FINANCIAL LIBERALIZATION AND CURRENCY CRISES: THE CASE OF TURKEY

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Abstract

This article aims at identifying the determinants of currency crises in Turkey in the period of 1980:01-2006:06. A broad set of explanatory variables was tested through the signals approach and bivariate and multivariate logit regressions. The same procedure is then repeated for the post-capital account liberalization period (1989.09-2006:06). The results obtained are novel and deviate widely from the existing literature. The findings suggest that conventional crisis indicators fail to provide a satisfactory explanation for the crises experienced in Turkey. For the period spanning 1980:01-2006:06, banking sector fragility index, short-term debt/international reserves, bank reserves/bank assets, US GDP, M1, and US 3-month T-Bill rate have been identified as significant leading indicators by both the signals approach and logit regressions. Analyzing the post-capital account liberalization period spanning 1989:09-2006:06 in isolation, strong evidence is obtained confirming the importance of US federal funds rate, banking sector fragility index, US GDP, and US 3-month T-Bill rate by both approaches. Overall, the results confirm the significance of global economic conditions, and suggest that financial liberalization has rendered the Turkish economy vulnerable to currency crises.

Key words: Currency crises, logit regression, signals approach, Turkey.
JEL classification: F31, F37.

1. Introduction

Turkey is one of the primary examples of the emerging economies that bought into the promises of the IMF-prompted financial liberalization policies in 1980s. The first phase of the liberalization process in the country was initiated in the early 1980s with the deregulation of the interest rates on bank deposits. The second phase of the financial liberalization process was completed in the late 1980s when all the restrictions on capital movements were lifted leading to a period characterized by financial openness and subsequent speculative attacks on the Turkish lira. It has been widely argued that financial liberalization was to blame for the currency crises that the country experienced during this period (see, for example, Yeldan, 1998; Alper, 2001; Erugrul and Selcuk, 2001; Ekinci, 2002; and Seyidoglu, 2003). Nevertheless, there exists no rigorous empirical attempt to support this assertion in the literature on Turkish currency crises, which contains only a handful of empirical studies. These studies extend only over the post-capital account liberalization period and focus on the crises of 1994 and 2000-2001, paying less attention to the periods of unsuccessful speculative attacks on the Turkish lira and they ignore the imperative distinction between pre- and post-capital account liberalization periods.

In the light of this motivation, the present study investigates the root causes of currency crises in Turkey in two separate sample periods representing both the entire liberalization era (1980:01-2006:06) and the post-capital account liberalization episode (1989:09-2006:06). Another novelty of the present research is that it contemplates the episode of currency crunch that the country recently experienced in May 2006, which has not received any empirical attention to date. The literature on currency crises is full of numerous and futile empirical efforts aiming at devising a successful Early Warning System (EWS) to predict future crises through monitoring the behavior of certain variables. It is now widely accepted that it is not possible to predict crises reliably because, particularly after the liberalization of capital flows, currency crises have been increasingly arising

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from self-fulfilling panic or pure contagion effects, i.e. inherently unpredictable market sentiments. Even if a successful EWS model can finally be devised, the signals identified by this model would presumably affect the behavior of both the policymakers and the financial market participants, which would quickly render the model obsolete. Therefore, it is more feasible to direct efforts towards the identification of weaknesses that typically render economies vulnerable to crises. For this reason, the present article departs from the existing literature in that it does not concern itself with the prediction of crises. Identification of the factors indicating the vulnerability of an economy to currency crises is essential for the design of effective strategies to avoid future currency crises and to strengthen the macroeconomic structure.

The rest of the article is structured as follows: The next section will introduce the data and explain the two methodologies that we will use. Section III and IV will present the empirical results obtained from the analysis of two sample periods. Section V will point out the conclusions that emerge from the study.

2. Data and Methodology

2.1. Data

A considerable number of variables can be considered as indicators of vulnerability to currency crises. Essentially, the choice of which variables to select depends on the perceived causes of crises as well as on the variables suggested by the earlier studies in the theoretical and empirical literature on currency crises. Accordingly, we selected our variables to proxy the conditions of current account, capital account, financial sector, real sector, fiscal sector, the global economy, and the domestic political setting. The data is monthly and spans the period between 1980:01 and 2006:06 unless mentioned otherwise. As Goldstein et al. (2000) explain, particularly in the context of signals approach, monthly data allows us to learn much more about the timing of the leading indicators, including differences among indicators in the first arrival and persistence of signals. Nonetheless, some variables were available only in annual or quarterly frequency. Following the existing empirical literature on crises (see, for example, Kumar et al 2003), these series have been interpolated using cubic spline technique from annual and quarterly data[1]. In order to enhance the possibility of identifying the crisis factors, the present study employs forty-two variables from various sources such as International Financial Statistics Database of the IMF, the Central Bank of the Republic of Turkey's Electronic Data Delivery System, World Bank's World Development Indicators Database, European Central Bank's Statistical Warehouse, US Federal Reserve Board Database and the Global Development Finance Statistics Database. Appendix I presents the list of potential pre-crisis indicators considered, provides justification to their selection, and indicates the sources of the data. A disadvantage of using high frequency data is the possible presence of seasonal effects. This problem is circumvented by using the data in 12-month percentage changes based on the suggestion of, *inter alia*, Eliasson and Kreuter (2001) and Jacobs et al. (2005)[2]. This practice eliminates seasonal effects, avoiding the possible non-stationarity problem of the variables in levels, and renders the indicators more comparable across time (Goldstein et al., 2000).

Crisis Definition

A growing body of studies uses a weighted index consisting of exchange rates, interest rates and reserves which was first introduced by Eichengreen et al. (1995). These studies either adopt ex-

[1] Kumar et al. (2003) argue that such interpolation is appropriate as a monthly observation from an interpolated annual series is based in part on the realization for the year (quarter) in which the crisis occurs and, at any given moment, we possess interim estimates of the annual (quarterly) data over the coming year. The current analysis does not lag any series so interpolation appears a reasonable approach. Still, we checked whether this has affected our results by repeating our estimations and calculations lagging the interpolated annual data by 12 months. The parameter values and t-statistics only slightly changed.

[2] This filter has not been used for the real effective exchange rate overvaluation, excess of real M1 balances, and the interest rates.

actly the same index or use modified versions of it (See, for example, Herrera and Garcia, 1999; Kibritcioglu et al., 1998; Krkoska, 2000; Gelos and Sahay, 2001; Cepni and Kose, 2006; and Walter, 2006).

In the present study, we will adopt a modified version of this index to take both successful and unsuccessful attacks on the Turkish lira into consideration. As Kaminsky *et al.* (1998) explains, such an index can be used to analyze speculative attacks under both fixed and flexible exchange rate regimes. Therefore, application of this crisis index in the present context is well justified as Turkey followed both fixed and a floating exchange rate regimes in the sample period. During the period under study, Turkish Central Bank followed various exchange rate policies: Prior to 1984, a fixed exchange rate was in effect. Between 1984 and 1993 the exchange rate changed daily in the context of a crawling peg exchange rate regime. After 1993, a managed-floating exchange rate regime was used until January 2000 when the country signed a stand-by agreement with the IMF. With this agreement a pre-announced crawling-peg against a dollar-German mark basket was adopted. However, this peg did not last long and collapsed with the currency crisis of February 2001. Since then, the Central Bank has been using a flexible exchange rate system. Therefore, we use an Exchange Market Pressure (EMP) index which would be applicable in the context of all exchange rate regimes. Accordingly, a currency crisis is assumed to occur when a speculative attack on the Turkish lira results in an official devaluation, or sharp depreciation of the currency, or forces the authorities to defend the currency by expending large volumes of international reserves or by sharply raising interest rates. Eichengreen et al.'s (1995) Exchange Market Pressure (EMP) index is chosen particularly because it is a model-independent, weighted index and it takes into consideration a reference country. Hence, it is more informative than the other variants of the EMP index in the literature. 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 choice of which exchange rate to use in the index is somewhat arbitrary. We depart from the existing crisis literature in that we use a Deutsche mark [1] and US dollars basket, which are the two prevalent foreign currencies in Turkey[2]. The EMP index is calculated as follows:

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

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 Deutsche mark-US dollar exchange rate basket, i denotes the domestic interest rate (3-month deposit rate), i^*_t corresponds to the same variable but for the country of reference (US prime loan rate). Following Girton and Roper (1977), $\tau_{,t}$ denotes the ratio of foreign reserves (net of gold) to domestic money (M1) for the domestic country, and r^*_t denotes the same concept for the country of reference, i.e. United States[3,4]. The higher the standard deviation, the lower weight would be imposed on the corresponding variable. 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.

[1] In January 1999, the euro was introduced and completely replaced Deutsche mark in December 2001. For the sake of consistency we consider Deutsche mark for the whole period under study and use the official fixed parity (1 euro = 1.95583 Deutsche mark) to recalculate exchange rates for the period 1999:01-2006:06.

[2] We weighted both series by 0.5 following Kipici and Kesriyeli (1997) who weighted these two currencies equally in an effort to calculate an index of real effective exchange rates for Turkey.

[3] In a time of capital inflow reversal, the central bank must be prepared to cover all its liquid liabilities with reserves unless the fixed exchange rate policy is abandoned. The appropriate yardstick with which to evaluate the abundance of reserves is a measure of liquidity compared with the stock of foreign exchange reserves, since, at a time of currency crisis, the larger the stock of privately held domestic liquid assets, the larger the contingent demand for foreign assets (Calvo, 1998; Karfakis and Moschos, 2004). Thus the ratio of foreign reserves to M1 is used as a liquidity measure.

[4] This definition of crisis is a major departure of the present study from the existing literature on Turkish currency crises.

