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# Are twin currency and debt crises special?

**Christian Bauer, Bernhard Herz and Volker Karb<sup>\*</sup>**

September 2005

## **Abstract**

We show theoretically and empirically that twin currency and debt crises should be treated as a particular crisis type. Twin currency and debt crises differ from both pure currency and pure debt crises in their determinants, the course of the crises, and their economic consequences. We find that each crises type has a unique set of macroeconomic causes. We also uncover internal contagion and selection bias effects which may lead to biased results if twin crises are not treated separately. Such a separation considerably improve the efficiency of early warning systems especially on debt and twin crises.

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# 1. Introduction

In the literature on currency and banking crises it has become the standard procedure to treat pure currency crises, pure banking crises and combined (“twin”) currency and banking crises as separate classes of crises. For example, in empirical studies the output effects and the frequencies are usually analyzed separately for each of these three types of crises.<sup>1</sup> In contrast, in the literature on debt and currency crises a similar distinction is still missing – even though empirically twin debt and currency crises are at least as frequent as the more prominent twin currency and banking crises.<sup>2</sup> The question we address therefore is: Should twin debt and currency crises also be regarded as a particular type of crisis, which should be analyzed separately from pure currency and pure debt crises (table 1)? Can such a classification help to better understand the interrelations between fiscal and exchange rate crises? And does it – on the empirical side – improve the quality of early warning indicators, which aim to predict financial crises? If debt and currency crises are interrelated due to common causes and / or direct contagion effects from one crisis to the other, an explicit consideration of these interrelations may indeed enhance the results of empirical analyses and the forecasts of early warning systems.

**Table 1: Default and devaluation**

	No devaluation	Devaluation
No default	Non-crisis	Pure currency crisis
Default	Pure sovereign debt crisis	Twin debt and currency crisis

Early warning systems of financial crises have been extensively proposed and analyzed in the literature.<sup>3</sup> However, their forecasting performance is mixed and often poor in the sense that indicators fail to predict crises that in fact do occur (type I errors) or that they predict crises in cases when in fact no crisis occurs (type II errors, “false alarms”; see IMF, 2002). For

<sup>1</sup> See e.g. IMF (1998), Glick and Hutchison (1999), Kaminsky and Reinhart (1999), DeLargy and Goodhart (1999), Bordo, Eichengreen, Klingebiel and Martinez-Peria (2001), Eichengreen (2002), and Bordo and Eichengreen (2003).

<sup>2</sup> Herz and Tong (2003) analyze a developing countries sample and find that 32 percent of all debt crises in their sample are linked to currency crises, while 20 percent of the currency crises are associated with debt crises. Reinhart (2002) finds that 84 percent of the defaults in her emerging markets sample are connected with currency crises and almost half of the currency crises in the sample are related to defaults. Recent, prominent examples of simultaneous debt and currency crises include Russia (1998) and Argentina (2001). Reinhart (2002) supposes that other countries, that recently experienced balance of payments and exchange rate problems such as Mexico, South Korea, Thailand, and Turkey, would most likely have suffered from debt service difficulties as well if they had not obtained vast international rescue packages.

<sup>3</sup> For a review see Edison (2003).

example, Frankel and Rose (1996) as one of the first approaches to study macroeconomic variables as predictors of currency crises yield only a low explanatory and predictive potential: While the numbers of false alarms remains below 1%, they only predict 5 out of 69 currency crises.

One reason for the little convincing results of traditional empirical analyses can be that they often mix pure debt or pure currency crises with twin debt and currency crises. We show that treating and analyzing currency, debt, and twin crises as separate events can improve the efficiency and the predictive power of early warning systems. Our approach distinguishes between the direct and indirect influences of indicator variables on the respective crisis types. If for example standard analyses of debt crises identify inflation as an important crisis predictor, this may well be the case because inflation in a first step can produce currency crises, which in turn via contagion effects trigger simultaneous debt crises. Thus, while inflation may in fact only be an indicator for twin debt and currency crises but not for “pure” debt crises, traditional analyses would show that it is an indicator of all kinds of debt crises, as the strong impact of inflation on twin crises is carried forward to the entire crises sample.

In our sample the predictive value of macroeconomic variables (i.e. the use of current indicator values to predict a crisis in the following year) is lowest for currency crises and best for twin crises. If twin crises are treated as a separate type of crises, 36% of all currency crises, 75% of all debt crises, and 50% of all twin crises are predicted correctly, while we get 1.6% false alarms for the prediction of currency crises, 12% false alarms for the prediction of debt crises, and 0.3% false alarms for the prediction of twin currency and debt crises. An extensive regression, which includes interaction terms between the explanatory variables, leads to a nearly perfect prediction of twin crises.

The remainder of the paper is organized as follows. Section 2 reviews major theoretical aspects on the causal interrelations between debt and currency crises. Section 3 presents some stylized facts on the determinants and consequences of currency, debt, and twin crises. We address the question whether the development of various key economic variables around crises situations supports the differentiation of these crises as three separate types. To address the question of common causes and contagion, we provide an illustration of the monetary and fiscal situation in a sample of countries 62 middle-income countries that experienced debt and / or currency crises during the last three decades. In Section 4, we present GLM estimations, which provide the grounding for a statistically more sophisticated analysis. We also use an extensive GLM model to evaluate early warning systems for the

different crisis types. Section 5 concludes. A comprehensive review of all estimation results and associated graphics can be found in the appendix.

## 2. Determinants of currency crises and sovereign debt crises

Currency crises and sovereign debt defaults are recurring phenomena. They are typically accompanied by a collapse in real economic activity, which in the past was particularly acute in emerging markets and developing countries.<sup>4</sup> Many authors therefore contributed to the task of identifying the causes of these crises and to the derivation of policy measures to avoid future crises. Based on the experiences of the Latin American emerging market crises in the 1960s and 1970s so-called first-generation currency crisis models (e.g. Krugman, 1979; Flood and Garber, 1984) focused on fundamental economic weaknesses such as excessive fiscal and monetary policies as major causes of the breakdown of fixed exchange rate regimes. Following the EMS crisis (1992-93), private devaluation expectations, which affect a government's policy decisions and thus can turn out to be self-fulfilling, became an important explanation of currency crashes in the so-called second-generation models (see e.g. Obstfeld, 1994; Obstfeld, 1996a; Ozkan and Sutherland, 1998). An essential insight of this literature is that it is not a change in the market sentiment alone that drives financial crises. Economic fundamentals still play an important role. In situations with sufficiently good fundamentals the government is able and willing to defend the exchange rate peg irrespective of the investors' expectations. In situations with very bad fundamentals it is the welfare maximizing option for the government to abandon the peg regardless of the private expectations. Only in between these two extreme cases there is a zone with multiple equilibria, a "gray area" in terms of Obstfeld (1996b). Here changes in private beliefs can lead to self-fulfilling currency crises.<sup>5</sup>

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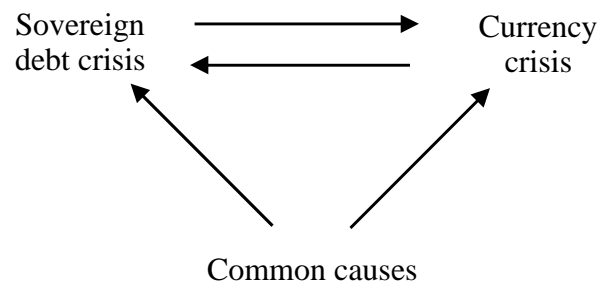
<sup>4</sup> Rose (2002) and Rose and Spiegel (2002) illustrate that sovereign debt repudiation can cause a serious breakdown in international trade. Dooley (2000) among others finds that debt defaults are usually followed by major output losses. Currency crises typically also cause enormous real economic setbacks. The IMF (1998) reports that from 1975 to 1997 61 percent of all currency crisis episodes were associated by a significant decline in GDP in terms of a negative deviation from trend output. In a sample of crises, which the IMF characterized as particularly serious („currency crashes”), even 71 percent of the crises led to significant output losses. Based on a panel analysis of 24 emerging markets covering the time from 1975 to 1997, Hutchinson and Noy (2002) found that currency and balance-of-payments crises reduce real GDP by five to eight percent over a period of two to three years. However, currency crashes do not in all cases cause a deep and long-lasting recession. For example following its crisis in 1998 Russia experienced positive GDP growth for the first time since the end of the Soviet Union. Growth was also accompanied by further positive developments, e.g. by a reduction of barter trade and by increased lending of the banking system to the private production (see Huang, Marin, and Xu, 2004). For a detailed description of the output effects during various crisis episodes see Gupta, Mishra, and Sahay (2003).

<sup>5</sup> For a comprehensive review on the first and second-generation currency crisis literature see Jeanne (2000).

The literature on sovereign debt defaults has similar features. The level and the maturity structure of the debt are among the most important fundamental factors for a government's decision to default on its debt service. In some situations default expectations of private investors may also trigger debt repudiation. If investors expect a (partial) default they demand higher interest rates to compensate for the default risk when they buy new bonds. This increases the government's debt service obligations and thus its incentive to actually default. If, instead, investors do not expect a default and thus do not demand an extra risk default premium, the government is able and willing to service its debt as agreed. Multiple equilibria with self-fulfilling private default expectations, however, become possible only if economic fundamentals are sufficiently bad, i.e. if for example the debt exceeds a crucial level. If the debt is lower than this crucial level, the government repays its debts even if default expectations cause the interest payments to rise. Cole and Kehoe (1998) show that lengthening the maturity increases this crucial level, i.e. with a longer maturity structure a higher debt level can be maintained without risking a financial crisis.

