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Determinants of Currency Crises in Emerging Markets:
An Empirical Investigation on Turkey[1]

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Abstract
This article aims at identifying the determinants of currency crises in Turkey the period 1980:01-2006:06. Following a general-to-specific model selection methodology, a broad set of pre-selected variables were tested through bivariate logit regressions. Significant variables were then used in a multivariate logit model. Strong evidence emerged that current account balance/GDP, short-term debt/long-term debt, domestic credit/GDP, foreign liabilities/foreign assets of banks, and fiscal balance/GDP are significant with correct signs. The measures of goodness-of-fit and in-sample predictive power of the model turned out to be favorable. The resulting model correctly calls 87.18% and 73.08% of the months at 10% and 20% levels, respectively.

Key words: Currency crises, logit-analysis, Turkey
JEL classification: F31, F37

I. Introduction

The aim of the present research is to empirically investigate the significant indicators of currency crises in Turkey in the period 1980:01-2006:06. We follow a methodology that improves upon the earlier empirical work in the related literature. In the majority of the earlier studies, attempts are made to describe the discrete crisis variable with a set of explanatory variables. The novelty of the present approach is that only the variables that have been pre-selected according to their noise-to-signal ratios through the signals approach in a recent study by Feridun (2006) are taken into consideration. Focusing on a set of variables whose empirical relevance to currency crises have already been established, the present analysis will try to answer the question whether the implicitly embedded functional relationship between the binary crisis variable and the selected individual indicators is justified. This will be done by means of logit regressions following a general-to-specific model selection methodology.

The major contribution of the present article to the existing literature is that it is the first country-specific approach applying this methodology to Turkey. Although some country-specific empirical work has been done on Turkey particularly to analyze the crises of 1994 and 2001, no work has been done using a sample that includes the extended periods of economic turbulence that the country suffered in the early 1980s[2]. In addition, the turmoil of 2006 has not been taken into consideration to date except a recent study by Feridun (2006), which forms the basis of the present analysis. The present article fills a gap in the related literature through analyzing a period that has not been analyzed before and employing a methodology that coherently combines two popular empirical approaches used in the existing literature.

The rest of the article is structured as follows: The next section will review the earlier applications of the signals approach. Section III will introduce the data used and the methodology that is followed. Section IV will present the empirical results and the last section will point out the conclusions that emerge from the study.

II, Literature Review

Applications of logit models in the literature on currency crises began with Goldfjan and Valdes (1997) and Klein and Marion (1997). Goldfjan and Valdes (1997) use logit regressions based on three separate crisis definitions for 26 countries to investigate the predictability of currency crises. Using the crisis episodes reported by Kaminsky and Reinhart (1996), they find that the only variable that helps to explain the presence of crises is overvaluation. Hence, the authors conclude that currency crises are largely unpredictable. Klein and Marion

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[2] See Feridun (2006) for a review of the literature on currency crises in Turkey.

(1997) end up with dissimilar results for 17 Latin American countries and Jamaica over the period between 1957 and 1991. The authors use a logit model to identify factors that influence the duration of currency pegs in a panel of monthly data. Results of their regression identify significant variables as sharp real appreciations as well as losses of foreign currency reserves. The authors also note that the predictive power of their model is quite high with probabilities as high as 0.89. Likewise, Kumar *et al.* (1998) use logit model for estimating the probability of crises for developing countries throughout the period of 1985:1-1998:3. To evaluate the model they calculate the trading strategies in which an investor goes long or short in the currency depending on whether crash probabilities are low or high. They find that variables having the highest explanatory power are low output and export growth rate and international reserves. They also report that their regressions have power to predict currency crises. Kumar *et al.* (2002) use the model for the period 1985 to 1999. They focus only on successful speculative attacks, and use only exchange rate changes to define crisis episodes. The authors evaluate forecasts on an out-of-sample basis, estimating the model for one part of the sample, and then forecasting crashes in the remaining sample period. They use various accuracy scores, goodness-of-fit tables and one-third of total observations for out of sample evaluation of their model. Their analysis fails to yield conclusive empirical evidence.

Bussiere and Fratzscher (2002) develop a multinomial logit model based on a variety of variables to predict financial crises in 32 emerging market economies between 1993 and 2001. Results of the regression reveal that the model would have correctly predicted the majority of crises in emerging markets. For the in-sample estimation, the model fails to anticipate only two of the emerging market crises in the sample. For the out-of-sample estimation, the model anticipates correctly most of the countries that were affected by the Asian crisis. Hence, the authors conclude that model predicts most currency crises in emerging markets during the 1990s, both in-sample and out-of-sample. They also note that the financial contagion channel, in particular, was an important factor in explaining currency crises in the sample. Jacobs et al (2004) estimate a logit model for Malaysia, Indonesia, Philippines, Singapore, South Korea and Thailand for the period between January 1970 and December 2001. The authors build different logit models for different versions of currency crises based on a broad set of indicators which they combine into factors using the factor analysis methodology. As a result of the factor analysis and the logit regressions, they find that the rates of growth of M1 and M2, GDP per capita, national savings, and import growth correlate with all definitions of currency crises. The authors also note that using the first differences of indicators instead of levels improves the predictive power of the model.