A currency crisis is considered to occur when the EMP index exceeds a certain threshold value. We identify months in which the index of speculative pressure is at least 1.5 standard deviations above the sample mean as instances of speculative attacks, i.e. currency crises. The value of 1.5 is used following Eichengreen et al. (1996) and Herrera and Garcia (1999) as it gives the best estimation of crises[1]. The threshold value is determined as:

$$\text{Threshold value} = \mu_{EMP} + 1.5(\sigma_{EMP}) = 1.0763, \quad (2)$$

where μ_{EMP} is the mean of the index, and σ_{EMP} is the standard deviation of the index. A currency crisis is observed when the value of the EMP index exceeds this threshold value. Accordingly, a dummy variable is introduced to take the value of 1 if a crisis occurs and 0, if otherwise. Nevertheless, to avoid counting the same crisis more than once, we set our "exclusion window"[2] as 12 months. In other words, 12 successive months immediately after the crisis take the value of 0 regardless of whether the value is above the threshold or not[3]. In light of these considerations, the crisis months that have been identified by the index are 1980:02, 1981:05, 1983:07, 1985:01, 1991:02, 1994:02, 1995:12, 2001:02, and 2006:06. Figure 1 shows the graphical representation of the estimated EMP index and the threshold.

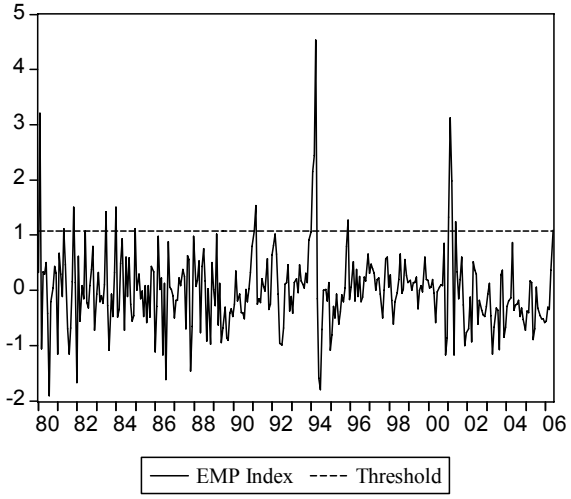

Fig. 1. EMP index

3. Methodology

Based on the identified crisis episodes, we will investigate the determinants of currency crises in Turkey using signals approach and logit regressions.

3.1. Signals Approach

The signal approach is a non-parametric methodology introduced by Kaminsky et al. (1998). It involves monitoring the evolution of a number of economic indicators that show a behavior which is different in tranquil period and prior to a crisis. When an indicator exceeds or falls below its

[1] We 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.

[2] Depending on the frequency of data used, exclusion windows of various lengths have been used in the literature. For instance, Moreno (1995) used a 5-month, Eichengreen et al., (1994) used a 6-month, Glick and Moreno (1999) used a 12-month, and Frankel and Rose (1996) used a 3-year exclusion windows. Based on the inspection of the frequency of the crisis months identified by our threshold (particularly during early 1980s), we opt for a 12-month exclusion window.

[3] Accordingly, we did not count these observations as currency crises: 1981:08, 1981:11, 1982:05, 1984:01, 1991:03, 1994:03, 1994:04, 2001:03, 2001:04.

own pre-determined threshold within a given period, this is interpreted as a crisis signal. This period is defined as the signaling horizon, or crisis window. In the literature, the crisis window spans from 6 months to 24 months[1]. In the present analysis, we defined it as 12 months in light of the number of observations and the frequency of identified crisis episodes. If an individual threshold is set too loose, the indicator will catch all the crises, but will also issue too many false signals, i.e. noise. If the threshold is set too tight, the indicator will not issue any false signals, but it may as well miss the crises. The outcome for each indicator can be considered in terms of a two by two matrix as shown in Table 1.

Table 1

Crises-Signals Matrix

	Crisis within 12 months	No crisis within 12 months
Signal issued	A	B
No signal issues	C	D

Source: Kaminsky et al. (1998).

For each variable, there are four possible categories A, B, C, and D. A is the number of months a good signal was sent (a crisis is correctly signaled), B is the number of months a false alarm signal was sent, C is the number of months in which no signal was sent but a crises followed, and D is the number of months in which no signal was sent and no crises followed. Any fluctuations of an indicator beyond its pre-determined threshold are considered abnormal and are taken as a signal that a crisis could occur in the next 12 months. An optimal signal is the one that is followed by a crisis within this signaling horizon. The threshold level for each variable is chosen to minimize the noise-to-signal ratio (NSR) which is the ratio of false signals to good signals and is calculated as:

$$NSR = [B/(B+D)]/[A/(A+C)]. \quad (3)$$

A signaling device that issues signals at random times would obtain an NSR equal to unity. Hence, those indicators which produce more false alarms than good signals, i.e. those having an NSR of above unity, are not helpful in predicting crises (El-Shazly, 2002). For each of the indicators, a two-step procedure is used to obtain the optimal set of thresholds: First, thresholds are defined in relation to percentiles of the distribution of observations of the indicator. Second, a grid of a reference percentile is considered and the optimal set of thresholds is defined as the one that minimizes the NSR ratio. In order to determine the variable-specific optimal threshold values, one of the two grids of reference percentiles between 70% and 95%, or 5% and 30% of the distribution are employed depending on the expected impact of the variable. For some variables a decline in the indicator increases the probability of a crisis, hence the threshold is below the mean of the indicator. For other variables the opposite is the case. The information about the expected impact of each variable on crisis likelihood is given in Table 2. Following the establishment of the relevance of the chosen set of variables as the leading indicators of currency crises by the signals approach, we will test the validity of the functional relationship between the dichotomous variable of currency crises using an econometric analysis since the signals approach ignores the interaction among variables, which may obscure the actual reasons for crises.

Having established the crisis index as a binary variable, we will use a limited dependent model. Compared to probit models, logit models typically perform better when the dependent variable is

[1] For instance, El-Shazly (2002) uses a 6-month, Brüggemann and Linne (2002) use a 18-month, and Kaminsky et al. (1998) use a 24-month signaling horizon.

not evenly distributed between the two outcomes (Manesse et al., 2003). As in the data only 30% of all outcomes are crisis entries, we opt for a logit model[1].

3.2. Logit Model

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, regression results are easily interpreted as the probability of a currency crisis. Traditional econometric modeling suggests that we estimate models with numerous explanatory variables and successively eliminate variables with relatively low t-statistics (Kumar et al., 2003). Nevertheless, owing to the large number of explanatory variables[2], we will successively eliminate the candidate variables by applying a general-to-specific model selection methodology suggested by Manasse et al. (2003), Linne and Bruggemann (2002), and Krznar (2004). Before moving to a multivariate framework, individual logit models with two variables will be estimated to test the possibility of any functional form between the crisis index and the contemporaneous values of the explanatory variables. Variables that are significant at 10% with correct signs are selected into the final model. Normally, a crisis model should consist of the variables in lagged form. However, it is difficult to decide on the appropriate lag length of monthly variables and is cumbersome to test all possible lags with the large number of variables considered. This issue is circumvented in the literature by, *inter alia*, Berg et al. (1999), Busssiere and Fratzcher (2002), Komilainen and Lukkarilla (2003)[3], and Krznar (2004) by employing a certain crisis-window in which all values of the crisis index take the value of 1. Following these authors, the present study adopts a 12-month crisis-window spanning the year before each particular crisis episode since potential explanatory variables are expected to worsen prior to crises. This allows the use of data without any lags and increases the number of ones in the sample from a statistical standpoint (Krznar, 2004)[4].

4. Empirical Results for the Period of 1980:01-2006:06

4.1. Results of Signals Approach

Table 2 presents the estimated thresholds and the results ranking the potential early warning indicators of currency crises according to their NSRs. Since NSR is a measure of the relative proportion of false signals to correct signals, closeness of values to zero indicates a high quality leading indicator of crises. We also calculate the unconditional crisis probability P(C) and the conditional crisis probability P(C|S)[5]. The conditional probability should display higher scores than the simple probability of crisis if the indicator has useful information (Kaminsky et al., 1998). From the estimates reported in Table 2, it is clear that the set of indicators for which the conditional probability

[1] In order to compare the sensitivity of the results to the assumption of a logit versus a probit model, we also estimated the regressions using the latter. The estimated parameters from a logit require scaling before they are comparable to those obtained from a probit estimation. Maddala (1983) suggests multiplying the logit parameters by $\sqrt{3}/\pi$ while Amemiya (1981) suggests that one multiply by 0.625. We found that the latter scaling factor produced closer results. In general, the scaled estimated parameters were broadly similar, especially when the parameters in question had large t-statistics. The fact that the parameters were not closer reflects the fact that the crisis events we are modeling are in the tail of the distribution i.e. there are muck more non-crisis periods than crisis periods, so the fat-tailed nature of the logistic distribution affected the results. The results of the probit models are available from the author upon request.

[2] A logit model cannot accommodate all 42 variables simultaneously as a large number of independent variables in the model would increase the probability of linear dependence between individual independent variables, i.e. multicollinearity (Krznar, 2004).

[3] Crisis index of Komulainen and Lukkarilla (2003) takes on the value of 1 in the month of crisis itself and the preceding 11 months. However, including the crisis month values of the explanatory variables may bias the results. Hence the crisis index in the present analysis does not take value of 1 in the crisis month and in the immediate aftermath.

[4] The values of the currency crisis index are equal to 1 not in the month of the crisis but in the preceding 12 months because including the crisis months' values would bias the results. This way, explanatory variables used in estimations will have leading indicator characteristics.

[5] P(C) is calculated as (A+C)/(A+B+C+D). P(C|S) is calculated as A/(A+B). A, B, C, and D represent the cells in the matrix in Table 2.

of a crisis is lower than the unconditional probability is the same as the set for which the NSR is higher than unity.