So far there exist only few theoretical studies on the simultaneous occurrence of sovereign debt and currency crises. However, there are several important links between debt and currency crises.

**Figure 1: Links between debt and currency crises**



Debt and currency crises can be positively correlated due to common causes and “internal contagion effects” between both types of crises. An example of common causes is a negative shock on GDP growth, which reduces the government's tax base. As the public budget situation deteriorates, default becomes more likely. At the same time, a slowdown in GDP growth also raises the government's incentive to devalue in order to stimulate economic activity. Other important variables that can be interpreted in the sense of common causes are the volume, the currency structure, and the maturity structure of sovereign debt. These debt

variables are all essential to determine the sustainability not only of the public debt burden but also of a country's balance of payments position.

There are also direct links between both kinds of crises ("internal contagion effects"). Devaluation can for example directly trigger a debt crisis as it increases the real value of foreign currency denominated debt<sup>6</sup> or as it leads to credit rating downgrades, which increase the country's interest rate risk premium.<sup>7</sup> The opposite causality, which runs from debt to currency crises, has already been stressed e.g. by the first-generation currency crisis models, which imply that excessive fiscal and debt policies can trigger speculative attacks.

Yet, the short discussion in section 1 has already shown, that debt defaults and currency devaluations need not always be positively associated. They can also be negatively related due to the complementary budget financing aspects. A deficit forces a government to choose among three options to finance the budget if neither an increase in tax revenues or a reduction of government spending are available: (1) default on debt coming due, (2) issuing new debt, thus raising the overall debt burden and raising the risk of a future debt repudiation, and (3) print money, which induces inflation and currency pressure and thus increases the risk of a currency crisis. If a government chooses to finance its budget via a monetary expansion it thereby lowers its need of debt default and vice versa.<sup>8</sup>

Bauer, Herz and Karb (2004) combine several of these factors into an integrated framework. Their approach includes the characteristic properties of the second generation currency crisis literature, but extends this framework to a government that - weighing the costs and benefits of its policy options - decides whether to abandon a fixed exchange rate peg and / or whether to default on its maturing debt service payments at the same time. The welfare function  $W_t$ , which the sovereign policymaker maximizes, is

$$W_t = Y_t - \lambda E_t - \eta F_t - cT_t. \quad (1)$$

$Y_t$  is the real GDP.  $\lambda$  and  $\eta$  are dummy variables, which indicate the government's decision to devalue ( $\lambda = 1$ ) or not to devalue ( $\lambda = 0$ ) and to default ( $\eta = 1$ ) or not to default ( $\eta = 0$ ) on its debt service obligations.  $E_t$  are the real costs of a devaluation (e.g. a loss of

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<sup>6</sup> Developing and emerging market economies generally suffer from the so-called "original sin" phenomenon: They are not able to issue large amounts of debt in their local currency so that they are forced to incur foreign currency denominated debts. On the causes, implications, and possible cures of original sin see Jeanne (2003), Eichengreen and Hausmann (2003) and Eichengreen, Hausmann, and Panizza (2002, 2003).

<sup>7</sup> See Calvo and Reinhart (2000) and Reinhart (2002) for empirical evidence and possible explanations of credit rating downgrades in the aftermath of devaluations.

<sup>8</sup> For a comprehensive overview over the theoretical and empirical links between currency and debt crises also see Herz and Tong (2003) and Dreher, Herz, and Karb (2004).

reputation). These costs depend in part on the devaluation rate, which reflects that interest rate risk premiums in affected countries typically rise in the aftermath of devaluations depending on the scale of devaluation.<sup>9</sup> Devaluation, however, also yields some benefits for the government, e.g. surprise devaluation (and the associated surprise inflation) can increase  $Y_t$  in terms of an expectations augmented Phillips curve.  $F_t$  are the real costs of a default, e.g. a loss of reputation, trade, and GDP. The term  $cT_t$  denotes the costs of taxation, which are assumed to be a linear function of the government's real tax revenue  $T_t$ .

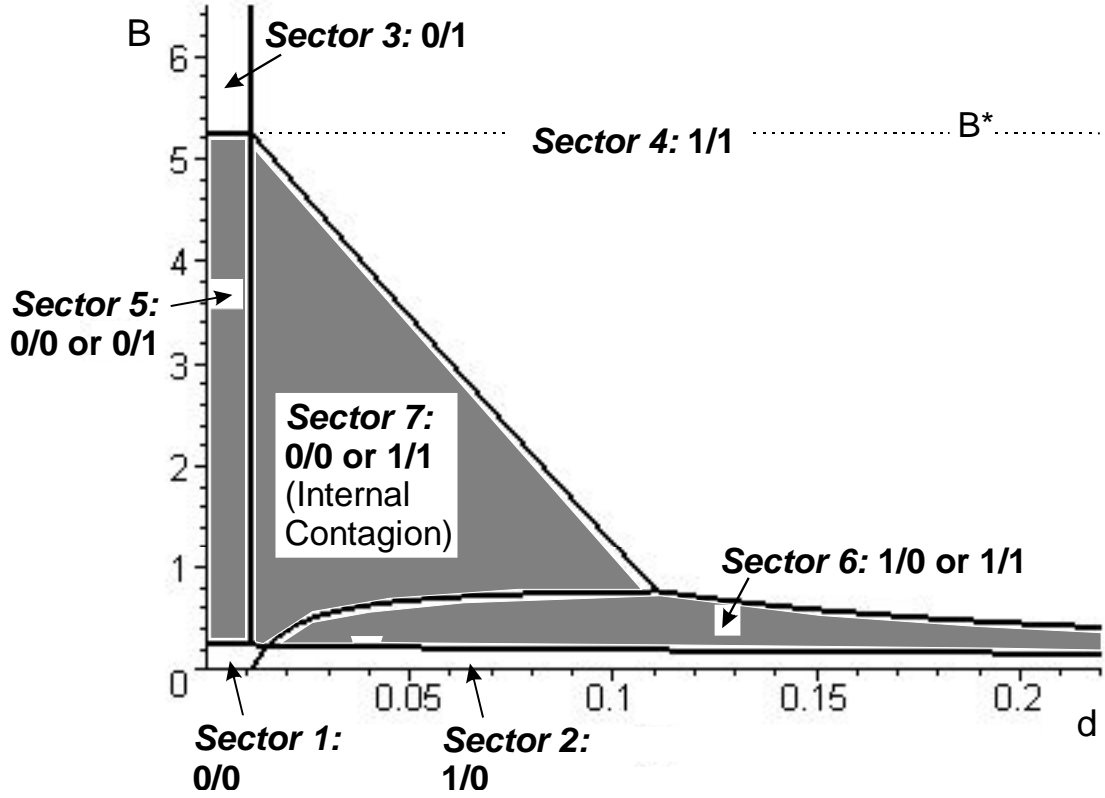
In maximizing public welfare, the government is bound by its budget constraint: As long as the government decides to honor its debt service obligations, expenditures on government consumption and repayment of old debt must be equal to tax revenues, new debt, and seigniorage. As Bauer, Herz, and Karb (2003) assume purchasing power parity to hold, the government's decision of to devalue involves the decision to allow for inflation by an expansion of the monetary base and thus also determines the amount of seigniorage. The default expectations of private investors determine, at what price the government can finance its budget by selling new debt. With all other variables in the budget constraint set exogenously from the government's point of view, the taxes, which the government needs to collect to balance its budget and which negatively affect public welfare according to equation 1, are determined as soon as the government makes her decision whether to default and whether to devalue.

Bauer, Herz, and Karb (2003) show, that as a result of the government's cost-benefit-analysis the decision whether to default and / or to devalue depends on both the level of public debt  $B$  and the monetary fundamental situation  $d$ , with an increase in  $d$  indicating deteriorating monetary fundamentals. However, in some situations, the decision to devalue can depend on the decision to default and vice versa. As a consequence, self-fulfilling private default expectations can in some situations cause not only debt crises but also currency crises. Figure 2 illustrates the government's optimal policy. The policy choice is denoted as a vector  $(\lambda/\eta)$ .

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<sup>9</sup> See Reinhart (2002) for empirical evidence that especially in emerging markets currency crises are often followed by credit rating downgrades.





**Figure 2: Optimal policies depending on the investors' default expectations.**

The sectors labeled 1, 2, 3, and 4 in figure 2 show the combinations of debt levels  $B$  and fundamentals  $d$  for which the welfare maximizing policy does not depend on private expectations. In sector 1, where the debt level is low and the fundamentals are good, the optimal policy decision is neither to devalue nor to default (“no crisis”: 0/0). In sector 2, where the monetary fundamentals are bad but the debt level is low, it is optimal to devalue (“currency crisis”: 1/0). In sector 3 with a high debt level and good monetary fundamentals it is the optimal policy decision to default (“debt crisis”: 0/1). In sector 4 with high debt levels and bad fundamentals it is optimal to both devalue *and* to default (“twin debt and currency crisis”: 1/1).

In accordance with the second-generation currency crisis literature, in between these situations of unique equilibria there is a gray area of multiple equilibria, which is two-dimensional in this case, however. In the sectors 5, 6, and 7 the investors' default expectations are self-fulfilling, i.e. it is optimal for the government to default on its debt service obligations only if investors expect a default and to not default otherwise. In sector 5, the fundamental economic situation is sufficiently good so that the government keeps the peg regardless of its debt policy and private expectations. In contrast, in sector 6, the monetary fundamentals are

sufficiently bad so that it is optimal for the government to devalue regardless of the debt policy. In sector 7 there is an “internal contagion” in effect. In this sector the policymaker’s debt policy also determines the exchange rate policy. If private investors expect a default, it is not only optimal for the government to actually default, but also to devalue. If, in contrast, investors do not expect a default, the government decides not to default *and also* not to devalue.