A detailed summary of the literature on the application of logit models is given in Appendix I. Overall, diverse applications of logit and probit models vary vastly in terms of the indices and the thresholds they use. These studies identified some significant variables as the common determinants of the crises both in single and multi-country studies. The present country-specific analysis aims of applying this methodology to explain the currency crises in Turkey.

III. Data and Methodology

Following the establishment of the relevance of the chosen set of variables as the leading indicators of currency crises through signals approach by Feridun (2006), the present article tests the validity of the functional relationship between the dichotomous variable of currency crises using logit analysis, which is a statistically more rigorous approach. The first step is the selection of potential explanatory variables.

Data

The present research does not attempt to break new ground in terms of the choice or definition of variables. It employs the data set used in a recent study by Feridun (2006)[3] who used signals approach to investigate the currency crises in Turkey. These variables are drawn from the literature and the theories of currency crises and sufficiently reflect the conditions of current account, capital account, financial sector, real sector, fiscal sector, the global economy and the political setting[4]. Data is monthly, spans the period 1980:01-2006:06[5], and is obtained from various sources such as the IMF's International Financial Statistics database, the Central Bank of the Republic of Turkey's Electronic Data Dissemination System, as well as the World Bank's

[3] The author considered 38 variables and identified 28 variables whose noise-to-signal ratios are below unity, i.e. emits more good signals than false alarms.

[4] A detailed description of the source of the series and the rationale of using them are given in Feridun (2007).

[5] Some variables were available only after mid-1980s. These variables are only tested in individual regressions based on the available period for each series. These are deposit money banks' net past due loans/total loans, Central Bank credit to public sector/GDP, bank reserves/bank assets, commercial bank loans to public sector, stock market index, and portfolio investments/GDP.

World Development Indicators and Global Development Finance Statistics databases. Some series have been linearly interpolated from annual and quarterly data where monthly series were not available.

A disadvantage of using low frequency data is the possible presence of seasonal effects. This problem is circumvented by using the data in 12-month percentage changes following, *inter alia*, Eliasson and Kreuter (2001) and Jacobs et al (2004)[6]. A visual inspection of the data confirms that all these series are *I(0)*, i.e. they have no unit root(s). Table 1, constructed following Manasse et al. (2003) and Trebeschi and Ciarlone (2006), gives the respective mean of each variable in the entire sample, for non-crisis episodes, for 12 months before the onset of a crisis, and for in-crisis months.

<Table 1 about here>

In general, the path of means from non-crisis to entry into crisis and finally exit from crisis is as expected. Most current account, capital account, financial sector, real sector, and fiscal sector variables generally indicate a worsening of the macroeconomic situation in the run-up to a crisis. They are also generally worse relative to tranquil months.

Crisis Definition

A priori, there is no single empirical definition of what should constitute a currency crisis. In the present study, currency crises are defined in the same way as in Feridun (2006). An index is built using the changes in exchange rates, interest rates, and international reserves of the Central Bank. The weights attached to the three components of the index, which are the inverse of the standard deviation for each component, equalize the volatilities of the three components and prevents the component with the highest volatility dominating the index. The index is calculated as follows:

$$EMP_t = \alpha\Delta e_t + \beta\Delta(i_t - i^*_t) - \gamma(\Delta\tau_{,t} - \Delta r^*_t) \qquad (1)$$

