Working Paper No. 366
Common determinants of currency crises: role of external balance sheet variables
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April 2009

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Abstract

This paper investigates the role of external balance sheet variables as determinants of currency crises in emerging market (EME) and advanced economies. A random effect probit model is used in a panel of 40 countries with monthly data over the January 1980–December 2004 period. The main results of the paper are as follows. First, size and, particularly, the composition of a country's external balance sheet are found to play an important role in the onset of crises. Second, EMEs seem to be more sensitive to external balance sheet variables than developed countries, and so too do economies with fixed or quasi-fixed exchange rate regimes. Third, further support is provided to standard theoretical explanations of currency crises. The likelihood of a crisis is found to increase with: the extent to which the real exchange rate rises above its trend; faster growth in broad money (relative to the level of international reserves); larger current account and budget balance deficits; lower GDP growth; and, if a neighbouring country already has a crisis. Economic fundamentals are also found to be a more important explanation of the onset of currency crises during the 1980s than during the 1990s, suggesting that more recent crises are less 'fundamentally' driven.

Key words: Currency crises, early warnings system, emerging markets.

JEL classification: F31, F33, F37.

Contents

Summary

This paper investigates the role of external balance sheet variables as determinants of episodes of currency crises in both advanced and emerging market economies (EMEs). There is a relatively well-established literature on the determinants of currency crises but only recently has some attention been made to the role of a country's external capital structure as a potential source of vulnerability. Since the Asian crisis, many economists have focused on the destabilising role of short-term debt flows, suggesting that their liberalisation between the late 1980s and the early 1990s was a major cause of episodes of crises in EMEs. More recently, the development of the balance sheet approach to financial crises has emphasised the role of external assets and liabilities in affecting a country's financial strength, and some empirical studies have provided support to the idea that debt flows are particularly prone to sudden stops in times of stress.

This paper uses a model to investigate the role of external balance sheet variables as determinants of currency crises in emerging and advanced economies over the January 1980 to December 2004 period. Using a new database on external assets and liabilities, this paper investigates the role of the size and the composition of the *stock* of gross external liabilities as possible determinants of a country's degree of vulnerability to crises. Our central finding is that the probability of a crisis is found to increase with the size of total liabilities (relative to GDP) and, particularly in EMEs, to decrease with the share of foreign direct investment (FDI) in total liabilities.

There are reasons in support of the idea that a country's vulnerability to crises increases with the stock of external debt. A large stock of external debt implies a large dependence on foreign sources of finance. Therefore, the larger the stock of external liabilities, the larger is the amount of capital that can potentially be withdrawn in a sudden stop. Then, from an empirical perspective, there is evidence to suggest that international capital flows are determined by external factors as well as domestic ones. Therefore, the larger the inflow, the more sensitive a country's external financing is likely to become to external conditions. However, it is still debated within the empirical literature whether a high level of debt necessarily increases the likelihood of a currency crisis.

As for the role of the composition of external liabilities on the determination of currency crises, there are reasons to suggest that a higher (lower) share of external debt (FDI) liabilities increases

(decreases) the susceptibility of a crisis. First, a lot of external debt is short term, whereas FDI is less fungible and, thus, more difficult to withdraw in a crisis. Second, contractual obligations for debt financing – unlike for equity – are unrelated to the performance of the economy, so an adverse shock may cause EMEs debt repayment difficulties and forward-looking investors may withdraw in anticipation of these problems. The empirical evidence supports the view that a high FDI (debt) share is likely to reduce (increase) the vulnerability of an economy to crises. Short-term debt flows are usually found more sensitive to shocks to other capital flows and more volatile than FDI. Moreover, both bank loan and bonds debt flows are largely reversed during periods of stress whereas portfolio equities are found to be less sensitive and FDI stable.

Our results also suggest that the composition of external liabilities has a more important impact on the degree of vulnerability of emerging rather than advanced economies. This might be due to the shorter maturity of debt that EMEs traditionally experience. In the presence of mismatches between short-term liabilities and long-term assets, a country is likely to be particularly vulnerable to crises. Another explanation may be related to the so-called 'debt intolerance' of emerging market economies, which suggests that in most emerging markets external debt to GNP ratio needs to be lower than 35% (and even lower if a country has a long history of crises or defaults) to be regarded as 'safe'. This is because emerging market economies tend to have a weaker fiscal structure, less-developed financial systems and a worse record of macroeconomic management and inflation than more advanced economies. Therefore, they are felt as less able to tolerate higher levels of indebtedness.

Countries with a fixed exchange rate regime are found to be more sensitive to external balance sheet variables than economies with more flexible regime. Under a flexible exchange rate, banks and firms may be more likely to be sensitive to currency risks. Indeed, they have a stronger incentive to match foreign currency liabilities with dollar assets than in the presence of a fixed exchange rate. On the other hand, for a given external liability structure, fixed exchange rate regimes are more likely to lead to currency mismatches because economic agents believe the government commitment to the peg will immunise them from exchange rate fluctuations.

This paper also provides further support to standard leading indicators of currency crises and it reinforces the view that crises during the 1990s were likely to be less 'fundamentally' driven than those in the 1980s.

1   Introduction

The currency crises in Mexico (1994-95), East Asia (1997-98), Russia (1998), Brazil (1998-99), Turkey (2000-01) and Argentina (2001) are recent examples of episodes of financial instability that have had a broader impact on the international financial system. In many cases these currency crises have also been associated with banking crises and have had large economic and social costs.[1]

Some currency crises appear to have caught investors, policymakers and researchers by surprise. A number of researchers have since investigated extensively the propagation of these phenomena. Studies on the determinants of currency crises have also opened the way to other analyses aimed at attempting to forecast episodes of instability. In particular, since the Asian crisis, several models have been developed to identify the build-up of financial vulnerabilities especially in emerging market economies (EMEs).

The main purpose of this paper is to investigate the role of external balance sheet variables as determinants of episodes of currency crises in both advanced and EMEs. There is a relatively well-established literature on currency crises but only recently has some attention been made to the role of a country's external capital structure as a potential source of vulnerability. Since the Asian crisis, many economists have focused on the destabilising role of short-term debt flows, suggesting that their liberalisation between the late 1980s and the early 1990s was a major cause of recent episodes of EME crises.[2] More recently, the development of the balance sheet approach to financial crises has emphasised the role of external assets and liabilities in affecting a country's financial strength.[3] Finally, some empirical studies have analysed the role of different types of capital flows in times of stress, suggesting that debt flows are particularly prone to sudden stops.[4]

This paper uses a probabilistic model to investigate the role of external balance sheet variables as determinants of currency crises in emerging and advanced economies over the January 1980 to December 2004 period. Our main finding is that the composition of external liabilities (as proxied by the share of gross external FDI liabilities in total liabilities) has a more important

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[1] On the costs of currency crises see, for instance, Bordo *et al* (2001). More specifically on the costs of banking crises see, in particular, Hoggarth *et al* (2002).
[2] See, for instance, Stiglitz (2000) and Miller and Zhang (2001). From an empirical perspective, Kaminsky and Reinhart (1996) and Demirguc-Kunt and Detragiache (1999) show the increased frequency of crises during periods of financial liberalisation.
[3] On the balance sheet approach to financial crises see, in particular, Rosemberg *et al* (2005).
[4] See, for instance, Levchenko and Mauro (2006) and Wei (2006).

impact than the size of the external balance sheet (as proxied by the share of external liabilities over GDP). Nevertheless, and consistently with previous literature (discussed in Section 2.2), the probability of a crisis is found to increase with the size of a country's gross external liabilities, especially of debt.

A novelty of this paper is that it investigates the composition and the size of external liabilities by using a new data set developed by Lane and Milesi-Ferretti (2006). Thus, different to the previous literature that focuses on the role of the composition of the capital *flows* on a country's degree of vulnerability to currency crises, this paper focuses on the composition of the *stock* of external liabilities.

Another important contribution of this paper is to provide further support to standard leading indicators of currency crises. The likelihood of a crisis is found to increase with: the extent to which the real exchange rate rises above its trend; faster growth in broad money (relative to the level of international reserves); larger current account and budget balance deficits; lower GDP growth; and, if a neighbouring country already has a crisis.

The remainder of this paper is structured as follows. The second section provides a brief survey of the theoretical and empirical literature on the determinants of currency crises. In Section 3, the econometric model is discussed and the choice of the dependent variable and the other regressors is explained. In Section 4, the empirical results are discussed as well as the likelihood of crises under different scenarios. Finally, some lessons are drawn from the major findings of the analysis.

2   Theoretical and empirical literature

2.1   *Theoretical and empirical literature on currency crises*

Several theoretical explanations have been provided for currency crises, which have subsequently been tested empirically. First-generation models explain the timing of speculative attacks as the result of inconsistencies between a fixed exchange rate and government policies.[5] They focus on the interlinkages between macroeconomic fundamentals and the likelihood of currency crises. For example, researchers have found variables such as a strong real exchange

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[5] First-generation models developed after the seminal work of Krugman (1979). See also, Flood and Marion (1998), Sarno and Taylor (2002) and Chui and Gai (2005).

rate, current account and fiscal deficits, strong credit growth and low foreign exchange reserves as important explanations of currency crises.