Figure 2 furthermore implies a kind of substitution effect of good monetary and fiscal fundamentals to prevent financial crises. The line, which separates sector 7 from sector 4, indicates that - as long as the debt level is neither sufficiently high to trigger an inevitable debt crisis nor sufficiently low to eliminate any threat of a debt crisis - good monetary fundamentals do not only prevent currency crises but also help to avert expectations-based debt crises. In these situations any policy measure that improves the monetary fundamentals yields a double dividend as it helps to prevent *both* types of crises at the same time. Also, as long as the monetary fundamentals are neither good enough to exclude any currency crisis risk nor bad enough to trigger an inevitable currency crash, a low debt level does not only avert a debt crisis but also helps to fight off expectations-driven devaluations. In these situations a sound fiscal and debt policy yields the same kind of double dividend. It also helps to prevent *both* crisis types.<sup>10</sup>

### 3. Stylized facts

#### 3.1. *Causes and consequences of different financial crises*

To give a first impression on the determinants of financial crises and their consequences we present the development of eight economic variables before and after crisis situations and compare them to their average level in non-crisis situations. The variables are the level of central government debt (% of GDP), external debt (% of GDP), net inflow foreign direct investment (% of GDP), annual growth of GDP per capita, inflation (log of annual change of consumer prices), overall budget balance including grants (% of GDP), total

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<sup>10</sup> On the other hand, the substitution effect may also be interpreted in a negative way. If the debt level is sufficiently high, it may not only trigger a debt crisis, in addition it can cause a currency crisis, even if the monetary fundamentals are relatively good. Analogously, sufficiently bad monetary fundamentals may not only cause currency crises but can also lead to debt crises even in situations with relatively low debt levels.

reserves in months of imports, and overvaluation.<sup>11</sup> The data are drawn from the World Bank World Development Indicators (WDI) 2004 data set.<sup>12</sup>

Our benchmark sample includes 62 middle-income countries with an annual GDP per capita between 766 and 9360 US Dollars and a population exceeding 1 million inhabitants. The sample covers the period from 1975 to 2002.<sup>13</sup>

The data on “debt crises” are adopted from Beers and Chambers (2002), where debt crises are defined as episodes, in which a debtor country unilaterally departs from the scheduled debt service, i.e. reschedules or ceases the debt service. The classification of “currency crises” corresponds to Frankel and Rose (1996). Currency crises are defined as a drop in the yearly mean of the US Dollar official exchange rate of more than 25 percent. Analogously to Glick and Hutchinson’s (1999) twin banking and currency crisis definition, we characterize twin debt and currency crises as debt crises accompanied by a currency crisis in the same year. These crisis definitions leave us with a sample of 796 data points without a crisis, 145 currency crises, 229 debt crises, and 102 twin crises.

Figures 3 and 4 visualize the behavior of the eight key macroeconomic variables three years before and after crisis episodes. The “0” on the time line denotes the crisis year.<sup>14</sup> Twin crisis episodes are counted separately and are neither added to the currency nor to the debt crises subsample. The solid black lines in figure 3 and 4 depict the average behavior of the economic variable around a currency crisis. The dotted lines plot debt crises and the dash-dotted lines plot twin debt and currency crises. The horizontal line denotes the variables’ averages in non-crisis periods.<sup>15</sup>

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<sup>11</sup> The official WDI terms are “Central government debt, total (% of GDP)”, “External debt, total (DOD, % of GDP)”, “Foreign direct investment, net inflows (% of GDP)”, “GDP per capita growth (annual %)", (logs of) “Inflation, consumer prices (annual %)", “Overall budget balance, including grants (% of GDP)”, “Total reserves in months of imports”. Overvaluation is defined as the deviation from the average US Dollar real exchange rate.

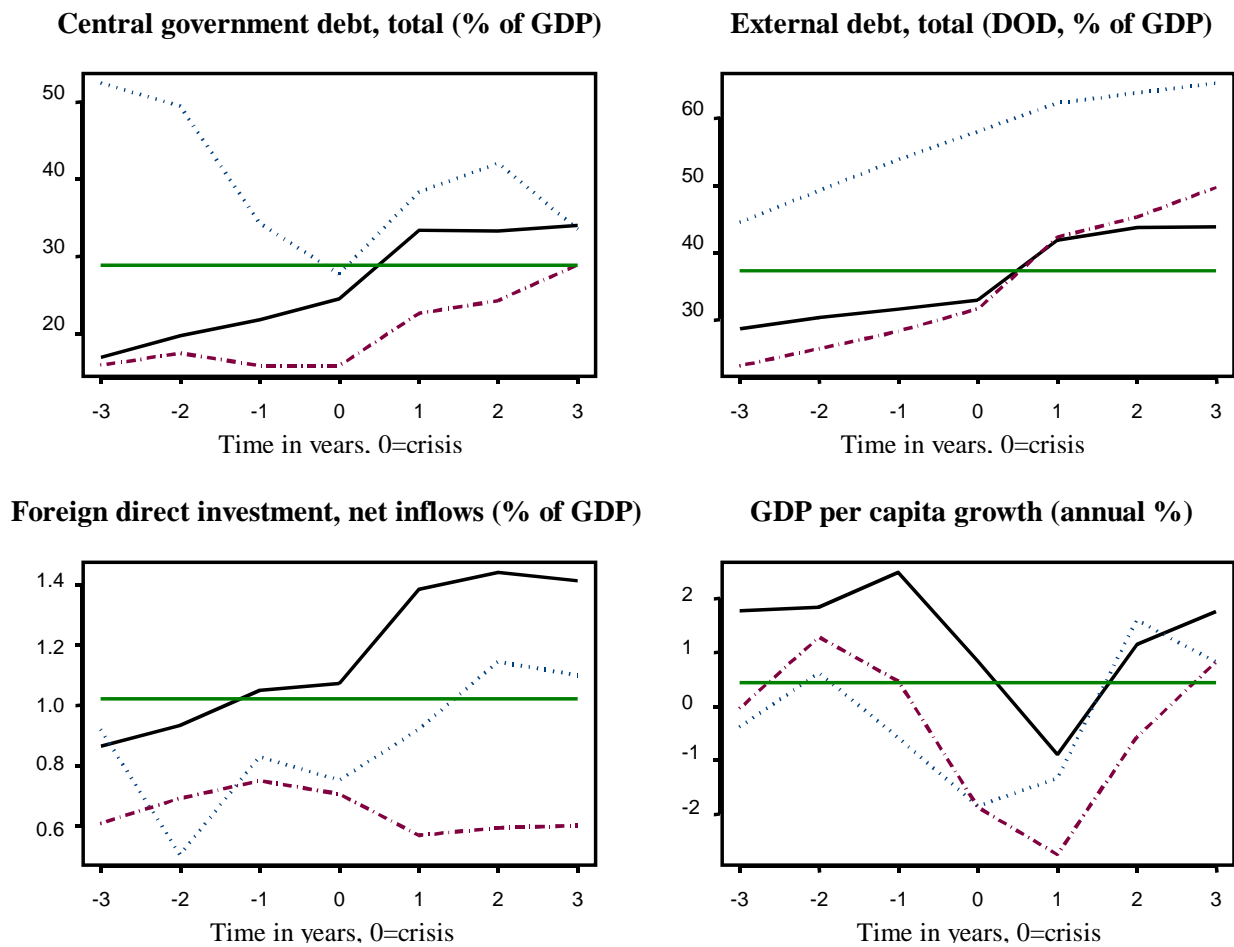
<sup>12</sup> <http://www.worldbank.org/data/wdi2004/index.htm>.

<sup>13</sup> The definition of middle-income countries refers to the World Bank classification.

<sup>14</sup> In the case of serial crisis episodes, i.e. if a country remains within a crisis situation for more than one year, the “0” in the figures 3 and 4 only indicates the first crisis year, i.e. the entry into a crisis. Alternatively we could use windows to account for repeated crises as in the graphical analysis by Frankel and Rose (1996). Such a classification would not change the results.

<sup>15</sup> We use a trimmed mean with 10% trim to robustify the estimate.

**Figure 3: Debt, FDI flows, and GDP growth before and after crises in middle-income countries (1975-2002).**



The visualizations already give a first impression on how twin crises differ from debt and currency crises. Figure 3 indicates that before a pure debt crisis central government debt and a country's external debt are higher than average. While the central government debt declines before the crisis and reaches its minimum in the actual crisis year, the external debt continually rises, i.e. in the run-up to a pure debt crisis central government debt seems to be transferred to non government bodies and at least partially converted into foreign debt. For pure currency and twin crises both government and external debt start at lower than average levels and increase sharply during the crises. This finding could be related to the original sin phenomenon, i.e. if a high share of a country's debt is denominated in foreign currency, the real value of this debt increases in the course of devaluation.

GDP growth might serve as an indicator to each of the crises, since it begins to decline in the year(s) before the incidence of the crises. While in the case of pure debt crises GDP

growth reaches its minimum in the crisis year and increases thereafter, countries with pure currency crises and twin crises face the lowest GDP growth in the year after the crisis which is actually an average decline of GDP of 1% and 2%, respectively). Though twin crises exhibit the strongest drop in growth among all crisis types, the growth paths recover on average within three years after the crisis.