where α, β and γ are weights that equalize the conditional volatilities of each component. More specifically, $\alpha=(1/\sigma_e)$, $\beta=(1/\sigma_i)$ and $\gamma=(1/\sigma_r)$ where σ_e is the standard deviation of e_t, σ_i is the standard deviation of $(i_t - i^*_t)$ and σ_r is the standard deviation of $(\Delta\tau_{,t}-\Delta r^*_t)$. Δe_{it} is the monthly change in the exchange rate, *i* denotes the domestic interest rate, i^*_t corresponds to the same variable but for the country of reference, $\tau_{,t}$ is the ratio of foreign reserves to domestic money (M1) for the domestic country and, r^*_t denotes the same concept for the country of reference. The higher the standard deviation, the lower weight would be imposed on the corresponding variable. The index captures either a successful attack (a sharp devaluation), or a successful defense (the exchange rate remains unchanged but the monetary authorities deter an attack by a combination of interest rate increases and foreign market interventions), or an unsuccessful defense (all three variables move sharply). A positive value of the index measures the depreciation pressure of the currency that can be signaled by a nominal depreciation, a widening of the interest rate spread, or a loss of foreign reserves, whereas a negative value of the index measures the appreciation pressure of the currency. Data used to calculate the index are as follows: Exchange rate is the TL/USD nominal exchange rate, interest rate is the nominal exchange rates (3-month deposit rate for Turkey and prime loan rate for USA), international reserves are reserves-gold and M1 is the narrow money (M1). A crisis month is defined as any month in which this index is more than 1.5 standard deviations above its mean. A dummy variable is constructed that takes the value of one if a crisis occurs and zero if otherwise. The value of 1.5 is used following Herrera and Garcia (1999) as it gives the best estimation of crises[7]. The pressure points that have been identified by the index are 1982:01, 1983:06, 1985:01, 1991:01, 1994:01, 2001:01 and 2006:06.

Methodology

Having identified the crisis episodes and the variables, we can now set up an econometric model that builds upon the results of Feridun (2006).[8] Following Manasse et al (2003), Linne and Bruggemann (2003), and

[6] This filter is not used for: the deviation of the real exchange rate from the trend, excess of real M1 balances, and the interest rates.

[7] Feridun (2006) tested different thresholds and found that a higher threshold misses the currency crunch of May 2006 whereas a lower threshold leads to too many crisis episodes.

[8] Using signals approach, Feridun (2006) eliminated real effective exchange rate overvaluation, industrial production index, trade balance/GDP, stock market index, public debt/GDP, domestic real interest rates,

Krznar (2004), the candidate variables will be successively eliminated by applying a general-to-specific model selection methodology. Before moving to a multivariate framework, a logit model with two variables is used to test the possibility of any functional forms between the dependent variable of a currency crisis and the contemporaneous values of the explanatory variables. Variables that are significant at 10% are selected into the final model.

Since the dependent variable is a binary variable, we use a binary choice model. Two popular binary choice models are the probit and logit models. The major difference is that the probit model is based on the normal distribution, whereas the logit model uses an S-shaped logistic function to constrain the probabilities to the [0,1] interval. Predicted probabilities calculated by these models in practice only slightly differ (Jacobs et al, 2004). In both models, an econometric regression is run on various variables to explain a dichotomous indicator equal to one (Y=1) if a crisis occurs within the specified time period, or equal to zero (Y=0) if otherwise. The probability that Y=1 is a continuous, monotonically increasing or decreasing function of a single variable X. This can be written as:

$$\text{Prob}(Y_i=1) = F(a + bX_i) \qquad (1)$$

where F(Z) is some continuous, monotonic function of Z, bounded between 0 and 1, and $Z_i = a + bX_i$. More than one explanatory variable may be incorporated as:

$$Z_i = \sum_{j=1}^{k} \beta_j X_{ij} \qquad (2)$$

Ordinarily X_{i1} would equal 1 so that β_1 would be the intercept term. The resulting log likelihood is:

$$\log(L) = \sum_{Y_i=1} \log F(Z_i) + \sum_{Y_i=0} \log(1 - F(Z_i)) \qquad (3)$$

This may be maximized numerically to obtain Maximum Likelihood estimates of the parameters. Cumulative probability distribution functions have the property that they are monotonically increasing and bounded between 0 and 1. Therefore any continuous probability distribution function is a candidate for F(Z). The Probit model has the property that Prob(Y=1) approaches 1 very rapidly as X and therefore Z increase, and approaches 0 very rapidly as X and Z decrease (assuming b > 0). In order to allow 0 and 1 to be approached more slowly, the following logistic distribution:

$$L(Z) = \frac{1}{1 + e^{-Z}} \qquad (3.4)$$

may instead be used for F(Z). By analogy to the Probit, this is called the *Logit* model. Probit and Logit models resolve some of the disadvantages associated with the signals approach. For instance, indicators are not transformed into dummies. So, information on the relative importance of each indicator is retained. Besides, they consider the significance of all variables simultaneously, making it easy to examine the explanatory power of new variables. Furthermore, regression results are easily interpreted as the probability of a currency crisis occurrence.

Compared to the probit model, the logit typically performs better when the dependent variable is not evenly distributed between the two outcomes (Manesse et al, 2003). In our data, only 28 percent of all outcomes are crisis entries. Therefore, we opt for a logit model. Normally, a logit model should consist of the variables in lagged form. However, it is hard to test long lags of monthly variables and also hard to decide how many observations should one go back. In order to circumvent this issue, following, *inter alia*, Berg et al (1999), Komilainen and Lukkarilla (2003), and Krznar (2004), the present study defines a crisis as not only the crisis month, but also the eleven months before since potential explanatory variables are expected to worsen prior to crises. In other words, a 1-year crisis window is used. Thus, the values of a currency crisis variable are equal to

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government changes, oil prices, M1 and FDI/GDP based on their noise-to-signal ratios. We will retain these variables in order to check whether logit regressions would confirm the author's results.

one not only in the month of the crisis but also in the preceding 11 months. This allows the use of data without any lags and increases the number of ones in the sample from a statistical standpoint (Krznar, 2004).