Table 2

Signals Approach (1980:01-2006:06)

Variable	Expected Impact on Crisis likelihood	Threshold (in per-centile)	A	B	C	D	NSR	P(Crisis/ Signal) A/(A+B)	P(Crisis/ Signal)-P(crisis) (A+C)/(A+B+C+D)	Persistence of sig-nals	Average Lead time of the first signal (in months)
Banking Sector Fragility Index	-	5	8	4	88	210	0.22	0.67	0.31	4.55	9.0
USD LIBOR Rate	+	90	5	4	55	153	0.31	0.56	0.28	3.23	7.0
Short Term Debt/International Reserves	+	95	7	6	89	209	0.38	0.54	0.31	2.63	6.2
Bank reserves/bank assets	-	5	14	14	46	146	0.38	0.50	0.27	2.63	3.2
Current Account Balance/GDP	-	95	4	4	92	214	0.44	0.50	0.31	2.27	4.0
FDI/GDP	-	5	2	2	94	218	0.44	0.50	0.30	2.27	8.0
US GDP	-	90	7	7	89	208	0.45	0.50	0.31	2.22	6.4
Spread between US 3-month T-Bill and Federal Funds Rate	+	85	12	12	84	198	0.46	0.50	0.31	2.17	5.6
M1	+	85	11	12	85	199	0.50	0.48	0.31	2.00	11.0
US Real T-Bill Rate	+	95	8	9	88	205	0.50	0.47	0.31	2.00	4.0
Federal Funds Rate	+	85	6	7	90	209	0.52	0.46	0.31	1.92	8.7
Foreign Liabilities/Foreign Assets of Banks	+	95	17	20	79	185	0.55	0.46	0.32		
M2/International Reserves	+	80	13	16	83	193	0.57	0.45	0.31	1.82	9.7
International Reserves/GDP	-	25	33	40	63	149	0.62	0.45	0.34	1.75	6.8
Capital Inflows/GDP	+	85	15	20	81	187	0.62	0.43	0.32	1.61	9.4
Public Debt/GDP	+	90	15	21	81	186	0.65	0.42	0.32	1.61	10.0
Fiscal Balance/GDP	-	10	11	16	85	195	0.66	0.41	0.31	1.54	3.3
Imports	+	95	27	38	69	157	0.69	0.42	0.33	1.52	9.7
Domestic Credit/GDP	+	70	17	26	79	179	0.72	0.40	0.32	1.45	8.3
Industrial Production Index	-	15	12	19	84	191	0.72	0.39	0.31	1.39	10.0
Commercial Bank Loans to Private Sector	+	95	16	26	80	180	0.76	0.38	0.32	1.39	4.5
Commercial Bank Loans to Public Sector	+	80	24	38	72	160	0.77	0.39	0.33	1.32	9.3
Exports	-	20	26	41	70	155	0.77	0.39	0.33	1.30	9.8
M2 Multiplier	+	85	20	33	76	169	0.78	0.38	0.32	1.30	10.8
Reserve Money/GDP	-	20	30	51	66	141	0.85	0.37	0.33	1.28	11.7
Portfolio investments/GDP	-	5	5	12	55	157	0.85	0.29	0.26	1.18	8.1
Government consumption/GDP	+	80	3	6	93	213	0.88	0.33	0.30	1.18	9.3
Excess real M1 balances	+	90	24	44	72	154	0.89	0.35	0.33	1.14	8.3
GDP per capita	-	5	16	33	80	173	0.96	0.33	0.32	1.12	9.0
Commercial Bank Deposits	-	25	44	78	52	100	0.96	0.36	0.35	1.04	6.4
Deposit money banks net past due loans/total loans	+	95	6	18	54	162	1.00	0.25	0.25	1.04	10.6
CPI Growth	+	85	18	44	78	160	1.15	0.29	0.32	1.00	6.3
Short-Term Debt/Long-Term Debt	+	75	3	10	57	161	1.17	0.23	0.26	0.87	10.5

Table 2 (continued)

Variable	Expected Impact on Crisis likelihood	Threshold (in per-centile)	A	B	C	D	NSR	P(Crisis/ Signal) A/(A+B)	P(Crisis/ Signal)-P(crisis) (A+C)/(A+B+C+D)	Persistence of sig-nals	Average Lead time of the first signal (in months)
Government Changes	+	N/A	6	17	90	199	1.26	0.26	0.31	0.85	6.0
Oil prices	+	90	12	36	84	174	1.37	0.25	0.31	0.79	8.0
Contagion Dummy	+	N/A	3	10	93	209	1.46	0.23	0.30	0.73	9.3
Real Effective Exchange Rate Overvaluation	+	85	8	30	88	184	1.68	0.21	0.31	0.68	8.9
Domestic Real Interest Rates	+	95	6	23	90	193	1.70	0.21	0.31	0.60	11.3
Stock Market Index	-	12	2	16	22	96	1.71	0.11	0.18	0.59	5.7
Real Interest Rate Differential	+	95	4	20	92	198	2.20	0.17	0.31	0.58	4.0
Central Bank Credit to Public Sector/GDP	+	93	1	8	59	165	2.77	0.11	0.26	0.45	3.3
Trade Balance/GDP	-	5	2	19	94	201	4.15	0.10	0.30	0.36	2.0

Another desirable feature in the potential leading indicators is that signals be more persistent prior to crises during the 12-month window than at other times. Table 2 presents a summary measure of the persistence of the signals measured as the average number of signals per period during the pre-crisis period compared to tranquil times. Indicators are ranked according to their performance. The indicator issuing the most persistent signals is the same as the indicator that has the lowest NSR. The opposite is the case for the indicator issuing the least persistent signals. A drawback of the signal's approach is that, in focusing on the 12-month window prior to the onset of the crisis, the criteria for ranking the indicators do not distinguish between an indicator that sends signals well before the crisis occurs and one that signals only when the crisis is imminent. In order to evaluate the performances of indicators, one should also consider the average number of months prior to crisis the first good signal occurs because a variable with lower NSR can be a useful leading indicator of currency crises only if it sends warning signals sufficiently early to enable policymakers to take preemptive measures to prevent approaching crises. Therefore, in addition to the ranking of the indicators according to their ability to predict crises, lead time of the signal is also estimated. Table 2 also presents the average number of months in advance of the crisis when the first signal occurs. On average, first ten indicators send the first signal 6.4 months before the crisis erupts, with M1 having the longest lead time and bank reserves/bank assets having the shortest. Overall, it can be concluded that the identified leading indicators are indeed leading as signaling, on average, occurs sufficiently early to allow for preemptive policy actions.

Overall, the results suggest that only a handful of variables may be considered to consistently provide information about vulnerability to a currency crisis in the sense that they correctly signal crises with negligible noise, and also provide signals early enough enabling policy-makers to take preventive measures. The variables which can provide some useful information about the risks of a possible crisis are banking sector fragility index, USD LIBOR rate, short-term debt/international reserves, bank reserves/bank assets, current account balance/GDP, FDI/GDP, US GDP, the spread between 3-month US T-Bill and federal funds rate, M1, and US real T-Bill rate.

Overall, results of the signals approach for the period of 1980:01-2006:06 suggest that indicators related to real sector and fiscal sector variables are not useful as leading indicators for crises. The same conclusion applies to current account variables with the exception of current account balance/GDP. On the other hand, capital account variables and the variables reflecting the global economic conditions are generally found to be functional as leading indicators. Above all, financial

sector variables, especially those indicating the fragility of the banking sector, are found to be the foremost indicators of currency crises for the period that we studied.

4.2. Results Logit Regressions

Results of bivariate logit models which investigate the possibility of functional forms between the dichotomous crisis index and the contemporaneous values of the individual explanatory variables are presented in Table 3. Positive values of each coefficient imply that increasing the variable will increase the probability of the crises while negative values imply the opposite. The size of each estimated coefficient reflects the relative effect of the variable on the predicted probability for crises. Nonetheless, 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 probability of crises. Hence, marginal effects of the significant explanatory variables, which we compile into a general logit model, are estimated by taking the derivatives of the parameter estimates. Results of the variable-by-variable logit regressions show that 3-month US real T-Bill rate, US GDP, foreign liabilities/foreign assets of banks, bank reserves/bank assets, M2/international reserves, banking sector fragility index, short-term debt/international reserves, M1, and federal funds rate are significant at 10% level. The signs of the estimated coefficients coincide with what we expect from economic theory. Based on the results of the variable-by-variable analysis, we combine those variables that appear to help predict crises into a general logit model[1].

Table 3

Coefficient Estimates of the Logit Models with Two Variables (1980:01-2006:06)

Variable	Expected Impact on Crisis likelihood	Logit Coefficient	Standard Errors	Z-Statistic	P>|z|
Government consumption/GDP	+	-0.666895	0.999015	-0.667553	0.5044
US Real T-Bill Rate	+	0.008402	0.002782	3.019994***	0.0025
Fiscal Balance/GDP	-	0.020389	0.672398	0.030323	0.9758
GDP per capita	-	-2.070894	1.601406	-1.293172	0.1960
US GDP	-	-0.322746	0.057608	-5.602442***	0.0000
Commercial Bank Loans to Public Sector	+	2.514881	3.425531	0.734158	0.4629
Excess real M1 balances	+	0.146872	1.969395	0.074577	0.9406
International Reserves/GDP	-	-1.151832	1.206750	-0.954491	0.3398
M2 Multiplier	+	1.225859	2.789007	0.439532	0.6603
Foreign Liabilities/Foreign Assets of Banks	+	0.513308	0.763213	3.672562***	0.0050
Bank reserves/bank assets	-	-0.239688	2.190382	-3.109428***	0.0029
Imports	+	0.927825	0.793768	1.168887	0.2424
Commercial Bank Deposits	-	-3.859221	3.347362	-1.152914	0.2489
Exports	-	0.503813	1.003442	0.502085	0.6156
M2/International Reserves	+	0.010684	0.002837	3.766075***	0.0002
Banking Sector Fragility Index	+	8.922337	5.767289	3.547059***	0.0018
Commercial Bank Loans to Private Sector	+	1.078855	1.159989	0.930056	0.3523
Capital Inflows/GDP	+	-0.000425	0.031489	-0.013500	0.9892
Reserve Money/GDP	-	-3.821631	2.349475	-1.626589	0.1038
Domestic Credit/GDP	+	-1.236772	3.307736	-0.373903	0.7085
CPI Growth	+	-0.417301	1.140233	-0.365979	0.7144

[1] Before moving to multivariate analysis we checked the selected series for multicollinerarity. We did not find evidence of strong correlation between any series.