Foreign direct investments sharply increase after pure currency and pure debt crises. This can be interpreted as the dissolution of uncertainty about the impending crisis or the assessment of international investors that inadequate policies, which led to the crises, are corrected. In the case of twin crises, however, FDIs further decline from an already low level after the crisis emerged. This may indicate that from foreign investors' point of view twin crisis countries seem to have more severe problems, which are not lessened by the crisis.

Figure 4 shows that average inflation declines during and after pure debt crises. In contrast, inflation increases after currency crises and in and - to an even greater extent - after twin crises. These crises typically result from government financing through a monetary expansion.

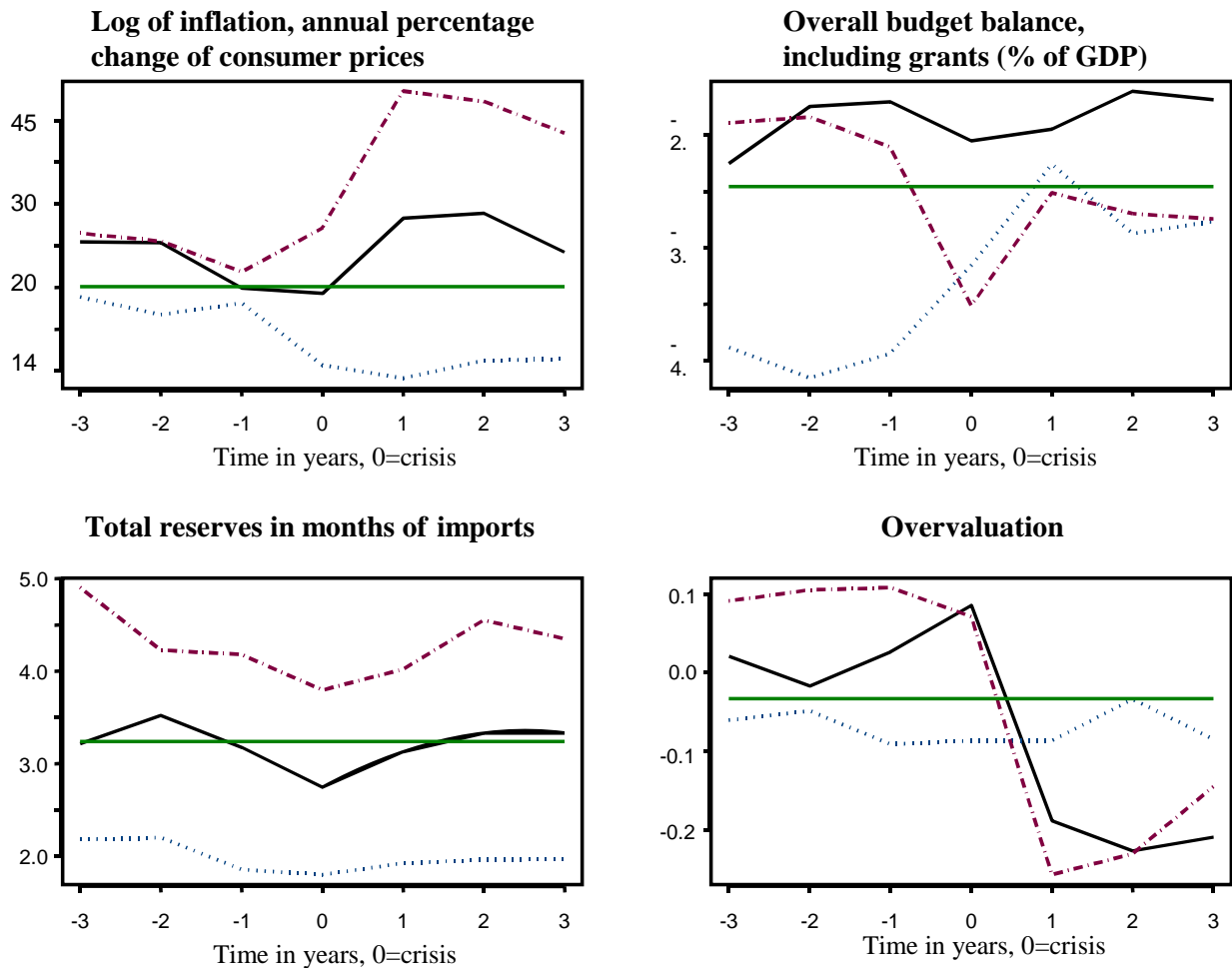
The upper right diagram in figure 4 depicts the overall budget balance around crises situations. While budget deficits before, during, and after currency crises are lower than the average in non-crisis situations, pure debt crises seem to be preceded by excessive budget deficits. Twin crises seem to be accompanied by large deficits only in the year of the crisis.

The reserves over imports ratio clearly differentiates among the three crisis types. In pure debt crises reserves are lower than average. In pure currency crises they are about average and in twin crises they are higher than average. For all three types of crises the reserves over imports ratios decline in the pre-crisis years, possibly due to an attempt to defend the currency and / or to service outstanding debt. The relatively low level for debt crises countries may originate from a group effect, namely that these countries tend to have floating exchange rate regimes and thus hold smaller amounts of reserves. Finally, the lower right diagram in figure 4 shows that currency as well as twin crises significantly reduce the overvaluation of the currency, while no effect is visible for pure debt crises.<sup>16</sup>

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<sup>16</sup> In part this may be due to the definition of real overvaluation as the difference of the current real exchange rate from its average. A large nominal devaluation and sticky prices in an otherwise undisturbed data series by definition imply that the real exchange rate is above average before and below average after a devaluation.

**Figure 4: Inflation, budget balance, reserves, and overvaluation before and after crises in middle-income countries (1975-2002).**



### 3.2. *Fiscal and monetary situation in crisis situations*

We now illustrate the differences between the three crises types in greater detail. Debt and currency crises are typically seen as the reflection of bad monetary and fiscal fundamentals. Figures 5 and 6 plot the external debt level as proxy variable for the fiscal fundamentals and the M2 to foreign reserves ratio as a proxy variable for the monetary fundamentals of our benchmark sample of 62 middle-income countries.<sup>17</sup> A rising M2 to reserves ratio indicates an increasing scale of liquidity in the financial system and thus deteriorating economic fundamentals in terms of the currency crisis literature.<sup>18</sup> A rising debt level indicates deteriorating economic fundamentals in terms of the debt crisis literature.

<sup>17</sup> Data are again drawn from World Bank Economic Development Indicators series. The debt variable refers to the World Bank's total external debt time series.

<sup>18</sup> See e.g. Calvo and Mendoza (1996), who point to a fatal M2 to foreign exchange reserves ratio as an important reason of the 1994-95 Mexican crisis.

Hausmann (2003) argues that the debt structure, i.e. the currency denomination and the maturity structure, significantly influence crises predictions. To account for the higher relevance of foreign denominated debt, we use the external debt and not the central government debt as explanatory variable in our analysis.