Before moving to a multivariate framework, separate logit models with two variables are built to test the possibility of any functional forms between the dependent binary crisis variable and the explanatory variables. This is done because a logit model cannot accommodate all 38 variables simultaneously. As Krznar (2004) explains, introduction of a large number of independent variables in the model increases the probability of linear dependence between individual independent variables, i.e. multicollinearity. The consequence is the impossibility of inverting the matrix of values of independent variables in the iterative manner to evaluate the probit model parameters, since this would be the case of a near-singular matrix (a matrix without a full rank). Therefore, only the variables that are significant at 10% level with correct signs are selected into the final logit model.

IV. Empirical Results

Table 2 presents the results of bivariate logit models which investigate the possibility of functional forms between the dependent variable of currency crises and the contemporaneous values of the individual explanatory variables. The size of each estimated coefficient reflects the relative effect of the variable on the predicted probability for the dependent variable, i.e. the binary crisis index. The sign of each coefficient shows the direction of the change in the probability of falling in the endpoint rankings when the independent variables change. Positive values imply that increasing the variable will increase the probability of the crises while negative values imply the opposite. Interpretation of the coefficient values is complicated by the fact that estimated coefficients from a binary dependent model cannot be interpreted as the marginal effect on the dependent variable. Hence, marginal effects of the explanatory variables on the probability of crises are estimated by taking the derivative of the parameter estimates.

<Table 2 about here>

Results of the variable-by-variable logit regressions show that current account balance/GDP, short-term debt/long-term debt, domestic credit/GDP, foreign liabilities/foreign assets of banks, and fiscal balance/GDP are significant. The signs of all coefficients coincide with what we expect from economic theory. The probability of crises increases when current account balance and fiscal balance deteriorate, and when foreign liabilities of banks, domestic credit and short-term debt increases. Short-term debt/long-term debt has the largest marginal impact on the probability of a crisis. Based on the results of the variable-by-variable analysis, we now combine those variables that appear to help predict crises into a general logit model.[9]

<Table 3 about here>

Table 3 presents the results of the final logit model. Estimated coefficients represent the impact of a one-unit increase in the independent variable, holding the other explanatory variables constant, on the log of the odds of the crisis index. The results indicate that the movements in the explanatory variables are correlated with the incidence of financial crises in the expected manner. The statistical characteristics of the model are also favorable. All the variables are significant to the level of 10%. The LR measure confirms the general statistical significance of the model. Hypothesis of no significance of all the coefficients in the model was rejected with significance at 1% level. In addition, McFadden R-squared indicates fairly good goodness-of-fit for the model.

We carry out two sensitivity tests to see how robust the estimated logit model is. First we drop observations with extreme values for the variables included in the logit. The direction of influence of the variables for which the extreme values are removed remains unchanged, and the coefficient estimates do not exhibit large falls in the z value. Second, we re-enter several random variables that dropped out of the specification process into the model to ensure that our specification process was not adversely affected by an omitted variable bias. In none of these cases do we see the model's goodness-of-fit improved. Hence, we conclude that the results of the model are robust.

<Table 4 about here>

[9] Before moving to multivariate analysis we check the series for multicolllinerarity. We see that some variables are strongly correlated but not the ones that we will use in the analysis. See Appendix II for the results.

Following Berg and Patillo (1999) and Linne and Bruggemann (2003), we also assess the power of the model in predicting crises in the sample. The standard method compares the estimated probabilities of a crisis with actual occurrences. To this end, a probability threshold was set to serve as a criterion for the decision whether a model signals a crisis or not. The probability threshold, as the value separating the pre-crisis period from the tranquil period, was set at 10% and 20%. Results indicate that the model has considerable potential to predict a currency crisis in the sample. The model correctly calls 87.18% and 73.08% of the months at 10% and 20% levels, respectively.

V. Conclusions

The results obtained in this study suggest that high fiscal deficits increased the vulnerability of the Turkish economy to crises. Besides, reliance of short-term debt increased the country's exposure to sharp increases in interest rates which may have additional negative consequences as the government might have needed to increase taxes to service the debt. In addition, high current account deficits made the country vulnerable to expectation shifts and less capable to generate external revenue to finance a balance of payments problem. As to the banking sector, excessive growth of domestic credit caused balance sheet problems for banks in terms of non-performing loans and currency mismatches, and increased the fragility of the banking sector. Another result that verifies this verdict is that foreign liabilities/foreign assets of banks were significant showing exposure of banks to exchange rate risk.