Table 3 (countinued)

Variable	Expected Impact on Crisis likelihood	Logit Coefficient	Standard Errors	Z-Statistic	P>|z|
Short-Term Debt/Long-Term Debt	+	-3.80E-05	0.000149	-0.254824	0.7989
Short Term Debt/International Reserves	+	0.606612	0.411827	3.472979***	0.0078
Portfolio investments/GDP	-	0.010293	0.021844	0.471207	0.6375
Deposit money banks net past due loans/total loans	+	-0.006289	0.768977	-0.008178	0.9935
Central Bank Credit to Public Sector/GDP	+	-0.010884	0.003120	-3.489023	0.0005
Current Account Balance/GDP	-	-0.000126	0.003399	-0.037191	0.9703
Real Interest Rate Differential	+	-0.022013	0.042810	-0.514195	0.6071
Real Effective Exchange Rate Overvaluation	+	-0.103147	0.137315	-0.751170	0.4526
Industrial Production Index	-	3.470851	5.229210	0.663743	0.5069
Trade Balance/GDP	-	3.19E-05	0.000346	0.092174	0.9266
Stock Market Index	-	-0.685296	1.319430	-0.519388	0.6035
Public Debt/GDP	+	-0.064192	1.052700	-0.060979	0.9514
Real Interest Rates	+	-0.022013	0.042810	-0.514195	0.6071
Government Changes	+	-0.602633	0.657268	-0.916876	0.3592
Oil prices	+	-0.296546	1.485923	-0.199570	0.8418
M1	+	0.009452	0.005096	1.854778*	0.0636
FDI/GDP	-	0.005685	0.033729	0.168546	0.8662
Federal Funds Rate	+	0.008960	0.002764	3.241148***	0.0012
USD LIBOR Rate	+	-0.004510	0.003646	-1.236853	0.2161
Spread between 3-month US T-Bill and Federal Funds Rate	+	0.000171	0.000428	0.399943	0.6892
Contagion Dummy	+	-1.297566	1.067719	-1.215269	0.2243

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

Table 4 presents the results of the final logit model. The results indicate that the movements in the explanatory variables are correlated with the incidence of currency crises in the expected manner. The statistical characteristics of the model are favorable. All the variables are significant at 10% level. 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.

Table 4

Coefficient Estimates of the Logit Models with Multiple Variables (1980:01-2006:06)

Variable	Expected Impact on Crisis likelihood	Logit Coefficient	Standard Errors	Z-Statistic	P>|z|	Marginal Effect[a]
3-month US Real T-Bill Rate	+	0.008613	0.003646	2.362595**	0.0181	0.365876
US GDP	-	-0.326416	0.059787	-5.459626***	0.0000	-0.067065
Foreign Liabilities/Foreign Assets of Banks	+	0.010634	0.003151	3.374403***	0.0007	0.001954
Bank reserves/bank assets	-	-13.16992	7.280977	-1.808812*	0.0705	-2.775423
M2/International Reserves	+	0.023775	0.005654	4.204567***	0.0000	0.003878

Table 4 (continued)

Variable	Expected Impact on Crisis likelihood	Logit Coefficient	Standard Errors	Z-Statistic	P>|z|	Marginal Effect[a]
Banking Sector Fragility Index	+	32.68563	11.12350	2.938432***	0.0033	5.556543
Short Term Debt/International Reserves[1]	+	3.133247	0.887642	3.529852***	0.0004	0.554764
M1	+	0.040817	0.009460	4.314826***	0.0000	0.007324
Federal Funds Rate	+	0.038007	0.018335	2.072873**	0.0382	0.008001
Constant		-1.555654	1.079058	-1.441679	0.1494	
McFadden R-squared[2]: 0.765001 LR statistic (5 df)[3]: 140.3485***						

Significant at the 10% level. *** Significant at the 1% level.
[a] Marginal effects are calculated at sample means.

A comparison of the results obtained from the logit analysis with those obtained from the signals approach indicates that the variables identified by both approaches as leading indicators of crises do coincide. In a sense, this also serves as a confirmation of the robustness of the results obtained by each approach. Next, we will repeat our analysis for the post-capital account liberalization period to see if the results would change.

5. Empirical Results for the Post-Capital Account Liberalization Period (1989:09-2006:06)

Liberalization of capital flows has exposed economies to speculative short-term capital movements and rendered them vulnerable to currency crises (Grabel, 1995). Hence, particularly in the post-capital account liberalization period, global liquidity conditions and financial flows are very likely to influence the vulnerability of the economy to currency crises (Kumar et al, 2003). Turkish economy is by no means an exception. Although Turkish financial liberalization efforts root back to early 1980s, the full capital liberalization was declared in August 1989 with the liberalization of the capital account. Since our sample period includes both pre- and post-capital account liberalization periods, following Komulainen and Lukkarilla (2003), we will analyze the post-capital account liberalization period (1989:09-2006:06) separately in order to investigate whether the capital account liberalization has changed the causes of currency crises in Turkey[4].

5.1. Results of Signals Approach

As evident from Table 5, the signals analysis indicates that variables related to the global liquidity conditions and the US monetary policy are indeed useful leading indicators of currency crises for the post-capital account liberalization period. These variables are US federal funds rate, US GDP,

[1] To check that the short-term debt to reserves ratio is not significant simply because the denominator diminishes before a crisis, we tested the level of short-term debt measured as a percentage of GDP. The result is the same: this variable is significant and contributes to the goodness-of-fit of the model.
[2] 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).
[3] 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).
[4] The pre-liberalization sample includes 6 crisis periods and the post-liberalization sample includes 4 crisis periods based on our crisis definition and the exclusion window of 12 months.

and the spread between 3-month US T-Bill and federal funds rate. Overall, we note that a number of variables are useful as leading indicators in both the entire sample period and the post-capital account liberalization period. These variables are banking sector fragility index, short-term debt/international reserves, current account balance/GDP, US GDP, the spread between 3-month US T-Bill and federal funds rate, M1, 3-month real US T-Bill rate, foreign liabilities/foreign assets, and international reserves/GDP. Nonetheless, capital inflows/GDP and portfolio investments/GDP are not identified as helpful leading indicators in the post-capital account liberalization period as expected. An interesting finding is that government consumption/GDP was found to be the most useful indicator of crises for the period under study. Another interesting finding is that although FDI/GDP and USD LIBOR rate are strong leading indicators for the period of 1980:01-2006:06, they are not among the useful indicators for the post-capital account liberalization period. Nonetheless, the results of the signals approach are, at most, suggestive and it would be erroneous to reach a definitive conclusion based on these results alone. Hence, we will seek to find evidence to support these findings using logit regressions for the same period.

Table 5

Signals Approach (1989:09-2006:06)

Variable	Expected Impact on Crisis likelihood	Threshold (in percentile)	A	B	C	D	NSR	P(Crisis/ Signal) A/(A+B)	P(Crisis/ Signal)-P(crisis) (A+C)/(A+B+C+D)	Persistence of signals	Average Lead time of the first signal (in months)
Government consumption/GDP	+	80	1	0	59	140	0.00	1.00	0.30	#DIV/0!	1.00
Federal Funds Rate	+	85	4	1	56	136	0.11	0.80	0.30	9.09	7.50
Banking Sector Fragility Index	-	5	6	2	54	133	0.15	0.75	0.31	6.67	8.33
Bank reserves/bank assets	-	5	12	7	48	122	0.27	0.63	0.32	3.70	3.80
US GDP	-	90	5	4	55	132	0.35	0.56	0.31	2.86	5.25
Short Term Debt/International Reserves	+	95	6	5	54	130	0.37	0.55	0.31	2.70	9.00
Spread between US 3-month T-Bill and Federal Funds Rate	+	85	11	9	49	121	0.38	0.55	0.32	2.63	5.25
Imports	+	95	13	11	47	117	0.40	0.54	0.32	2.50	9.25
M1	+	85	11	10	49	120	0.42	0.52	0.32	2.38	11.00
US Real T-Bill Rate	+	95	3	3	57	135	0.43	0.50	0.30	2.33	2.00
FDI/GDP	-	5	2	2	58	137	0.43	0.50	0.30	2.33	10.00
Current Account Balance/GDP	-	95	4	4	56	133	0.44	0.50	0.30	2.27	4.00
Foreign Liabilities/Foreign Assets of Banks	+	95	7	7	53	127	0.45	0.50	0.31	2.22	8.40
International Reserves/GDP	-	25	15	15	45	111	0.48	0.50	0.32	2.08	7.80
Public Debt/GDP	+	90	8	9	52	124	0.51	0.47	0.31	1.96	1.75
USD LIBOR Rate	+	90	6	7	54	128	0.52	0.46	0.31	1.92	7.25
Fiscal Balance/GDP	-	10	5	6	55	130	0.53	0.45	0.31	1.89	9.25
Exports	-	20	16	21	44	104	0.63	0.43	0.32	1.59	11.20
Portfolio investments/GDP	-	5	9	13	51	119	0.66	0.41	0.31	1.52	9.33
Commercial Bank Deposits	-	25	33	39	27	69	0.66	0.46	0.36	1.52	11.20
GDP per capita	-	5	11	16	49	114	0.67	0.41	0.32	1.49	4.40
Commercial Bank Loans to Public Sector	+	80	19	27	41	95	0.70	0.41	0.33	1.43	9.40
Capital Inflows/GDP	+	85	9	14	51	118	0.71	0.39	0.31	1.41	8.00

Table 5 (continued)