**Figure 5: Distribution of crisis episodes**

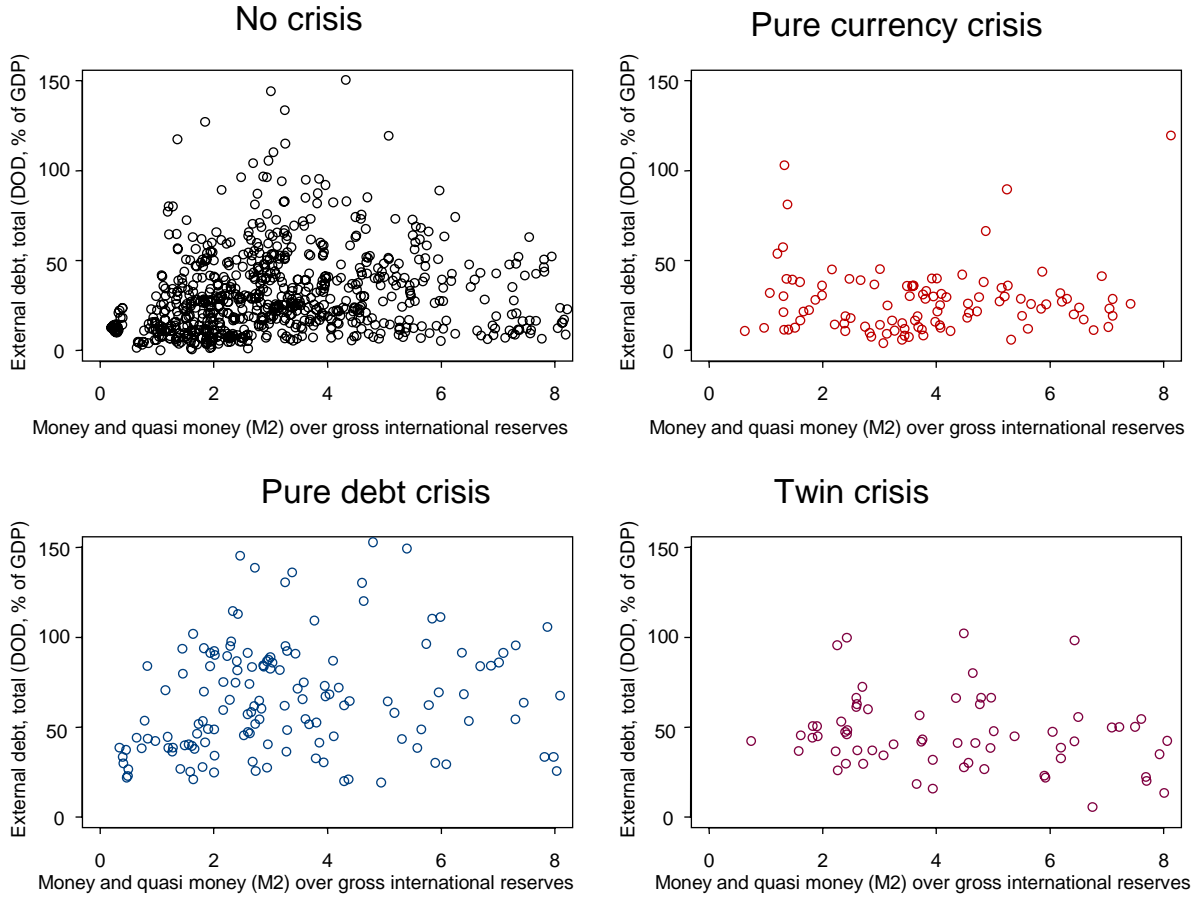
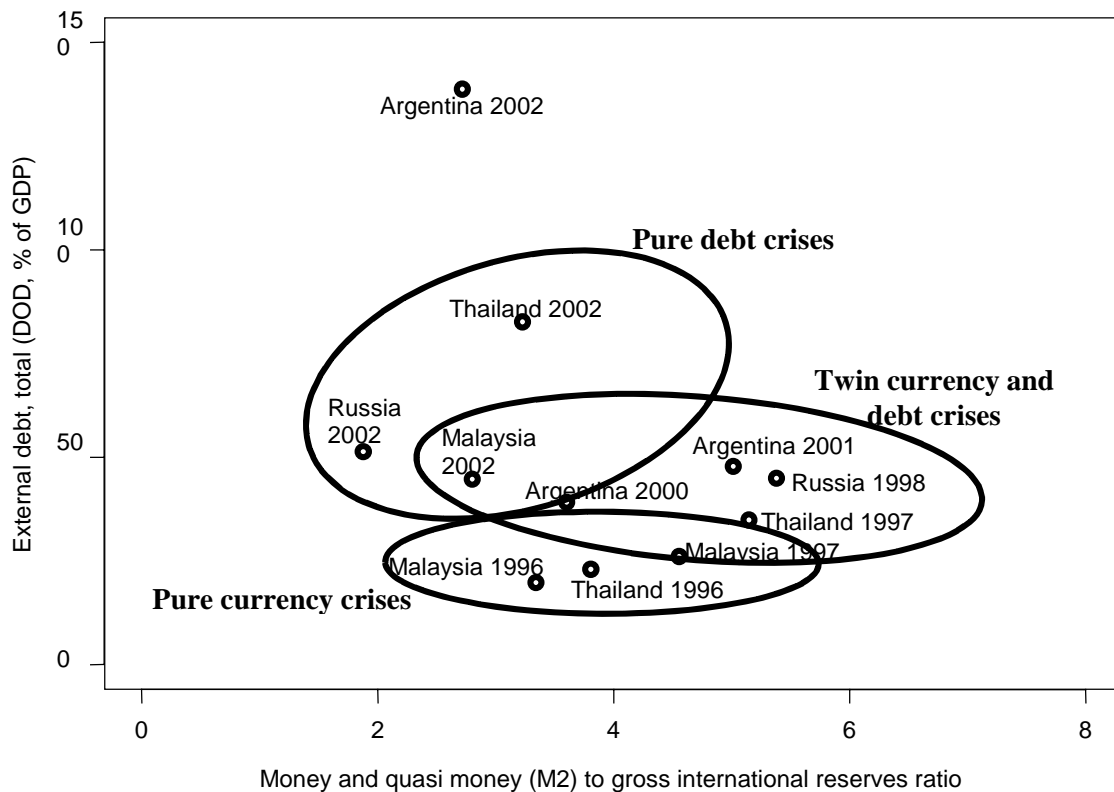


Figure 5 structures the sample into the four subgroups of countries, which experienced “no crisis” (marked black in the following), “debt crises” (blue), “currency crises” (red), and “twin debt and currency crises” (purple). As data range from 1974 to 2002 and every year is represented by one data point, each country appears at most 29 times in the figure if data are available for all years.

Figure 6 combines all episodes into one plot. The ellipses in figure 6 are minimal volume ellipsoid (MVE) estimates of the occurrences of the different crisis types. The centers of the ellipsoids are a robust estimate of the bivariate average of the monetary and the debt variable of the countries that suffered from a debt crisis, a currency crisis, or a twin debt and

currency crisis, respectively. The edges of the ellipses indicate a distance of one multivariate standard deviation from the center in the respective groups.

**Figure 6: Mean and dispersion of the indicator variables before and during crises**



Selected data points of recent prominent crises are added to the plot of the crisis ellipsoids. Argentina moved from the south west of the twin crisis ellipsoid in 2000 towards the northeast indicating a rising likeliness for a twin crisis, which in fact emerged in 2001. Its 2002 data in the north of the debt ellipse corresponds to the continuing debt crisis. Likewise the Russian Federation moved from its 1998 level in the center of the twin crisis ellipse and has left the twin crises zone. Given its 2002 position in the west of the debt ellipse and considering its early repayment of debts, Russia seems to have left the crisis area. Thailand and Malaysia moved inside the twin crisis ellipse from 1996 to 1997 and faced a twin banking and currency crisis. The stable situation in 2002 in these countries corresponds to data points outside the twin crisis zone.

These stylized illustrations provide some interesting insights. Not surprisingly, in figure 5 the non-crisis episodes are concentrated in the lower left part. This means that if a country's debt level is low and its economic fundamentals are sound, there are typically no



financial crises. Pure “debt crisis” episodes frequently occur, if the debt level is high while the monetary fundamentals are in good condition. The debt crisis ellipse in figure 6 indicates that the critical debt level seems to be around 40 percent of GDP. Pure “currency crisis” episodes frequently occur at low debt levels, if the monetary fundamentals are bad. Twin debt and currency crises in general occur when a country’s debt level is high and the monetary fundamentals are bad.

The slightly negatively sloped twin crisis ellipse points to that kind of substitution effect between the fiscal and the monetary fundamentals dimensions, which was predicted by figure 2. Very low debt levels may not only prevent debt crises but can also contribute to prevent currency crises. Analogously, very good monetary fundamentals may not only avert currency depreciations but can also help to avoid debt crises.

It is important to note though, that the ellipses in figure 6 only indicate a distance of one standard deviation from the bivariate average of the specific crisis episodes. Therefore the intuition of the figure only is, that countries placed below and / or left of the ellipses due to relatively low debt levels and / or relatively good monetary fundamentals are on average less frequently subject to crises than countries placed inside the ellipses. This does not at all mean, however, that countries outside the ellipses are safe from crises. The respective crises are only more frequent among the countries within the ellipses than among the countries outside the ellipses. On the other hand, not all countries inside a crisis-indicating ellipse will inescapably face a crisis. For example several countries suffered from debt crises even though their debt level was much lower than the 40 percent of GDP, which is suggested as critical by the debt crisis ellipse<sup>19</sup>, while at the same several of the “no crisis” episodes in figure 5 overlap with the debt and currency crisis ellipses in figure 6. In this respect the data illustrated in the figures 5 and 6 are also well in accordance with the prediction of figure 2 and the whole second generation currency crisis literature, that there is a gray area where the optimal policy depends crucially on the private market participants’ expectations. The dispersion of the data can be interpreted as an indication, that it is actually not the fundamental situation of a country alone that determines whether a financial crisis takes place but that shifts in private expectations play an important role as well. Medium debt levels and monetary fundamentals make a country vulnerable to financial crises in terms of self-fulfilling creditor panics. The situation is stable as long as there is no reversal in the market sentiment. However, as soon as an external shock causes creditors to fear devaluation and / or default, rising interest rate risk premiums and inflation expectations make it more costly for the government to service its

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<sup>19</sup> For a discussion of emerging markets’ debt reschedulings and defaults at debt levels as low as 15 to 40 percent of GDP see Reinhart, Rogoff, and Savastano (2003) and Reinhart and Rogoff (2004).

debt and / or to keep a peg. If these expectations-driven costs become prohibitively high, the government chooses to default and / or to devalue. An important aspect of every policy measure in this situation is therefore to stabilize private expectations.

An interesting question is how the combinations of debt to GDP ratios and M2 to reserves ratios above and right of the ellipses should be interpreted. Do worse fiscal fundamentals and / or worse monetary fundamentals indicate a diminishing risk of experiencing the respective type of crisis? In the case of the pure currency crisis and the pure debt crisis ellipses the answer can indeed be yes. Above and right of the debt and the currency crises ellipses the frequency (or the “risk”) of pure currency crisis and pure debt crisis episodes actually *decreases* with deteriorating fundamentals simply because at the same time the frequency (“risk”) of twin debt and currency crises *increases*. In the case of the twin crisis ellipse, however, the upper right edge of the ellipse simply defines the distance of one multivariate standard deviation from the average debt to GDP ratio and the M2 to reserves ratio in the subsample of combined debt and currency crises and indicates that there are only very few data points further outside in the deteriorating fundamentals area.

The intuitive appeal of these two main explanatory variables, the debt level in the case of debt crises and the reserves to money ratio in the case of exchange rate crises, is tested by a simple comparison of the mean of those variables in crisis and non-crisis situations. We test the null hypothesis of equal means against the alternative that the mean in crisis situations is higher for each variable and each type of crisis with a Wilcoxon test. The null is rejected with p-values below 1% with the exception of testing the debt level with currency crises. This means that the average money to reserves ratio is significantly higher in crises situations, and that the average debt level is significantly higher in situations of debt or twin crises, but not in currency crises.