Combined with the results of Feridun (2006), the present research reveals the most important explanatory variables of crises. Although identification of these variables can not replace the sound judgment of policy-makers in guiding policy, it can still play an important role in emphasizing the areas that require special attention. Nevertheless, there is scope for further improvements in several areas. For instance, the sample period can be divided into subsets to investigate if the results would change Also, more work needs to be done to check how much different definitions of the crisis index would affect the results. Finally, although it seems to be a difficult attempt, further indicators related to political circumstances could be included in the empirical analysis. These are left for future work.

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Table 1. Mean of the Variables Used in the Regressions

Variable	Full Sample	Tranquil months	During 12 months before crises	During 12 months after crises
Government consumption/GDP	0.022039	0.052561	0.066117	0.096266
US Real T-Bill Rate	0.003395	0.003097	0.004185	0.003829
US GDP	0.004494	0.004144	0.005213	0.004590
GDP per capita	0.046228	0.042630	0.043624	0.048077
Fiscal Balance/GDP	0.021224	0.019572	0.004620	0.035847
Commercial Bank Loans to Public Sector	0.042612	0.039296	0.049430	0.071970
Excess real M1 balances	0.004945	0.004560	0.004336	0.004352
International Reserves/GDP	-0.00095	-0.000510	-0.002900	-0.000766
M2 Multiplier	0.004512	0.007174	0.009024	0.013139
Foreign Liabilities/Foreign Assets of Banks	0.053854	0.055625	0.057708	0.056823
Bank reserves/bank assets	-0.00349	-0.004439	-0.005584	-0.008130
Imports	0.022109	0.028121	0.035374	0.041505
Commercial Bank Deposits	0.042814	0.044457	0.068502	0.059739
Exports	0.021317	0.027114	-0.034107	0.049660
M2/International Reserves	0.034023	0.043276	0.014437	0.029260
Banking Sector Fragility Index	0.052231	0.066436	0.063570	0.051678
Commercial Bank Loans to Private Sector	0.026011	0.033085	0.021618	0.020596
Capital Inflows/GDP	0.034372	0.033720	0.034995	0.030073
Reserve Money/GDP	0.021399	0.027218	0.034238	0.049851
Domestic Credit/GDP	0.024567	0.023671	0.027197	0.025039
CPI Growth	0.001889	0.001051	0.002322	0.002925
Short-Term Debt/Long-Term Debt	0.000288	0.000161	0.000202	0.000294
Short Term Debt/International Reserves	-0.02044	-0.011375	-0.014308	-0.020832
Portfolio investments/GDP	-0.59188	-0.329371	-0.414316	-0.603244
Deposit money banks net past due loans/total loans	0.049121	0.037335	0.034385	0.040065
Central Bank Credit to Public Sector/GDP	0.053863	0.029974	0.037704	0.054897
Current Account Balance/GDP	2.859585	2.819904	2.578755	2.490667
Real Interest Rate Differential	0.057832	-0.137925	0.173496	0.252610
Real Effective Exchange Rate Overvaluation	0.044666	0.106525	0.043998	0.045101
Industrial Production Index	0.002788	0.006649	0.008364	0.002178
Trade Balance/GDP	0.747123	0.950312	0.095397	0.740498
Stock Market Index	0.070561	0.089751	0.072898	0.064379
Public Debt/GDP	-0.01512	-0.019232	-0.024192	-0.035224
Domestic Real Interest Rates	0.061227	0.067878	0.077963	0.082634
Oil prices	0.007263	0.008238	0.011621	0.011920
M1	0.045152	0.057431	0.072243	0.065186
FDI/GDP	0.536443	0.682335	0.658309	0.549698