While some of the predictions based on first-generation models have been confirmed empirically during the 1970s and the 1980s, more recent speculative attacks have taken place without large apparent external or fiscal imbalances (eg in Europe in 1992 and in Mexico in 1994). Second-generation models highlight the strategic complementarities between agents that could lead to multiple equilibria.[6] A major contribution of this second class of models is that a crisis can be the result of self-fulfilling expectations; for example, market expectations of the government ability to defend the peg are an important element of the costs of defending it.[7] However, as shown in Sachs *et al* (1996), macroeconomic fundamentals are still important because they determine the range of possible equilibria.[8] Therefore, variables such as GDP growth, interest rates, the inflation rate and unemployment can provide useful insights into a country's degree of vulnerability to currency crises.

Neither first nor second-generation models of currency crises are good at explaining the East Asia crisis in 1997-98. This has led to the emergence of a third generation of models[9] that concentrates on the degree of liquidity of the banking system.[10] These more recent models of currency crises concentrate on the existence of government guarantees and adequate methods of supervision[11] as well as on the potential for currency mismatches in credit-constrained economies.[12] In these models, high short-term external liabilities (relative to reserves), weak banking supervision, government guarantees and a high share of non-performing loans (in total loans) are likely to increase the likelihood of a crisis. On the other hand, large FDI inflows and high levels of bank deposits are likely to reduce the vulnerability of the system to currency crises.

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[6] The seminal paper on second-generation models is due to Obstfeld (1986). See also, Sarno and Taylor (2002).
[7] On second-generation models see, in particular, Obstfeld (1996).
[8] Morris and Shin (1998) show that if the assumption that private agents have 'common knowledge' is relaxed, in the sense that they are unsure about others' behaviour in equilibrium, then multiple equilibria exists only at certain levels of fundamentals.
[9] See, for instance, Radalet and Sachs (1998).
[10] For a survey on third-generation models see, in particular, Krugman (1999) and Chui (2002).
[11] See, in particular, Corsetti *et al* (1999).
[12] See, for instance, Krugman (1999). On the balance sheet effects see, also, Aghion *et al* (2001) and Aghion *et al* (2000) for an analysis of the optimal monetary policy response to a financial crisis with credit-constrained economies.

Also the potential for a currency crisis to propagate from one country (group of countries) to another country (group of countries)[13] and their interaction with banking crisis[14] have been extensively investigated. And several empirical studies have provided evidence that certain economic fundamentals such as current account, budget balance, real GDP growth and others provide useful information on the onset of a crisis.[15]

2.2 *External liability structure and currency crises*

Academics and policymakers have recently concentrated their attention on the role of the size and the composition of the external balance sheet in assessing a country's vulnerability to currency crises.[16]

There are several reasons to suggest that a country's degree of vulnerability to crises is likely to increase with the size of its gross external liabilities. First, a large stock of external debt implies a large dependence on foreign sources of finance. Therefore, the larger the stock of external liabilities, the larger is the amount of capital that can potentially be withdrawn in a sudden stop. Second, from an empirical perspective, Mody and Taylor (2002) found evidence that international capital flows are determined by external factors as well as domestic ones. Therefore, the larger the inflow, the more sensitive a country's external financing is likely to become to external conditions. In a sample of 33 middle-income economies over the 1980-2003 period, Jeanne and Rancière (2006) find, *inter alia*, that a sudden stop is more likely the higher the ratio of total gross external liabilities to GDP. However, Ghosh and Ghosh (2003) report evidence that a higher ratio of external debt to reserves are positively correlated with crises but their coefficients are not statistically significant; and Frankel and Wei (2004) concluded that a high level of debt does not necessary increase the likelihood of a currency crisis.

As for the composition of external liabilities, there are reasons to suggest that a higher share of external debt (FDI) liabilities increases (decreases) the susceptibility of a crisis. First, a lot of external debt is short term, whereas FDI is less fungible and, thus, more difficult to withdraw in a crisis. Second, contractual obligations for debt financing – unlike for equity – are unrelated to the performance of the economy, so an adverse shock may cause EMEs debt repayment difficulties and forward-looking investors may withdraw in anticipation of these problems. The

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[13] See also Frankel and Rose (1996) and Frankel and Wei (2004).
[14] See Kaminsky and Reinhart (1996) and Glick and Hutchison (1999).
[15] See for instance, Eichengreen *et al* (1996), Frankel and Rose (1996), Kruger *et al* (1998), Berg *et al* (1999b), and more recently, Bussière and Fratzscher (2002), Kumar *et al* (2003), Berg *et al* (2004), Fontaine (2005) and, with particular reference to the Asian crises, Asian Development Bank (2005).
[16] See, for instance, Allen *et al* (2002) and Rosemberg *et al* (2005).

empirical evidence supports the view that a high FDI (debt) share is likely to reduce (increase) the vulnerability of an economy to crises. Chuhan *et al* (1996) provides empirical evidence that short-term debt flows are more sensitive to shocks to other capital flows than FDI. Moreover, in an investigation of the role of the composition of capital flow, Frankel and Rose (1996) found that a low share of FDI (relatively to debt) flows is associated with a higher likelihood of a crisis, and Frankel and Wei (2004) found that a higher ratio of FDI and equity inflows (as a share of gross foreign liabilities) is likely to reduce the vulnerability of a country to crises. More recently, Levchenko and Mauro (2006) focus on a large sample of advanced, emerging and developing countries over the 1970-2003 period. They find that both bank loan and bonds debt flows are largely reversed during periods of stress. On the other hand, portfolio equities are found to be less sensitive and FDI stable.[17] Finally, Wei (2006) finds that debt flows are more volatile than FDI or portfolio investment.[18]

3 A probabilistic model

3.1 *Currency crises dating system*

In this paper currency crises are modelled as a binary variable that takes the value of 1 in periods when a crisis occurs and 0 otherwise. Following the currency crises literature an exchange market pressure index ($EMPI_{it}$) is used to identify episodes of currency crises.[19] This index consists of exchange rate depreciation and loss of reserves, weighed to have the same impact.[20] More precisely, the index is defined as follows:

$$EMPI_{it} = \Delta e_{it}/e_{it} - (\sigma_{ie}/\sigma_{ir})*\Delta R_{it}/R_{it} \qquad (1)$$

where, for i (country) = 1….N and t (time) =1…T, Δe is the change in nominal exchange rate, e is the nominal exchange rate at the beginning of the period and ΔR is the change in international reserves, R are the reserves at the beginning of the period and σ_e and σ_r are the country specific standard deviation of the relative changes in exchange rate and reserves respectively.[21] The index increases with the degree of currency depreciation and reduction in the

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[17] See, in particular, Becker *et al* (2006).

[18] Frankel and Wei (2004) show also that in some cases authorities tend to expand their short-term foreign currency borrowing during periods of stress (eg Mexico in 1994). More precisely, in the six to twelve-month period leading up to the crisis, they found that the composition of inflows is likely to tilt towards debt and away from FDI or equity.

[19] The seminal paper on the exchange market pressure index is Girton and Roper (1977). See also Eichengreen *et al* (1995). Unlike the latter, interest rates are not included in this paper. This is because for the set of countries under analyses, it is not possible to find sufficiently long data series.

[20] This approach is the same as those in Komulainen and Lukkarila (2003) and Peltonen (2006).

[21] The exchange market pressure index depends on the definition of its determinants (reserves and exchange rate) as well as on the length of the sample used. Theory does not provide an optimal approach to derive the weights. In this paper, they are derived to have the same conditional variance. This ensures that each component has the same weight in the determination of the index.

level of reserves. A main advantage of this approach is that it captures both successful currency attacks, which lead to currency depreciation and unsuccessful ones (at least as reflected in a fall in foreign exchange reserves).

A crisis is said to have occurred if the exchange market pressure index (EMPI) is above a threshold. One limitation of this 'conversion' rule of the EMPI into a binary variable is the arbitrariness of the choice of the threshold.[22] The robustness of our results to alternative rules will be provided but it is worth noting that some recent papers suggested using extreme value theory to improve the dating of crises.[23]

The focus of this paper is on the period leading up to the crisis, rather than the crisis itself. Therefore, as shown in equation (**2**), the dependent variable ($Y_{i,t}$) is assumed to be one if the index is above the threshold any time within a twelve-month crisis window,

$$Y_{i,t} = 1 \text{ if for at least one } EMPI_{i,t+h} > \mu_{EMPIi} + \beta\, \sigma_{EMPIi} \qquad (2)$$

$Y_{i,t} = 0$ *otherwise*

h:[1...12]; i (country)= 1....N and t (time)=1...T

where μ_{EMPI} is the country-specific mean and σ_{EMPI} is the country-specific standard deviation of the index.[24] Although the dependent variable is assumed to be one if a crisis occurs any time in a twelve-month crisis window, the crisis month *(ie h:[1...12])* is excluded to avoid potential endogeneity problems, which can arise from the use of foreign currency reserves and nominal exchange rate as explanatory variables as well as in the measure of the crisis index.

The approach above allows for the crises probability to occur any time within a crisis window of twelve months.[25] A twelve-month crisis window should provide a good trade-off between two important countervailing effects.[26] On the one hand, economic fundamentals weaken as a crisis approaches. On the other hand, from a policymaker's point of view, the earlier it is possible to identify signs of vulnerability, the more time there is to take effective corrective action.

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[22] This is usually identified as a large (25% or more) depreciation (as in Frankel and Rose (1996) or as a certain number of standard deviations above the mean (as in Eichengreen *et al* (1995).

[23] See, for example, Pontines and Siregar (2004).

[24] Theory does not provide any clear criterion to identify the value of *β*. Throughout this paper, the benchmark for *β* is 2.5. However, sensitivity analyses have been carried out around this benchmark.

[25] This method implies an average in sample pre-crisis probability of 11.5% during the 1980s, 13.2% during the 1990s and 12.3% during the whole January 1980-December 1998 period.