## 4. Empirical analysis

### 4.1. GLM estimations

We finally use our approach to build a classification and an early warning system for the different crises. Like Frankel and Rose (1996) we use a number of macroeconomic variables to explain and predict crises. In contrast to their approach, we are not restricted to currency crises but analyze all three types of crises: pure currency crises, pure debt crises, and twin debt and currency crises. Within the GLM model we first use contemporary variables to explain the occurrence of each type of crisis separately. We then use the lagged variables in a

GLM estimation to constitute an early warning system. Current macroeconomic values are used to predict the probability of a currency, debt, or twin crisis in the following year. The explanatory models perform slightly better than the predictive ones. Both types of models, explanatory and predictive, show similar results in comparison to the traditional estimations. We thus present only the results for the predictive models in the text and leave the results of the explanatory model to the appendix.

The macroeconomic explanatory variables are external debt (% of GDP), M2 over reserves, short term debt, net inflow foreign direct investment (% of GDP), GDP per capita annual growth, overall budget balance including grants (% of GDP), interest rate spread (lending rate minus deposit rate), total reserves in months of imports, inflation (consumer prices, annual), total expenditure (% of GDP), and overvaluation.<sup>20</sup> We used most of these variables to present the stylized facts about financial crises in section 3.1. They account for main factors determining the government's decisions like financial stability, balance of internal and external finance, stability of the financial system, and various expectations.

In total we present five estimations for the explanation and the prediction case. These estimations differ in the definition of the dependent variable. In each regression the dependent variable is binomial. The first three estimates cover pure currency, pure debt, and twin crises. E.g. in the first regression on pure currency crises, "1" is assigned to each case with a currency and without a debt crisis. "0" is assigned to all other cases (pure debt crises, twin crises, and non-crisis situations). The specific crisis type is compared to the entire sample.

To be able to compare our approach to the classical results, the last two estimations are based on the traditional method to distinguish between currency and debt crises, which does not consider twin currency and debt crises as a separate crisis type. Instead, each case in which a currency crisis occurs, i.e. both pure currency crises and twin crises, are marked "1". Analogously, every situation in which a debt crisis occurs, i.e. both pure debt crises and twin crises, are marked "1".

**Table 2: Crisis definitions for the regressions**

	Crisis type	Explanation
1	Pure currency crisis	Currency crisis, no debt crisis
2	Pure debt crisis	Debt crisis, no currency crisis
3	Twin crisis	Simultaneous currency and debt crisis
4	All currency crises	Pure currency and twin crises
5	All debt crises	Pure debt and twin crises

<sup>20</sup> The data is again drawn from the World Bank World Development Indicators (WDI) 2004 data set.

The regression equations

$$l(y^j) = \sum_{i=1}^{11} \theta_i^j x_i$$

connect the 11 independent macroeconomic variables with the probability of the occurrence of the dependent variable  $y^j$ ,  $j=1..5$ , indicating the five types of crises as defined in table 2.

When we compare our approach, i.e. treating twin crises as a separate type of crisis, to the traditional approach, our main findings concern (a) the predictability of crises, (b) internal contagion effects, and (c) selection bias effects. We furthermore find that there are specific macroeconomic explanations for each single type of crisis.

(a) With respect to *the predictability of crises*, the differentiated analysis of each crisis type significantly improves the predictability of pure debt and twin crises but not of pure currency crises. The predictability of twin crises is better than that of any other crisis type. More than half of the twin crises in the sample can be predicted with only a negligible number of false alarms.

(b) With respect to *internal contagion effects* we find that inflation seems to be a significant factor in traditional empirical studies of debt crises only because it is relevant for twin crises. While it is in fact not relevant for pure debt crises, it rather has a strong impact only on twin crises as it promotes currency crises, which can trigger debt crises via contagion. This impact influences estimations on mixed pure debt and twin crisis samples.

(c) We also encounter *pre-selection bias effects*. Foreign exchange reserves for example have a significant *negative* influence on the probability of pure debt crises, but a significant *positive* influence on twin crises, i.e. pure debt crises are associated with comparatively low reserve ratios, while twin crises are connected with comparatively high reserve ratios. This finding can be due to a pre-selection bias with regard to the exchange rate system: A need for high reserve ratios typically arises only in countries with fixed exchange rate regimes. Fixed exchange rate regimes are, however, more likely subject to a speculative attack than countries with floating exchange rates. Thus in countries with high reserve ratios (i.e. fixed exchange rate regimes) debt crises are more likely to be associated with simultaneous currency crises than in countries with low reserve ratios (i.e. flexible exchange rates).

In the following we discuss the specific macroeconomic determinants for the different types of crisis in greater detail and highlight how treating twin crises as a separate type of crisis deepens our understanding of the causes of the respective crises.

#### 4.2. *Macroeconomic crisis indicators*

As it is standard in the literature, we interpret significant coefficients from our estimations as relevant for the explanation and accordingly for the prediction of the respective types of crisis. Insignificant estimates are perceived as irrelevant. Table 3 gives the results of the GLM regressions of the predictive models. The complete tabulation of the estimated coefficients can be found in section 6.3 of the appendix. Significant results correspond to p-values below 5%.

**Estimated coefficients of the predictive crisis models**

	Pure currency crises	Currency crises including twin crises	Pure debt crises	Debt crises including twin crises	Twin crises
Intercept	<b>-4.96**</b>	<b>-5.08**</b>	<b>-7.76**</b>	<b>-9.53**</b>	<b>-8.69**</b>
External debt, total (dod, % of GDP)	-0.23	0.02	<b>2.42**</b>	<b>2.79**</b>	0.92
Money and quasi money (M2) to gross international reserves ratio	<b>0.61*</b>	<b>0.64**</b>	-0.15	0.17	<b>0.61*</b>
Short-term debt (% of total external debt)	0.01	0.02	0.02	0.03	0.01
Foreign direct investment, net inflows (% of GDP)	<b>-0.20*</b>	<b>-0.24**</b>	<b>-0.15*</b>	<b>-0.20**</b>	-0.30
GDP per capita growth (annual %)	<b>0.11**</b>	0.05	0.01	-0.01	-0.02
Overall budget balance, including grants (% of GDP)	0.01	-0.06	0.01	-0.06	<b>-0.28**</b>
Interest rate spread (lending rate minus deposit rate)	-0.01	0.00	-0.01	0.01	0.01
Total reserves in months of imports	0.09	<b>0.15*</b>	<b>-0.24**</b>	-0.12	<b>0.32**</b>
Inflation, GDP deflator (log of annual change)	<b>0.69**</b>	<b>0.88**</b>	0.15	<b>0.36**</b>	<b>0.82**</b>
Expenditure, total (% of GDP)	0.01	<b>-0.04*</b>	<b>-0.08**</b>	<b>-0.13**</b>	<b>-0.14**</b>
Overvaluation	<b>1.06**</b>	<b>0.81*</b>	<b>0.74*</b>	<b>0.85*</b>	0.70

**Bold:** Significant at the 1% level (\*\*) or the 5% level (\*).

#### **Currency crises:**

Significant factors for the prediction of currency crises are the money/GDP ratio, FDI (negative), inflation, and overvaluation. This finding holds for pure currency crises as well as for the combination of pure currency and twin crises. Most of these results are well known from the literature on currency crises (e.g. Frankel and Rose, 1996; Dreher, Herz, and Karb, 2004). A high level of the monetary base, high inflation rates, and overvaluation typically indicate a potential currency crisis. Also a decline in FDI, indicating a loss of confidence of

international investors, is commonly viewed as a sign of an evolving crisis. The significant negative impact of FDI on the risk of financial crises is common to all types of crises.

Interestingly, the impact of GDP growth on the probability of *pure* currency crises is significantly positive while it is insignificant for the joined currency and twin crises sample, i.e. higher growth seems to raise the risk of pure currency crises, but not the risk of currency crises in general. This result, which might be surprising at first sight, becomes clear if the separation of pure currency and twin crises is taken into account. A country with weak monetary fundamentals (high monetary base, high inflation) and strong real fundamentals (high growth rates) is likely to resolve its problems solely within the monetary sector, i.e. with a pure currency crisis. In contrast, countries with bad monetary fundamentals *and* low growth rates are more likely to be subject not only to a currency crisis but also to an additional debt crisis. Thus in a subsample of countries with bad monetary fundamentals countries with low growth rates are more likely to experience twin crises than pure currency crises. From a reverse perspective this implies that higher growth can make the occurrence of pure currency crises more likely only because it makes twin crises less likely.

Reserves and public expenditure constitute a further difference between pure currency crises and the combined currency and twin crises sample. These two indicators are significant indicators for combined currency and twin crises but insignificant for pure currency crises. Obviously both variables are relevant for twin crises only but not for pure currency crises. Thus the impact on the regression results in the combined currency and twin crises sample originates only from the twin crises in the sample. The *positive* impact of reserves on the probability of twin crises is interpreted as a pre-selection bias and explained in detail in the twin crises paragraph below.

### **Debt crises:**

There are only two significant factors that raise the probability of debt crises in both the pure debt crises and the debt and twin crises sample. These are the external debt over GDP ratio and overvaluation. Higher FDI and expenditures/GDP ratios lower these probabilities.

