An Early Warning Signals Approach to the Currency Crises: The Turkish Case

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Abstract

The global economic and financial instability context of the 1990s and 2000s also affected the Turkish economy. Actually, the 1980s in Turkey are characterized by a radical transformation of its economy through significant efforts of liberalization. With an out-looking economy and a liberalized financial system in the early 1990s, Turkey was an example of successful liberalization process for the other developing countries. However, this "remarkable" liberalization process, which was performed without ex ante correction of persistent macroeconomic imbalances, worsened economic and financial instabilities and caused two severe crises in April 1994 and February 2001. This paper aims to illustrate the essential causes of these crises by developing a binomial and multivariate logit model which estimates the predictive ability of 16 economic and financial indicators in a sample that covers the period January 1990-December 2002. In addition, the paper evaluates the out-of-sample forecast performance of the model in the period January 2003-December 2008 in which two other currency crises occurred in May 2006 and October 2008. The paper finds that the Turkish crises are mainly due to excessive budget deficits, high money supply growths, sharp rises in short-term external debt, growing riskiness of the banking system (in particular currency and liquidity mismatches), and external adverse shocks.

Keywords: Currency crises, Leading vulnerability indicators, Crisis prediction, Turkey.

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I. Introduction

After a relative stability in the post-World War II period, the world economy has again become familiar to financial crises following the collapse of the Bretton Woods system. The first wave of the currency and debt crises that occurred particularly in Latin American countries in early 1980s was first followed by the 1992-1993 European exchange-rate mechanism (ERM) crisis and then by two large-scale crisis episodes: the collapse of the Mexican peso at the end of 1994 and the consecutive financial crises in East Asia that began with the devaluation of Thai baht in July 1997 and induced a chain reaction in many Asian economies. The common characteristic of these two crises is their tendency to spread to other economies (contagion). However, the latter created much more external consequences, affecting the whole global economy, while the former had only a regional impact. The series of crises continued on with the violent devaluation of the Russian rubble in August 1998, the outbreak of the Brazilian currency crisis in early 1999 and the eruption of the Argentinean financial crisis in 2001-2002. This global economic and financial instability context of the 1990s 2000s affected the Turkish economy as well which suffered from two severe crisis episodes in April 1994 and February 2001, and two relatively less severe currency crises in May 2006 and October 2008. These striking and recurrent crisis episodes stimulated a large discussion on the theoretical specification of the crisis models on the one hand, and on the empirical analyses that aim at identifying the causes and origins of the crises on the other hand. This paper thus intends to sum up these theoretical and empirical developments and also to construct an early warning system (EWS) through a logit model which illustrates the main causes of these Turkish crisis episodes.

This paper is organized as follows. Section II clarifies the stylized facts of the Turkish crises. Section III summarizes the theoretical and empirical literature on currency crises. Section IV implements the development of the EWS (construction of crisis index, description of the explanatory variables of the econometric model). Section V presents the estimation results and asses the model’s predictive ability both in-sample and out-of-sample and Section VI concludes and discusses some policy implications to prevent future crisis in the Turkish economy.

II. Brief history of the Turkish economy (1980-2008)

Following the inability of the existing economic and political system in resolving the severe currency and debt crisis of 1978-1980, Turkey reoriented its development strategy, based on import substitution on the real side and on negative real interest rates on the financial side, by adopting a radical structural adjustment program in January 1980. This program which aimed to implement a market-based mode of regulation was largely supported by international organizations (the IMF and the World Bank). With the implementation of this liberalization process, the political and monetary authorities intended to restore economic growth and stability by improving economic and financial efficiency, increasing domestic savings and attracting foreign capitals.

The early phase of the program (1980-1984) was mostly characterized by the trade liberalization process consisted in export promotion and gradual import liberalization, accompanied by the regulated capital movements and regular depreciation of Turkish lira (Boratav and Yeldan, 2002). While the second phase of the program (1985-1989) was characterized by the process of the domestic and external financial liberalization, consisting of the abolition of interest rate controls, the liberalization of the exchange rate regime allowing residents (banks as well as households) to make transactions in foreign currency, the creation of the interbank money market and of the Capital Market Board and the liberalization of the capital movements. This large structural reform program obtained an initial success by reducing the triple-digit inflation rates to 30-40%, increasing the export earnings and ensuring an economic growth of around 5% of GDP per year. With an out-looking economy and a liberalized financial system in the early 1990s, the Turkish liberalization process was presented by the IMF and the World Bank as an example of “success story” to other developing countries. However, this "remarkable" transformation from inward-oriented economy to the outward-oriented one, which was performed without ex ante correction of persistent macroeconomic imbalances, worsened the economic and financial weaknesses by exposing the domestic economy to short-term volatile capital movements, and then caused two deep financial crises occurred in April 1994 and February 2001 with severe economic and social consequences.

What are the determinants of these financial crises? Do they present common characteristics or do they have different origins? After a relative improvement of government's budget balances in the 1980-1987 period, public sector deficits and domestic prices started to rise again. The widening of the public sector deficits largely resulted from expansionist fiscal policies of the government, large subsidies granted to exporting firms, inefficient and archaic fiscal structure and populist economic policies of successive governments. Hence the public sector borrowing requirement (PSBR) and public debt followed a steady rising trend parallel to the widening of public deficits. This context drove to an increase of domestic interest rates and of the inflation rate in the late 1980s. The rise of inflation and the gradual depreciation of the Turkish lira that were combined with the capital account liberalization led to a large dollarization of the Turkish economy in the early 1990s.

The initial success of the stabilization program was indeed reached in part through a drastic reduction of the real wages which was facilitated in the context of repressive military regime (1980-1983). Following the return of the parliamentary democracy in 1987, the different coalition governments implemented large increases in real labor incomes that degraded public fiscal balances and reduced international trade competitiveness that engendered large trade and current account deficits. The international political context of the Gulf War in 1991 and consequently raising oil prices also played an important role in the deterioration of the current account balance (around 5% of GDP in 1993 before the onset of the 1994 crisis).

These fiscal and current account deficits led to a huge stock of public debt (65 billion of USD) largely compensated by the domestic financial institutions that preferred to invest in Treasury funds instead of granting credits to private sector (crowding-out effect). In this context, domestic banks got into debt in foreign currency with the international financial markets in order to invest in the public sector securities in domestic currency. This generated a strong growth of the domestic banks short positions. On the other hand, short-term foreign debt of the Turkish economy reached to 18.5 billion USD, while its international reserves stock was attaining only 7 billion USD in 1993.

In order to reduce this high public debt stock and to extend its maturity, the government imposed long-termed and low-rated government securities to domestic investors, whereas it started to monetize public deficits in the second half of 1993. This policy change led to an excessive domestic credit growth of 95% that contributed to an increase of domestic inflation rate and thus a rise in foreign money demand to the Central Bank. The successive speculative attacks against Turkish lira that began in the end of January 1994 followed by the degradation of Turkey's credit rating accelerated capital outflows. The domestic interest rates skyrocketed (from 70-80% in December 1993 to 700% in March 1994). The Government's interventions in the exchange market by selling its international reserves stocks could not avoid large currency depreciation of about 100%. This currency crisis then spread out to the banking system which was largely exposed to currency and maturity risks (the banking sector foreign liabilities had reached to 43% of its total liabilities in the late 1993). The Savings Deposit Insurance Fund (SDIF) took control over three small-scale banks (Marmarabank, TYT Bank and Impexbank). Following this banking liquidity crisis, banks (in particular foreign capital banks) limited domestic credit allocation or lent in foreign currency. This lending policy just transferred currency risk on their borrowers and also worsened economic contraction (-6% of GDP in 1994).

In order to prevent a possible systemic crisis, monetary authorities signed a stand-by agreement with the IMF on 5th April 1994. This stabilization program aimed to limit fiscal deficits by increasing tax revenues and reducing government expenditures. Besides, the Central Bank announced total deposit insurance so as to restore depositors' confidence in the Turkish banking sector. However, even if this policy measure restored depositors' confidence in the short-term, it was at the origin of the failure and the transfer of eight commercial and investment banks to the SDIF in the 1998-1999 period. Furthermore, the implementation of drastic policy measures of the stabilization program restored a certain economic and financial stability in the short-run, but mid-term structural adjustment measures of the program such as reforms of the social security and fiscal systems and privatization of state owned enterprises (SOS) were not achieved. Thus, chronic imbalances of the Turkish economy were not corrected. The occurrence of the 1997-1998 Asian crisis and particularly of the 1998 Russian crisis affected the Turkish economy that recorded a slowing-down and capital outflows of 10 billion USD in the late 1998. The August 1999 earthquake eliminated the Turkish monetary authorities' last hopes of economic recovery. In the end of 1999, Turkish economy was characterized by chronic high inflation, contraction of economic activity, large public debt (over 70% of GDP), high public sector borrowing requirement (about 16% of GDP), inefficient and fragile banking system, and domestic and foreign investors' generalized defiance into the Turkish economy and financial institutions. This instability context led Turkish authorities to sign another stand-by agreement with the IMF.

Turkey thus entered the new millennium with an exchange-rate-based stabilization program which was supported by the IMF stand-by credits. The country undertook to decrease the inflation rate to 25% in 2000 then to 12% in 2001. The program was also accompanied by a restrictive budgetary and monetary policy which enabled the Central Bank to increase the domestic liquidity only with capital inflows (that gave the program a currency board character).

The program found a positive echo among economic agents: the capital inflows accelerated (15.2 billion USD in 2000), the interest rates strongly decreased (from more than 80% to about 40%), and the consumption sharply increased in particular with low-cost bank credits. However, this sharp increase of domestic consumption mainly met by importations slowed down the inflation fall and led to an overvaluation of the Turkish lira (about 15%) compared to the pre-announced parity of the fixed exchange rate. This deteriorated in turn the trade balance (deficit of 27 billion USD at the end of 2000) and the current account balance (deficit of 9.8 billion USD, 4.9% of the GDP). Besides, the rise of the short-term debt associated to the failure in achieving the privatization goals increased the tensions in the Turkish money market and created doubts on the sustainability of the program. The international investors became then increasingly reluctant in renewing their credit lines, which increased the domestic interest rates and their volatility. Furthermore, the strong exposure of the banking system to currency and interest rate mismatches, and to credit and default risks enhanced these doubts. At the end of October 2000, the SDIF took control over two small scale banks (Etibank, Bank Kapital).

Besides, domestic banks started to cover their short currency positions in order to strike their balance sheets at the end of the year. This accelerated the demand for liquidity and increased more the interest rates, and then weakened more the illiquid banks that began distress sales of their Treasury bonds. In the end of November, the leading banks suspended their credit lines to the interbank market. The interest rates skyrocketed (overnight rate about 4000%) and the foreign investors started to leave the country. This was the beginning of the banking system liquidity crisis. In order to protect the banking sector and to limit the rise of the interest rates, the Central Bank suspended its currency board commitment and bailed out the illiquid banks. However, the investors were reassured only on December 6th, with the 7.5 billion USD IMF Supplemental Reserve Facility.[2] On the same day, Demirbank, the sixth largest bank of the Turkish banking system, was transferred to the SDIF.

Nevertheless, the strong deterioration of the financial structure of the public banks and the SDIF banks and their massive requirements for short-term credits increased again the interest rates that led investors to question the sustainability of the fixed exchange system. Actually, it was the rumors of political instability that triggered the second shock. The country underwent a strong speculative attack against its currency and was forced to let the currency float. The currency crisis worsened in turn the banking liquidity crisis. Here is an example of so-called twin crises a la Kaminsky and Reinhart (1999).

The analysis of the 2000-2001 Turkish financial crisis mainly confirms the new crisis approaches by referring on the one hand to animal spirits and on the other hand to the banking system fragility. Whereas the macroeconomic fundamentals of the country did not justify a crisis of such scale, the financial crisis broke out on February 19th 2001 with the argument between the Prime Minister and the President of the Republic which was perceived by financial markets as a signal of political instability. The days following this scene were crucial in the country's crisis management. Turkey defended the fixed exchange rate parity by mobilizing its reserve stocks (5 billion USD in three days) and increasing the overnight interest rates to 8000%. However, following the investors' generalized distrust, the monetary authorities were forced to let the currency float, on February 22nd, 2001. In only one day, the Turkish lira depreciated of more than 35% against the US dollar.[3]

The real economy was also affected by this severe financial crisis in spite of the implementation of the new economic stabilization program announced on 14th April 2001 by the new Minister of Economy, Kemal Dervis, ex Vice-president of the World Bank. The main purpose of this program, backed by the 19 billion USD IMF stand-by credits, was to restore economic stability and restructure the financial system which cost over 50

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[2] IMF's Supplemental Reserve Facility is a sort of short-term credit granted to the countries which suffer balance of payments problems and/or currency crises.
[3] See Ari and Dagtekin (2008) and Uygur (2001) for an amplified study on the stylized facts of the 2000-2001 Turkish financial crisis.

billion USD to the Turkish economy. Despite the high decline of economic activity (around 8% of GDP) in 2001, the implementation of many structural reforms provided a rapid economic recovery from 2002 onwards. Although, even the Turkish economy seems now more stable, it still remains vulnerable to external shocks as the May 2006 and October 2008 currency crises confirmed. Actually, the last global financial crisis of late 2008 has heavily affected Turkey: the Turkish lira has depreciated of more than 25% against the US dollar and the 2009 economic perspectives have now turned to negative with expectations of economic recession (more than 4% of GDP) and rising unemployment. Note that the actual risks of the Turkish economy may be summarized to the current account deficit which is more than 7% of GDP and to the private sector foreign debt stock that is superior to 150 billion USD.