[26] Choosing a twelve-month crisis window follows Bussière and Fratzscher (2002).

3.2 Econometric model

For the general case of an unbalanced panel with N countries that are observed over T periods, a general binary dependent variable model can be formulated in terms of an underlying latent variable (Y^*_{it}) defined as follows[27]

$$Y^*_{it} = \beta X_{it} + \varepsilon_i + \mu_{it} \qquad i = 1....N \; ; \; t = 1...T \tag{3}$$

where X_{it} is the vector of explanatory variables, β is a vector of corresponding parameters estimated for m explanatory variables, ε_i is the unobserved individual country-specific heterogeneity, which explains the specific features of the group (eg country) that are constant over time and, finally, μ_{it} is an independently and normally distributed disturbance term with zero mean and unit variance.

The latent (Y^*_{it}) and observed binary variable (Y_{it}) are related through the following measurement equation:

$$Y_{it} = 1 \qquad if \; Y^*_{it} > 0 \tag{4}$$
$$= 0 \qquad otherwise$$

Then, $Y_{it} = 1$ when Y^*_{it} is above a certain threshold (assumed equal to 0 for simplicity). It follows that

$$P(Y_{it} = 1 \,|\, X_{it}) = P(Y^* > 0 \,|\, X_{it}) = P(\beta X_{it} + \varepsilon_{it} + \mu_{it} > 0 \,|\, X_{it}) = P(\varepsilon_i \le \beta X_{it} + \mu_{it} \,|\, X_{it}) \tag{5}$$

which represents the cumulative distribution function of the error distribution evaluated at $(\beta X_{it} + \mu_{it})$. The latter can also be written as follows:

$$P(Y=1 \,|\, X_{it}) = \Phi \,(\beta \, X_{it}) \tag{6}$$

where Φ is the normal cumulative distribution. Equation (**6**) summarises the relationship between the crisis probability and the explanatory variables.

The estimated coefficients in a binary regression are related to the effect of the independent variables on the estimated probability but they cannot be directly interpreted as changes in the dependent variable as a result of a change in the explanatory variable. Indeed, the marginal impact of a change in one explanatory variable depends on the values of other variables as well as the value of this variable.[28] In order to study the magnitude of the impact of a marginal change in an independent variable under different scenarios, marginal impacts can be derived at different levels of the explanatory variables (eg mean, median and given percentile etc).

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[27] See, for instance, Verbeek (2004).
[28] For a discussion of the non-linear properties of discrete choice models see Greene (2002) and Wooldridge (2002).

A random effect probit model is chosen to estimate the probability of a crisis conditional on a set of explanatory variables.[29] This approach allows us to fully exploit the cross-sectional and time-series information contained in the panel data set. It is also free from the incidental parameter problem and it provides unbiased estimates in the presence of heterogeneity of the country-specific term.[30] In particular, it specifies this term as randomly distributed across cross-sectional units. However, it relies on the very strong assumption that the country-specific term (ε_i) is uncorrelated with the regressors (X).

3.3 Explanatory variables

The vector of explanatory variables X consists of quantitative (eg macroeconomic) as well as qualitative (eg dummy variables) indicators. Table A provides a description of all the variables tested in this study. The indicators found statistically and economically significant are discussed below.

- Deviation of the real effective exchange rate from its non-linear trend. Currency crises are often preceded by periods of overvaluation.[31] Changes in the real exchange index capture the impact of inflation differentials as well as of changes in the nominal trade-weighted exchange rate. Deviation of this indicator from its long-run equilibrium is a proxy for the degree of overvaluation/undervaluation of the currency. As a proxy for the equilibrium value of the real exchange rate a HP filter[32] and a simple average trend are used.

- Current account balance (percentage of GDP). Large current account deficits are likely to be associated with a higher degree of vulnerability. Above a certain level, market participants may judge that the deficit is unsustainable and expect currency devaluation.

- Government budget balance (percentage of GDP). Large budget deficits are likely to reduce the government's ability to repay debt and to increase the risk of monetisation.[33] Therefore, higher fiscal deficits are likely to reduce investors confidence in the domestic currency.

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[29] A similar approach has been used in previous work. See for instance, Esquivel and Larrain (1998) and Komulainen and Lukkari (2003).

[30] The incidental parameter arises in every fixed-effects model. This type of model accounts for heterogeneity $(\varepsilon_i \neq 0)$ treating the constant heterogeneous term ε_i as a fixed unknown parameter, by including N dummy variables in the model. However, the process of estimation of β and ε_i provide consistent results only under the assumption that the number of periods T goes to infinity. Therefore, the incidental parameter problem arises because for fixed T, the number of parameters grows with the sample size N. This problem is extensively discussed in Greene (2002).

[31] See, for instance, Kaminsky *et al* (1998) and Berg *et al* (1999b).

[32] The HP filter is a simple time series smoothing technique often used in the determination of long-run equilibria.

[33] This is a typical indicator of the first generation. See for instance, Krugman (1979).

- Real GDP growth. Lower GDP growth is likely to increase the vulnerability of the economy to a currency crisis. Indeed, financial crises are usually preceded by recessions.[34]

- M2 over reserves. In the months leading up to a crisis, as emphasised by several empirical studies,[35] a central bank is likely to sell a substantial amount of official reserves. And in the wake of a crisis, depositors will start to convert domestic money into foreign exchange. This indicator captures the ability of the central bank to meet the demand of depositors who want to convert their savings into foreign currency.

- External balance sheet variables. It is expected that the likelihood of a crisis increases with the size of gross external liabilities (relative to GDP). As for the composition of external liabilities, the evidence discussed earlier suggests that the likelihood of a crisis is likely to decrease with the share of external FDI liabilities (in total liabilities).

- Cross-country contagion. A dummy variable is included to account for the existence of a crisis at the same time in another country in the same region (ie regional contagion) or elsewhere (ie global contagion).[36]

- Regional dummies. Regional dummies are included to assess the existence of differences in the probability across region to levels of the fundamentals.

3.4   Data

This paper uses actual or interpolated monthly data for a sample of 40 emerging and advanced economies over the January 1980-December 2004 period.[37] The actual length of the data set is constrained by the absence of data for the advanced economies that joined the euro in January 1999. Therefore, the main analysis is restricted to the January 1980-December 1998 period. When we exclude the six countries that entered the euro in 1999, the sample period is extended until December 2004.

The main advantage of using high-frequency data is that they are more suitable to capture the sudden nature of currency crises. On the other hand, monthly series are not directly available for all the indicators (eg current account, GDP, GDP deflators and budget balance). In these cases,

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[34] Kaminsky *et al* (1998), Bussière and Fratzscher (2002) and Peltonen (2006).

[35] Sachs *et al* (1996) and Kaminsky *et al* (1998).

[36] Beckmann *et al* (2005) and Fontaine (2005) use a similar approach to model contagion. For a survey on modelling contagion see Pericoli and Sbracia (2001) and Fratzscher (2003).

[37] The data consists of 28 developing countries (World Bank classification): 10 Latin American (Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Mexico, Peru, Uruguay and Venezuela); 7 Asian (India, Indonesia, Korea, Malaysia, Philippines, Singapore and Thailand); 7 East European (Czech Republic, Hungary, Israel, Poland, Russia, Slovak Republic and Turkey,); 4 African (Egypt, Morocco, South Africa and Tunisia) and 12 advanced economies (Finland, France, Germany, Iceland, Ireland, Italy, Japan, Norway, Spain, Sweden, Switzerland and the United Kingdom).

linear interpolation is used to derive the monthly point from annual data. This paper uses annual data because data series in quarterly format from a single source (eg IFS online) are available only for a limited number of countries and periods. Rather than combining alternative data sources, in order to maintain a certain consistency within different countries, it is preferred to use annual data for the entire data set.[38] As shown in Table A, the majority of the data are from the IMF-IFS online.

Data for the external balance sheet variables are from the new Lane and Milesi-Ferretti (2006) that provide estimates of the external assets and liabilities for a large set of countries over the 1970-2004 period.[39] A novel feature of this data set is that the stock of assets and liabilities is based on direct measures of stock and cumulative flows (adjusted for valuation effects). To the best of my knowledge, this is the first paper that uses this data set to investigate the determinants of currency crises.

4   Empirical results

4.1   Dating currency crises

In order to check that the currency crisis index is consistent with what are usually regarded as past currency crisis episodes, the $EMPI_{it}$ discussed earlier is plotted in Charts 1 and 2 (Appendix II).[40] As shown in Chart 1, for the whole set of countries included in this study, the crisis dating system identifies 95 major episodes of currency instability over the January 1980 to December 1998 period. This implies 0.13 crises per country per year. Other studies have found similar results. For instance, on the basis of a sample of 50 countries for the 1975-97 period, IMF (1998) identified 158 episodes of crises (eg 0.14 crises per country per year). Kaminsky and Reinhart (1996) focused on a sample of 20 countries over the period 1970-95 and identified 71 episodes of crises (eg 0.14 currency crises per country per year). Chart 1 also provides a breakdown of the number of crises per year and by region. According to the crisis-dating system used, there are 44 episodes of instability in the 1980s, and 51 during the 1990s. Countries in Latin America experienced 31 episodes of instability followed by more advanced economies (30), emerging Asia (19), Africa (9) and, finally, emerging Europe (6).[41] Chart 1 identifies some

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[38] A similar approach has been followed by Bussière and Fratzscher (2002) and Peltonen (2006).

[39] According to Lane and Milesi-Ferretti (2006), debt includes debt securities, bank loans and deposits, portfolio equity is ownership of shares below 10% and FDI is equity participation above 10%.