The difference between specifications that do and do not treat twin crises as a separate type of crisis is even more important in the analysis of debt crises than for currency crises. On the one hand, there is a significant positive influence of inflation on debt crises only in the mixed “debt or twin crisis” sample but not in the “pure debt crisis” sample. On the other hand, the reserves/imports ratio has a significant negative influence only for pure debt crises. Based on these findings we can draw the following conclusions. Firstly, the significant positive

influence of inflation on the crisis probability in the mixed “debt or twin crisis” sample debt only stems from its influence on the twin crises sample. This means that inflation does not raise the probability of debt crises as such. Instead, it increases the probability of a currency crisis in a first step, which may then trigger a simultaneous debt crisis as well via contagion effects. Secondly, the negative influence of reserves on the debt crisis probability – commonly interpreted as a financing resource – is more relevant for pure debt crises. The estimated coefficient for the mixed debt and twin crises sample is lower and only weakly significant (p-value of 5.2%) since this sample also includes twin crises which are associated with comparatively high reserve ratios (see next paragraph).

### **Twin crises:**

High money/GDP ratios, high debt/GDP ratios, a high reserves/imports ratio, and inflation all raise the probability of twin crises.<sup>21</sup> High FDI, a high budget balance, and a high expenditure/GDP ratio all lower this probability. The significance and sign of most of these variables are as expected in accordance with the debt and currency crisis literature. Fiscal deficits significantly raise the probability of twin crises but not the probability of pure currency or pure debt crises. Furthermore, although overvaluation significantly raises the probability of pure currency as well as pure debt crises, it does not significantly influence the probability of twin crises.

There is also a positive influence of reserves on the probability of twin crises. This effect could be due to a selection bias. Reserves over imports distinguish between pure debt and twin crisis. Reserves lower the probability of pure debt crises and raise the probability of twin crises. The difference between pure debt and twin crises is the occurrence of a currency crisis simultaneously to the debt crisis. A currency crisis typically occurs only if the exchange rate is managed and market pressure builds up until the target rate cannot be held up anymore, so that an abrupt and strong devaluation takes place. In order to manage the exchange rate in the first place, however, a certain amount of reserves is necessary. Thus, countries without reserves cannot manage their exchange rates and will hardly be subject to a currency crisis in terms of our definition.

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<sup>21</sup> The p-values of debt/GDP and FDI are 5.1%.

### 4.3. *Crisis predictions*

#### **Twin crises**

Twin crises are easier to predict than any other type of crisis. We use a cutoff value of 0.3 for the GLM probability estimate to define the crisis prediction and obtain the following results.

**Contingency table for the prediction of twin crises as a unique type of crisis**

		True incidence				$\Sigma$
		Non-crisis	Pure currency crisis	Pure debt crises	Twin crisis	
Predicted incidence	Non-crisis	363	38	111	14	526
	Twin crisis	1	3	8	15	27
$\Sigma$		364	41	119	29	553

Over half of the twin crises (15 out of 29) are predicted correctly. In 11 cases a twin crisis was predicted but turned out to remain a pure currency crisis (8) or a pure debt crisis (3). In only 1 of the non-crisis situations (0.3%) the model predicts a twin crisis, i.e. the number of false alarms is negligible. In 502 cases (363 non-crises, 38 pure currency crises, 111 pure debt crises) the model correctly predicts, that no twin crisis will occur.

As a comparison we provide the results of the estimations with the traditional crisis definitions. For this purpose we combine the results of the GLM estimations on all currency and all debt crises. A twin crisis is predicted if a debt and a currency crisis are indicated at the same time. To allow the comparability of the two approaches, the cutoff values are adjusted to match the number of false alarms in table 4.



**Contingency table for the prediction of twin crises with traditional crisis definition**

		True incidence			
		Non-crisis	Pure currency crisis	Pure debt crises	Twin crisis
Predicted incidence	Non-crisis	363	34	117	20
	Twin crisis	1	7	2	9

Obviously the traditional approach predicts twin crises less exactly than our approach which treats twin crises as a separate types of crisis. With the same number of false alarms (1 alarm in 364 non-crises situations) our approach correctly predicts 15 out of 29 twin crises (52%), while the traditional approach reaches only 9 out of 29 (31%). A binomial test that compares the number of correct predictions in both approaches shows that the number of correct predictions is significantly higher in our approach (p-value of 0.6%, using the traditional crisis definition as null hypothesis) and significantly smaller in the traditional approach (p-value of 2%, using our crisis definition as null hypothesis).

**Predictability of debt and currency crises**

The explanation and prediction of currency crises within macroeconomic early warning systems is an extensive but barely successful field of research. A number of different approaches with various sets of variables, e.g. Frankel and Rose (1996), do not find convincing results for the hypothesis that macroeconomic variables might serve as reliable predictors of currency crises.

With regard to debt crises, the literature finds poor evidence for the suitability of macroeconomic variables for the construction of an early warning system (see IMF 2002). We show that macro based warning systems experience a qualitative improvement if twin crises are treated as a separate crisis type. Their predictive power is significantly worse if debt crises are defined in the traditional way, including both pure debt crises and twin debt and currency crises.

**Currency crises**

In order to analyze our early warning system, we proceed in the same way as above. Again, we set the cutoff value for the GLM probability estimation to 0.3 and use the current

values of the explanatory variables to predict the probability of a crisis in the following year.<sup>22</sup> A currency crisis is predicted if either the pure currency crisis predictor or the twin crisis predictor exceeds the threshold. The results are tabulated in table 6.

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<sup>22</sup> Obviously, a higher threshold results in a lower number of alarms, i.e. a smaller number of false alarms as well as a smaller number of correct warnings. We use a common threshold for the estimations of all three types of crises in order to reduce the number of free variables and to increase the tractability of the analysis. The threshold of 0.3 results in a reasonable average number of false alarms. Raising this value would not drastically reduce the number of false alarms in the currency crisis model but reduce its efficiency. Lowering the threshold would increase the number of false alarms in the debt crisis model (12%) to inefficient levels.

**Table 6: Contingency table for the prediction of currency crises with twin crises as a unique type of crisis**

		True incidence		
		Non-crisis	Pure currency or twin crisis	Pure debt crises
Predicted incidence	Non-crisis	358	45	110
	Currency or twin crisis	6	25	9

**Table 7: Contingency table for the prediction of currency crises with traditional crisis definition**

		True incidence		
		Non-crisis	Pure currency or twin crisis	Pure debt crises
Predicted incidence	Non-crisis	358	49	112
	Currency or twin crisis	6	21	7

Although the overall performance of the new approach is not entirely satisfactory, it still works better than the construction of a warning system based on conventional crisis definitions. Both hit rates - 25 out of 70 correct currency crisis predictions in our approach and 21 out of 70 in the traditional approach - do not differ significantly. The binomial tests yield p-values of 12% and 19%.<sup>23</sup>

The performance of both approaches is still significantly better than the results of Frankel and Rose (1996), who predict only 5 out of 69 currency crises correctly. The reason might be either the choice of the explanatory variables or – more likely – the choice of the countries at stage. Our sample of emerging countries might be more homogenous with respect to the causes of financial crises than the larger Frankel and Rose (1996) sample.

### Debt crises

Debt crises are defined as an alarm signal by the pure debt crisis or the twin crisis predictor. Again current values of the variables are used to predict the probability of a crisis in the following year. The threshold for the GLM probability estimates is again 0.3. The results are shown in table 8.

<sup>23</sup> For the explanatory model our approach performs weakly but significantly better (p-value of 5.7%). The results are shown in the appendix.

**Table 8: Contingency table for the prediction of debt crises with twin crises as a unique type of crisis**

		True incidence		
		Non-crisis	Pure debt or twin crisis	Pure currency crises
Predicted incidence	Non-crisis	319	38	33
	Debt or twin crisis	45	110	8

**Table 9: Contingency table for the prediction of debt crises with traditional crisis definition**

		True incidence		
		Non-crisis	Pure debt or twin crisis	Pure currency crises
Predicted incidence	Non-crisis	317	97	21
	Debt or twin crisis	47	51	20

The traditional approach predicts only 34% of all debt crises correctly (51 out of 148). With a hit ratio of 74% our approach of treating twin crises as a separate type of crisis thus yields better results also with regard to the prediction of debt crises. A comparison of the number of correct predictions in both approaches with a binomial test shows that the number of correct predictions is in fact significantly higher in our approach (taking the traditional crisis definition as null hypothesis) and significantly lower in the traditional approach (taking our crisis definition as null hypothesis). The p-values of both tests are numerically 0. Our results lead to the conclusion, that an early warning system for debt crises can successfully be based on macroeconomic variables. However, such a warning system can be successful if and only if twin crises are treated as a separate type of crisis.

## 5. Conclusions

The theoretical and empirical evidence presented in our paper strongly suggests to regard twin debt and currency crises as a particular type of crisis, which should be analyzed separately from pure currency and pure debt crises. Such a classification helps to better understand the interrelations between fiscal and exchange rate crises. Each of the three types of crisis - pure currency, pure debt and twin debt and currency crises - is characterized by a unique set of causes and consequences. Theory suggests a number of possible interrelations between debt and currency crises, which include common causes, contagion effects from one crisis to the other, and complementary budget financing aspects.

Recapitulating the results of our GLM estimations we can state that the approach to treat twin crises as a distinct type of crisis also significantly improves the predictive power of early warning systems. Our early warning system predicts 36% of all currency crises, 75% of all debt crises, and 50% of all twin crises correctly, while we get only 1.6% false alarms for the prediction of currency crises, 12% false alarms for the prediction of debt crises, and 0.3% false alarms for the prediction of twin crises. With these results our approach performs significantly better than traditional early warning systems on currency and debt crises which typically do not differentiate between pure currency crises (or pure debt crises respectively) and twin crises.