III. The review of the theoretical and empirical crisis literature

The recurrent crisis episodes since the collapse of the Bretton Woods system led to a flourishing crisis literature. Following the first wave of currency crises, in particular those that came out in Latin America in the late 1970s and the early 1980s, Krugman (1979) and Flood and Garber (1984) developed the so-called first generation crisis models[4] in which currency crises are linked to persistent economic imbalances (large and growing fiscal deficits and/or gradual domestic credit growth) that are in conflict with a fixed exchange rate regime. Actually, the monetization of the persistent fiscal deficits in the fixed exchange rate regime leads to domestic credit growth and in parallel to gradual loss of foreign exchange reserves of the government. When the reserves stock reaches a critical threshold, investors perfectly know that the domestic exchange rate is no longer sustainable. Investors attack then the domestic currency in order to avoid capital losses due to a possible devaluation. Here, the investors' "rational" reaction triggers the currency crisis; however, the crisis would break out even in the absence of a speculative attack when the government foreign exchange reserves are "naturally" exhausted.

The outbreak of the 1992-1993 ERM crisis led to the development of the new crisis models, in particular by Obstfeld (1994, 1996, 1997). In these so-called second generation models, a crisis can be triggered without ex ante significant deterioration of

[4] For a detailed analysis of the generation of currency crises, see Eichengreen et al. (1994 and 1995), and Flood and Marion (1998).

macroeconomic fundamentals in contrary to first generation crisis models. Therefore, even if economic policies are consistent with the fixed exchange regime, a speculative attack may occur while investors shift their expectations towards the sustainability of the exchange rate. Unlike the first generation models where policymakers are supposed to have a mechanical and simplified behavior against a speculative attack (selling international reserves and then floating the peg when the reserves stock is exhausted); in the second generation models policymakers are supposed to have an optimizing behavior by adapting their policy to the shift of the investors' anticipations. That means when policymakers face a speculative attack, they decide to maintain or to abandon the peg after comparing the costs of such policy decision. This may be defined as the government loss function. Indeed, here economic policies are not predetermined as in the first generation models, but they are adapted to the problems of the economy and to the investors' expectations about the macroeconomic fundamentals observed in period t, but also about the sustainability of the government policies in $t+1$. This interaction between the government and investors creates multiple equilibria that may lead to the occurrence of self-fulfilling currency crises. In these models the exact timing of the crisis is unpredictable in contrary to the first generation models. However, one may show whether a country is vulnerable to a crisis according to the fragility of some macroeconomic fundamentals. When a country enters to the "crisis zone" (Jeanne, 1997), a shift in investors' expectations – generally triggered by sunspot dynamics – may bring a crisis.

The outbreak of the 1997 Asian crisis led to a reorientation of the crisis models. Indeed, Asian crisis countries did not have large budget deficits and economic policies were not expansionary; thus there were no Krugman-type policy inconsistency problems that led to a gradual loss of reserves. On the other hand, unemployment and inflation rates were relatively low and the average economic growth was around 7% in the 1993-1996 period; thus, there were no Obstfeld-type trade-off problems that force the government to devalue or to maintain the peg. These assumptions were in fact mainly confirmed by low interest rate spreads or high credit ratings of Asian economies to the approach of the crisis. This shows clearly that the Asian crisis was not expected and the dominant crisis theories failed to understand these consecutive crisis episodes that began with the Thai baht devaluation. Several theoretical studies were then conducted in order to explain the characteristics of these violent and contagious crisis episodes that resulted largely from the banking sector weaknesses in a financially liberalized economy. In this sense, some modelers put forward the structural distortions such as implicit or explicit public guarantees and inadequate banking regulation system in the worsening of the financial vulnerability (Krugman, 1998 and Corsetti, Pesenti and Roubini, 1999). Others focus on the self-fulfilling nature of the Asian crisis by modeling the dynamics of the financial instability based on the Diamond and Dybvig (1983) bank runs model (Chang and Velasco, 1998, 2001). Some others formalize a financial fragility, due to an increase of short-term foreign debt, which may contribute to the occurrence of a financial crisis. The depreciation of the domestic currency deteriorates then the balance sheets of the firms whose bankruptcies lead to economic contraction (Krugman, 1999 and Aghion, Bacchetta and Banerjee, 2000). Finally, some make efforts to combine these different approaches (Irwin and Vines, 1999, 2003, Schneider and Tornell, 2000, Burnside, Eichenbaum and Rebelo, 2004).

The very high costs of crises in terms of economic contraction, unemployment, and necessary financial restructuration process for the public sector (and also for the private investors in terms of capital losses) have led to a proliferation of empirical studies (developed mainly by scholars, international financial institutions, central banks and investment banks) beside the theoretical models that have tended to explain crisis mechanism. These empirical models have aimed to predict crises by assessing their potential economic and financial determinants, and also in some cases by measuring political risks and developments in global economy. These studies have been also used by policymakers to prevent future crises by detecting their causes earlier. In this sense, they have been frequently called ‘early warning systems’ that are likely to inform policymakers (and investors as well) about the occurrence of a crisis in a near future.

Two main approaches have been adopted for constructing EWSs; signals approach initiated by Kaminsky, Lizondo and Reinhart (1998) and the logit/probit approach initiated by Eichengreen et al. (1994, 1996) and by Frankel and Rose (1996).[5] Regardless of the method adopted, the empirical models construct first a crisis index as the dependent variable in order to identify crisis episodes. Some modelers describe currency crises as large depreciation or devaluation episodes (Frankel and Rose, 1996 and Kumar, Moorthy

[5] Note that others methods have been also used for developing early warning systems. Here, we do not analyze them but just state some of them for information: OLS approach of Sachs, Tornell and Velasco (1996) and of Bussière and Mulder (1999a, 1999b), artificial neural network of Nag and Mitra (1999), Fisher discriminant analysis of Burkart and Coudert (2000) and Markov-switching approach of Abiad (1999, 2003). One may find them in a detailed version in Abiad (1999, 2003) that realize a rough survey of recent empirical literature on currency crises.

and Perraudin, 2003 inter alia), while some others consider currency crises as instances where a currency come under severe speculative pressure (Eichengreen et al., 1994, 1995, 1996 and Kaminsky et al., 1998 inter alia). This second currency crisis definition takes into account both the situations where speculative attacks lead to currency devaluation and where the authorities successfully defend the currency by intervening in the foreign exchange market and/or rising domestic interest rates. The authors that adopt the second definition construct then an index of speculative pressure or exchange market pressure ISP as a weighted average of (real or nominal) exchange rate changes s, international reserves changes r and interest rates movements i.

(1) $$ISP_t = \Delta s_t$$

(2) $$ISP_t = \frac{1}{\sigma_s}\Delta s_t - \frac{1}{\sigma_r}\Delta r_t + \frac{1}{\sigma_i}\Delta i_t$$

The weights of the components of the crisis index are often chosen so as to equalize their volatility and thus avoid the possibility of one of the components dominating the index (Aziz, Caramazza and Salgado, 2000). Note that specifically the weights are frequently the inverse of the standard deviation σ of the corresponding component. The "successful" attack approach may be criticized for its limited crisis definition given that every speculative attack has a social cost for the government (reserves losses or interest rate rises) while the speculative pressure approach is mostly criticized because of that arbitrary weighting procedure of the components. However, as noted in many papers (Eichengreen et al., 1995 and Lestano and Jacobs, 2007), using different weights for the components do not have much effect on the crisis index.

Once components of the crisis index and their weights are determined, one specifies an arbitrary threshold. When the crisis index exceeds this threshold level, a monthly or annual observation is classified as crisis. The crisis index becomes then a binary crisis variable C_t which takes a value of 1 if a crisis occurs and of 0 otherwise.

(3) $$C_t = \begin{cases} 1 \text{ if } ISP_t > \phi\sigma_{ISP} + \mu_{ISP} \\ 0 \text{ otherwise} \end{cases}$$

The threshold level is generally set to a multiple ϕ of the standard deviation of the index σ_{ISP} plus the mean of the index μ_{ISP}. Values of the thresholds used in the literature have been ranged from $1.5\times\sigma$ to $3\times\sigma$ above the mean of the index. However, different choices of thresholds may generate identification of the different crisis dates as some studies obviously showed it (Kamin, Schindler and Samuel, 2001 and Lestano and Jacobs, 2007). Note also that crisis dates may be different from one study to another according to the index components (whether interest rates and/or reserves are included into the index), and to the nominal or real character of the index components. This is why empirical studies should use different crisis definitions and different values of thresholds, as I do in this paper, in order to asses the robustness of their crisis dating schemes.

After defining crisis dating mechanism, the next step of constructing an EWS consists in selecting the adequate methodology. The non parametric signaling approach aims to monitor whether some key variables tend to behave unusually prior the onset of a crisis. They firstly build a crisis index and secondly transform the early warning indicators of the model into binary signals by defining an "optimal" threshold for each indicator. Therefore, when an indicator X_t^j crosses beyond a given threshold level $\bar{X}_t^j$, it issues a warning signal that a possible currency crisis may come out within a specified period (called signaling horizon) of usually 12-24 months. An indicator X_t^j becomes then a signal S_t^j which defines the condition of the transition from a non-crisis state (0) to a crisis state (1) in the following manner:

(4)
$$S_t^j = \begin{cases} 1 \text{ if } \left|X_t^j\right| > \left|\bar{X}_t^j\right| \\ 0 \text{ if } \left|X_t^j\right| \le \left|\bar{X}_t^j\right| \end{cases}$$

A signal S_t^j is called a "good signal" if a crisis occurs within the signaling horizon and a "false signal" or "noise" otherwise. A perfect indicator should provide only good signals: A and $D > 0$ and B and $C = 0$, but it is not the case in practice. So, Kaminsky et al. (1998) choose a threshold in order to minimize the noise-to-signal ratio, i.e. the ratio of false signals to good signals $(B/B+D)/(A/A+C)$. This synthetic measure also allows evaluating the performance of each indicator: indicators with noise-to-signal ratios below (above) unity are considered significant (insignificant) and the insignificant indicators are discarded outright.

Table 1. The performance of an indicator

	Crisis within 24 months	No crisis within 24 months
Signal issued	*A*	*B*
No signal issued	*C*	*D*

Here, A represents the number of months in which an indicator issued a good signal, B represents the number of months in which an indicator signaled a crisis where there was no crisis in reality, C is the number of months in which an indicator failed to signal a crisis which actually occurred and D is the number of months in which an indicator did not correctly issue any signal.

Kaminsky (1999) puts forward the analysis by constructing leading composite indicators as a weighted sum of the signaling indicators, where each indicator is weighted by the inverse of its noise-to-signal ratio. These composite indicators provide some information on the vulnerability of an economy to an upcoming crisis. However, as Edison (2003) states, the interpretation of the conditional probability of a future crisis based on the values of the composite indicators remains difficult.[6] Besides, contrary to logit/probit non linear regressions, the signaling approach does not let itself to statistical tests and the estimated probabilities are less directly derived. Moreover, on looses some information when threshold levels are set for the indicators; for instance, an indicator does not give any signal even though it derives unusually from its trend, because it is just below the threshold, also once an indicator crosses the threshold, one cannot observe how deteriorated the indicator is. However, this approach presents an important advantage of giving policymakers an easily interpretable picture of problems of the economy by showing clearly which indicators exceed the calculated threshold level.

The discrete-dependent-variable approach (or non linear regressions) evaluates directly the conditional probability of a crisis given a set of early warning indicators (that are not transformed into binary signals and are included into the econometric analysis in linear

[6] Berg and Pattillo (1998, 1999) embed the univariate signaling approach in a multivariate probit framework. They find that their model does have a better predictive performance in the anticipation of the 1997 Asian crisis compared to the initial signaling approach.

way) contrary to the signaling approach which aims to observe the unusual behavior of the individual indicators (transformed to binary signals) before the onset of a crisis and to evaluate ability of each indicator in forecasting crisis episodes.

The method firstly requires construction of a crisis dummy variable ISP_t that serves as the endogenous binary crisis variable C_t which takes a value of 1 if a crisis occurs and 0 otherwise. One may define the crisis dummy variable as a large depreciation of the domestic currency as in the equation (1) or a large speculative pressure on currency as in the equation (2). A period is called a crisis episode when this crisis index exceeds a specific threshold level as described above in the equation (3).

The estimated model takes then the following form:

(5) $$\text{Prob}\left(C_t \middle| X_{t-k}\beta\right) = F\left(X_{t-k}\beta\right)$$

where the probability of a crisis $C_t = 1$ is estimated one or k-step before the occurrence of a crisis, conditional on a given set of lagged explanatory variables X_{t-k}. β is the vector of parameters or coefficients of the variables and F is a cumulative distribution function. If the cumulative distribution function is logistic or normal, we have the logit or probit model where the probability of a crisis is calculated in the following manners. These two below equations do have very similar estimation results so the preference of one to other is up to the modeler.[7]

(6) $$\text{Prob}\left(C_t = 1 \middle| X_{t-k}\beta\right) = F\left(X_{t-k}\beta\right) = \frac{\exp\left(X_{t-k}\beta\right)}{1+\exp\left(X_{t-k}\beta\right)}$$

(7) $$\text{Prob}\left(C_t = 1 \middle| X_{t-k}\beta\right) = \Phi F\left(X_{t-k}\beta\right) = \int_{-\infty}^{X_t} \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{1}{2} X_{t-k}^2\right) dX_{t-k}$$

This approach has the advantage of summarizing the information about the crisis probability in one easily interpretable number (0 in case of non crisis and 1 in case of the

[7] Here, I present a summary of the logit/probit models. For more details about discrete-choice models, see Maddala (1983), Davidson and MacKinnon (1999), Wooldridge (2002), Green (2003), Gujarati (2004).

crisis). In addition, it considers all the early warning indicators simultaneously in a multivariate framework, observes marginal contribution of an each indicator and thus allows discarding the insignificant ones from the analysis. Furthermore, this approach lends itself to standard statistical tests that measure robustness of the estimation results. However, in this approach the interpretation of the estimated coefficients of the indicators remains difficult because of the non linear nature of the model. Also, unlike the signaling approach, it is unable to rank indicators according to their ability of forecasting accuracy.