[40] In order to avoid overcounting some crises episodes, if more than one crisis is identified over the same three-month period, they are considered as the same crisis.

[41] The majority of countries in this study have experienced at least one crisis. This might introduce some selection bias. However, the number and diversity of our sample implies that this bias is likely to be relatively small. On the selection bias see Edison (2003).

major past episodes of instability. All the main episodes of the crises are highlighted (eg Exchange Rate Mechanism and the East Asian and Russian crises of 1998). Comparing our episodes of crises with those reported in Glick and Hutchison (1999) and Kaminsky *et al* (1998) shows a great deal of overlapping. Note that if the exchange market pressure index is extended until December 2004 for a subset of economies (excluding the six European economies that adopted the euro in 1999), the number of crises increases from 95 to 106.

Chart 2 reports the EMPI and the corresponding threshold, defined as the mean plus 2.5 standard deviations of the index, for four countries with past currency crisis: Malaysia, Mexico, the United Kingdom and Russia. As shown in the chart, over the January 1980-December 1998 period, there has been one major crisis in the United Kingdom (September 1992), three in Mexico (February and December 1982 and December 1994), two in Malaysia (July and December 1997), and one in Russia (August 1998).

Chart 3 shows the time series of the crises index for the four economies mentioned above, where I have used the conversion threshold to avoid overcounting crisis episodes. In the case of Malaysia and Mexico, the period of vulnerability is sensitive to the assumptions made but as shown in the robustness section the main results of this paper remain valid under these alternative assumptions.

4.2 Common determinants of currency crises

The most representative model is reported in Table A (Appendix I). The explanatory variables are simultaneously estimated with a random effect probit. Indicators that are not statistically and economically significant are manually stepwise deleted. The degree of statistical significance of each specification is assessed with several tests. The null that each single indicator is zero is tested with a z-test on each parameter. Then, the joint hypothesis that all the coefficients are zero is examined using a chi squared test. In order to approximate the explanatory power of the model, the value of the likelihood function for the full model ($L(1)$) as well as for the model with the constant only ($L(0)$) are considered and pseudo R-squared is computed.

The results for the most parsimonious model over the period are reported in Table B. The table is divided in two parts. Part I reports results obtained with the 40 countries over the January 1980-December 1998 period, while Part II is based on the extended sample over the January 1980-December 2004 period but excluding the european countries that adopted the euro

in 1999. For each part, the first column lists the key explanatory variables, the second column reports results for the whole period, while the third and fourth columns report the marginal impact of a 1% change in the value of each indicator at weak and median levels of the fundamentals respectively. Depending on *a priori* expectations of each indicator, a weak fundamental is, unless otherwise stated, the value of each variable in the 25th or 75th percentile of its distribution. For instance, in the case of M2 to reserves, a weak level corresponds to the value assumed at the 25th percentile; on the other hand, the weak level of the deviation of the exchange rate equals the 75th percentile.[42] The fifth and sixth columns report the model estimation results for the 1980s and for the 1990s respectively. For each indicator, the sign, the degree of statistical significance and the standard error of the coefficients (in brackets) are reported in the table. Unless otherwise stated, the estimated probability of crises is also shown at weak levels of each explanatory variable.

Several observations emerge from Table B (Part I). Consistent with prior studies, the crisis probability is found to increase with total external liabilities (over GDP) and to decrease with the share of FDI in total liabilities. Over the whole sample period (Table B, Part I), the results suggest that the composition of external liabilities rather than its size has a more important impact on the degree of vulnerability. For instance, under the case of weak fundamentals, a 1% increase in the share of FDI in total external liabilities decreases the likelihood of crises by approximately 0.5%. On the other hand, a 1% increase in the size of total external liabilities (over GDP) translates into a 0.02% increase in the degree of vulnerability.

These results suggest that a larger share of equity and FDI liabilities can attenuate a country's degree of vulnerability to currency crises. However, one potential problem is that countries with weak fundamentals are more likely to have only access to debt financing. Therefore, the relationship between the share of FDI (in total liabilities) and the likelihood of crises may reflect the weaker state of fundamentals of the economy. The relatively stronger impact of FDI in total liabilities compared with the external liabilities (over GDP) is broadly consistent with previous studies discussed above.[43] Furthermore as shown in Chart 4, most currency crises seem to have occurred in presence of a low share of FDI in total liabilities but not necessary at a high level of external debt liabilities (in GDP).[44] Another possibility is that our econometric results may underestimate the true impact of high indebtedness. For example, countries with high debt may

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[42] It should also be noted that the percentiles are sample specific.
[43] See Section 2.2.
[44] Similar results were reported by Reinhart *et al* (2003) who investigated a series of episodes of default or restructuring of external debt in middle income economies during the 1970-2001 period. For instance, they showed that more than half of the default episodes occurred at ratios of external debt to GNP below 60%.

take countervailing measures to reduce the probability of a currency crisis that cannot be fully controlled for in our specifications.[45]

A further three measures of external balance sheet variables were tested: the sum of external assets and liabilities (over GDP), that can be viewed as a *de facto* measure of international financial integration; the twelve-month growth rate of total gross external liabilities to GDP; and the difference between external assets and liabilities (over GDP) – a proxy for currency mismatch. However, only the twelve-month growth rate of the total gross liabilities to GDP and the *de facto* measure of capital market integration provide results that are little changed than when we used the gross total external liabilities over GDP indicator.

Table B (Part I) again provides support to previous findings in the empirical literature on currency crises. Consistently with our expectations, the increase in the deviation of the real exchange rate from trend (derived from the HP filter),[46] current account and budget deficits, the growth of broad money (relative to the international reserves) and a reduction in the growth of real GDP are good leading indicators of currency crises. In terms of the impact of a change of these variables on the likelihood of crises, under the weak scenario assumption, a 1% increase in the deviation of the real exchange rate translates in to a 1.2% increase in the likelihood of a crisis. Similarly, a 1% increase in GDP growth corresponds to a 1.3%, a 1% increase in the current account (over GDP) reduction in the crisis probability translates into a 1.1% and a 1% increase in the budget balance (over GDP) leads to a 1.2% reduction in the likelihood of a crisis. Finally, a 1% increase in the growth rate of M2 over foreign exchange reserve translates into a 0.02% increase in the likelihood of a crisis.

The simple regional contagion dummy is significant at the 5% level in the whole sample and at the 1% level during the 1990s. However, it is largely insignificant during the 1980s. This finding provides support for the idea that crises during the 1990s were more interdependent than during the 1980s. In addition, the growth in M2 over reserves loses statistical significance in the more recent period, perhaps suggesting that crises of the 1990s are less related to fundamental factors. As for the impact, the contagion dummy has a large impact on the likelihood of a crisis. Under weak fundamentals, a crisis in another country increases the likelihood of a crisis by approximately 5.5%.

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[45] Although the test implemented is based on the share of FDI in total liabilities, in some unreported results I found that a high share of FDI in GDP reduced the probability of a crisis.
[46] Qualitatively similar results were found with the deviation of the real exchange rate from a simple linear trend.

As shown in Table B, results obtained with the longer period (Part II) while excluding European countries that adopted the euro in 1999 are qualitatively consistent with those obtained over the January 1980-December 1998 period (Part I) although the FDI share (in total liabilities) loses its statistical significance during the more recent period.[47]

Finally, Table B (Part I) shows that the estimated probability of a crisis rises (from 7.9% to 23.4%) to above the in-sample pre-crisis probability (ie 12.3%) as a result of the worsening of the state of fundamentals in the key explanatory variables (ie from median to weak levels). Furthermore, assuming weak levels of the fundamentals, estimated crises probabilities for the 1990s are more than double those of the 1980s.

4.3 Financial openness and the structure of external liabilities

Rather than using the marginal impact (as in Table B), discrete changes are used below to illustrate the links between the composition and size of external liabilities and the likelihood of currency crises under different scenarios.

Table C (column I) shows the estimated crisis probability under three different levels of total liabilities over GDP[48] (low, median and high) and at two levels of fundamentals (median and weak), while all other variables are also assumed either to take median or weak values. As shown in Table C (column I), a more financially open economy (ie with higher gross external liabilities/GDP) is likely to be relatively more vulnerable to crises, especially when the economic fundamentals are weak.

Table C (column II and III) provides estimated crises probability obtained from the most parsimonious model estimated over the January 1980-December 2004 period, at three levels (low, median and high) of the liability structure (ie share of FDI over total liabilities) and at low, medium and high degrees of financial openness (ie total external liabilities over GDP), while assuming that all other key variables are at weak levels. In addition to the estimated crisis probabilities, the marginal impact associated with the simple contagion dummy is also reported in brackets.

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[47] Note also that if the emerging market pressure index was computed using mean and standard deviation for the January 1980-December 2004 period, the M2 over reserves indicator loses its statistical significance.
[48] There are three degrees of financial openness: low, median and high. Low is defined as the median minus 50% of its value, and high is the median plus 50% its value.

Under the assumptions above, the results show that the composition of external liabilities plays a more important role in a country's degree of vulnerability (ie estimated crises probabilities). Indeed, for any level of total liabilities, a lower share of debt in total liabilities reduces the likelihood of a crisis and, at any share of debt in total liabilities, a lower size of total external liabilities (in GDP) reduces a country's degree of vulnerability to crises as well as the potential impact of contagion effects. More precisely, an increase in the share of debt liabilities (in total liabilities) increases the probability of a crisis more than an increase in total liabilities (in GDP). In other words, a more financially open economy with a lower share of debt liabilities (in total liabilities) is less vulnerable to episodes of crises than a less financially open economy with a larger share of debt liabilities. Therefore, it seems that countries with a large share of equity and FDI (in total liabilities) are likely to be more resilient to episodes of instability.