Variable	Expected Impact on Crisis likelihood	Threshold (in percentile)	A	B	C	D	NSR	P(Crisis/ Signal) A/(A+B)	P(Crisis/ Signal)-P(crisis) (A+C)/(A+B+C+D)	Persistence of signals	Average Lead time of the first signal (in months)
Central Bank Credit to Public Sector/GDP	+	93	3	5	57	133	0.72	0.38	0.30	1.39	8.00
CPI Growth	+	85	15	23	45	103	0.73	0.39	0.32	1.37	9.25
Domestic Credit/GDP	+	70	14	23	46	104	0.78	0.38	0.32	1.28	9.50
Reserve Money/GDP	-	20	20	33	40	88	0.82	0.38	0.33	1.22	11.00
M2 Multiplier	+	85	17	29	43	95	0.83	0.37	0.33	1.20	10.00
Excess real M1 balances	+	90	14	25	46	102	0.84	0.36	0.32	1.19	9.40
Commercial Bank Loans to Private Sector	+	95	8	15	52	118	0.85	0.35	0.31	1.18	10.50
M2/International Reserves	+	80	5	10	55	126	0.88	0.33	0.31	1.14	4.00
Deposit money banks net past due loans/total loans	+	95	8	16	52	117	0.90	0.33	0.31	1.11	6.67
Industrial Production Index	-	15	5	11	55	125	0.97	0.31	0.31	1.03	4.67
Stock Market Index	-	12	4	9	56	128	0.99	0.31	0.30	1.01	9.50
Domestic Real Interest Rates	+	95	7	18	53	116	1.15	0.28	0.31	0.87	4.67
Oil prices	+	90	8	23	52	110	1.30	0.26	0.31	0.77	5.80
Real Effective Exchange Rate Overvaluation	+	85	6	18	54	117	1.33	0.25	0.31	0.75	9.33
Short-Term Debt/Long-Term Debt	+	75	3	11	57	127	1.59	0.21	0.30	0.63	7.67
Trade Balance/GDP	-	5	3	15	57	123	2.17	0.17	0.30	0.46	7.67
Government Changes	+	N/A	3	15	57	123	2.17	0.17	0.30	0.46	6.00
Real Interest Rate Differential	+	95	3	16	57	122	2.32	0.16	0.30	0.43	10.00
Contagion Dummy	+	N/A	1	11	59	129	4.71	0.08	0.30	0.21	12.00

5.2. Results of Logit Regressions

Results of the bivariate logit models covering the post-capital account liberalization period are summarized in Table 6. Strong evidence emerged that US federal funds rate, M2/international reserves, banking sector fragility index, foreign liabilities/foreign assets of banks, US GDP, and 3-month US real T-Bill rate are significant in explaining the occurrence of crises. These results are generally in line with the logit estimates obtained for the period of 1980:01-2006:06. Nonetheless, bank reserves/bank assets, short-term debt/international reserves, and M1 did not turn out to be significant in the post-capital account liberalization period. These findings confirm the power of some of the leading indicators obtained from signals approach for the post-capital account liberalization period albeit with the exception of a number of variables such as government consumption/GDP, short-term debt/international reserves, M1, imports, bank reserves/bank assets, and the spread between 3-month US T-Bill rate and federal funds rate. We combined the significant series into a general logit model as shown in Table 7[1]. The results are encouraging. Overall, the significance of federal finds rate, banking sector fragility index, 3-month US T-Bill rate, US GDP, and short-term debt/GDP has been verified by both the signals approach and the logit analysis.

[1] Again, prior to building the general model we checked the selected series for multicollinerarity and did not find evidence of correlation among any pairs.

Table 6

Coefficient Estimates of the Logit Models with Two Variables (1989:09-2006:06)

Variable	Expected Impact on Crisis likelihood	Logit Coefficient	Standard Errors	Z-Statistic	P>|z|
Government consumption/GDP	+	0.822053	2.659485	0.309102	0.7572
US Real T-Bill Rate	+	0.010207	0.003131	3.260192***	0.0011
Fiscal Balance/GDP	-	4.116872	2.862182	1.438368	0.1503
GDP per capita	-	-7.160001	0.323427	-1.656094	0.9677
US GDP	-	-0.522162	0.157648	-3.312200***	0.0009
Commercial Bank Loans to Public Sector	+	3.052109	4.395581	0.694359	0.4875
Excess real M1 balances	+	0.094991	2.396808	0.039632	0.9684
International Reserves/GDP	-	-1.097750	2.026194	-0.541779	0.5880
M2 Multiplier	+	0.056193	3.453267	0.016272	0.9870
Foreign Liabilities/Foreign Assets of Banks	+	1.386015	1.644995	1.842569*	0.0995
Bank reserves/bank assets	-	0.143599	2.163535	0.066372	0.9471
Imports	+	0.743850	1.278177	0.581962	0.5606
Commercial Bank Deposits	-	-10.46990	1.523010	-0.314808	0.0206
Exports	-	0.116801	1.417013	0.082428	0.9343
M2/International Reserves	+	0.016376	0.003708	4.416972***	0.0000
Banking Sector Fragility Index	+	21.67176	7.839483	2.764437***	0.0057
Commercial Bank Loans to Private Sector	+	-2.629292	2.030772	-1.294726	0.1954
Capital Inflows/GDP	+	-0.007097	0.034298	-0.206918	0.8361
Reserve Money/GDP	-	-4.709064	2.927666	-1.608470	0.1077
Domestic Credit/GDP	+	-4.477376	4.110504	-1.089252	0.2760
CPI Growth	+	1.258228	1.460749	0.861358	0.3890
Short-Term Debt/Long-Term Debt	+	-0.000166	0.000181	-0.919483	0.3578
Short Term Debt/International Reserves	+	-0.917198	0.563459	-1.627799	0.1036
Portfolio investments/GDP	-	0.013345	0.020372	0.655063	0.5124
Deposit money banks net past due loans/total loans	+	-0.176459	0.772831	-0.228328	0.8194
Central Bank Credit to Public Sector/GDP	+	-0.009030	0.003342	-0.701625	0.4369
Current Account Balance/GDP	-	0.000481	0.003372	0.142787	0.8865
Real Interest Rate Differential	+	0.052814	0.068849	0.767099	0.4430
Real Effective Exchange Rate Overvaluation	+	-0.100980	0.194724	-0.518578	0.6041
Industrial Production Index	-	10.10039	7.842765	1.287861	0.1978
Trade Balance/GDP	-	-1.86E-05	0.000401	-0.046339	0.9630
Stock Market Index	-	-0.685296	1.319430	-0.519388	0.6035
Public Debt/GDP	+	-1.345362	1.766604	-0.761552	0.4463
Real Interest Rates	+	0.054108	0.069086	0.783207	0.4335
Government Changes	+	-1.395247	1.057219	-1.319734	0.1869
Oil prices	+	0.150665	1.851018	0.081396	0.9351
M1	+	0.008254	0.006245	1.321796	0.1862
FDI/GDP	-	0.016220	0.033704	0.481232	0.6304
Federal Funds Rate	+	0.011817	0.003204	3.688661***	0.0002
USD LIBOR Rate	+	-0.010521	0.004621	-0.476999	0.6228
Spread between US 3-month T-Bill and Federal Funds Rate	+	8.21E-05	0.000477	0.172196	0.8633
Contagion Dummy	+	41.11223	NA	NA	NA

[a] Marginal effects are calculated at sample means.
* Significant at the 10% level, ** Significant at the 5% level, *** Significant at the 1% level.

Table 7

Coefficient Estimates of the Logit Models with Multiple Variables (1989:09-2006:06)

Variable	Expected Impact on Crisis likelihood	Logit Coefficient	Standard Errors	Z-Statistic	P>|z|	Marginal Effect
Federal Funds Rate	+	0.043643	0.018852	2.315019	0.0206	0.004763
M2/International Reserves	+	0.013797	0.004018	3.433677	0.0006	0.000534
Banking Sector Fragility Index	+	0.015805	0.003960	3.991537	0.0001	0.002653
Foreign Liabilities/Foreign Assets of Banks	+	0.404196	0.186959	2.161955	0.0306	0.005223
US GDP	-	-0.495452	0.215346	-2.300729	0.0214	-0.008432
US Real T-Bill Rate	+	0.040472	0.018699	2.164449	0.0304	0.003112
Constant		-3.234149	1.295861	-2.495754	0.0126	
McFadden R-squared[1]: 0.683660 LR statistic (5 df)[2]: 141.71014***						

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

5.3. Sensitivity Tests

We carried out two sensitivity tests suggested by Manasse et al. (2003) to see how robust the estimated logit model is. First, we dropped observations with extreme values for the variables included in the logit. The direction of influence of the variables for which the extreme values were removed remains unchanged, and the coefficient estimates did not exhibit large falls in the z value. Second, we re-entered 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 did we see the model's goodness-of-fit improved. Hence, we concluded that the results of the model are robust[3].

6. Conclusions

In this article, we have used signals approach and logit regressions to explore the causes of currency crises in Turkey for the period of 1980:01-2006:06. Overall, our findings suggest that conventional crisis indicators fail to provide a satisfactory explanation for crises despite the economic intuition: We did not find strong evidence indicating an obvious linkage between the macroeconomic fundamentals and currency crises. For the entire period spanning 1980:01-2006:06, only banking sector fragility index, short-term debt/international reserves, bank reserves/bank assets, US GDP, M1, and US 3-month T-Bill rate have been identified as significant leading indicators by both the signals approach and logit regressions. Still, the fact that banking sector fragility index turned out a significant leading indicator is not surprising as it has been widely documented in the literature that banking sector problems and currency crises are interrelated. This is particularly in line with the literature on Turkish currency crises where the fragility of the banking sector has fre-

[1] 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).

[2] 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).

[3] Results are available from the author upon request.

quently been noted as one of the leading causes of currency crises in Turkey (See, for example, Celasun, 1998; and Ozatay and Sak, 2002).

Analyzing the post-capital account liberalization period between 1989:09 and 2006:06 in isolation, we find evidence that the importance of US federal funds rate, banking sector fragility index, US GDP, and US 3-month T-Bill rate has been confirmed by both approaches, suggesting that these results are not driven by the specific method of estimation. Additionally, strong evidence emerged that foreign liabilities/foreign assets of banks significantly increase the probability of currency crises in the post-capital account liberalization period. In both samples, indicators pertaining to global economic conditions substantially increase the likelihood of currency crises. Signals analysis, in particular, revealed that these indicators become more important in explaining crises during the post-capital account liberalization period, while conventional variables such as current account deficit/GDP diminish in significance. On the other hand, logit estimates indicate that bank reserves/bank assets, short-term debt/international reserves, and M1 are not significant indicators of crises after the liberalization of capital flows.

On the whole, there exists a general consensus on the significance of banking sector fragility index, US GDP, US real T-Bill rate by both approaches for both sample periods. The importance of indicators of global economy is an interesting and novel result, and indicates an increased vulnerability to downturns in global capital markets. The fact that banking sector variables are indeed leading indicators of currency crises for this period is along the lines of the literature where it has been widely argued that financial liberalization increases the possibility of a crisis if the banking sector is fragile. This, coupled with our results confirming the significance of global economic conditions, reveals that financial liberalization has indeed rendered the Turkish economy vulnerable to crises. A possible explanation to this is that the greater degree of openness in financial sector provided greater scope for speculative attacks due to global liquidity conditions.