The third step in the construction of an EWS consists in selecting a set of potential crisis determinants. In that sense, one surveys both the theoretical crisis literature and the former empirical studies that put forward some potential key crisis factors.[8] Regardless of the methodology adopted and/or countries and period of the sample selected, some indicators generally emerge as informative and significant in predicting crisis episodes: overvaluations of the domestic currency, high ratios of M2 to foreign exchange reserves, domestic credit growths, high ratios of short-term debt to foreign exchange reserves, and also outbreak of a crisis in another country (contagion). This shows the fact that –as stated in Arias 2003– in order to explain crisis episodes, particularly those that came out in the late 1990s, one needs to combine the determinants underlined in the so-called first, second and third generation crisis models.

However, note that some indicators that are significant in some studies are not in others. This may result from the different sample countries, the different sample periods or the different adopted methodologies. Since the developing and industrialized countries present different structural economic characteristics, the origin of the crises may shift from one group to other. Thus, some indicators like current account deficits that explain well the emerging market crises may not be informative in the industrialized country crises. Moreover, as shown in Cartapanis, Dropsy and Mametz (1998), the significance of the indicators may change according to the regional differences. For instance, while a high ratio of the domestic credit to GDP is a good indicator in explaining the crises of the Latin American countries, it does not play a crucial role in the occurrence of the Asian crises.

[8] Note actually that the empirical studies adapt their crisis indicators to the developing theoretical crisis literature. While the early papers (Blanco and Garber, 1986) focused on the public deficits, increase in domestic credit as crisis indicators, the recent studies (Abiad, 2003, Mulder, Perrelli and Rocha, 2002, 2007 and Ari and Dagtekin, 2007, 2008) took into account the impact of the debt variables and/or of financial or corporate sector fragility indicators in predicting crisis episodes.

Furthermore, as noted in Abiad (2003), the crisis determinants may change even in the outbreak of the crises occurred in a specific region. Abiad underlines that only the overvaluation of the domestic currency is a common and significant indicator in the occurrence of the crises in five Asian countries (Indonesia, Malaysia, Philippines, South Korea and Thailand). This is why I adopt in that paper one-country-approach limiting the empirical analysis to the Turkish crises occurred in April 1994 and February 2001. Here, I also limit the sample period from January 1990 to December 2002, because Turkey undertook important liberalization efforts during the 1980s that radically transformed its economy. In this case, a selected sample that covers pre- and post-liberalization periods could bias estimation results given the changing volatility of the variables.

There is another factor of limiting this empirical study to the Turkish crises that is the limited in-sample and in particular out-of-sample forecast performance of the empirical papers that adopt multiple-country-approach as stated in Berg and Pattillo (1998) and Berg, Borensztein and Pattillo (2004). Of course, the predictions of those empirical models are significantly better than random guesses even in predicting the out-of-sample crises, but they generate a substantial number of false alarms and many missed crises. Actually, the forecast performance of an EWS model is measured by its ability to predict correctly and sufficiently in advance actual crisis episodes in-sample and also out-of-sample.[9] In order to evaluate the performance of EWS models, one compares the predicted probability of a crisis typically produced by the EWS model with the actual crisis probability. However, the latter is not directly observable; one needs then to compare the predicted probability with the actual occurrence of crises. As the predicted probability is a continuous variable, a necessary step consists in specifying a probability level (the cut-off threshold) above which the predicted probability sends an alarm signal, implying that the model expects an upcoming crisis at some point along the forecasting horizon (Bussière and Fratzscher, 2002, Berg et al., 2004).

What is then the “optimal” threshold level? Choosing a lower threshold value would raise the number of correctly predicted crises, but at the expense of increasing the number of

[9] Indeed, a good EWS model should generate successful in-sample and out-of-sample predictions. In this sense, the modeler chooses an estimation sample in which the model is estimated in order to predict occurrence of the crises and to detect which variables help to explain their occurrence. The model is then re-estimated in another sample period which does not belong to the initial sample. Alternatively, some modelers prefer to divide their initial sample period in sub-samples in which they re-estimate the model after testing its forecast performance in the whole sample period.

false alarms (Type II errors). By contrast, choosing a higher threshold value would reduce the number of false alarms, but at the expense of increasing the number of missed crises (Type I errors). The modeler solves here this trade-off problem by defining a threshold probability according to the relative importance given to Type I errors versus Type II errors. As stated in Chui (2002), the modeler may naturally choose a cut-off threshold of 50%. However, as underlined in Esquivel and Larrain (1998), the sample is relatively unbalanced in favor of non crisis periods to crisis periods. Thus, choosing a threshold of 50% would underestimate the predictive power of the EWS model. This is why many empirical studies have also used the thresholds of 25% and of 20% in order to evaluate the forecasting performance of their models. Moreover, as noted in Bussière and Fratzscher (2002), Type II errors might be less important for policymakers whose main interest is in preventing crises. Thus, the policymakers would certainly find less costly to implement preemptive measures while the predicted crisis does not occur, than not to implement such defense measures while a non predicted crisis arises which possibly could have been prevented or the effect of which could have been lowered by these preemptive policies. This is why the policymakers could tolerate more false alarms and might prefer a lower threshold value, contrary to the private investors whose aim is in predicting the next crisis of a particular country more accurately, so they might choose a higher cut-off value.

Table 2. The trade-off problem

	Crisis within the forecasting horizon (1 to 24 months), $C_t = 1$	No crisis within the forecasting horizon (1 to 24 months), $C_t = 0$
Signal issued, $S_t = 1$	A	B (Type II error)
No signal issued, $S_t = 0$	C (Type I error)	D

The private investors and the policymakers also differentiate one from the other for their preference of the forecasting horizon length. Since the policymakers are interested in preventing of crises, they favor a relatively long prediction window (from 12 to 24 months) that may give sufficient time to the authorities for taking some preventive measures. Meanwhile, the private investors prefer a shorter horizon (from 1 to 3 months) in order to adjust their portfolios to the foreign exchange risks.

IV. The model

IV.1. Methodology and the crisis index

I consider that the logit/probit approach seems more adapted for the construction of an EWS model since it evaluates directly the conditional probability of a crisis given a set of early warning indicators and also lends itself to standard statistical tests that evaluate robustness of the estimation results. The estimated logit model takes then the following form:

$$\text{Prob}\left(C_t \middle| X_{t-1}\beta\right) = F\left(X_{t-1}\beta\right) \qquad (8)$$

where the crisis probability $C_t = 1$ is estimated one month before the occurrence of a crisis, conditional on a set of 16 one-month lagged explanatory variables X_{t-1}. F corresponds here to the logistic cumulative distribution function where the probability of a crisis is calculated according to the equation (6). In the framework of a logit model, the right-hand side is constrained to 0 or 1 and is then compared to the observed value of the binary crisis variable C_t.

Since the crisis is a discrete event, I construct a latent crisis variable which takes the form of an index of speculative pressure $ISP1$. This crisis index which is naturally dependent variable of the multivariate logit model defines the crisis as an episode of speculative pressure on the foreign exchange market. In this sense, the crisis index takes into account both the situations where speculative attacks lead to currency devaluation and where the authorities successfully defend the currency by intervening in the foreign exchange market and/or rising domestic interest rates. The index is composed of the monthly real exchange rate changes, the international reserves changes and the nominal interest rate changes, weighted by the inverse of their respective standard deviations. The crisis index increases with a depreciation of the domestic exchange rate, a significant loss of international reserves and a considerable rise of the interest rate.

$$ISP1_t = \frac{1}{\sigma_{RER}}\left(\frac{RER_t - RER_{t-1}}{RER_{t-1}}\right) - \frac{1}{\sigma_{RES}}\left(\frac{RES_t - RES_{t-1}}{RES_{t-1}}\right) + \frac{1}{\sigma_{NIR}}\left(NIR_t - NIR_{t-1}\right) \qquad (9)$$

where $RER = (NER \times P^*)/P$,

RER = Real exchange rate (an increase corresponds to a real depreciation of the domestic currency),

NER = Nominal exchange rate (TL/USD). Data gathered from the IMF International Financial Statistics (IFS, January 2006, IFS line 186.AE,

P^* = Consumer prices index US, IFS line 11164,

P = Consumer prices index Turkey, IFS line 18664,

RES = International reserves – Gold (in USD), IFS line 186.1L.D,

NIR = Nominal interest rate, IFS line 18660L,

σ_{RER} , σ_{RER} , σ_{RER} = Standard deviations of the components of the index.

Any month when the values of the index $ISP1$ exceeds a specified threshold equal to the index mean μ_{ISP1} plus three standard deviations of the index $3\sigma_{ISP1}$ is classified as crisis episode.[10]

$$(10) \qquad C_t = \begin{cases} 1 & \text{if } ISP1_t > 3\sigma_{ISP1} + \mu_{ISP1} \\ 0 & \text{otherwise} \end{cases}$$

The index $ISP1$ at the threshold of three standard deviations above the index mean correctly identifies the exact timing of the April 1994 and February 2001 Turkish crises as shown on Figure 2. I also define three more thresholds, respectively set to 1.5, 2 and 2.5 standard deviations above the index mean in order to illustrate the sensitivity of the crisis dating mechanism to the changing arbitrary threshold levels in terms of standard deviations. The index $ISP1$ identifies at any threshold level the April 1994 and February 2001 crises. However, since I have not defined an exclusion window, the April 1994 and February 2001 crises are detected more than once as if they are different crisis episodes at

[10] Many modelers like Eichengreen et al. (1996) or Frankel and Rose (1996) inter alia use a crisis-window (or exclusion window) of 3 to 36 months length. This means that they discard a second (or subsequent) crisis observation identified by crisis index which occur within given proximity to the first crisis. In other words, they define as crisis, not only the crisis month, but also all the period of the crisis-window. Bussière and Fratzscher (2002) justify adoption of a crisis-window by the difficulty to predict the exact timing of a crisis rather than to predict whether a crisis will occur within a specific time horizon. I have not defined a crisis-window within the framework of this paper.

the threshold levels below three standard deviations. I observe that as expected the higher the value of the threshold, the lower the number of identified crises.

Figure 1. The crisis index ISP1

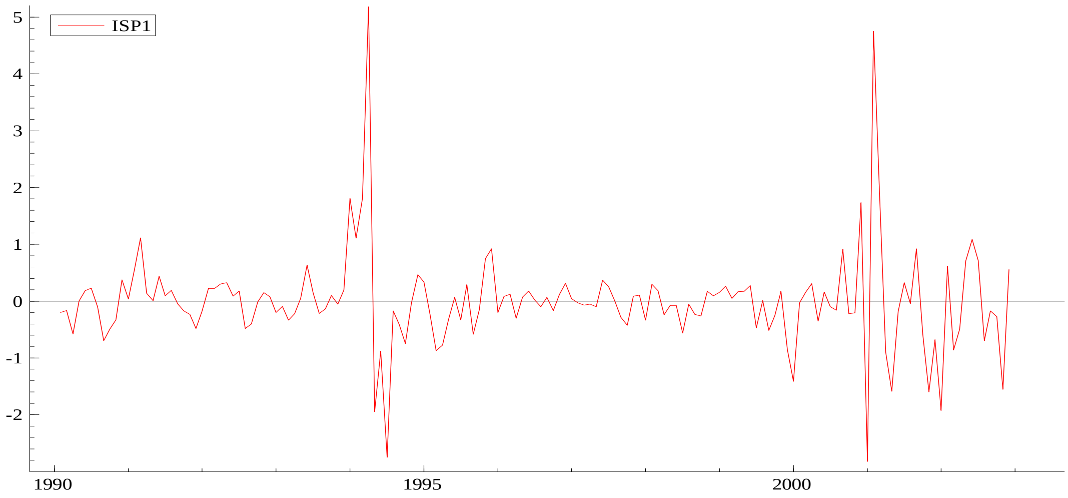
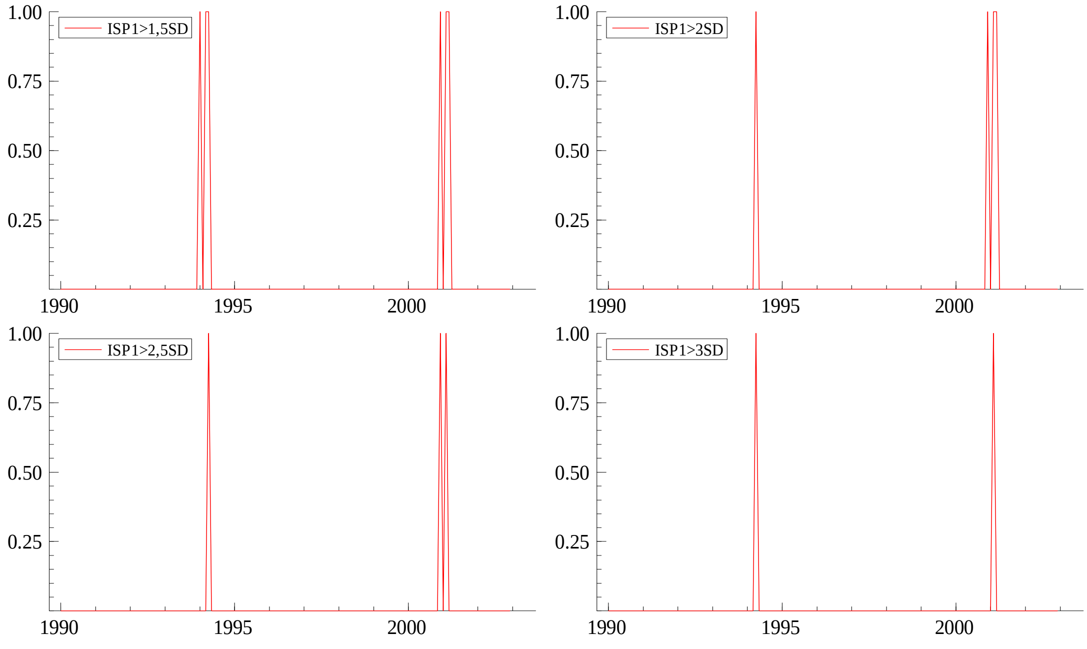


Figure 2. The exact timing of the Turkish crises identified by the index ISP1 at different threshold levels



I also adopt two other currency crisis definitions $ISP2$ and $ISP3$ in order to illustrate the sensitivity of the crisis dates to the changing crisis definitions. The index $ISP2$ thus is a weighted average of the monthly real exchange rate changes and of the international reserves changes, excluding the nominal interest rate changes, while the index $ISP3$ is only composed of the monthly real exchange rate changes.

