–1995 | 1979, 1989 | 1991–1997 |
| Bangladesh | 1987–1996 | 1975 | NA |
| Myanmar | 1996–1997 | 1975, 1977 | NA |
| Sri Lanka | 1989–1993 | 1977 | 1980–1997 |
| China, P.R.: Hong Kong | 1982–1986 | | NA |
| India | 1993–1997 | 1976, 1991, 1995 | 1991–1997 |
| Indonesia | 1994, 1997 | 1978, 1983, 1986, 1997 | 1983–1997 |
| Korea | 1997 | 1980, 1997 | 1984–1997 |
| Lao People's D. R. | 1991–1994, 1997 | 1995 | NA |
| Malaysia | 1985–1988, 1997 | 1986, 1997 | 1978–1997 |
| Nepal | 1988–1994 | 1975, 1981, 1984, 1991, 1995 | NA |
| Pakistan | | | NA |
| Philippines | 1981–1987, 1997 | 1983, 1986, 1997 | 1981–1997 |
| Singapore | 1982 | 1975 | NA |
| Thailand | 1983–1987, 1997 | 1981, 1984, 1997 | 1989–1997 |
| Botswana | 1994–1995 | 1984, 1996 | NA |
| Burundi | 1994–1997 | 1976, 1983, 1986, 1989, 1997 | NA |
| Cameroon | 1987–1993, 1995–1997 | 1982, 1984, 1994 | NA |
| Equatorial Guinea | 1983–1985 | 1991, 1994 | NA |
| Ethiopia | 1994–1995 | 1992 | NA |
| Ghana | 1982–1989, 1997 | 1978, 1983, 1986 | NA |



| | Banking Crises[a] | Currency Crises[b] | Financial Liberalization[c] |
|---|---|---|---|
| Guinea-Bissau | 1995–1997 | 1991, 1996 | NA |
| Kenya | 1985–1989, 1992–1997 | 1975, 1981, 1985, 1993, 1995, 1997 | 1991–1997 |
| Madagascar | 1988 | 1984, 1986, 1991, 1994 | NA |
| Malawi | | 1982, 1985, 1992, 1994 | NA |
| Mali | 1987–1989 | 1993 | No liberalization |
| Mauritius | 1996 | 1979 | NA |
| Morocco | | 1983, 1990 | NA |
| Mozambique | 1987–1997 | 1993, 1995 | NA |
| Nigeria | 1993–1997 | 1986, 1989, 1992 | 1990–1993 |
| Zimbabwe | 1995–1997 | 1982, 1991,1994, 1997 | NA |
| Sierra Leone | 1990–1997 | 1988, 1990, 1997 | NA |
| Swaziland | 1995 | 1975, 1979, 1982, 1984 | NA |
| Tunisia | 1991–1995 | 1993 | NA |
| Uganda | 1994–1997 | 1981, 1987, 1989 | 1991–1997 |
| Zambia | 1995 | 1985, 1994 | 1992–1997 |
| Fiji | | 1986 | NA |
| Hungary | 1991–1995 | 1989, 1994 | NA |
| Romania | 1990–1997 | 1990 | NA |

[a] Banking crisis onsets defined as first year of period of bank distress.
[b] Currency crisis defined by criteria described in text, with 24-month exclusion windows between crisis imposed.
[c] Years in sample with liberalized domestic interest rates. NA denotes information not available.

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