The explanation for the contradiction between the evidence that emerged in the present article and those provided by the literature lies in the selection of sample period, data frequency, and the methodology. In fact, results of any empirical work on currency crises, including those of the present analysis, must be treated with caution due to several technical limitations of available methodologies. In particular, certain issues such as the definition of a currency crisis, selection of the time horizon of the pre-crisis period, dependence of the results on the choice of an arbitrary threshold value, frequency of data, and use of certain series in interpolated form, and the small number of crisis episodes with different characteristics, may affect the statistical reliability of our results. In particular, the previous studies on Turkish currency crises considered narrower sample periods focusing on particular crisis incidences rather than analyzing multiple crises from a broader perspective. On the whole, our results suggest that currency crises are not all alike, even in the context of a single country, and that it is a difficult endeavor to spot any common patterns across various crises episodes.

The results on several variables such as international reserves/GDP, interest rates, real effective exchange rate overvaluation, and current account balance/GDP were not as anticipated by the review of the literature. For the sample periods under study, we failed to detect strong empirical evidence to agree that these variables were among the underlying causes of currency crises in Turkey. In a sense, this means that, in the case of Turkey, even if various indicators that are commonly known to form the background to currency crises are followed systematically, incipient problems that may eventually lead to currency crises might not be detected. Obviously, relying solely on the result of the present analysis might not be sufficient to detect future financial crises either. It is practically impossible to recognize and correctly interpret warning signals for all currency crises because each has its own characteristics. Nonetheless, close monitoring of the identified leading indicators would vastly assist the policy makers in forestalling potential crises.

In conclusion, the major contribution of the present article is the identification of certain variables whose variation in a certain trend may help policy-makers to foresee future crises. The results of the present study emphasize the need for a careful monitoring of various indicators of financial

sector and global economic conditions by the central banks. Given the high degree of international capital mobility, the results obtained in this analysis are also relevant for other emerging markets and for countries intending to liberalize. Although identification of these variables can not replace the sound judgment of policy-makers in guiding policy, it still plays an important role in emphasizing the areas that require special attention.

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APPENDIX I. Potential Crisis Indicators and Sources of Data

Variable	Rationale	Data Source
Current Account		
Exports	Declining export growth implies that the government may devalue in order to empower the exports. Besides it shows a loss in competitiveness and possible problems of domestic enterprises. It also inhibits the country's ability to earn foreign exchange to finance an existing current account deficit (Kaminsky et al., 1998; Berg and Pattillo, 1999; Bruggemann and Linne 2002).	IFS line 70DZF
Imports	Excessive import growth may show that the exchange rate is overvalued which could lead to a loss in competitiveness and worsening in the current account (Kaminsky et al., 1998; Berg and Pattillo, 1999; Edison, 2003).	IFS line 71DZF
Real Effective Exchange Rate Overvaluation [a]	Used as a proxy of external vulnerability. Currency overvaluation could lead to deteriorations in the current account and is often perceived by the market as an indication that the country will have to devalue. It may also cause a loss of competitiveness and a recession. Ultimately it adversely affects a country's ability to service its debt (Kaminsky et al. 1998, 1999; Dermirguc-Kunt and Detragiache, 2000).	CBRT EDDS
Trade Balance/GDP	Weak exports or excessive import growth could lead to deteriorations in the current account which can lead to currency crises (Fratzcher, 2002; Edison, 2003).	Exports-imports (IFS line 70DZF-71DZF)/GDP (CBRT EDDS)
Current Account Balance/GDP	High deficits make the country vulnerable to expectation shifts and less capable to generate external revenue to finance a balance of payments problem whereas surplus is expected to indicate a diminished probability to devalue and thus to lower the probability of a crisis (Fratzcher, 2002; Kamin et al., 2001; Lanoie and Lemarbre, 1996; Marchesi, 2003).	CBRT EDDS
Capital Account		
International Reserves/GDP	Declining level of international reserves may trigger a speculative attack against the currency and shows that a currency is under devaluation pressure. It may also be used as indicators of a country's financial difficulty, dealing with debt repayment (Kaminsky et al., 1998; Berg and Pattillo, 1999; Marchesi, 2003).	International Reserves (IFS line 1LD)/GDP(CBRT EDDS)
M2/International Reserves	Used as a proxy of reserve adequacy. It captures to what extent the liabilities of the banking system are backed by international reserves. It assesses the short-term liquidity and convertibility of a country's currency. Fearing devaluation, economic agents may substitute local currency for foreign currency. This ratio shows the extent to which the Central Bank can withstand this pressure. (Kamin et al., 2001; Calvo, 1998; Fratzcher, 2002).	M2 (IFS line 35ZLF)/International Reserves (IFS line 1LD)
Short-Term Debt/Long-Term Debt	Excessive reliance on short-term debt is an indicator of financial vulnerability as the shorter and more concentrated the debt maturity the more likely debt crises are to occur. In addition, short-term debt may increase a country's exposure to sharp increases in interest rates, which may have additional negative consequences, as governments may need to increase taxes in order to service the debt (Barro, 1997; Borensztein et al., 2005).	WDI*
Short-Term Debt/ International Reserves	Used as an indicator of reserve adequacy. A high short-term debt/international reserves ratio is a vulnerability indicator, signifying exposure to crises (Rodrik and Velasco, 1999). As a rule of thumb known as the Greenspan-Guidotti rule, international reserves should cover at least the level of short-term debt (Fratzcher, 2002).	(Foreign debt with maturity of less than 1 year/international reserves) WB GDFS*
FDI/GDP	Higher amount of FDI implies a lesser share of the current account being financed by volatile portfolio inflows and should lower the probability of crisis. Also, higher FDI ratios may be indicative of more attractive economic policies and prospects. FDIs are long-term capital inflows which increase the productive capacity of the country and produce the revenues necessary to cover future capital outflows (Evans et al., 2000).	(IFS line 78 BED)/GDP
Portfolio Investments/GDP	Reflects the changes in expectations of foreign investors. When portfolio investments take a sudden drop or reverse, this can be taken as a sign of loss of confidence, and may be the immediate cause of a currency crisis (Jotzo, 1999).	IFS line 78BFD/GDP (Data available after 1985)
Capital Inflows/GDP	Used as a proxy for financial account and vulnerability to a sudden stop of capital inflows (Komulainen and Lukkorilla, 2003).	Capital Inflows (IFS line 78BJD)/GDP
Reserve Money (High-Powered Money)/GDP	Used as a proxy of seignorage, i.e. monetization of the government deficit. Currency crises may take place if a deficit is financed through seignorage, as this may cause agents to expect a crisis and push the economy to a bad equilibrium (Obstfeld, 1986).	Reserve money (IFS line BL)/GDP(CBRT EDDS)
Financial Sector		
Banking Sector Fragility Index (BSFI)	Used as a proxy for fragility of banking sector. The index consists of a weighted average of bank credits to the domestic private sector, bank deposit and the foreign liabilities of banks (See Kibritcioglu, 2003). Calculated as: $[((\%\Delta CPS-\mu_{CPS})/\sigma_{CPS}) + ((\%\Delta FL-\mu_{FL})/\sigma_{FL}) + ((\%\Delta DEP-\mu_{DEP})/\sigma_{DEP})]/3$ where $\%\Delta$ indicates the difference in 12-month changes in data that has been used. *CPS, FL* and *DEP* stand for credits to the domestic private sector, the foreign liabilities of banks and bank deposit, respectively.	Foreign Liabilities of banks (IFS line 26C), credits to the domestic private sector (IFS line 32DZF), bank deposit (IFS line 24+ 25)
M1	Used as a proxy of liquidity. High growth of M1 may indicate excess liquidity which can lead to speculative attacks on the currency thus leading to a currency crisis (Eichengreen et al., 1995).	IFS line 34ZF
M2 Multiplier	A higher M2 multiplier indicates higher growth in money supply which may lead to higher inflationary expectations and expectations of a future devaluation of the currency. The resulting real appreciation of the exchange rate may put a peg under pressure (Bruggemann and Linne, 2002).	M2 (IFS line 35 ZLF)/base money (IFS line 14ZF)