(11) $$ISP2_t = \frac{1}{\sigma_{RER}}\left(\frac{RER_t - RER_{t-1}}{RER_{t-1}}\right) - \frac{1}{\sigma_{RES}}\left(\frac{RES_t - RES_{t-1}}{RES_{t-1}}\right)$$

(12) $$ISP3_t = \frac{RER_t - RER_{t-1}}{RER_{t-1}}$$

Figure 3. The crisis indexes ISP2 and ISP3

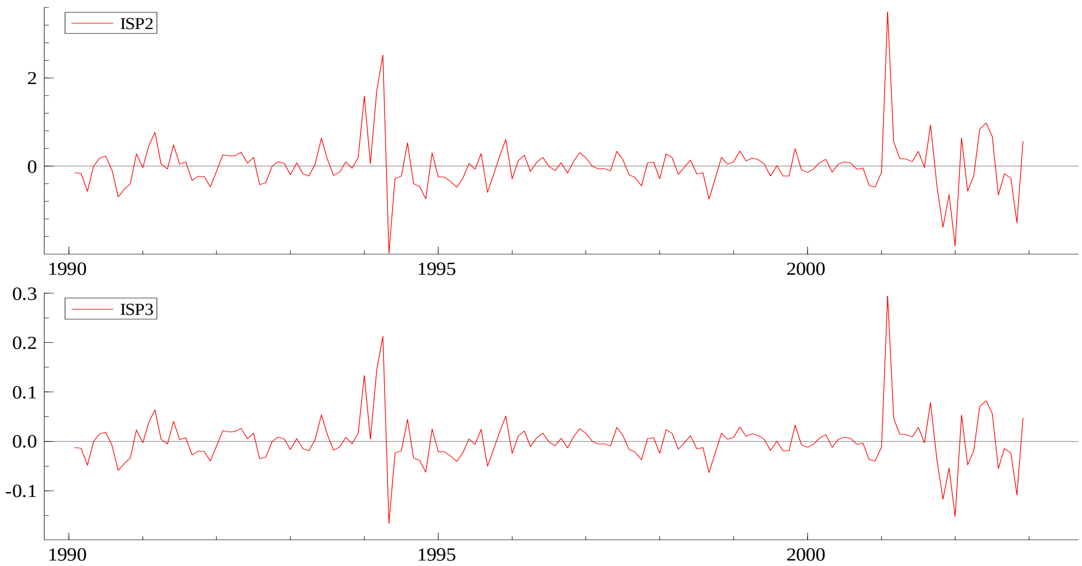
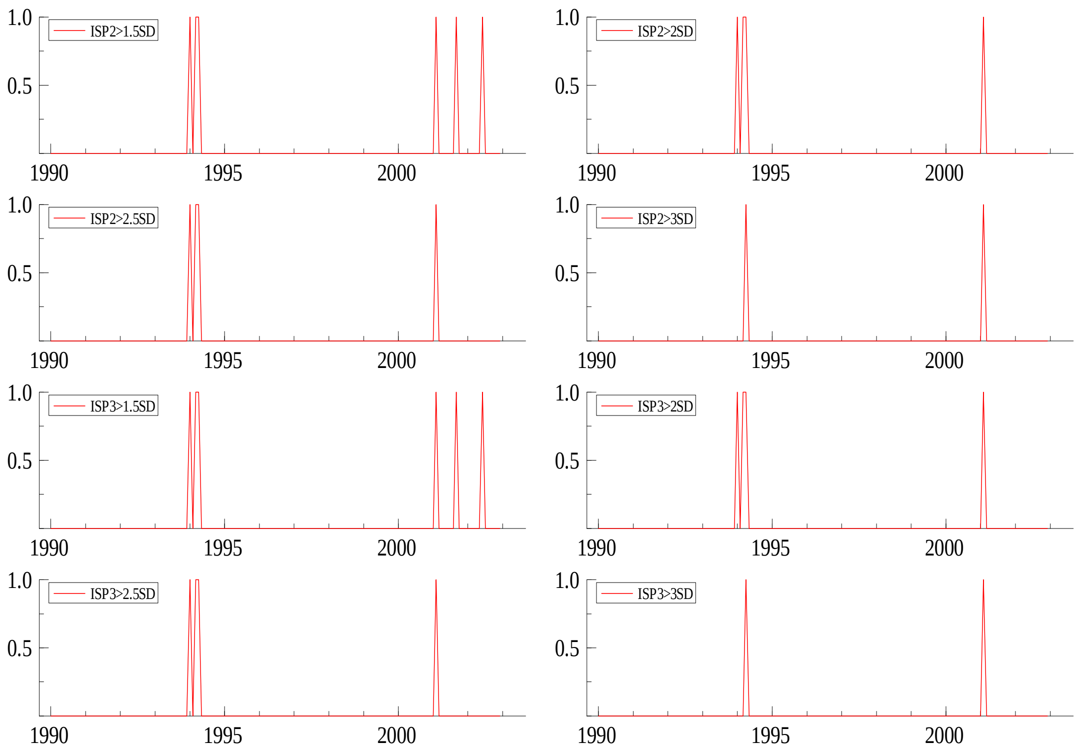


Table 3. Descriptive statistics of the crisis indexes

Index	Mean	SD	Skewness	Kurtosis	Max.	Normality (T=155)	ADF (T=151, C: 5%= -3.4 C:1%= -4.0)	
Lags							0	1
ISP1	0.0058	0.905	1.982	11.854	5.178	Chi2=58.71 [0.00]**	-11.10**	7.97**
ISP2	0.0069	0.570	1.713	11.619	3.492	Chi2=75.16 [0.00]**	-10.79**	-8.10**
ISP3	0.00058	0.0481	1.713	11.619	0.2944	Chi2=75.16 [0.00]**	-10.78**	-8.30**

As one may easily observe on Figures 1 and 3, the three different crisis indexes correctly detect the Turkish crisis episodes. Nevertheless, the means and standard deviations of the indexes diverge across crisis definitions. The normality (chi-square) and stationnarity (Augmented Dickey-Fuller, ADF) tests presented in Table 3 highlight that each index is normally distributed and stationary as the unit root null hypothesis of the ADF test is rejected at the 5% level. As for the identified crisis episodes at different threshold levels, the three crisis indexes behave very similarly as one may clearly see on Figures 2 and 4. This confirms the results of Lestano and Jacobs (2007) who found that the number and dates of the crises identified by different crisis definitions had not considerably changed in the case of the six Asian countries. That thus weakens some criticisms formulated against the characterization of the crises by the construction of the binary crisis indices.

Figure 4. The exact timing of the Turkish crises identified by the indexes ISP2 and ISP3 at different threshold levels



IV.2. Data description and transformation and explanatory variables

The model is estimated using monthly data from January 1990 to December 2002 in order to determine the main factors of the Turkish crises. As stated above, the main reason to start the sample period in 1990:01 is due to the important trade and financial liberalization process undertaken during the 1980s that radically transformed the Turkish economy. In this sense, a selected sample that covers pre- and post-liberalization periods could seriously bias the estimation results given the changing volatility of the explanatory variables.

The econometric study is also limited to the crises of one country. This one-country approach may be criticized as crises are relatively rare events and the main goal of the EWS models is to find common fundamentals across various crisis episodes. However, as I showed in the previous section, the determinants of the crises change on the one hand from one period to another since the modelers adapt their theoretical models to the changing nature of the crises (first, second and third generations crisis models) and on the other hand from one country to another since some empirical works (Cartapanis et al., 1998, Abiad, 2003) found few similarities across different crisis episodes. It should also be noted that there is a difficulty to define what the homogeneous character that different countries share is. Bussière and Fratzscher (2002) cite openness to capital flows as common characteristic while composing their country sample, but is that sufficient?

Most data are gathered from the IFS CD-ROM (January 2009) and completed from the sources of the Central Bank of the Republic of Turkey (CBRT).[11] In this paper, I use monthly data rather than quarterly or annual data that better capture the sudden nature of crises and variance of indicators. Where monthly data are unavailable, I generate the monthly series by interpolation or extrapolation via frequency conversion method (Linear Match Last) of the EViews software. The explanatory variables of the binomial logit model are selected on the basis of the theoretical and empirical currency crisis literature. I explore here a broad set of 16 indicators that are classified then into three categories. Note that $BUDGET$, GDP, $PSBR$, CA, $SHORTDEBT$, FDI and $PORTINVEST$ initially found at quarterly or annually frequency are transformed into monthly basis. The ISE initially found at weekly basis is also converted into monthly frequency. Moreover, overvaluation of the domestic currency is defined as deviation of the real exchange rate from a Hodrick-Prescott trend $RER - hpRER$. TOT is the ratio of unit value of exports to unit value of imports. $BLOAN$ is composed of bank claims to public and private sectors. $BASSET$ includes total bank claims and foreign assets. $BLIAB$ includes total bank domestic and foreign currency liabilities. $BRES$ includes demand, time and saving deposits. $BSHORTPOS$ is the ratio of bank foreign assets to foreign liabilities.

[11] The CBRT provides an electronic data delivery system (EDDS) on its web page www.tcmb.gov.tr.

Table 4. Explanatory variables of the model

Category/Concept	Notation	Source/Transformation	Indicators' economic interpretation, references and awaited impact on the crisis index	Expected Sign
Public and real sector				
-Real sector imbalances				
1) Industrial production	IPROD	*IFS18666B	*The periods of economic slowdown often precede currency crisis episodes. The growth of industrial production should thus lower the crisis probability. Reference: Second generation crisis theory	(-)
2) Istanbul Stock Exchange	ISE	*CBRT	*The collapse of the stock exchange index, which illustrates a massive withdrawal of capital flows, can be perceived as a harbinger of the crisis. Reference: Second and third generation crisis theory	(-/+)
3) Inflation	INFL	*IFS18664	*High inflation rates often lead to increasing interest rates that create negative impacts over real and financial sectors. The crisis index should thus react to the rise in inflation rates. Reference: First and second generation crisis theory	(+)
-Public sector imbalances				
4) Budget balance/GDP	BUDGET/GDP	*CBRT/IFS18699B	*High budget deficits are expected to raise the crisis probability, since they reduce available national savings and may lead to high inflation and interest rates. This situation increases then the vulnerability to shocks and lowers investors' confidence. Reference: First generation crisis theory	(-)
-Monetary imbalances				
5) M2/International reserves	M2/RES	*IFS18635L/IFS186.1L.D	*This ratio measures the adequacy of the central bank reserves to cover the banking system liabilities in a bank run or a currency crisis, since individuals may rush to convert their domestic currency deposits into foreign currency. An economy will be all the more vulnerable to a confidence crisis as the ratio of money supply to the international reserves is high. Reference: First and third generation crisis theory	(+)

External balance and capital flows				
-External current imbalances				
6) Deviation of the real exchange rate from trend	RER-hpRER	*RER = (NER×P*)/P NER:IFS186.AE P*: IFS11164 P: IFS18664.	*An overvaluation of real exchange rate is believed on the one hand to attract short-term foreign capitals, which would contribute to the overheating of the domestic economy, and on the other hand to decrease the international competitiveness of a country compared to its commercial competitors, that can generate unsustainable external positions. Overvalued exchange rate would thus imply a rise of the probability of a crisis. (Reference: First generation crisis theory	(-)
7) Current account/GDP	CA/GDP	*IFS18678ALD/IFS18699B	*A rise (fall) in this ratio is generally associated with large external capital inflows (outflows). This indicates a diminished (high) probability to devalue and thus to lower (increase) the probability of a crisis. Reference: First and second generation crisis theory	(-)
-External indebtedness				
8) Short-term foreign debt/International reserves	SHORTDEBT/RES	*CBRT/IFS186.1L.D	*Higher foreign short-term debt increases vulnerability to liquidity problems, thus to a reversal of capital flows and hence raises the crisis probability. Reference: Second and third generation crisis theory	(+)
-Composition of capital inflows				
9) Foreign direct investments/ Portfolio investments	FDI/PORTINVEST	*IFS18678BED/IFS18678BGD	*The rise in FDIs relative to portfolio investments shows the increasing ability of a country to attract long-term capitals, which can be considered as a sign of the investors' confidence to the country's economic policies. Moreover, the rise in FDIs implies financing of current account deficits by much less volatile capital flows and should thus lower the crisis probability. Reference: Second and third generation crisis theory	(-)
-External shocks				
10) Terms of trade	TOT	*IFS18674.D/IFS18675.D	*Increases in the terms of trade should strengthen a country's balance of payments position and hence lower the probability of a crisis. In addition, a country is all the more vulnerable to a deterioration of its terms of trade as it is strongly open to international trade. Reference: First and second generation crisis theory	(-)