Table 2. Coefficient Estimates of the Logit Models with Two Variables

Variable	Expected Impact on Crisis likelihood	Logit Coefficient	Standard Errors	Z-Statistic	P>|z|	Marginal Effect[a]
Government consumption/GDP	+	-0.7700	1.0879	-0.7078	0.4791	-0.2149
US Real T-Bill Rate	+	0.0088	0.4113	0.0214	0.9829	-0.0021
Fiscal Balance/GDP	-	-4.7127	2.6593	-1.7722*	0.0764	-0.1751
GDP per capita	-	-1.6339	1.6072	-1.0166	0.3094	-0.4195
US GDP	-	0.2651	0.6537	0.4056	0.6850	0.0613
Commercial Bank Loans to Public Sector	+	-0.6245	0.9711	-0.6431	0.5202	0.0897
Excess real M1 balances	+	-0.2079	2.0187	-0.1030	0.9180	-0.0552
International Reserves/GDP	-	-0.4090	0.6577	-0.6219	0.5340	-0.1126
M2 Multiplier	+	0.2473	2.8915	0.0855	0.9318	0.0660
Foreign Liabilities/Foreign Assets of Banks	+	1.5593	0.9089	1.7155*	0.0862	0.4119
Bank reserves/bank assets	-	1.1098	2.2128	0.5015	0.6160	0.1872
Imports	+	-0.1513	0.8345	-0.1812	0.8562	-0.0294
Commercial Bank Deposits	-	-4.4221	3.4461	-1.2831	0.1994	-1.2440
Exports	-	0.2451	1.0238	0.2394	0.8108	0.0623
M2/International Reserves	+	-30.4023	8.8881	-8.4205	0.5446	-7.3167
Banking Sector Fragility Index	+	-11.9937	5.9226	-2.0251	0.1429	-2.8606
Commercial Bank Loans to Private Sector	+	-0.6245	0.9711	-0.6431	0.5202	-0.0745
Capital Inflows/GDP	+	-0.0048	0.0324	-0.1493	0.8813	-0.0013
Reserve Money/GDP	-	-0.8836	1.1258	-0.7849	0.4325	-0.2314
Domestic Credit/GDP	+	9.2843	2.9463	3.1511***	0.0016	2.6473
CPI Growth	+	-0.4927	1.1665	-0.4224	0.6728	-0.1339
Short-Term Debt/Long-Term Debt	+	46.0486	8.0992	5.6856***	0.0000	13.2777
Short Term Debt/International Reserves	+	-0.0130	0.1754	-0.0742	0.9409	-0.0027
Portfolio investments/GDP	-	0.0114	0.0215	0.5324	0.5945	0.0020
Deposit money banks net past due loans/total loans	+	0.0422	0.8890	0.0474	0.9622	0.0106
Central Bank Credit to Public Sector/GDP	+	-0.6245	0.9711	-0.6431	0.5202	-0.0751
Current Account Balance/GDP	-	-12.8460	5.8837	-2.1832**	0.0290	-3.5912
Real Interest Rate Differential	+	-0.0249	0.0431	-0.5776	0.5636	-0.0051
Real Effective Exchange Rate Overvaluation	+	0.0176	0.8100	0.0217	0.9827	0.0052
Industrial Production Index	-	1.5460	5.3642	0.2882	0.7732	-0.0574
Trade Balance/GDP	-	-0.2030	0.2132	-0.9524	0.3409	-0.0561
Stock Market Index	-	-0.8785	1.3779	-0.6376	0.5237	-0.1416
Public Debt/GDP	+	-0.3604	0.9025	-0.3994	0.6896	-0.0827
Domestic Real Interest Rates	+	-0.0250	0.0433	-0.5777	0.5635	-0.0054
Government Changes	+	0.2226	2.6023	0.0770	0.8386	0.0594
Oil prices	+	-0.4871	1.5358	-0.3172	0.7511	-0.1058
M1	+	-2.6120	1.9865	-1.3148	0.1886	-0.7298
FDI/GDP	-	0.0124	0.0328	0.3791	0.7046	0.0032

[a]Marginal effects are calculated at sample means.

* Significant at the 10% level, ** Significant at the 5% level, *** Significant at the 1% level.

Table 3. Coefficient Estimates of the Logit Models with Multiple Variables

Variable	Expected Impact on Crisis likelihood	Logit Coefficient	Standard Errors	Z-Statistic	P>|z|	Marginal Effect
Fiscal Balance/GDP	-	-5.4285	2.8166*	-1.9273	0.0539	-1.3118
Foreign Liabilities/Foreign Assets of Banks	+	1.9160	1.1587*	1.6535	0.0982	0.5648
Domestic Credit/GDP	+	10.7295	3.6747***	2.9197	0.0035	3.7963
Short-Term Debt/Long-Term Debt	+	51.6572	8.8391***	5.8441	0.0000	17.9588
Current Account Balance/GDP	-	-11.5144	6.5345***	-1.7620	0.0781	-3.7914
Constant		-1.3146	0.3642	-3.6101	0.0003	
McFadden R-squared[10]: 0.7739 LR statistic (5 df)[11]: 58.41967***						

* Significant at the 10% level. *** Significant at the 1% level.