Variable	Rationale	Data Source
Domestic Credit/GDP	Excessive growth of domestic credit may serve as an indicator of the fragility of the banking system as it increases the chances of bank failures due to balance sheet problems and in terms of non-performing loans and currency mismatches (Bruggemann and Linne, 2002).	Domestic Credit(IFS line 32ZF)/GDP(CBRT EDDS)
Deposit Money Banks Net Past Due Loans/Total Loans	Used as a proxy for the quality of the asset portfolio and the credit risk. A high ratio is an indicator of inefficiency of the financial institutions (Rahman et al., 2004).	CBRT EDDS (data available after 1986)
Excess Real M1 Balances	Used as a proxy for excessive monetary expansion (Zhuang and Dowling, 2002).	(IFS line 34/64)/(trend derived using Hodrick-Prescott (HP) filter).
Central Bank Credit to Public Sector/GDP	Rapid growth in credit fueled by excessive monetary expansion makes the economy more vulnerable to crises (Corsetti et al.. 1998; Sachs et al., 1996).	IFS line 12C (data available after 1986)
Domestic Real Interest Rates	Used as proxy of financial liberalization. High real interest rates signal a liquidity crunch and can also increase the probability of loan defaults (Kaminsky et al., 1998; Edison, 2003; Dermirguc-Kunt and Detragiache, 2000).	3-month deposit rate (IFS line 60L)
Commercial Bank Deposits	Used as a proxy of liquidity risk and banking sector fragility. Contractions in commercial bank deposits often reflect distress and problems in the banking sector and increase the chances of a bank run. Also, a weak banking system increases the probability of speculative attack since the investors know that the government will be reluctant to increase interest rates (Chang and Velasco, 2000; Berg and Pattillo, 1999; Edison, 2003).	IFS line 24+ IFS line 25
Bank Reserves/Bank Assets	Adverse macroeconomic shocks are less likely to lead to crises in countries where the banking system is liquid. High ratio indicates banks' soundness (Dermirguc-Kunt and Detragiache, 1997).	(IFS line 20ZF)/(IFS lines 21+22a+22g (data available after 1986)
Foreign Liabilities/Foreign Assets of Banks	Used as a proxy of banking sector fragility measuring exchange rate exposure and the imbalance between foreign currency denominated liabilities and foreign currency denominated assets (Corsetti et al., 1998; Kibritcioglu, 2003).	Foreign Liabilities (IFS line 26C)/Foreign Assets of Banks (IFS line 21ZF)
Commercial Bank Loans to Public Sector	Currency and banking crises have been linked to rapid growth in credit fueled by excessive monetary expansion in many countries (Zhuang and Dowling, 2002).	IFS line 12C (data available after 1986)
Commercial Bank Credit to Private Sector	Used as a proxy for lending boom, which may increase the ratio of bad loans to total assets, thereby weakening the banking system. The rapid increase of the credit to the private sector may also indicate that a large amount of credit is going to dubious projects (Kibritcioglu, 2003).	IFS line 32DZF
Real Sector		
Industrial Production Index	Economies are more vulnerable to crises when economic growth slows down. Lower output growth indicates a deceleration of the economy (Berg and Pattillo, 1999; Hardy and Pazarbsioglu, 1999).	CBRT EDDS**
Stock Market Index	A decline in the asset prices may lead to loan defaults. It also signals a loss of investor confidence. Besides, it indirectly measures contagion (Kaminsky et al., 1998; Berg and Pattillo, 1999; Edison, 2003; Komilainen and Lukkarilla, 2003).	ISE National -100 Index (CBRT EDDS, data available after 1996)
GDP Per Capita	Negative per capita growth is assumed to increase the policymaker's incentives to switch to a more expansionist policy, which can be achieved through a nominal devaluation of the currency (Esquivel and Larrain, 1998).	EDDS*
Consumer Price Index (CPI)	Inflation rate is likely to be associated with high nominal interest rates and may proxy macroeconomic mismanagement which adversely affects the economy and the banking system and may lead to currency instability (Dermirguc-Kunt and Detragiache, 1997; Lanoie and Lemarbre, 1996).	IFS line 64XZF
Fiscal Sector		
Fiscal Balance/GDP	High deficits increase the vulnerability to shocks. They could lead to a worsening in the current account position, which could put pressure on the exchange rate (Dermirguc-Kunt and Detragiache, 2000; Zhuang and Dowling, 2002).	Budget balance (IFS line 80 and the treasury web site)/GDP[1]*
Public Debt/GDP	Higher indebtedness is expected to raise vulnerability to a reversal in capital inflows, and hence to raise the probability of a crisis (Lanoie and Lemarbre, 1996).	WDI *
Government Consumption/GDP	Higher expenditure net of revenues would have positive effect on the likelihood of crisis (Saqib, 2002). Large fiscal deficits could lead to a worsening in the current account position, which could in turn put pressure on the exchange rate (Zhuang and Dowling, 2002).	Government Consumption (IFS line 91F and WDI)/GDP*
Global Economy		
3-month US Real T-Bill Rate	High US interest rates may induce capital outflows (Edison, 2003; Kamin et al., 2001; Milesi-Ferretti and Razin, 1998). The yield on the three-month U.S. treasury bill can be considered a key short-term risk-free rate that usually serves as a benchmark for pricing other high-yield assets in world capital markets, and that would most likely reflect changes in global liquidity and economic conditions (Arora and Cerisola, 2001).	US T-bill rate (IFS 60p)-CPI (IFS line 64x)

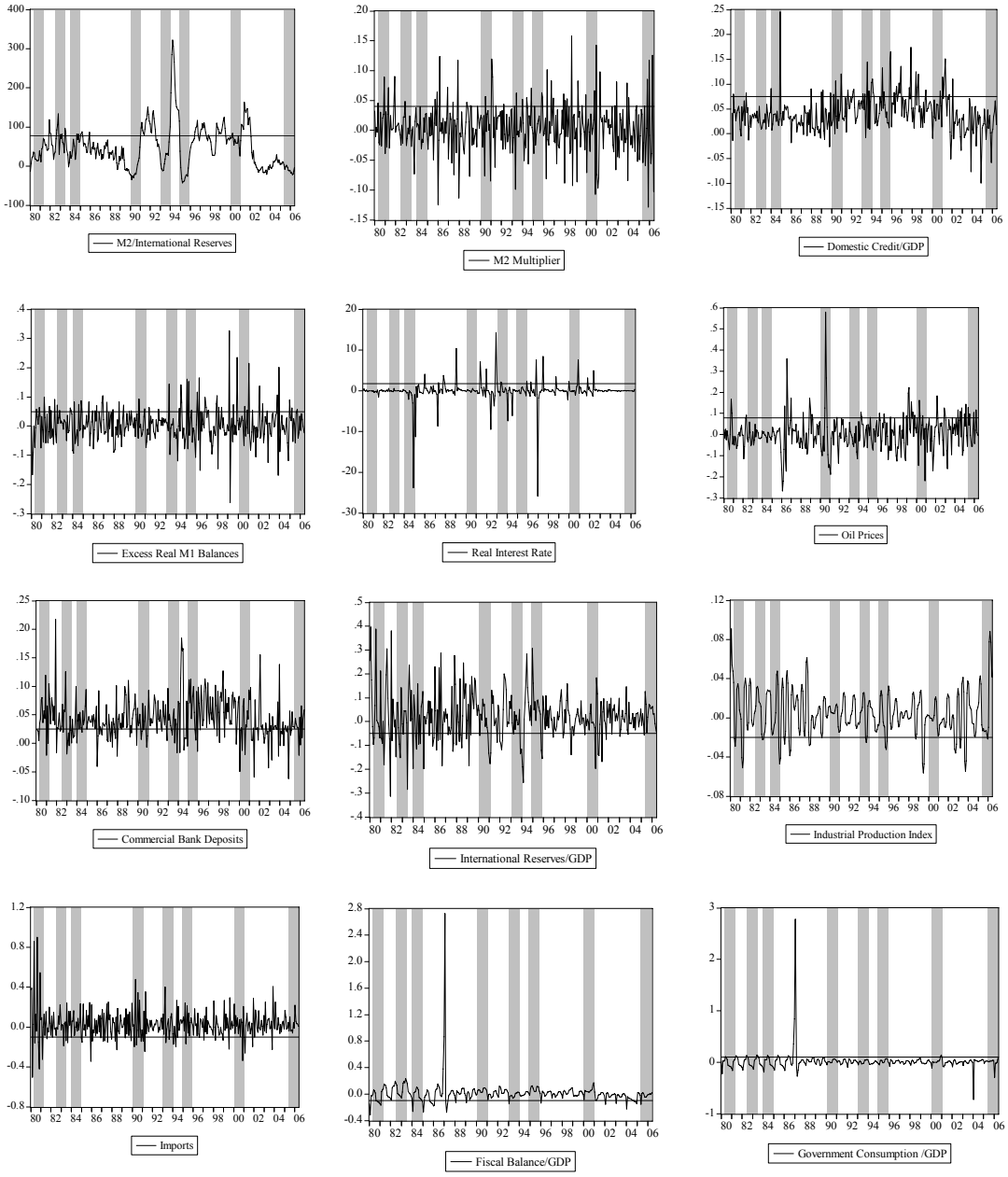
[1] Until 1999 from IFS line 80, after 1999 annual from treasury web site (www.hazine.gov.tr).

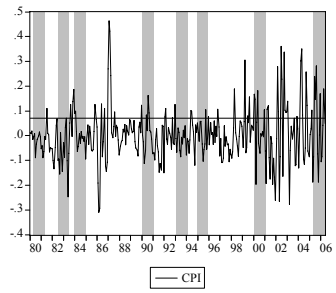
Variable	Rationale	Data Source
US GDP	Higher foreign output growth should strengthen exports and thus reduce the probability of a crisis (Edison, 2003; Kamin et al., 2001).	WDI*
World Oil Prices	High oil prices pose a danger to the current account position, and also could lead to domestic recessions (Edison, 2003).	IFS line 176 (Crude oil prices)[1]
Real Interest Rate Differential	Defined as foreign interest rates (3-month US deposit rate) less domestic interest rate (3-month Turkey deposit rate). The higher the differential, the larger is the probability of an outflow of reserves and may signal devaluation expectations (Komulainen and Lukkarilla, 2003).	IFS line 60L for Turkey – IFS line 60L for USA
Interest Rate Spread (3-month bonds)	In addition to the direct impact of changes in U.S. interest rates on rates in developing countries, interest rate spreads (the differences between yields on sovereign bonds of developing countries and U.S. treasury securities of comparable maturities), which are a proxy for country risk, have tended to move in the same direction as the changes in U.S. interest rates.	FRB Online Database
Contagion Dummy	Currency crises may pass contagiously from one country to another (Eichengreen et al., 1996).The contagion dummy takes the value of one if there has been a major financial crisis during the month and zero if otherwise. Crisis dates were obtained from Kaminsky et al. (2003).	Kaminsky et al. (2003)
USD LIBOR Rate	Used as a proxy for global liquidity conditions (Ades et al., 2000) changes in U.S. interest rates, or likewise in global liquidity conditions, would be expected to influence positively country risk and sovereign spreads in developing countries (Arora and Cerisola, 2001).	ECB Database
Spread between the yield on 3-month US t-bill and the US federal funds rate	Captures heightened uncertainty about the expected stance of U.S. monetary policy (Arora and Cerisola, 2001).	US T-bill rate (IFS 60p) – FRB Online Database
US Federal Funds Rate	Used as a direct measure of U.S. monetary policy. Changes in US monetary policy have been felt by developing countries through effects on the cost and availability of funds (Arora and Cerisola, 2001).	FRB Online Database
Political		
Government Change Dummy	Used as a proxy for political instability. Takes the value of 1 if there is election and 0, if otherwise.	The National Assembly of Turkey web site (www.tbmm.gov.tr)

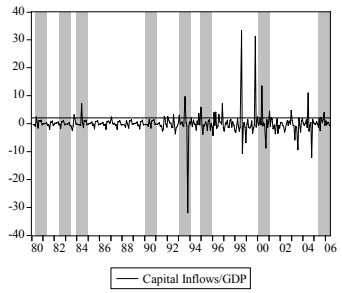
NOTES: GDP used in calculations is obtained from CBRT EDDS is linearly interpolated from annual (until 91) and monthly (after 91).
* linerarly interpolated from annual data;
** liıneraly interpolatd from quarterly data;
[a] (CPI-based real effective exchange rate index calculated using the IMF weights for 19 countries). An increase in the index shows appreciation of the Turlish lira.
Calculated as: (REER-$REER_{t-24}$)/$REER_{t-24}$ (Fratzscher, 2002).
Data Sources Key:
IFS: International Financial Statistics Database of the IMF,
CBRT EDDS: the Central Bank of the Republic of Turkey's Electronic Data Delivery System,
WDI: World Bank's World Development Indicators Database,
ECB: European Central Bank's Statistical Warehouse,
FRB: US Federal Reserve Board Database,
WB GDFS: Global Development Finance Statistics Database.