11) Nominal US interest rate	NIRUS	*IFS11160LC	*The probability of a crisis increases in parallel to a rise in US interest rates, since the investors would prefer to reallocate their portfolios in favor of more stable placements. The domestic country may then record capital outflows and/or undergo a rise in external debt repayment costs. Reference: Second and third generation crisis theory	(+)
Financial sector				
-Financial fragility				
12) Bank loans/Bank deposits	BLOAN/BDEPO	*from IFS18622A to IFS18622G/IFS18624+IFS18625	*A high loans-to-deposits ratio may indicate an increasing difficulty of the banking system to attract additional financial sources and/or an excessive growth of bank loans. This leads to increasing banking system fragility with an inadequate level of liquidity to respond shocks and to high crisis probability. Reference: First and third generation crisis theory	(+)
13) Bank reserves/Bank assets	BRES/BASSET	*IFS18620/18621+from IFS18622A to IFS18622G	*This rough capital adequacy ratio shows the ability of the banking system to face the bank runs. Adverse macroeconomic shocks are then less likely to lead to crises in countries where the banking system is liquid. Reference: Third generation crisis theory	(-)
14) Bank deposits/M2	BDEPO/M2	*IFS18624+IFS18625/ IFS18635L	*The high ratio of bank deposits to M2 indicates the increasing confidence of the households and investors in the banking system. The probability of crisis should then decrease following the rise in this ratio. Reference: Third generation crisis theory	(-)
15) Bank short position	BSHORTPOS	*IFS18621/IFS18626C	*This ratio shows the ability of the banking system foreign assets to offset its foreign liabilities. A fall of this ratio should thus increase the probability of a crisis. Reference: Third generation crisis theory	(-)
16) Central bank credit to banks/Bank liabilities	CBCRED/BLIAB	*IFS18626G/CBRT	*An increase in this ratio may indicate financial weakness, since its purpose is to bail-out weak banks and hence should raise the probability of a crisis. Reference: Third generation crisis theory	(+)

Source: Cartapanis et al. (1998), Kamin et al. (2001), Abiad (2003), Lestano, Jacobs and Kuper (2003), Ari and Dagtekin (2007, 2008) and completed by the author.

IV.3. Model specification

I first assess stationnarity of the early warning indicators using the ADF unit root test. I find that all the 16 indicators are stationary (at level or in variation) as the unit root null hypothesis of the ADF test is rejected at the 5% or 10% level. These 16 explanatory variables enter then in the econometric analysis with one-month lag (forecast horizon). The choice of one-month forecast horizon may be criticized, since some structural problems of the economy should have an adverse effect in the long-run contrary to liquidity problems that have rather a short-term impact (Bussière, 2007). Therefore, using one-month lag for all the variables may bias the estimation results. The choice of a short horizon is also inappropriate from the perspective of policymakers who favor a relatively long forecast horizon (from 12 to 24 months) in order to have sufficient time for taking preventive measures. It is nevertheless clear that monthly data capture better the sudden and brutal nature of crises. This is why I prefer one-month lagged explanatory variables. However, I also use different lags (3, 6 and 12 months) in order to test how far in advance the model correctly predicts Turkish crisis episodes.

As I classified the 16 indicators into three categories, I initially estimate the model with the indicators of the each category and then estimate the "final" model with the economically (correctly signed) and statistically significant indicators. There are two main reasons for adopting this approach; first avoiding or at least limiting multicolinierarity risk among a broad set of 16 indicators and second increasing the robustness of the final model by estimating it with only significant indicators. This approach also allows illustrating what the essential determinants of the Turkish crises are: public sector imbalance, financial liberalization (or capital flows) or banking sector fragility. Moreover, it should be noted that I test the forecast performance of each group of indicators at 50%, 25% and 20% threshold levels. Finally, I assess the out-of-sample forecast performance of the logit model by estimating the model in a sample that covers January 2003-December 2008 period.[12]

[12] Note that, in order to demonstrate that significance of the estimation results is not crisis indicator-dependent $ISP1$, I also estimate two other logit models by using $ISP2$ and $ISP3$ as dependent crisis variable. I find that the estimation results do not indicate any major difference in terms of the significance of the explanatory variables compared to the final model of the econometric analysis. They also reach to predict the 1994 and 2001 Turkish crises at 25% and 20% threshold levels. The estimation results of the models using $ISP2$ and $ISP3$ as dependent crisis variable are available upon request.

V. Estimation results

V.I. First estimations

The Tables 5, 6 and 7 illustrate on the one hand the results of the successive logit models estimated with each category of one-month lagged early warning indicators, and on the other hand the forecast performance (goodness-of-fit) of these models.

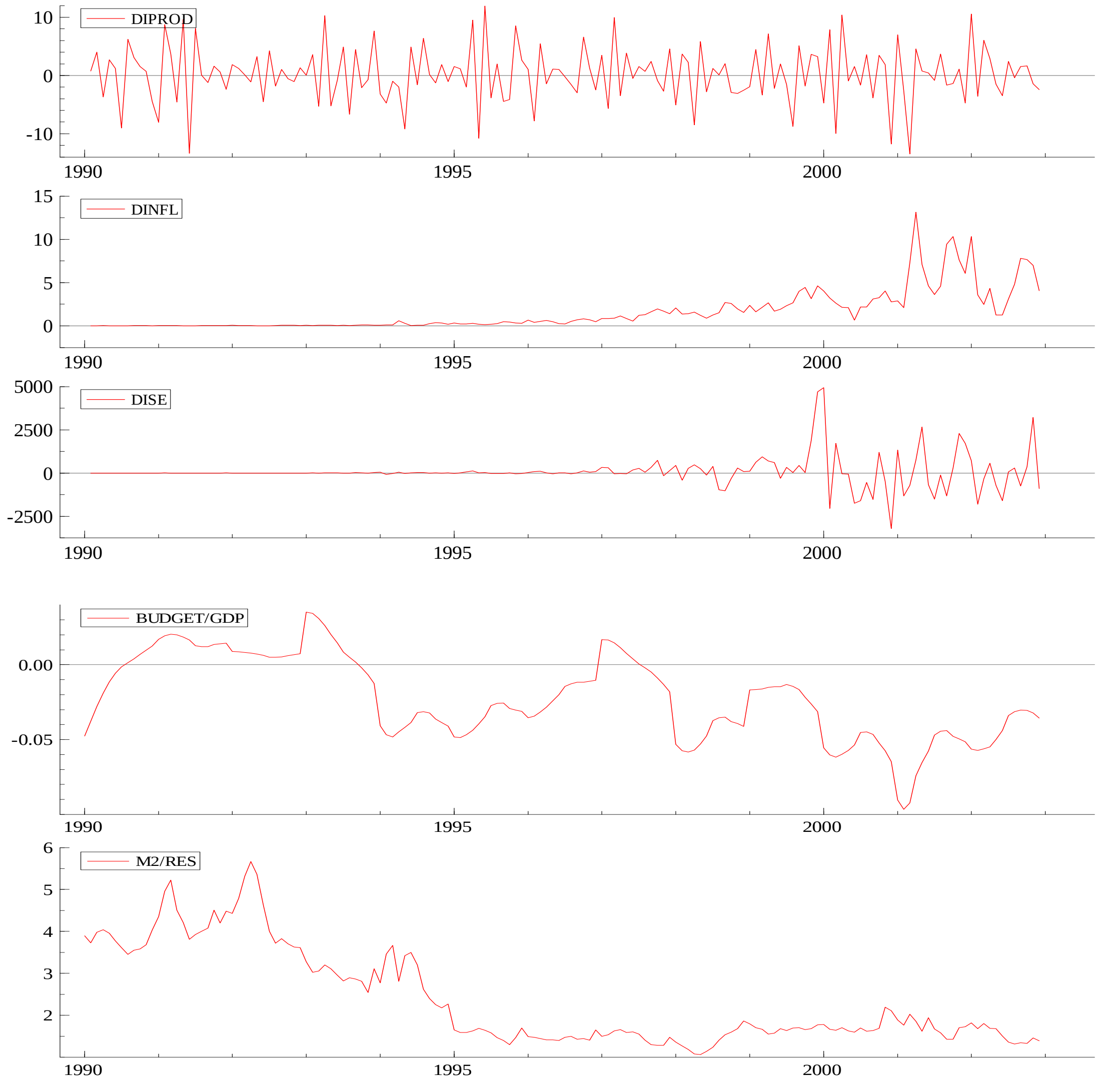
Table 5. The public and real sector variables

Dependent Variable: ISP1>3SD / Sample (adjusted): 1990M03 2002M12 – 154 Observations				
Variable	**Coeff.**	**Std. error**	**z-Stat.**	**Prob.**
C	-4.709463	0.939276	-5.013929	0.0000
DIPROD[1]	0.134204	0.159241	0.842772	0.3994
DISE	0.000477	0.000515	0.925570	0.3547
DINFL	-0.689701	0.663105	-1.040108	0.2983
BUDGET/GDP	-38.01572	30.06430	-1.990757	0.0968
M2/RES	9.125319	7.949217	1.747952	0.1010
Mean dependent variable	0.012987	Std. deviation of dependent variable		0.113588
Std. error of regression	0.087576	Akaike		0.094932
Log likelihood	-3.309749	Schwarz		0.173814
Restr. log likelihood	-10.67457	Hannan-Quinn		0.126973
Avg. log likelihood	-0.021492	LR stat. (5 variables)		8.702964
Prob. (LR stat.)	0.002063	McFadden R^2		0.489941
Observations: Dep=0 / 1	152 / 2	Total		154

[1]D before a variable indicates its first difference.

Prediction evaluation (cut-off C = 0.5)			
		Estimated prob.	
	Dep=0	Dep=1	Total
P(Dep=1)≤C	152	2	154
P(Dep=1)>C	0	0	0
Total	152	2	154
Correct	152	0	152
% Correct	100.00	0.00	98.70
% Incorrect	0.00	100.00	1.30
Prediction evaluation (cut-off C = 0.25)			
P(Dep=1)≤C	152	1	153
P(Dep=1)>C	0	1	1
Total	152	2	154
Correct	152	1	153
% Correct	100.00	50.00	99.35
% Incorrect	0.00	50.00	0.65
Prediction evaluation (cut-off C = 0.2)			
P(Dep=1)≤C	151	1	152
P(Dep=1)>C	1	1	2
Total	152	2	154
Correct	151	1	152
% Correct	99.34	50.00	98.70
% Incorrect	0.66	50.00	1.30

Figure 5. Evolution of the public and real sector variables



One easily observes in Table 5 that the indicators $IPROD$, $INFL$ and ISE are neither correctly signed nor statically significant contrary to the indicators $BUDGET/GDP$ and $M2/RES$. I thus exclude them from the final model. The positive sign of the $IPROD$ which indicates that the industrial production growth increases the probability of a crisis in the Turkish economy is not very surprising as one may see a high economic growth trend before the outbreak of the Turkish crises. One hence affirms that the Turkish crises do have tendency to occur at the end of the economic overheating cycle. However, the insignificance of $INFL$ ISE are quite surprising, since high chronic inflation rates were one of the main problems of the Turkish economy in the last three decades and as one may see on the above Figure 5 that the ISE Index recorded a sharp fall just before the outbreak of the Turkish crises. On the other hand, $BUDGET/GDP$ is correctly signed and significant at the 10% level as well as $M2/RES$. High public deficits and high money growth relative to international reserves due to monetization of public deficits at the end of 1993 and to non-sterilization of capital inflows during 2000 are then two main factors of the Turkish crises. Moreover, this logit model using the Quadratic hill climbing method is quite robust as the McFadden R^2 is above 48% (very rare for a logit model of which the R^2 ratio is generally around 20% to 40%) and LR statistic probability is below the 1%. Nevertheless, the model reaches only to predict the 2001 Turkish crisis at the 25% cut-off level signaling a false crisis alarm as well.

As indicated in Table 6, the indicators CA/GDP and $NIRUS$ do not have expected signs on the crisis index and statistical significance, hence they are excluded from the final model. The indicator $FDI/PORTINVEST$ is correctly signed, but it is not statistically significant, exceeding the 10% probability level, thus it is not included into the final model either, contrary to the indicators $RER-hpRER$, $SHORTDEBT/RES$ and TOT. The insignificance of CA/GDP is also quite surprising, since the current account deficit had reached to 5% of GDP in the year preceding the Turkish crises. The insignificance of $NIRUS$ may lead one to affirm that the external shocks had a limited impact on the occurrence of Turkish crises, but the high significance of TOT weakens this statement. The insignificance of $FDI/PORTINVEST$ is not very unexpected as the long-term investment to the Turkish economy had never exceeded one-billion USD per year in spite of trade and financial liberalization efforts implemented during the 1980s. One may see only after the severe 2001 financial crisis that huge long-term capital inflows accelerated towards to the Turkish economy, particularly for the acquisition of the domestic banks transferred to the SDIF and of the highly profitable state-owned-enterprises (SES) like Turk Telekom, Tekel, Petkim etc.