4.4   *EMEs versus developed economies*

There are some important differences between advanced economies and EMEs over the whole period (Table D, Part I). In particular, some variables lose their statistical (eg M2 over reserves, real GDP growth and debt or FDI liabilities (over total liabilities)) or economical (eg budget balance (over GDP)) significance and are no longer good leading indicators of currency crises. However, the deviation of the real exchange rate, the current account deficit, the size of external balance sheet and regional contagion are still valid indicators of the onset of currency crises.

The more important role of liability composition effects in EMEs compared with advanced economies might be due to the shorter maturity of debt that EMEs traditionally experience. In presence of mismatches between short-term liabilities and long-term assets, a country is likely to be particularly vulnerable to crises. Another explanation may be related to the so-called 'debt intolerance' of emerging market economies. Reinhart *et al* (2003) noted that in most emerging market economies external debt to GNP ratio needs to be lower than 35% (and even lower if a country has a long history of crises or defaults) to be regarded as 'safe'. This is because emerging market economies tend to have a weaker fiscal structure, less developed financial systems and a worse record of macroeconomic management and inflation than more advanced economies. Therefore, they are felt as less able to tolerate higher levels of indebtedness.

The current reduction in the share of debt external liabilities in emerging markets is likely to reduce the vulnerability of these economies to episodes of instability and, therefore, it should be seen as a positive development.[49]

4.5 Floaters versus non-floaters

The random effects model discussed in Section 4.2 is re-estimated to separate the sample into floating and non-floating exchange rate regimes.[50] Results on the sensitivity to different assumptions on the exchange rate are reported in Table E. Part I of the table shows results using the whole set of countries in the data set over the January 1980-December 1998 period, while Part II refers to January 1980-December 2001 period, until the end of the *de facto* exchange rate regime data set developed by Reinhart and Rogoff (2002).

As shown in Table E (Parts I and II), under floating exchange regimes, neither the composition nor the size of the external balance sheet seem to play any role in the determination of currency crises.[51] Under a flexible exchange rate, banks and firms may be more likely to be sensitive to currency risks. Indeed, they have a stronger incentive to match foreign currency liabilities with dollar assets than in presence of a fixed exchange rate. On the other hand, for a given external liability structure, fixed exchange rate regimes are more likely to lead to currency mismatches because economic agents believe the government commitment to the peg will immunise them from exchange rate fluctuations.[52]

4.6 Robustness checks

The most parsimonious random effect model estimated over the January 1980-December 1998 period is re-estimated using pooled probit and logit, with and without Huber White robust standard errors to account for possible heteroskedasticity in the estimated residual.[53] Second, the impact on the results of different assumptions on the threshold definition is tested using two

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[49] For the 28 emerging market economies used in this study, according to Lane and Milesi-Ferretti (2006), the share of debt liabilities over total liabilities has fallen from 74% over the period 1991-95 to 56% over the period 2001-04. On the other hand, over the same period, the share of FDI (equity) liabilities over total liabilities had increased from 19% (8%) to 32% (13%).

[50] The distinction between types of exchange rate regime is based on the classification proposed by Reinhart and Rogoff (2002) for a set of 153 countries over the 1946-2001 period. More precisely, flexible and non-flexible regimes are defined as follows. Flexible regimes include managed and freely floating, while currency board, peg and horizontal band narrower or equal to 2%, crawling pegs and bands narrower or equal to 5% are classified as non-flexible.

[51] Interestingly, under floating regimes, variable proxy for M2 over reserves and real GDP are no longer good leading indicators of currency crises.

[52] On this point see, for instance, Edwards (2001).

[53] See Greene (2002) for a discussion.

alternative thresholds corresponding to the mean plus 2 and 3 standard deviations rather than plus 2.5 standard deviation used above. Third, in order to avoid overcounting crisis episodes every crisis arising over a three-month period was assumed to be the same crisis. In order to assess the robustness of this definition, two alternative assumptions were tested. Each separate episode of crisis as identified by the EMPI is included as a single crisis. Alternatively, we consider as one crisis all crises arising over a six-month period. Fourth, the model was also estimated using a crises index obtained using the deutschemark as a reference country for the European economies that adopted the euro in 1999 to account for possible problems arising from the derivation of the EMPI based on the US dollar. Fifth, the most parsimonious specification was also tested using a structural approach that treats the EMPI as a dependent variable rather than converting it into a crisis index.[54] This approach avoids choosing a conversion rule and it allows investigating structural weaknesses that contribute to severe exchange market pressure, although it does not provide an estimate of the crisis likelihood.

As shown in Table F, the main results of this paper are robust to the sensitivity tests highlighted above and most of the indicators identified as important common determinants of currency crises are also found to contribute to severe exchange market pressure when a structural rather than binary approach is used.[55]

Finally, in and out-of-sample performance of the model at different thresholds are reported in Table G. The table suggests that the model has reasonable in and out-of-sample performance especially at the regional level. At the 20% threshold, the model estimated with the whole set of countries captures approximately 30% of the pre-crisis episodes, but this share rises to 64% and 50% for Latin America and emerging Asia respectively if the model is estimated regionally.

5   Conclusion

This paper investigates the role of external balance sheet as determinants of currency crises using a new data set on external assets and liabilities. Our main finding is that the composition of external liabilities (as proxied by the share of gross external FDI liabilities in total liabilities) has a more important impact than the size of the external balance sheet (as proxied by the share of external liabilities over GDP) on a country's degree of vulnerability to crises. Moreover,

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[54]A similar approach has been followed by Sachs *et al* (1996).
[55] Note that the current account (percentage of GDP) loses economical and statistical significance at standard degree of confidence when the structural model is estimated over the January 1980-December 2004 period but it is still economically significant over the January 1980-December 1989 period.

EMEs seem to be more sensitive to external balance sheet variables than developed countries, and so too do economies with fixed or quasi-fixed exchange rate regimes.

In addition to the role of the external balance sheet, this paper investigates standard leading indicator variables used in the literature. Deviations in the real effective exchange rate from its trend, an increase in growth rate of broad money (relative to international reserves), a slowdown in real GDP growth, current account and budget deficits are also found to be good leading indicators of currency crises. However, domestic fundamental variables are found more important in explaining crises in the 1980s than the 1990s. A crisis in a neighbouring country is also found to increase the crisis probability, particularly during the 1990s, reinforcing the view that crises during the 1990s were likely to be less 'fundamentally' driven than those in the 1980s.

Appendix I: List of tables

Table A: Data source and overview of the explanatory variables

Indicators	Source	Frequency	Transformation
Deviation of the real effective exchange rate from non-linear trend	Real effective exchange rate is IFS line REC. The trend is derived from the Hodrick-Prescott filter using E-views 3.1 The HP filter was calculated with a parameter of 14,400. Data for Argentina, Brazil, Mexico, India, Indonesia, Korea, Thailand, Turkey, Egypt and Peru`are not available on the IFS and they are obtained from JPMorgan. The two indices are not entirely consistent but, to the best of my knowledge, there is no single database that provides real effective exchange rate data for the whole set of countries in my dataset.	Monthly	((Real effective exchange rate minus non-linear trend (HP filter))/ non-linear trend)*100
Current account deficit/ GDP	Monthly current account data are obtained from interpolation of annual data from IFS line 78ALD. Similarly, monthly GDP is interpolated from annual data (IFS line 99 BP).	Interpolated from annual	Levels (%)
Budget balance/ GDP	Government deficit or surplus is taken from IFS line 80. Monthly GDP is interpolated from annual data (IFS line 99BP).	Interpolated from annual	Levels (%)
Exports	IFS line 70	Monthly	Twelve-month changes (%)
Imports	IFS line 71	Monthly	Twelve-month changes (%)
M2/reserves	M2 is defined as IFS line 34 plus 35 converted into dollars (using IFS line AE). Reserves are from IFS line 1LD. If a data point is available from the quarterly IFS series, it is used to generate the correspondent monthly point from the available quarterly series. This is the case for Colombia, South Africa, Hungary, Poland and Sweden.	Monthly	Levels (%) and Twelve-month changes (%)
M2 multiplier	The ratio of M2 (IFS lines 34 plus 35) to base money (IFS line 12).	Monthly	Levels (%) and Twelve-month changes (%)
Domestic credit/ GDP	Domestic credit is obtained from IFS line 52. The monthly GDP was interpolated from annual data (IFS line 99 BP)	Monthly /interpolated from annual	Levels (%) and Twelve-month changes (%)
Real GDP	Real GDP is obtained as GDP divided by the GDP deflator. GDP is obtained by linear interpolation from IFS annual data line 99B. GDP Deflators are obtained from linear interpolation of IFS annual data line 99BIP	Interpolated from annual	Twelve-month change (%)
Real interest rate differential (ie domestic – foreign)	Real domestic interest rate is compared with interest rate in the United States. The interest rate differential is constructed as the difference between real rates for the domestic and foreign countries. Real rate are defined as follows: money market rate (IFS line 60B) deflated using consumer prices (IFS line 64...XZF). If money market rate is not available we use deposit rate (IFS line 60L)	Monthly	(%)
Hyperinflation	Inflation rate is derived as percentage per annum. This is obtained from IFS line 64..XZF.	Monthly	Dummy if inflation rate is higher than 40%, then 1.
Bank foreign liabilities/ GDP	Foreign bank liabilities are from IFS line 26C. Monthly GDP is interpolated from annual data (IFS line 99BP).	Monthly/ interpolated from annual	Levels (%)
Short-term debt/ foreign exchange reserve	Short term debt is obtained from BIS (claims of BIS-reporting banks on individual countries). Monthly data interpolated from annual. International reserves are from IFS line 1L.	Interpolated from annual/ monthly	Levels (%)
Portfolio capital flow/ GDP	Portfolio flows are interpolated from annual data obtained from IFS 78BGD. Monthly GDP is interpolated from annual data (IFS line 99BP).	Interpolated from annual	Levels (%)
Foreign direct investment/GDP	Foreign direct investment is interpolated from IFS annual data 78BED. Monthly GDP is interpolated from annual data (IFS line 99BP).	Interpolated from annual	Levels (%)
Debt/ total liabilities	Debt and total liabilities interpolated from annual data obtained from Lane and Milesi-Ferretti. (2006)	Interpolated from annual	Levels (%)