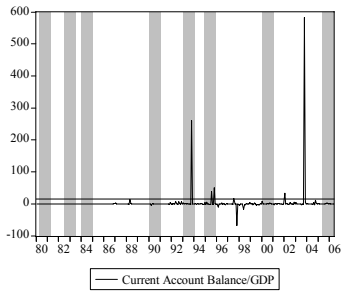
[1] US dollar per barrel (Spot prices).

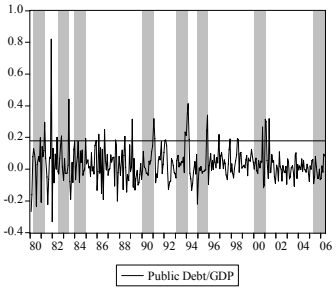
APPENDIX II. GRAPHICAL REPRESENTATION OF EXPLANATORY VARIABLES

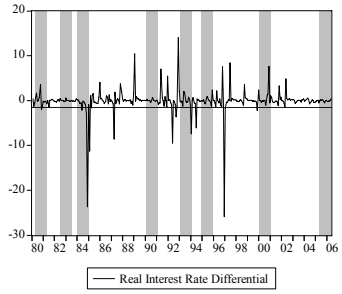


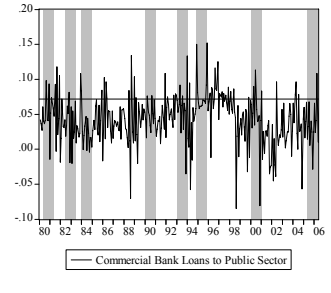

CPI

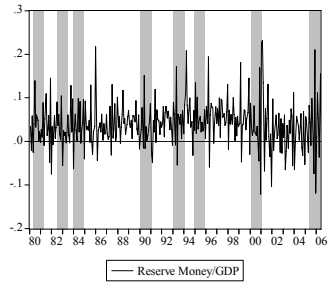

Capital Inflows/GDP

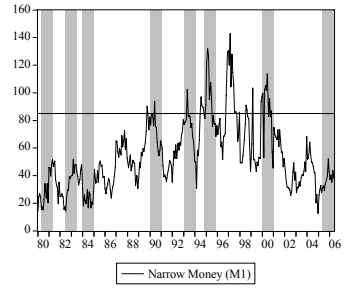

Current Account Balance/GDP

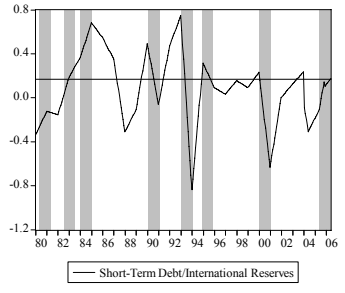

Public Debt/GDP

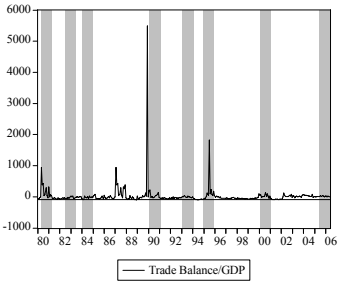

Real Interest Rate Differential

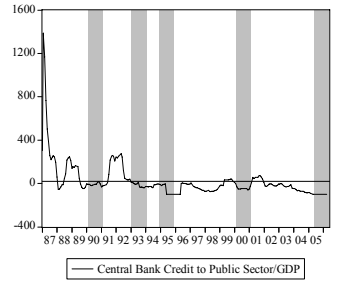

Commercial Bank Loans to Public Sector

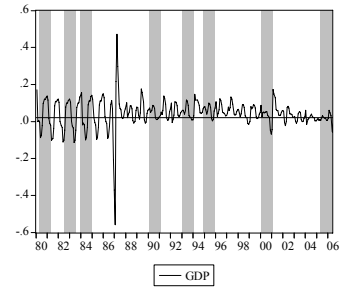

Reserve Money/GDP

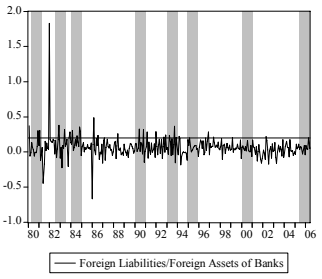

Narrow Money (M1)

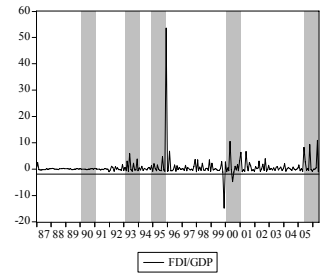

Short-Term Debt/International Reserves

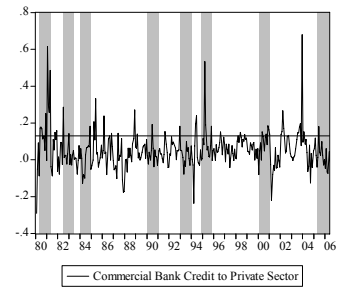

Trade Balance/GDP

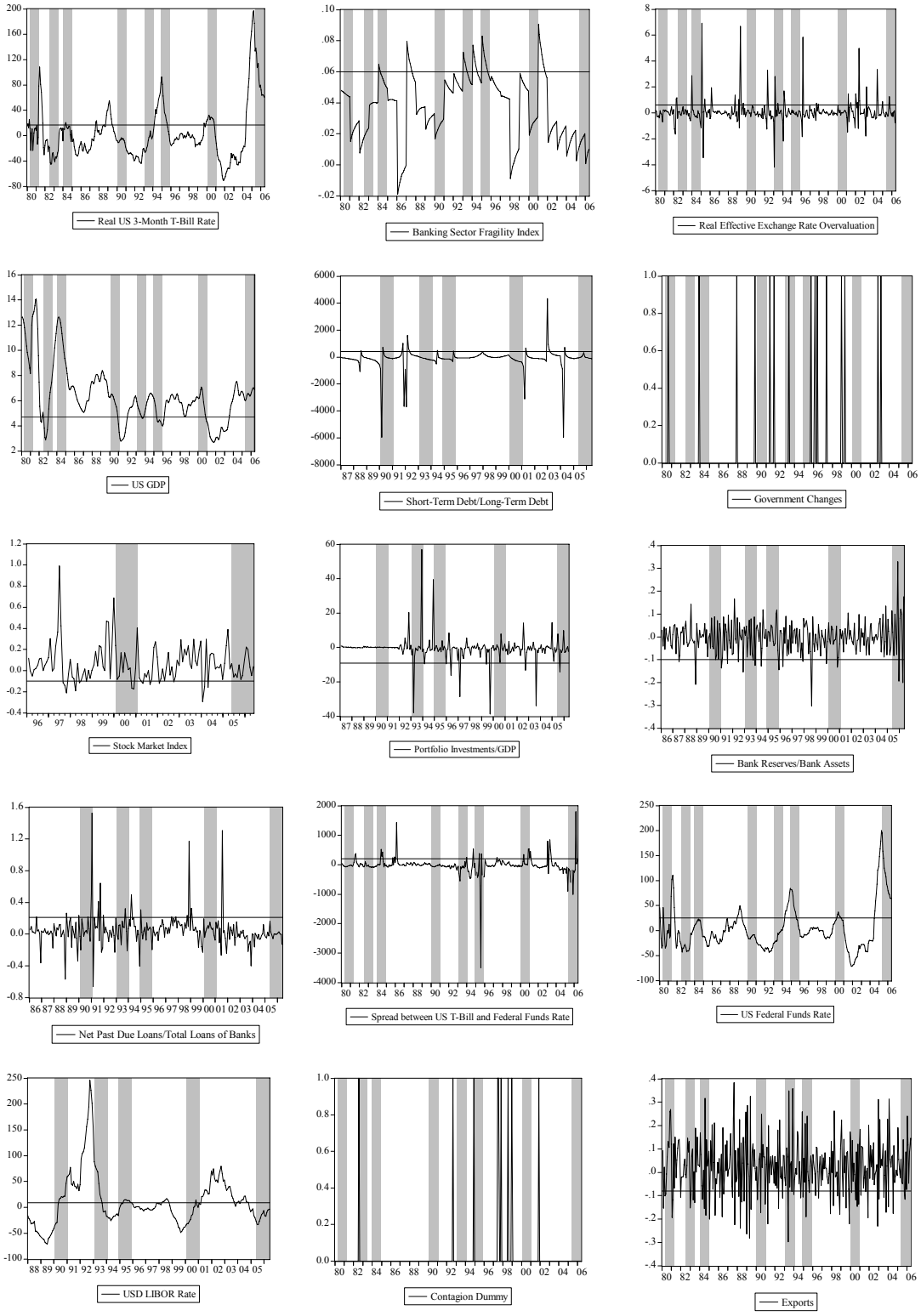

Central Bank Credit to Public Sector/GDP


GDP


Foreign Liabilities/Foreign Assets of Banks


FDI/GDP


Commercial Bank Credit to Private Sector



Note: The shaded areas in the graphs mark the 12-month window before crises. The greater the incidence of the flashing indicators within these windows, the more vulnerable the economy is to a crisis.