One the other hand, $RER-hpRER$ which represents the deviation of the real exchange rate from trend, is quite significant. In the both Turkish crisis episodes, one may see real currency appreciation of around 10% generally due to short-term capital inflows. The domestic currency overvaluation before the outbreak of the 2001 crisis can also be explained by implementation of the exchange-rate-based stabilization program. As detailed in Calvo and Végh (1999) and Rodrik and Velasco (1999), these programs generate, like in the Turkish example, an initial consumption boom that contributes a high economic growth, but to the detriment of real currency appreciation and of unsustainable commercial and current account deficits. This is followed then by a stage of liquidity squeeze which leads to sharp increases in interest rates and forces later the government to realign its currency rate. The indebtedness indicator *SHORTDEBT / RES* is also correctly signed and quite significant. This ratio which reaches to 250% and 150% respectively before the outbreak of the 1994 and 2001 Turkish crises indicate the increasing vulnerability of the Turkish economy to external shocks, a reversal of capital inflows and a liquidity crisis. Besides, the logit model is robust as the McFadden R^2 is above 49% and LR statistic probability is below the 5% level. However the model predicts only the 1994 Turkish crisis, not the 2001 one.

Figure 6. Evolution of the external balance and capital flows variables

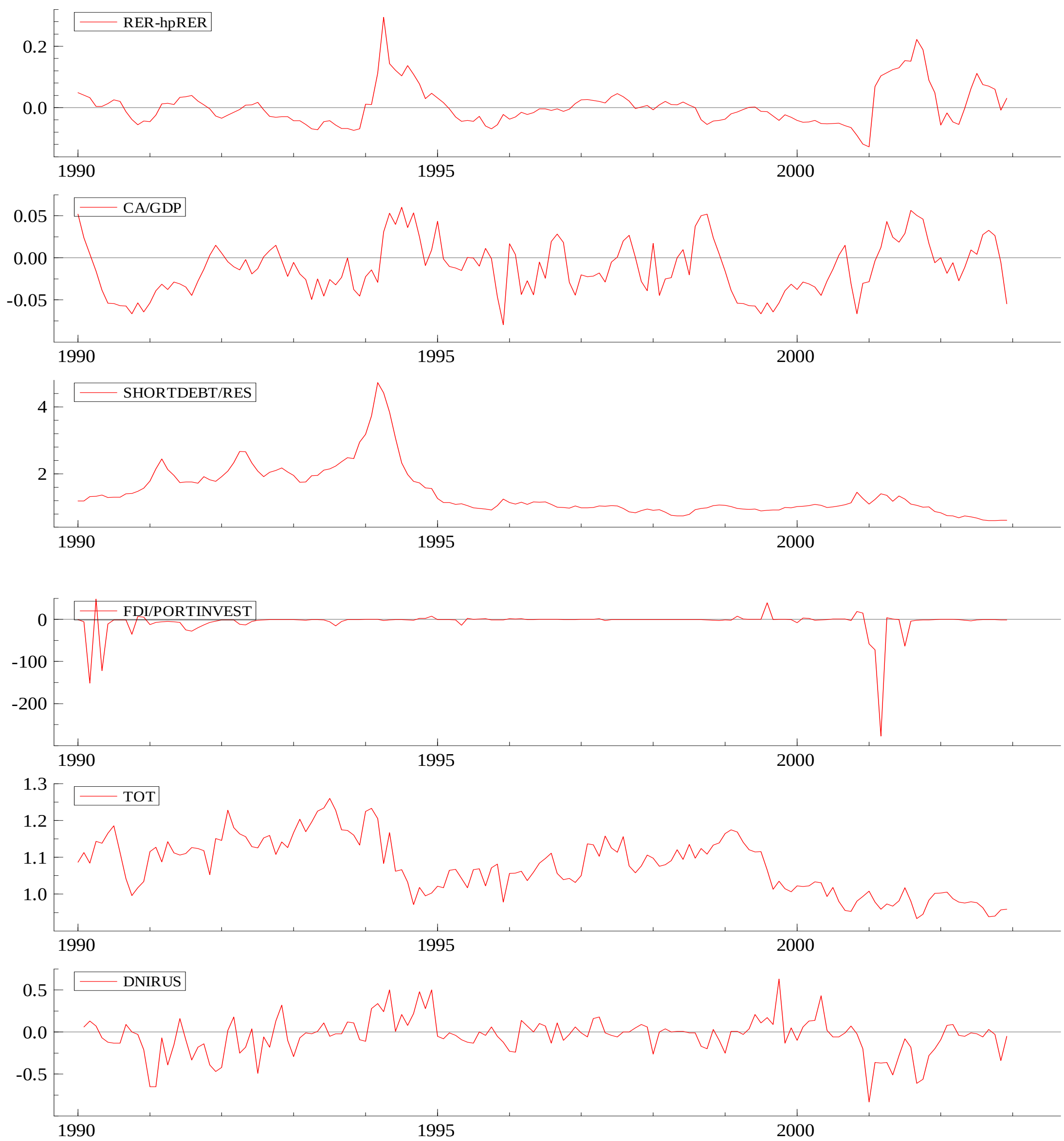


Table 6. The external balance and capital flows variables

Dependent Variable: ISP1>3SD / Sample (adjusted): 1990M03 2002M12 – 154 Observations				
Variable	**Coeff.**	**Std. error**	**z-Stat.**	**Prob.**
C	-16.32039	7.857995	-2.076915	0.0378
RER-hpRER	-40.07275	26.22353	-1.928122	0.0865
CA/GDP	54.68034	374.7998	0.145892	0.8840
SHORTDEBT/RES	4.565086	2.511774	1.817475	0.0691
FDI/PORTINVEST	-0.038929	0.023868	-0.931034	0.2529
TOT	-45.02369	32.49055	-1.615747	0.1058
DNIRUS	-4.727027	5.433952	-0.869906	0.3844
Mean dependent variable	0.012903	Std. deviation of dependent variable		0.113223
Std. error of regression	0.105384	Akaike		0.146493
Log likelihood	-5.353197	Schwarz		0.264303
Restr. log likelihood	-10.68760	Hannan-Quinn		0.194345
Avg. log likelihood	0.034537	LR stat. (6 variables)		10.66880-
Prob. (LR stat.)	0.058357	McFadden R^2		0.499121
Observations: Dep=0 /1	152 / 2	Total		154

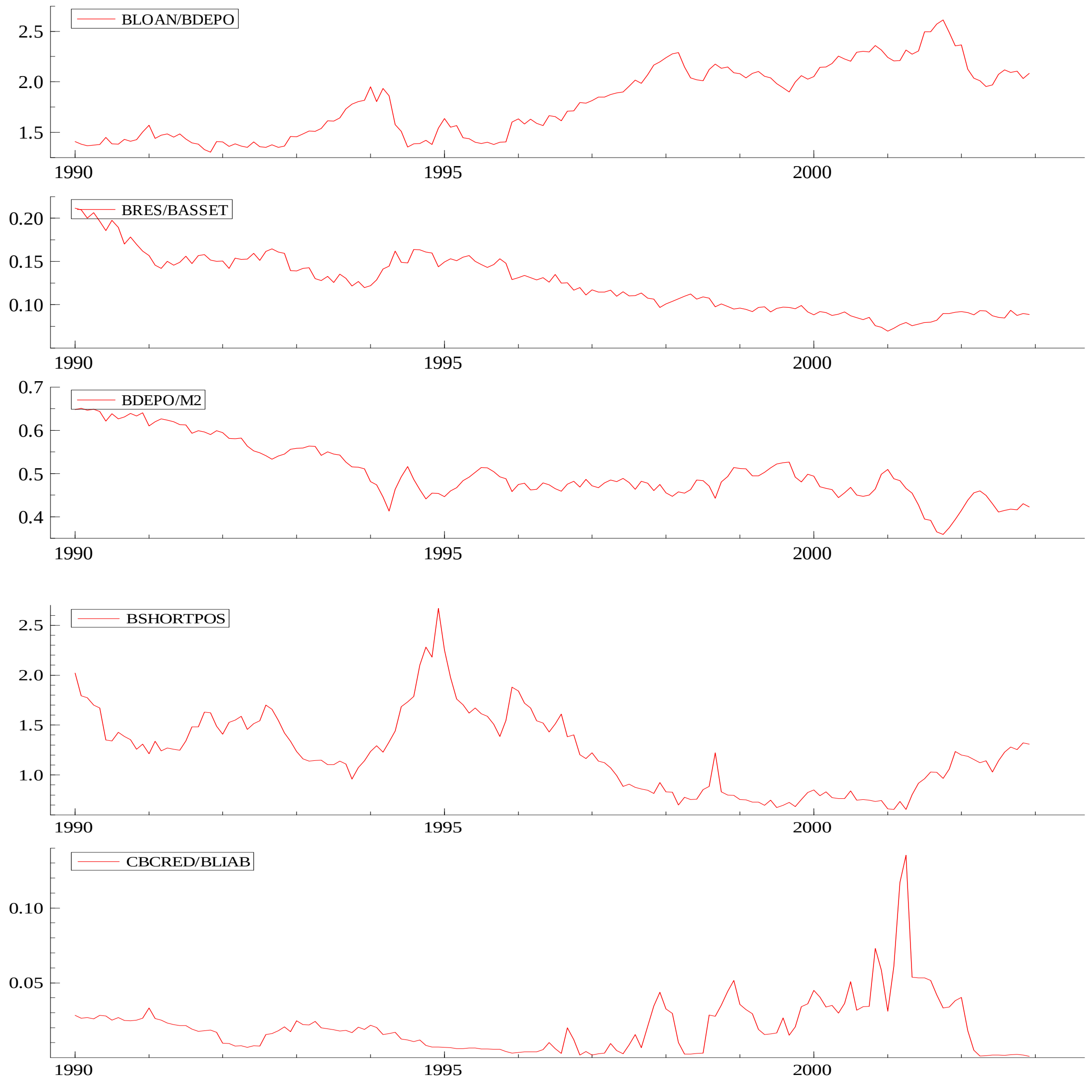
Prediction evaluation (cut-off C = 0.5)			
		Estimated prob.	
	Dep=0	Dep=1	Total
P(Dep=1)≤C	151	1	152
P(Dep=1)>C	1	1	2
Total	152	2	154
Correct	151	1	152
% Correct	99.34	50.00	98.70
% Incorrect	0.66	50.00	1.30
Prediction evaluation (cut-off C = 0.25)			
P(Dep=1)≤C	151	1	152
P(Dep=1)>C	1	1	2
Total	152	2	154
Correct	151	1	152
% Correct	99.34	50.00	98.70
% Incorrect	0.66	50.00	1.30
Prediction evaluation (cut-off C = 0.2)			
P(Dep=1)≤C	151	1	152
P(Dep=1)>C	1	1	2
Total	152	2	154
Correct	151	1	152
% Correct	99.34	50.00	98.70
% Incorrect	0.66	50.00	1.30

Table 7. The financial sector variables

Dependent Variable: ISP1>3SD / Sample (adjusted): 1990M02 2002M12 – 155 Observations				
Variable	**Coeff.**	**Std. error**	**z-Stat.**	**Prob.**
C	-6.082985	1.769755	-3.437191	0.0006
BLOAN/BDEPO	6.079142	15.02239	0.404672	0.6857
BRES/BASSET	20.00708	17.08105	1.162729	0.2449
BDEPO/M2	-0.371116	9.999737	-0.037113	0.9704
BSHORTPOS	-10.32351	7.769934	-1.328648	0.1840
CBCRED/BLIAB	-79.51412	39.29049	-1.023750	0.2130
Mean dependent variable	0.012987	Std. deviation of dependent variable		0.113588
Std. error of regression	0.110350	Akaike		0.177222
Log likelihood	-7.646090	Schwarz		0.295545
Restr. log likelihood	-10.67457	Hannan-Quinn		0.225284
Avg. log likelihood	-0.049650	LR stat. (5 variables)		6.056955
Prob. (LR stat.)	0.300716	McFadden R^2		0.223710
Observations: Dep=0 /1	153 / 2	Total		155

Prediction evaluation (cut-off C = 0.5)			
	Estimated prob.		
	Dep=0	Dep=1	Total
P(Dep=1)≤C	153	2	155
P(Dep=1)>C	0	0	0
Total	153	2	155
Correct	153	0	153
% Correct	100.00	0.00	98.71
% Incorrect	0.00	100.00	1.29
Prediction evaluation (cut-off C = 0.25)			
P(Dep=1)≤C	153	2	155
P(Dep=1)>C	0	0	0
Total	153	2	155
Correct	153	0	153
% Correct	100.00	0.00	98.71
% Incorrect	0.00	100.00	1.29
Prediction evaluation (cut-off C = 0.2)			
P(Dep=1)≤C	152	2	154
P(Dep=1)>C	1	0	1
Total	153	2	155
Correct	152	0	152
% Correct	99.34	0.00	98.71
% Incorrect	0.66	100.00	1.29

Figure 7. Evolution of the financial sector variables



As shown in Table 7, the indicators $BRES/BASSET$ and $CBCRED/BLIAB$ do not have economic and statistical significance contrary to the indicators $BLOAN/BDEPO$, $BDEPO/M2$ and $BSHORTPOS$ that are correctly signed, but are not statistically significant. On the other hand, the logit model estimated with only financial fragility variables is not robust either, as the McFadden R^2 is around 20% and LR statistic probability are above the 10% level. Moreover, the model does not reach to predict any of the Turkish crises. These disappointing results, probably due to the colinearity problems among the financial sector indicators, lead me to construct a financial fragility index IFF as a weighted average of monthly changes in banking sector loans to private sector, in banking sector foreign liabilities and in banking sector deposits. This index increases with a sharp growth in bank loans to the private sector (measuring credit risk), a considerable rise in bank foreign liabilities (measuring currency risk) and a significant fall of bank deposits (following a bank run for example).[13]