FDI / total liabilities	FDI and total liabilities interpolated from annual data obtained from Lane and Milesi-Ferretti. (2006)	Interpolated from annual	Levels (%)
External asset minus liabilities (over GDP)	Total assets plus total liabilities divided GDP. Monthly total assets and liabilities are obtained from Lane and Milesi-Ferretti. (2006). Also GDP is from Lane and Milesi-Ferretti (2006). Monthly data are obtained via interpolation of annual data.	Interpolated from annual	Levels (%)
External asset plus liabilities (over GDP)	Total assets plus total liabilities divided GDP. Monthly total assets and liabilities are obtained from Lane and Milesi-Ferretti. (2006). Also GDP is from Lane and Milesi-Ferretti. (2006). Monthly data are obtained via interpolation of annual data.	Interpolated from annual	Levels (%)
Total liabilities/GDP	Interpolated from annual data obtained from Lane and Milesi-Ferretti. (2006). Also GDP is from Lane and Milesi-Ferretti. (2006). Monthly data are obtained via interpolation of annual data.	Interpolated from annual	Levels (%) and Twelve-month changes (%)
Exchange market pressure index			
Nominal exchange rate	IFS line AE..ZF	Monthly	Monthly change (monthly degree of depreciation)
International reserves minus gold	IFS line 1L..DZF	Monthly	Monthly change

Table B: Most parsimonious model

	1980/1-1998/12 (ie 40 countries)					1980/1-2004/12 (ie 34 countries)				
	Part I					Part II				
	1980/1-1998/12	Weak	Median	1980/1-1989/12	1990/1-1998/12	1980/1-2004/12	Weak	Median	1980/1-1989/12	1990/1-2004/12
Deviation of real exchange rate	0.0405*** (0.0028)	1.2445	0.5964	0.0252*** (0.0034)	0.0861*** (0.0061)	0.0368*** (0.0026)	1.0264	0.5212	0.0242*** (0.0034)	0.0775*** (0.0052)
Current account over GDP (levels)	-0.0355*** (0.0589)	-1.0887	-0.5217	-0.0692*** (0.0093)	-0.0567*** (0.0109)	-0.0333*** (0.0056)	-0.9286	-0.4715	-0.0665*** (0.0096)	-0.0472*** (0.0087)
Budget balance over GDP (levels)	-0.0392*** (0.0054)	-1.2022	-0.5761	-0.0826*** (0.0076)	-0.0327** (0.0136)	-0.0568*** (0.0055)	-1.5840	-0.8043	-0.0851*** (0.0081)	-0.0289*** (0.0107)
M2/reserve (growth rate)	0.0006** (0.0003)	0.018	0.0088	0.0010*** (0.0004)	0.0001 (0.0011)	0.0011*** (0.0003)	0.0310	0.0158	0.0010*** (0.0004)	-0.0010 (0.0011)
Real GDP growth	-0.0434*** (0.0054)	-1.3344	-0.6394	-0.0431*** (0.0079)	-0.0652*** (0.0092)	-0.0495*** (0.0053)	-1.380	-0.7001	-0.0415*** (0.0079)	-0.0742*** (0.0087)
Total liabilities/GDP (b) (levels)	0.0007*** (0.0001)	0.0201	0.0097	0.0001 (0.0001)	0.0005*** (0.0001)	0.0002*** (0.0001)	0.0066	0.0034	0.0001 (0.0002)	0.0003*** (0.0001)
FDI liabilities/ total liabilities (levels)	-0.0159*** (0.0039)	-0.4893	-0.2344	-0.0343*** (0.0072)	-0.0019 (0.0066)	-0.0115*** (0.0026)	-0.3215	-0.1633	-0.023*** (0.0083)	0.00113 (0.0038)
Regional contagion	0.1691** (0.0709)	5.4517	2.7504	0.0029 (0.1109)	0.4023*** (0.1104)	0.1839** (0.0797)	5.4714	2.9207	-0.0352 (0.1189)	0.5584*** (0.1241)
Advanced economies	-0.0059 (0.1816)	-0.1821	-0.0872	-0.4221** (0.2082)	0.3870 (0.2861)	-0.0150 (0.1665)	-0.4171	-0.2112	-0.0254 (0.3545)	0.6069*** (0.2027)
Constant	-1.7304*** (0.1509)	n.a.	n.a.	-1.3440*** (0.2517)	-1.8160*** (0.3037)	-1.4869*** (0.1256)	n.a.	n.a.	-1.6308*** (0.2456)	-1.9424*** (0.1728)
Estimated crises prob. (a)		23.4	7.9	13.6 (a)	27.1 (a)		19.9	7.5	13.8 (a)	14.6 (a)
OBS	7403			3760	3643	7818			3042	4776
Model chi square (P>χ)	0.0000			0.0000	0.0000	0.0000			0.0000	0.0000
Pseudo R-squared	13.0			26.5	24.7	15.2			23.9	22.8
L(0)	-2836.8			-1373.3	-1460.7	-2769.2			-1224.8	-1529.2
L(1)	-2468.1			-1008.9	-1099.5	-2347.8			-932.2	-1181.3

Author's calculations

Unless otherwise stated values in table show, marginal impacts at weak level of economic fundamentals in percentage terms; Standard errors in brackets.

* Indicates that the coefficient is significant at 10% level.

** Indicates that the coefficient is significant at 5% level.

*** Indicates that the coefficient is significant at 1% level.

(a) Estimated crises probability estimated at weak levels (ie 25th or 75th percentile).

(b) Note that this is estimated using monthly interpolated data on total external liabilities and GDP. Thus, this coefficient needs to be multiplied by twelve if used with annual data.

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Table C: Crises probability, financial openness and capital structure

Crises probability (%)*	Part I **		Part II ***			Part III ***		
Capital structure	**Fundamentals**		**Share of FDI of total external liabilities**			**Share of FDI of total external liabilities**		
Financial openness	**Median (a)**	**Weak (b)**	**High**	**Median**	**Low**	**High**	**Median**	**Low**
Low	7.2	29.2	2.8 (1.4)	6.8 (2.7)	8.3 (3.1)	14.3 (4.5)	25.7 (6.3)	29.1 (6.6)
Medium	7.8	32.4	3.2 (1.6)	7.5 (2.9)	9.1 (3.3)	16.3 (4.9)	28.6 (6.6)	32.2 (6.8)
High	8.7	35.4	3.6 (1.7)	8.2 (3.1)	9.9 (3.5)	18.6 (5.3)	31.6 (6.7)	35.3 (7.1)

Author's calculations

*Estimates based on the most parsimonious random effect model estimated over 1980/1-2004/12 period (Table B Part II). Financial openness defined as gross external liabilities over GDP (levels): Low = Median - 25% ; Medium = Median of the whole sample; High = Median + 25%. Capital structure defined as share of FDI liabilities over total external liabilities. In brackets, marginal impacts associated to the regional contagion dummy.

** Other indicators: a) at median level; b) at weak level (15th and 85th percentile).

*** Share of FDI liabilities of total external liabilities: High = 50%; Medium = median of the whole sample (ie 14%); Low = 5%. Other indicators: always at weak levels (15th and 85th percentile).