As major reasons for the inferior performance of the traditional approach we identify internal contagion and selection bias effects which may lead to biased results if twin crises are not treated separately. While for example in traditional empirical analyses inflation is often found to be a significant predictor for debt crises, we show that in fact it has no significant influence on the risk of pure debt crises. It rather increases the probability of currency crises which then can trigger debt crises via contagion effects. Inflation thus seems to be an important explanatory variable in traditional debt crisis samples only because of its relevance for twin crises which is carried forward to the entire sample. The example of the foreign exchange reserves shows how selection bias effects affect the predictive value of empirical analyses. Reserves have a significant *negative* influence on the probability of pure debt crises, but a significant *positive* influence on twin crises, i.e. pure debt crises are associated with comparatively low reserve ratios, while twin crises are connected with comparatively high reserve ratios. A possible explanation for this result is that high reserve ratios are less important under floating exchange rates than in fixed exchange rate systems. As countries with fixed exchange rates are more likely to become subject to speculative attacks and currency crises in terms of our crisis definition, debt crises are more likely to be associated by simultaneous currency crises in countries with high reserve ratios (i.e. fixed exchange rate regimes) than in countries with low reserve ratios (i.e. flexible exchange rates). We furthermore find that growth seems to raise the probability of pure currency crises, while it does not significantly influence the crisis risk in the combined currency and twin crises sample. A possible explanation for this finding is that countries with weak monetary but strong real fundamentals are likely to be able to confine crises to the monetary sector. Countries with weak monetary fundamentals are in general likely to encounter currency crises, but they are likely to experience a simultaneous debt crisis as well only if growth is

low. Thus with higher growth rates the probability of pure currency crises declines simply as the probability of twin crises increases.

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## 6. Appendix

### 6.1. Results of the explanatory model

The explanatory model uses contemporary values of the macroeconomic variables to analyze the determinants of the different types of crises.

**Table 10:**  
**Contingency table for the explanation of twin crises as a unique type of crisis**

		True incidence			
		Non-crisis	Pure currency crisis	Pure debt crises	Twin crisis
Predicted incidence	Non-crisis	351	41	122	14
	Twin crisis	3	5	5	16

**Table 11:**  
**Contingency table for the explanation of twin crises with traditional crisis definition**

		True incidence			
		Non-crisis	Pure currency crisis	Pure debt crises	Twin crisis
Predicted incidence	Non-crisis	351	39	121	20
	Twin crisis	3	7	6	10

**Table 12:**  
**Contingency table for the explanation of currency crises with twin crises as a unique type of crisis**

		True incidence		
		Non-crisis	Pure currency or twin crisis	Pure debt crises
Predicted incidence	Non-crisis	347	46	121
	Currency or twin crisis	7	30	6

**Table 13:**  
**Contingency table for the explanation of currency crises with traditional crisis definition**

		True incidence		
		Non-crisis	Pure currency or twin crisis	Pure debt crises
Predicted incidence	Non-crisis	347	52	121
	Currency or twin crisis	7	24	6

**Table 14:**  
**Contingency table for the explanation of debt crises with twin crises as a unique type of crisis**

		True incidence		
		Non-crisis	Pure debt or twin crisis	Pure currency crises
Predicted incidence	Non-crisis	314	40	32
	Debt or twin crisis	40	117	14

**Table 15:**  
**Contingency table for the explanation of currency crises with traditional crisis definition**

		True incidence		
		Non-crisis	Pure debt or twin crisis	Pure currency crises
Predicted incidence	Non-crisis	313	98	20
	Debt or twin crisis	41	59	26

## 6.2. *Estimated coefficients of the predictive model*

The predictive model uses the values of the macroeconomic variables one year prior to the crises to find predictors for the different crises types.

**Table 16:**  
**Estimated coefficients of the predictive pure currency crisis model**

	Value	Std. Error	t value	Pr(> t )
Intercept	<b>-4.96</b>	1.34	-3.70	0.000
External debt, total (dod, % of GDP)	-0.23	0.25	-0.92	0.360
Money and quasi money (M2) to gross international reserves ratio	<b>0.61</b>	0.25	2.43	0.016
Short-term debt (% of total external debt)	0.01	0.02	0.81	0.417
Foreign direct investment, net inflows (% of GDP)	<b>-0.20</b>	0.09	-2.31	0.021
GDP per capita growth (annual %)	<b>0.11</b>	0.04	2.74	0.006
Overall budget balance, including grants (% of GDP)	0.01	0.04	0.18	0.859
Interest rate spread (lending rate minus deposit rate)	-0.01	0.01	-0.99	0.324
Total reserves in months of imports	0.09	0.06	1.42	0.157
Log of inflation, GDP deflator (annual %)	<b>0.69</b>	0.21	3.33	0.001
Expenditure, total (% of GDP)	0.01	0.02	0.47	0.641
Overvaluation	<b>1.06</b>	0.38	2.80	0.005

**Table 17:**  
**Estimated coefficients of the predictive pure debt crisis model**

	Value	Std. Error	t value	Pr(> t )
Intercept	<b>-7.76</b>	1.23	-6.30	0.000
External debt, total (dod, % of GDP)	<b>2.42</b>	0.30	8.04	0.000
Money and quasi money (M2) to gross international reserves ratio	-0.15	0.18	-0.86	0.389
Short-term debt (% of total external debt)	0.02	0.01	1.24	0.214
Foreign direct investment, net inflows (% of GDP)	<b>-0.15</b>	0.06	-2.34	0.019
GDP per capita growth (annual %)	0.01	0.03	0.39	0.696
Overall budget balance, including grants (% of GDP)	0.01	0.04	0.35	0.729
Interest rate spread (lending rate minus deposit rate)	-0.01	0.00	-1.31	0.191
Total reserves in months of imports	<b>-0.24</b>	0.07	-3.56	0.000
Log of inflation, GDP deflator (annual %)	0.15	0.12	1.24	0.216
Expenditure, total (% of GDP)	<b>-0.08</b>	0.01	-5.61	0.000
Overvaluation	<b>0.74</b>	0.37	1.97	0.049

**Table 18:**  
**Estimated coefficients of the predictive twin crisis model**

	Value	Std. Error	t value	Pr(> t )
Intercept	<b>-8.69</b>	2.16	-4.02	0.000
External debt, total (dod, % of GDP)	0.92	0.47	1.96	0.051
Money and quasi money (M2) to gross international reserves ratio	<b>0.61</b>	0.30	2.06	0.040
Short-term debt (% of total external debt)	0.01	0.03	0.43	0.666
Foreign direct investment, net inflows (% of GDP)	-0.30	0.15	-1.95	0.051
GDP per capita growth (annual %)	-0.02	0.05	-0.48	0.632
Overall budget balance, including grants (% of GDP)	<b>-0.28</b>	0.10	-2.86	0.004
Interest rate spread (lending rate minus deposit rate)	0.01	0.01	0.52	0.604
Total reserves in months of imports	<b>0.32</b>	0.11	2.88	0.004
Log of inflation, GDP deflator (annual %)	<b>0.82</b>	0.29	2.80	0.005
Expenditure, total (% of GDP)	<b>-0.14</b>	0.04	-4.05	0.000
Overvaluation	0.70	0.52	1.34	0.180

**Table 19:**  
**Estimated coefficients of the predictive currency crisis model including twin crises**

	Value	Std. Error	t value	Pr(> t )
Intercept	<b>-5.08</b>	1.22	-4.18	0.000
External debt, total (dod, % of GDP)	0.02	0.24	0.10	0.921
Money and quasi money (M2) to gross international reserves ratio	<b>0.64</b>	0.21	3.10	0.002
Short-term debt (% of total external debt)	0.02	0.02	1.01	0.314
Foreign direct investment, net inflows (% of GDP)	<b>-0.24</b>	0.08	-2.92	0.004
GDP per capita growth (annual %)	0.05	0.03	1.56	0.119
Overall budget balance, including grants (% of GDP)	-0.06	0.04	-1.36	0.174
Interest rate spread (lending rate minus deposit rate)	0.00	0.01	0.44	0.657
Total reserves in months of imports	<b>0.15</b>	0.06	2.55	0.011
Log of inflation, GDP deflator (annual %)	<b>0.88</b>	0.18	4.78	0.000
Expenditure, total (% of GDP)	<b>-0.04</b>	0.01	-2.56	0.011
Overvaluation	<b>0.81</b>	0.34	2.35	0.019

**Table 20:**  
**Estimated coefficients of the predictive debt crisis model including twin crises**

	Value	Std. Error	t value	Pr(> t )
Intercept	<b>-9.53</b>	1.35	-7.08	0.000
External debt, total (dod, % of GDP)	<b>2.79</b>	0.33	8.42	0.000
Money and quasi money (M2) to gross international reserves ratio	0.17	0.20	0.84	0.399
Short-term debt (% of total external debt)	0.03	0.02	1.86	0.064
Foreign direct investment, net inflows (% of GDP)	<b>-0.20</b>	0.07	-2.85	0.005
GDP per capita growth (annual %)	-0.01	0.03	-0.25	0.801
Overall budget balance, including grants (% of GDP)	-0.06	0.04	-1.38	0.169
Interest rate spread (lending rate minus deposit rate)	0.01	0.01	1.23	0.220
Total reserves in months of imports	-0.12	0.06	-1.94	0.052
Log of inflation, GDP deflator (annual %)	<b>0.36</b>	0.14	2.61	0.009
Expenditure, total (% of GDP)	<b>-0.13</b>	0.02	-7.20	0.000
Overvaluation	<b>0.85</b>	0.42	2.03	0.043