(13) $$IFF_t = \frac{1}{\sigma_{BLOAN}}\left(\frac{BLOAN_t - BLOAN_{t-1}}{BLOAN_{t-1}}\right) - \frac{1}{\sigma_{BDEPO}}\left(\frac{BDEPO_t - BDEPO_{t-1}}{BDEPO_{t-1}}\right) + \frac{1}{\sigma_{BFXLIAB}}\left(\frac{BFXLIAB_t - BFXLIAB_{t-1}}{BFXLIAB_{t-1}}\right) + \varepsilon_t$$

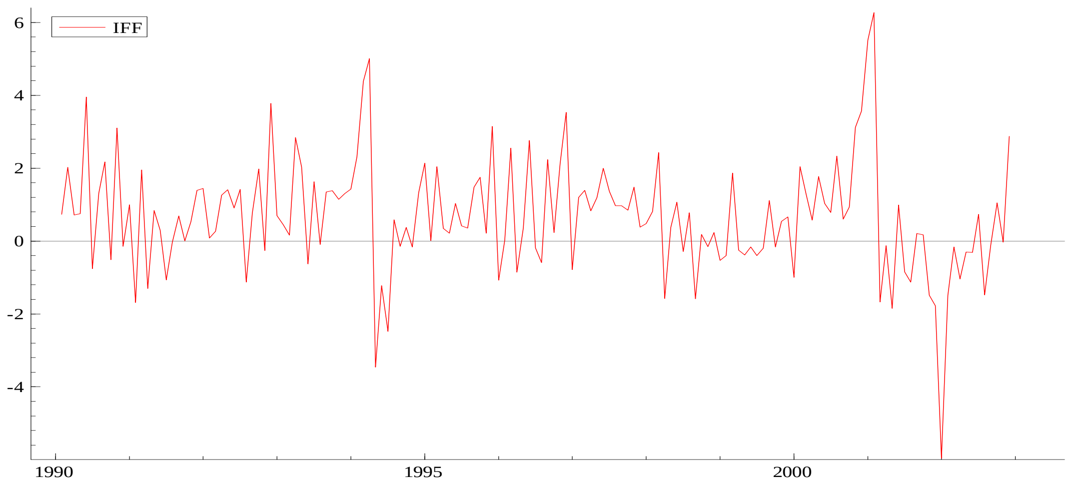
where $BLOAN$ = Banks loans granted to private sector, IFS line 18622D,

$BDEPO$ = Banks deposits, IFS line 18624+IFS line 18625,

$BFXLIAB$ = Banks foreign liabilities,

σ_{BLOAN}, σ_{BDEPO}, $\sigma_{BFXLIAB}$ = Standard deviations of the components of the index.

Figure 8. Evolution of the financial fragility index IFF



V.2. Estimation results of the final model

The final logit model which is estimated with 5 significant indicators of the previous models and IFF, confirms my initial intuitions that the 1994 and 2001 Turkish crises are due to combination of different macroeconomic imbalances (high budget deficits, high money supply growths, real exchange rate appreciation and high short-term foreign debt stocks), of banking sector weaknesses (increasing credit and currency risks) and of external shocks

[13] Actually, this index is inspired from Kibritcioglu's (2002) banking sector fragility indicator.

(terms of trade). On the other hand, the model is very robust as the ratio R² is above 80% and predicts correctly both Turkish crises at 25% and 20% cut-off level while it only sends two false alarms. (See also appendix for the forecast figures of the consecutive logit models).

Table 9. The crisis indicators of the final model

Dependent Variable: ISP1>3SD / Sample (adjusted): 1990M03 2002M12 – 154 Observations				
Variable	**Coeff.**	**Std. error**	**z-Stat.**	**Prob.**
C	-34.59522	29.79916	-1.160946	0.2457
BUDGET/GDP	-31.10227	23.06038	-1.905757	0.0651
M2/RES	5.621488	4.600233	1.293155	0.1406
RER-hpRER	-35.22090	18.60615	-1.892971	0.0584
SHORTDEBT/RES	5.241099	2.551735	2.053935	0.0400
TOT	-38.55529	25.59744	-1.706217	0.0920
IFF	1.010604	0.360812	2.800914	0.0051
Mean dependent variable	0.012987	Std. deviation of dependent variable		0.113588
Std. error of regression	0.065310	Akaike		0.074781
Log likelihood	-1.758105	Schwarz		0.113662
Restr. log likelihood	-10.67457	Hannan-Quinn		0.106822
Avg. log likelihood	-0.011416	LR stat. (6 variables)		17.83293
Prob. (LR stat.)	0.000476	McFadden R²		0.835300
Observations : Dep=0 /1	152 / 2	Total		154

Prediction evaluation (cut-off C = 0.5)			
		Estimated prob.	
	Dep=0	Dep=1	Total
P(Dep=1)≤C	Dep=0	Dep=1	Total
P(Dep=1)>C	152	1	153
Total	0	1	1
Correct	152	2	154
% Correct	152	1	153
% Incorrect	100.00	50.00	99.35
Prediction evaluation (cut-off C = 0.25)			
P(Dep=1)≤C	151	0	151
P(Dep=1)>C	1	2	3
Total	152	2	154
Correct	151	2	153
% Correct	99.34	100.00	99.35
% Incorrect	0.66	0.00	0.65
Prediction evaluation (cut-off C = 0.2)			
P(Dep=1)≤C	151	0	151
P(Dep=1)>C	1	2	3
Total	152	2	154
Correct	151	2	153
% Correct	99.34	100.00	99.35
% Incorrect	0.66	0.00	0.65

V.3. Results of the models estimated with three-, six- and twelve-month lagged indicators

In this section, I aim to demonstrate how far in advance the model correctly predicts Turkish crisis episodes. In this sense, I estimate successive logit models with three ($t-3$)-, six ($t-6$)- and twelve-month ($t-12$) lagged early warning indicators while the dependent crisis variable remains at t. I follow again the same approach of estimating logit models with each category of indicators and then estimating the final models with the economically and statistically significant indicators. The below Tables 10, 11 and 12 illustrate the estimation results of these successive logit models regressed with lagged indicators.

Table 10. The external balance and capital flows variables at different lags

Dependent variable: ISP1>3SD / Sample (adjusted): 1990M05 2002M12 – 152 Observations				
Variable	**Coeff.**	**Std. error**	**z-Stat.**	**Prob.**
C	-3.426344	19.30713	-0.177465	0.8591
RER-hpRER_3	-28.30680	17.01282	-1.530045	0.1017
CA/GDP_3	-63.55546	283.2227	-0.224401	0.8224
SHORTDEBT/RES_3	3.976889	2.333258	1.704437	0.0883
FDI/PORTINVEST_3	0.117487	0.107456	1.051721	0.1986
TOT_3	-17.88634	5.352700	-3.341554	0.0008
DNIRUS_3	-5.785965	6.320475	-0.915432	0.3600
Sample (adjusted): 1990M08 2002M12 – 149 Observations				
C	7.473560	16.05613	0.465465	0.6416
RER-hpRER_6	-45.68384	26.26644	-1.739247	0.0820
CA/GDP_6	35.01585	31.05767	0.804845	0.4209
SHORTDEBT/RES_6	2.354051	1.579943	1.852192	0.0605
FDI/PORTINVEST_6	-0.004381	0.062276	-0.070346	0.9439
TOT_6	-15.42475	11.30994	-1.891092	0.0729
DNIRUS_6	3.109453	2.406261	1.630015	0.0965
Sample (adjusted): 1991M02 2002M12 – 143 Observations				
C	-40.28128	27.82585	-1.447621	0.1477
RER-hpRER_12	-79.74983	50.09384	-1.592009	0.1014
CA/GDP_12	-51.08556	37.01844	-1.584367	0.0862
SHORTDEBT/RES_12	-5.150785	5.169965	-0.996290	0.3191
FDI/PORTINVEST_12	0.029575	0.109115	0.271041	0.7864
TOT_12	-34.47890	27.94638	-1.433752	0.1031
DNIRUS_12	4.736415	4.021526	1.567526	0.0749

Table 11. The public and real sector variables at different lags

Dependent variable: ISP1>3SD / Sample (adjusted): 1990M05 2002M12 – 152 Observations				
Variable	**Coeff.**	**Std. error**	**z-Stat.**	**Prob.**
C	-8.274106	3.535651	-2.340193	0.0193
DIPROD_3	-0.026647	0.144799	-0.184027	0.8540
DISE_3	-0.000355	0.000819	-0.433330	0.6648
DINFL_3	0.090938	0.259649	0.350235	0.7262
BUDGET/GDP_3	-54.61167	33.83731	-1.613948	0.1065
M2/RES_3	1.882979	0.903286	1.672519	0.0983
Sample (adjusted): 1990M08 2002M12 – 149 Observations				
C	-3.585450	2.223727	-1.612360	0.1069
DIPROD_6	0.037153	0.148318	0.250493	0.8022
DISE_6	-0.000597	0.000987	-0.604991	0.5452
DINFL_6	-0.093735	0.452563	-0.207121	0.8359
BUDGET/GDP_6	-43.61881	45.26051	-0.457890	0.6470
M2/RES_6	-0.257510	0.778764	-0.330665	0.7409
Sample (adjusted): 1991M02 2002M12 – 143 Observations				
C	-12.78800	7.351222	-1.739575	0.0819
DIPROD_12	1.103921	0.733690	1.054615	0.2324
DISE_12	-0.005403	0.003212	-1.482545	0.0997
DINFL_12	-2.298823	1.380661	-0.545572	0.2106
BUDGET/GDP_12	64.07862	42.31994	1.157211	0.2472
M2/RES_12	1.734622	2.503640	0.852026	0.5854

Table 12. The financial sector indicators at different lags

Dependent variable: ISP1>3SD / Sample (adjusted): 1990M04 2002M12 – 153 Observations				
Variable	**Coeff.**	**Std. error**	**z-Stat.**	**Prob.**
C	-7.679068	15.33681	-0.500695	0.6166
BLOAN/BDEPO_3	8.937415	7.604825	1.175230	0.2399
BRES/BASSET_3	-32.86394	76.59535	-0.429059	0.6679
BDEPO/M2_3	-7.430916	6.904013	-1.076318	0.2818
BSHORTPOS_3	3.769296	5.651172	0.666994	0.5048
CBCRED/BLIAB_3	3.995997	26.50873	0.150743	0.8802
Sample (adjusted): 1990M07 2002M12 – 150 Observations				
C	5.576106	18.70582	0.298095	0.7656
BLOAN/BDEPO_6	6.463196	9.760415	0.662184	0.5079
BRES/BASSET_6	18.49912	85.47018	0.216439	0.8286
BDEPO/M2_6	-7.218589	7.397369	-0.975832	0.3291
BSHORTPOS_6	-9.757101	11.42294	-0.854167	0.3930
CBCRED/BLIAB_6	-36.50266	55.36076	-0.659360	0.5097
Sample (adjusted): 1991M01 2002M12 – 144 Observations				
C	30.61940	28.93251	1.058304	0.2899
BLOAN/BDEPO_12	-15.36407	10.74148	-1.430350	0.1526
BRES/BASSET_12	-61.16141	125.9541	-0.485585	0.6273
BDEPO/M2_12	4.035552	8.180150	0.493335	0.6218
BSHORTPOS_12	-8.329869	8.264133	-1.007954	0.3135
CBCRED/BLIAB_12	25.83621	29.81381	0.866585	0.3862

According to the estimation results of the models, some indicators do have short-term impact ($BUDGET/GDP$, $M2/RES$ or $SHORTDEBT/RES$) while some others do have rather mid- or long-term impact (ISE, CA/GDP or $NIRUS$) on the crisis probability. Moreover, some indicators are in general economically and statistically significant whatever the lag is used ($RER-hpRER$ or TOT) while some others are never economically and statistically significant ($IPROD$, $INFL$, $FDI/PORTINVEST$).

After illustrating economic and statistical significance of the early warning indicators at different lags, I evaluate now the forecast performance of the final models estimated only with significant indicators. Firstly, as shown in Table 13, one may clearly observe that 6 indicators ($BUDGET/GDP$, $M2/RES$, $RER-hpRER$, $SHORTDEBT/RES$, TOT, IFF) that are significant at one month lag, are also significant at three month lag. This means that the Turkish economy was already vulnerable three months before the outbreak of the crises that the model reaches to correctly signal at 20% threshold level. Secondly, the estimation results of the logit model regressed with six-month lagged significant indicators (Table 14) indicate that $NIRUS$ becomes economically and statistically significant for the first time. The indicators $RER-hpRER$, $SHORTDEBT/RES$, TOT and IFF are still significant contrary to $BUDGET/GDP$ and $M2/RES$ that do not form part of the final model. Besides, the model continues to correctly signal the increasing crisis probability six months before the occurrence of the 1994 and 2001 Turkish crises at 20% threshold level crisis. Lastly, as illustrated in Table 15, $SHORTDEBT/RES$, one of the key indicators of the logit model, does not form part of the final model estimated with twelve-month lagged variables. The indicators ISE and CA/GDP become economically and statistically significant for the first time and the indicators $RER-hpRER$, TOT and IFF do have again economic and statistical significance. Moreover, the model correctly predicts the occurrence of the 1994 and 2001 Turkish crises at 20% cut-off level. Actually, the prediction of the 1994 crisis is not very surprising as Ozatay (1996, 1999) states that the Turkish government was already insolvent as for the end of 1992. However, signalling of the 2001 crisis twelve months before its occurrence is quite surprising since the Turkish government had implemented an exchange-rate based stabilization programme in January 2000. This may be explained by the fact that the Turkish economy was showing some signs of economic and financial vulnerability at the end of the 1998-1999 period that forced the government to sign a stand-by agreement with the

IMF. One may then state that the implementation of the stabilization programme reduced the riskiness of the Turkish economy, without nonetheless being able to prevent the occurrence of the crisis in early 2001. This result should encourage the construction of the EWS models of which main objective is to inform the monetary authorities about the vulnerability of the economy so that they take necessary pre-emptive measures.