Table D: Emerging market versus more advanced economies

	Emerging Markets					Advanced economies
	Part I			Part II		Part I
	1980/1 – 1998/12	1980/1 – 1989/12	1990/1- 1998/12	1980/1- 2004/12	1990/1- 2004/12	1980/1 – 1998/12
Deviation of real exchange	0.0418*** (0.0030)	0.0265*** (0.0035)	0.0932*** (0.0069)	0.0381*** (0.00274)	0.0751*** (0.0054)	0.0647*** (0.0097)
Current account over GDP (levels)	-0.0321*** (-0.0681)	-0.0582*** (-0.1051)	-0.087*** (-0.015)	-0.0423*** (0.0062)	-0.073*** (0.0107)	-0.0749*** (0.0136)
Budget balance over GDP (levels)	-0.0652*** (0.0064)	-0.0965*** (0.0086)	-0.1151*** (0.0232)	-0.0599*** (0.0058)	-0.026* (0.0137)	0.0331*** (0.01154)
M2 reserve (growth rate)	0.0013*** (0.0003)	0.0011*** (0.0004)	0.0001 (0.0015)	0.0011*** (0.0001)	-0.0007 (0.0012)	-0.0005 (0.0006)
Real GDP growth	-0.0434*** (0.0061)	-0.0451*** (0.0082)	-0.0415*** (0.0129)	-0.0502*** (0.0055)	-0.0843*** (0.0095)	-0.0048 (0.0154)
Total liabilities/GDP (levels)	0.0011*** (0.0001)	0.0002 (0.0002)	0.0019*** (0.0003)	0.0004*** (0.0001)	0.0003** (0.0001)	0.0003*** (0.0001)
FDI liabilities/ total liabilities (levels)	-0.0114** (0.0045)	-0.0202** (0.0101)	-0.0327*** (0.0076)	-0.0117*** (0.0027)	0.0024 (0.004)	-0.0087 (0.0092)
Regional contagion	0.1658* (0.0884)	-0.0193 (0.1228)	0.7209*** (0.1638)	0.2143** (0.0833)	0.6365*** (0.134)	0.2549** (0.1231)
Asia	0.8512*** (0.3175)	0.0556 (0. 4829)	2.1476*** (0.4065)	0.4973* (0.2437)	1.2421*** (0.4077)	
Latin America	0.7684*** (0.2834)	0.7721* (0.4663)	1.056*** (0.3352)	0.4572* (0.2238)	0.2682 (0.2838)	
Africa	0.2339 (0.3456)	0.3878 (0.5934)	0. 3917 (0.6997)	0.0639 (0.2903)	0.3343 (0.5097)	
Constant	-2.8204*** (0.2800)	-2.3006*** (0.4948)	-4.1288*** (0.3780)	-1.9777*** (02001)	-2.4211*** (0.2483)	-1.3514*** (0.2105)
Observations	5023	2434	2589	6487	4053	2380
Model chi square (P>χ)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pseudo R-squared	19.2	27.9	35.3	18.0	25.4	7.2
L(0)	-1910.2	-1032.2	-865.7	-2300.5	-1242.8	-926.4
L(1)	-1543.3	-744.1	-559.8	-1886.1	-926.6	-859.7

Author's calculations

Unless otherwise stated values in table show, marginal impacts at weak level of economic fundamentals in percentage terms; Standard errors in brackets.
* Indicates that the coefficient is significant at 10% level.
** Indicates that the coefficient is significant at 5% level.
*** Indicates that the coefficient is significant at 1% level.

Table E: Floaters versus non-floaters

	40 Countries		34 Countries	
	Part I		Part II	
	Floaters	**Non-floaters**	**Floaters**	**Non-floaters**
	1980/1 – 1998/12	**1980/1 – 1998/12**	**1980/1 – 2001/12**	**1980/1 – 2001/12**
Deviation of real exchange	0.0198*** (0.0033)	0.1312*** (0.0072)	0.0158*** (0.0031)	0.1282*** (0.0074)
Current account over GDP (levels)	-0.0442*** (0.0098)	-0.0324*** (0.0092)	-0.0488*** (0.0093)	-0.0106 (0.0095)
Budget balance over GDP (levels)	-0.0828*** (0.0083)	0.0222** (0.0102)	-0.0761*** (0.0079)	-0.0298** (0.012)
M2/reserve (growth rate)	0.0008 (0.0006)	0.0006* (0.0003)	0.0005 (0.0006)	0.0014*** (0.0004)
Real GDP growth	-0.0007 (0.0088)	-0.0592*** (0.0087)	-0.0341*** (0.0085)	-0.0407*** (0.0089)
Total liabilities/GDP (levels)	0.0001 (0.0002)	0.0007*** (0.0001)	-0.000005 (0.0001)	0.0009*** (0.0001)
FDI liabilities/ total liabilities (levels)	0.0098 (0.0095)	-0.0168*** (0.0055)	-0.0013 (0.0062)	-0.0174*** (0.0052)
Regional contagion	0.1322 (0.1082)	0.1492 (0.1103)	0.1969* (0.1155)	0.096 (0.1335)
Advanced economies	0.4126 (0.3567)	0.4146** (0.2151)	0.5624 (0.3995)	-0.4473* (0.2343)
Constant	-1.6591*** (0.2988)	-2.1139*** (0.1916)	-1.5352*** (0.3135)	-2.2801*** (0.1812)
Observations	2146	5262	2332	4770
Model chi square (P>χ)	0.0000	0.0000	0.0000	0.0000
Pseudo R-squared	14.9	26.8	15.3	31.6
L(0)	-1053.9	-1729.8	-1088.9	-1419.2
L(1)	-896.8	-1266.9	-922.3	-970.6

Author's calculations

Unless otherwise stated values in table show, marginal impacts at weak level of economic fundamentals in percentage terms; Standard errors in brackets.
* Indicates that the coefficient is significant at 10% level.
** Indicates that the coefficient is significant at 5% level.
*** Indicates that the coefficient is significant at 1% level.

Table F: Robustness checks

	Pooled probit (a)	Pooled logit (a)	Alternative hypotheses on the thresholds		Alternative hypotheses on the crises index			Alternative definition of the dependent variable		Alternative modelling approach (d)	
			Mean EMPI + 3SD	Mean EMPI + 2SD	No adjust	6 months	12 months	(b)	(c)	Random effect	Fixed effect
Deviation of real exchange rate	+***	+***	+***	+***	+***	+***	+***	+***	+***	+***	+***
Current account over GDP (levels)	-***	-***	-***	-***	-***	-***	-***	-***	-***	+	+
Budget balance/GDP (levels)	-***	-***	-***	-***	-***	-***	-***	-***	-***	-***	-***
M2/reserve (growth rate)	+***	+**	+**	+**	+**	+**	+	+***	+	+***	+***
Real GDP growth	-***	-***	-***	-***	-***	-***	-***	-***	-***	-***	-***
Total liabilities/ GDP (levels)	+***	+***	+***	+***	+***	+***	+***	+***	+**	+***	+***
FDI liabilities/ total liabilities (levels)	-***	-***	-*	-**	-**	-**	-**	-***	-***	-**	-***
Regional contagion	+***	+***	+**	+**	+***	+	+**	+***	+*	+***	+***
Advanced economies	+	+	+	+	+	+	+	+	+	-***	-***
Constant	-***	-***	-***	-***	-***	-***	-***	-***	-***	-***	-***
OBS	7403	7403	7403	7403	7403	7403	7403	7403	7816	7401	7401
Model chi square (P chi square)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pseudo R-squared	8.1	8.7	13.3	12.8	12.9	13.4	9.3	14.2	10.7	18.6	17.7
L(0)	-2836.8	-2836.8	-2813.7	-2836.8	-2876.7	-2772.9	-2558.3	-2995.4	-3040.7		
L(1)	-2607.2	-2589.1	-2439.3	-2473.9	-2504.9	-2402.1	-2319.3	2570.9	-2714.7		

Source: Author's calculation based on the most parsimonious global model of Table B (Part I).
(a) Results are unchanged if Huber White robust standard errors are used.
(b) Crisis index obtained using deutschmark rather than US dollar as reference country for European economies that joined the euro in 1999.
(c) Crisis index derived using mean and variance over the period January 1980-December 2004.
(d) Dependent variable EMPI and most parsimonious set of regressors used in Table B (Part I) are included with a one-month lag.

Table G: Model performance

| %	All countries			EMEs			Latin America			Emerging Asia			EMEA		
	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
5	41	86	34	54	84	50	48	92	39	63	75	62	53	60	53
	(46)	(69)	(43)	(53)	(71)	(51)	(53)	(95)	(48)	(57)	(81)	(52)	(67)	(57)	(68)
10	66	58	68	73	54	75	65	74	63	70	70	70	69	48	71
	(73)	(50)	(75)	(74)	(50)	(77)	(77)	(76)	(77)	(62)	(73)	(60)	(78)	(40)	(81)
15	77	39	83	80	40	85	72	58	75	77	68	78	74	45	77
	(81)	(34)	(87)	(84)	(35)	(90)	(86)	(46)	(92)	(65)	(67)	(65)	(86)	(37)	(90)
20	82	29	90	84	32	91	76	50	81	83	64	85	82	34	86
	(83)	(28)	(89)	(86)	(21)	(94)	(88)	(29)	(96)	(67)	(61)	(68)	(90)	(17)	(96)
25	85	23	94	87	27	95	79	43	87	86	54	89	88	30	93
	(84)	(17)	(92)	(87)	(13)	(96)	(89)	(19)	(98)	(67)	(54)	(70)	(91)	(13)	(97)
50	88	7	99	89	14	99	85	22	98	94	43	98	91	23	97
	(88)	(8)	(98)	(88)	(4)	(98)	(88)	(0)	(100)	(70)	(30)	(77)	(93)	(2)	(100)

(a) Total correct predictions.

(b) Pre-crises periods correctly predicted.