Table 4. Predictive Performance of the Multiple Variable Logit Model

	Cutoff Probability at 10%	Cutoff Probability at 20%
Percentage of months with accurate crisis prediction	87.18 %	73.08 %
Percentage of months with accurate prediction of a tranquil period	26.79 %	51.20 %
Percentage of months with inaccurate crisis prediction	12.82 %	26.92 %
Percentage of months with inaccurate prediction of a tranquil period [d]	73.21 %	48.80 %

[a] Crisis is accurately predicted if the estimated probability exceeds the probability threshold and a crisis starts in the course of the next 12 months.
[b] A tranquil period has been accurately predicted if the estimated probability does not exceed the probability threshold and a crisis does not start in the next 12 months.
[c] Crisis is inaccurately predicted if the estimated probability exceeds the probability threshold and a crisis does not start in the course of the next 12 months.
[d] A tranquil period has been inaccurately predicted if the estimated probability does not exceed the probability threshold and a crisis starts in the next 12 months.

[10] McFadden R2 is a measure of the goodness-of-fit of a model that is obtained when the ratio of the log of the function maximum with a restriction on parameters (all parameters equal zero) and the log of the probability function maximum without the restriction regarding the parameters are deducted from one; it corresponds to R2 as a measure of goodness-of-fit of models estimated by OLS (Krznar, 2004).
[11] LR measure is equal to the multiple of (-1) and the difference between the logarithm of the maximum of the probability function with a restriction on parameters (in this case the restriction requires all the parameters to be equal to zero) and an "average" logarithm of the function probability maximum without a restriction. Therefore a larger LR measure relates to a higher statistical significance of the model. LR measure is analogue to the F measure in the models estimated by OLS (Krznar, 2004).

APPENDIX I
A SUMMARY OF THE EMPIRICAL STUDIES USING LOGIT MODELS

Reference	**Sample / Period**	**Variables / Frequency**	**Crisis Index / Threshold**	**Significant Variables / Conclusions**
Goldfjan and Valdes (1997)	26 developing and developed countries (1984-1997)	Monthly macroeconomic and financial variables	weighted average of real exchange rate and reserve changes. Threshold: Mean + 3 std. dev.	Only exchange rate
Klein and Marion (1997)	7 Latin American countries and Jamaica (1957-1991)	Monthly financial, openness, and trade concentration variables	Index and threshold of Kaminsky *et al*. (1997)	Exchange rate and international reserves
Kumar *et al*. (1998)	20 developing countries (1985-1998)	Monthly macroeconomic and financial variables	Weighted average of real exchange rate and reserve changes. Threshold: Mean + 2 std. dev.	Output, exports and international reserves
JP Morgan (1998)	25 industrial and emerging countries (1980-1997)	Monthly macroeconomic and financial variables	Changes of exchange rates. Threshold: Over 10 percent real depreciations of	Number of local crashes and international reserves/debt
Goldman Sachs (1998)	N/A	Monthly macroeconomic, political stability and financial variables	Weighted average of three-month exchange rate and reserve changes. Threshold: Not mentioned	Credit booms, the real exchange rate, export growth, international reserves, stock prices, political risk
Credit Suisse First Boston (2001)	N/A	The real exchange rate, debt/exports, credit to the private sector, output, reserves/ imports, stock prices, oil prices and a regional contagion dummy	Weighted average of three-month exchange rate and reserve changes. Threshold: depreciation greater than 5 percent and at least double the preceding month's depreciation.	N/A
Weller (2001)	19 emerging countries (1980-1998)	Monthly political freedom and capital mobility variables	Used the list of banking crises in Kaminsky and Reinhart (1999).	Financial liberalization
Eliason and Kreuter (2001)	10 East Asian and Latin	Monthly macroeconomic,	Weighted averages of exchange	The index successfully portrays

	American countries (1990-2000)	financial, foreign and contagion variables	rates and interest rates. Threshold: currency depreciations of more than 10%, or the interest rate increases more than 20%	the East Asian and Latin American crises of the 1990s
Kumar *et al.* (2002)	32 developing countries (1985-1999)	Monthly macroeconomic and institutional variables	Exchange rate changes. Threshold: Mean + 3 std. dev.	No conclusive empirical evidence found
Saqib (2002)	Brazil (1994-1998)	Monthly internal, external and political variables	Same index as in Kaminsky *et al*. (1997)	Political factors along with conventional factors explain the Brazilian crisis
Bussiere and Fratzscher (2002)	32 emerging market economies (1993-2001)	Monthly external and internal macroeconomic variables	Weighted average of real exchange rate, reserve and interest rate changes. Threshold: Mean + 3 std. dev.	Only financial contagion
Lestano *et al.* (2003)	Malaysia, Indonesia, Philippines, Singapore, South Korea and Thailand (1970-2001)	Monthly macroeconomic and financial data	Index and threshold of Goldfjan and Valdes (1997)	M1 and M2, bank deposits, GDP per capita and national savings, M2/foreign reserves, foreign reserves, real interest rate and inflation
Manasse *et al* (2003)	47 Emerging market economies (1970-2002)	Annual macroconomic data	(Investigated debt crises)	Indicators of external debt, macroeconomic conditions, and political economy factors
Jacobs *et al* (2004)	Countries of Lestano *et al.* (2003)	Variables of Lestano *et al.* (2003)	Index and threshold of Goldfjan and Valdes (1997)	M1, M2, GDP per capita, imports and national savings
Krznar (2004)	Croatia (1996-2003)	Monthly macroeconomic and financial data	Weighted average of nominal exchange against the euro and international reserve change. Threshold: Mean + 2 std. dev.	R real exchange rate, balance of public finances/GDP, current account balance/GDP, inflation and external debt

APPENDIX II
CORRELATION MATRIX

	Current Account Balance/GDP	Central Bank Credit to Public Sector/GDP	Commercial Bank Deposits	BSFI	Domestic Credit/GDP	CPI Growth	Excess real M1 balances	Exports	Fiscal Balance/GDP	Foreign Liabilities/Foreign Assets of Banks	GDP per capita	Government consumption/GDP	Imports	International Reserves/GDP	M2 Multiplier	US Real T-Bill Rate	US GDP	Short Term Debt/International Reserves	Short-Term Debt/Long-Term Debt	Reserve Money/GDP	Real Interest Rate Differential	M2/International Reserves
Current Account Balance/GDP	1.00	0.07	0.04	0.02	0.02	-0.06	0.07	-0.11	0.00	-0.08	-0.04	0.01	-0.07	0.04	-0.01	0.03	0.01	0.01	-0.01	0.03	0.01	0.01
Central Bank Credit to Public Sector/GDP		1.00	0.40	0.04	0.01	0.00	0.31	0.00	-0.01	-0.05	-0.10	-0.02	-0.01	-0.05	0.11	-0.04	0.03	0.03	-0.01	0.00	-0.06	0.09
Commercial Bank Deposits			1.00	0.15	-0.02	-0.04	0.33	0.09	-0.06	0.02	0.07	-0.06	-0.04	-0.04	0.29	0.00	0.14	0.12	0.04	-0.03	-0.09	0.16
BSFI				1.00	0.04	0.05	-0.04	0.01	0.01	-0.01	0.03	-0.01	0.08	-0.08	0.13	-0.01	0.01	0.03	-0.11	-0.02	0.03	0.18
Domestic Credit/GDP					1.00	0.23	0.05	-0.03	0.56	0.00	-0.76	0.98	0.00	0.72	-0.01	-0.03	-0.08	0.01	-0.06	0.96	0.00	0.04
CPI Growth						1.00	-0.06	0.05	0.24	-0.05	-0.06	0.25	0.12	0.27	0.00	-0.15	-0.05	0.01	0.00	0.23	-0.02	-0.17
Excess real M1 balances							1.00	0.10	0.02	0.02	-0.04	0.01	-0.19	0.02	-0.30	-0.06	0.04	0.02	0.03	0.15	-0.06	0.04
Exports								1.00	-0.03	0.00	0.06	-0.03	0.30	0.01	0.02	0.02	0.07	-0.07	0.01	-0.01	0.04	-0.02
Fiscal Balance/GDP									1.00	-0.01	-0.75	0.98	0.01	0.73	0.00	-0.02	-0.05	-0.03	-0.04	0.94	0.03	-0.01
Foreign Liabilities/Foreign Assets of Banks										1.00	0.05	-0.02	0.03	0.05	0.08	0.04	-0.07	-0.01	-0.03	-0.04	-0.01	-0.03
GDP per capita											1.00	-0.76	0.02	-0.57	-0.02	0.01	0.02	0.02	0.01	-0.75	-0.07	0.02
Government consumption/GDP												1.00	0.02	0.77	0.00	-0.02	-0.06	-0.03	-0.05	0.96	0.03	-0.02
Imports													1.00	0.04	0.17	-0.10	0.01	-0.02	0.00	-0.02	-0.03	-0.03
International Reserves/GDP														1.00	-0.04	-0.01	-0.05	-0.04	-0.03	0.73	0.01	-0.42
M2 Multiplier															1.00	0.03	0.15	-0.03	-0.01	-0.19	-0.03	0.18
US Real T-Bill Rate																1.00	0.00	0.00	0.01	-0.03	-0.09	-0.01
US GDP																	1.00	-0.01	0.00	-0.09	-0.25	0.01
Short Term Debt/International Reserves																		1.00	0.01	0.00	-0.01	0.05
Short-Term Debt/Long-Term Debt																			1.00	-0.05	-0.04	-0.05
Reserve Money/GDP																				1.00	0.02	0.01
Real Interest Rate Differential																					1.00	-0.03
M2/International Reserves																						1.00