(c) Non pre-crises periods correctly predicted. In sample performance over the 1980/1-1997/1 period. In brackets, out-of-sample performance over the period 1997/2-2004/12.
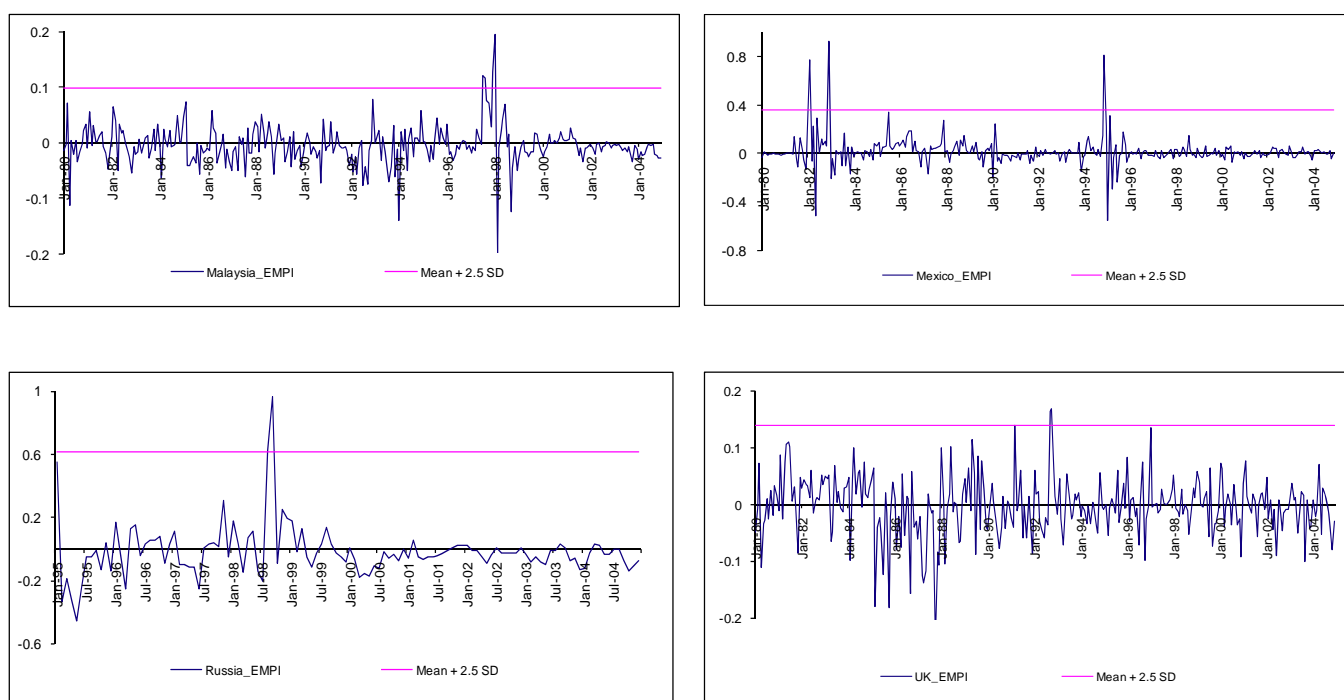
Appendix II: List of charts

Chart 1: Number of crises per region and per year
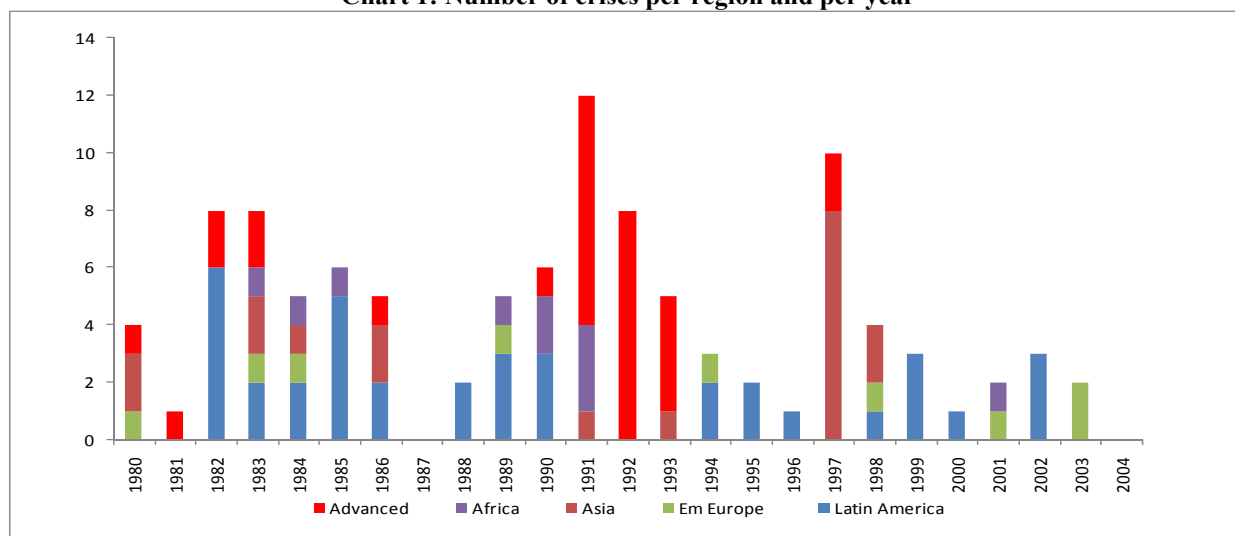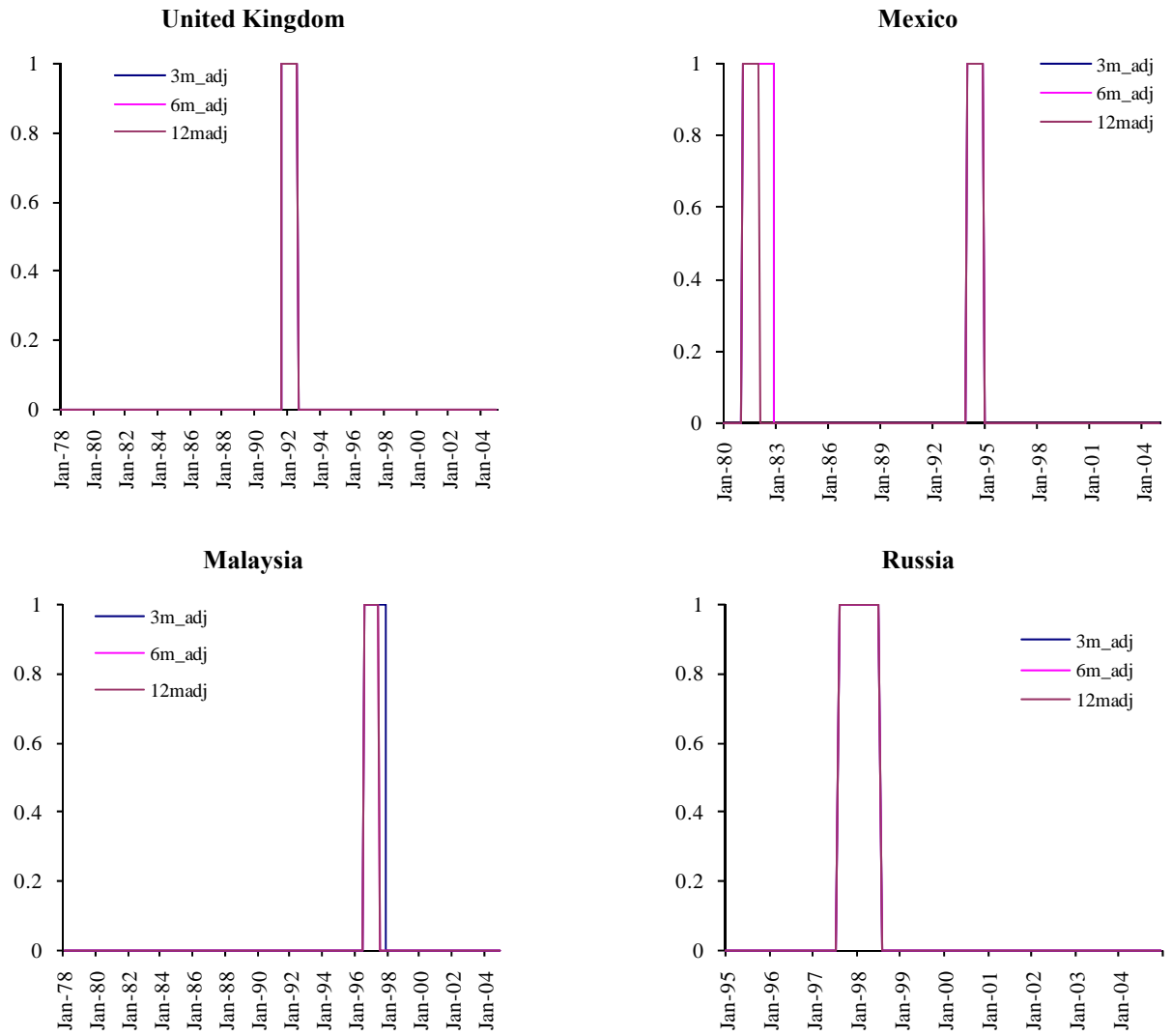

Source: Author's calculations

### Chart 2: Exchange market pressure index for selected economies

Source: Author's calculations

Chart 3: Crises index

United Kingdom

Legend: 3m_adj, 6m_adj, 12madj

Mexico

Legend: 3m_adj, 6m_adj, 12madj

Malaysia

Legend: 3m_adj, 6m_adj, 12madj

Russia

Legend: 3m_adj, 6m_adj, 12madj

Source: Author's calculations

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Chart 4: Total external liabilities (percentage of GDP) and FDI (as share of total liabilities) in the year of the currency crisis
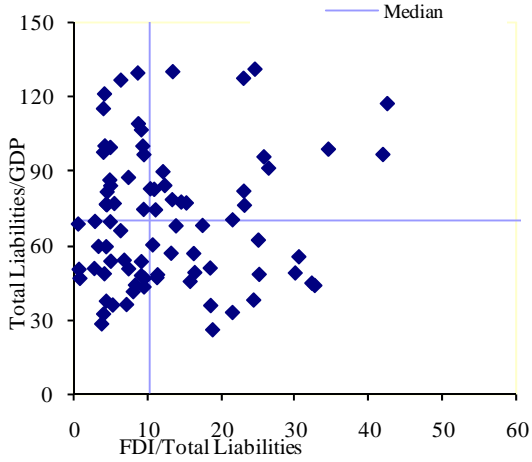
Source: Author's calculations

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