Table 13. The final model estimated with three-month lagged crisis indicators

Dependent variable: ISP1>3SD / Sample (adjusted): 1990M05 2002M12 – 152 Observations				
Variable	**Coeff.**	**Std. error**	**z-Stat.**	**Prob.**
C	-8.582021	4.864199	-1.764324	0.0777
BUDGET/GDP_3	-59.78419	32.21310	-2.166329	0.0303
M2/RES_3	2.477013	1.582755	1.124274	0.1562
RER-hpRER_3	-69.07755	34.16718	-1.677932	0.0811
SHORTDEBT/RES_3	5.738344	2.761176	2.078225	0.0377
TOT_3	-23.55810	16.24262	-1.450388	0.0970
IFF_3	1.104251	0.426723	1.908148	0.0564
Mean dependent variable	0.013158	Std. deviation of dependent variable		0.114327
Std. error of regression	0.077872	Akaike		0.128970
Log likelihood	-2.801750	Schwarz		0.268228
Restr. log likelihood	-10.64825	Hannan-Quinn		0.185542
Avg. log likelihood	-0.018433	LR stat. (6 variables)		15.69300
Prob. (LR stat.)	0.015500	McFadden R^2		0.736882
Observations : Dep=0 /1	150 / 2	Total		152

Prediction evaluation (cut-off C = 0.5)			
	Estimated prob.		
	Dep=0	Dep=1	Total
P(Dep=1)≤C	150	1	151
P(Dep=1)>C	0	1	1
Total	150	2	152
Correct	150	1	151
% Correct	100.00	50.00	99.34
% Incorrect	0.00	50.00	0.66
Prediction evaluation (cut-off C = 0.25)			
P(Dep=1)≤C	149	1	150
P(Dep=1)>C	1	1	2
Total	150	2	152
Correct	149	1	150
% Correct	99.33	50.00	98.68
% Incorrect	0.67	50.00	1.32
Prediction evaluation (cut-off C = 0.2)			
P(Dep=1)≤C	148	0	148
P(Dep=1)>C	2	2	2
Total	150	2	152
Correct	148	2	150
% Correct	98.30	100.00	98.13
% Incorrect	1.70	0.00	1.97

Table 14. The final model estimated with six-month lagged crisis indicators

Dependent variable: ISP1>3SD / Sample (adjusted): 1990M08 2002M12 – 149 Observations				
Variable	**Coeff.**	**Std. error**	**z-Stat.**	**Prob.**
C	-8.868939	3.927648	-2.258079	0.0239
RER-hpRER_6	-53.37847	36.38706	-1.666963	0.0924
SHORTDEBT/RES_6	3.666596	1.108981	1.601088	0.1059
TOT_6	-33.13404	25.80706	-1.310205	0.1301
DNIRUS_6	6.213295	4.620204	1.727874	0.0795
IFF_6	1.207451	0.714632	1.850019	0.0353
Mean dependent variable	0.013423	Std. deviation of dependent variable		0.115082
Std. error of regression	0.111102	Akaike		0.151873
Log likelihood	-5.990390	Schwarz		0.292369
Restr. log likelihood	-10.60811	Hannan-Quinn		0.208952
Avg. log likelihood	-0.040204	LR stat. (5 variables)		9.235450
Prob. (LR stat.)	0.415830	McFadden R^2		0.535301
Observations : Dep=0 /1	147 / 2	Total		149

Prediction evaluation (cut-off C = 0.5)			
		Estimated prob.	
	Dep=0	Dep=1	Total
P(Dep=1)≤C	146	1	147
P(Dep=1)>C	1	1	2
Total	147	2	149
Correct	146	1	147
% Correct	99.32	50.00	98.66
% Incorrect	0.68	50.00	1.34
Prediction evaluation (cut-off C = 0.25)			
P(Dep=1)≤C	146	1	147
P(Dep=1)>C	1	1	2
Total	147	2	149
Correct	146	1	147
% Correct	99.32	50.00	98.66
% Incorrect	0.68	50.00	1.34
Prediction evaluation (cut-off C = 0.2)			
P(Dep=1)≤C	145	0	145
P(Dep=1)>C	2	2	4
Total	147	2	149
Correct	145	2	147
% Correct	98.64	100.00	98.66
% Incorrect	1.36	0.00	1.34

Table 15. The final model estimated with twelve-month lagged crisis indicators

Dependent variable: ISP1>3SD / Sample (adjusted): 1991M02 2002M12 – 143 Observations				
Variable	**Coeff.**	**Std. error**	**z-Stat.**	**Prob.**
C	-25.78749	15.62668	-1.565891	0.1174
DISE_12	-0.003772	0.002394	-1.575334	0.1152
RER-hpRER_12	-33.84496	16.13256	-1.736689	0.0689
CA/GDP_12	-32.20064	15.90156	-2.009257	0.0272
TOT_12	-39.36170	26.65560	-1.476676	0.1098
DNIRUS_12	13.41450	10.42751	1.586453	0.0983
IFF_12	0.826694	0.346368	1.931910	0.0280
Mean dependent variable	0.014085	Std. deviation of dependent variable		0.118257
Std. error of regression	0.081690	Akaike		0.109665
Log likelihood	-2.786212	Schwarz		0.213743
Restr. log likelihood	-10.51121	Hannan-Quinn		0.151958
Avg. log likelihood	-0.019621	LR stat. (6 variables)		15.44999
Prob. (LR stat.)	0.003853	McFadden R^2		0.674929
Observations : Dep=0 /1	141 / 2	Total		143

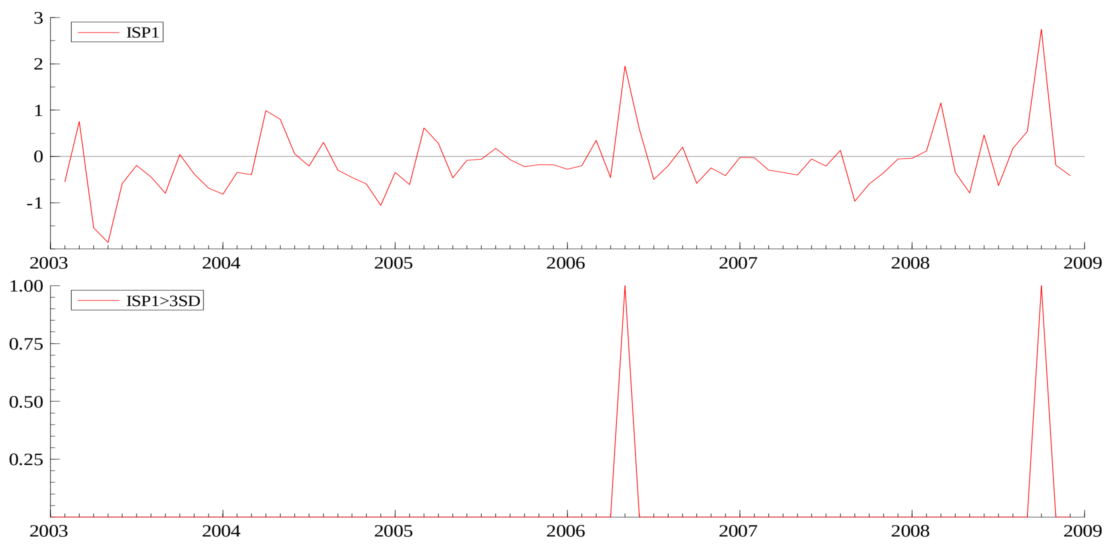
Prediction evaluation (cut-off C = 0.5)			
		Estimated prob.	
	Dep=0	Dep=1	Total
P(Dep=1)≤C	140	1	141
P(Dep=1)>C	1	1	2
Total	141	2	143
Correct	140	1	141
% Correct	99.30	50.00	98.59
% Incorrect	0.70	50.00	1.41
Prediction evaluation (cut-off C = 0.25)			
P(Dep=1)≤C	140	1	141
P(Dep=1)>C	1	1	2
Total	141	2	143
Correct	140	1	141
% Correct	99.30	50.00	98.59
% Incorrect	0.70	50.00	1.41
Prediction evaluation (cut-off C = 0.2)			
P(Dep=1)≤C	140	0	140
P(Dep=1)>C	1	2	3
Total	141	2	143
Correct	140	2	142
% Correct	99.30	100.00	99.60
% Incorrect	0.70	0.00	0.70

V.4. Out-of-sample results and forecasts

Since Berg and Pattillo's (1998, 1999) justified criticisms formulated against the predictive power of the EWS models that are only estimated in-sample (estimating a model using data on a set of crises and then evaluating its performance according to the estimated results and to the prediction ability), it has become frequent to test the forecast performance of the EWSs out-of-sample given that "the key is the prediction of futures crises, not the ability to fit a set of observations after the fact" as stated in Berg and Pattillo (1999). A 'good' EWS model should thus provide both successful in-sample and out-of-sample predictions. However, as the determinants of the crises may vary significantly through time, a good EWS model in-sample may not be quite performing in predicting out-of-sample crises. This observation hence tones down in part Berg and Pattillo's criticisms.

I hereby evaluate the out-of-sample predictive performance of the logit model by estimating it in a sample period (2003:01-2008:12). The goal is to demonstrate whether the model predicts the May 2006 and October 2008 currency crises.[14] In that sense, I firstly construct a crisis index of $ISP1$ type which defines currency crises as episodes of high speculative pressures on currency. I secondly set a crisis threshold at three standard deviations $3\sigma_{ISP1}$ above the index mean μ_{ISP1}. This index perfectly detects both Turkish crises as shown on the below Figure 9.

Figure 9. The crisis index ISP1 for the period 2003-2008



[14] These data are also gathered from the IFS (January 2009) and the CBRT.

Table 16. The crisis indicators of the out-of-sample model (2003:01-2008:12)

Dependent Variable: ISP1>3SD / Sample (adjusted): 2003M03 2008M12 – 70 Observations				
Variable	**Coeff.**	**Std. error**	**z-Stat.**	**Prob.**
C	95.48652	114.2935	0.835450	0.4035
BUDGET/GDP	-58.63212	41.39370	-1.658033	0.0973
M2/RES	-0.360438	1.892620	-0.190444	0.8490
RER-hpRER	-69.74268	44.34187	-1.205470	0.1609
SHORTDEBT/RES	-4.200362	15.73407	-0.266960	0.7895
TOT	-57.08049	38.16238	-1.319352	0.1536
IFF	1.072229	0.778991	1.348105	0.1309
Mean dependent variable	0.028571	Std. deviation of dependent variable		0.167802
Std. error of regression	0.123421	Akaike		0.209000
Log likelihood	-3.814993	Schwarz		0.333849
Restr. log likelihood	-9.081849	Hannan-Quinn		0.198313
Avg. log likelihood	-0.054500	LR stat. (6 variables)		10.53371
Prob. (LR stat.)	0.103902	McFadden R²		0.579932
Observations: Dep=0 /1	68 / 2	Total		70

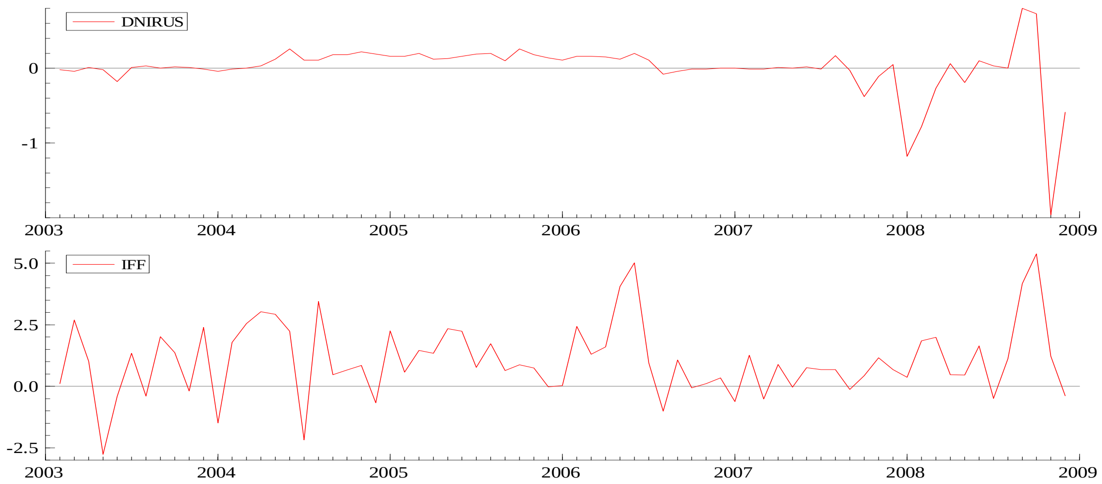
Prediction evaluation (cut-off C = 0.5)			
		Estimated prob.	
	Dep=0	Dep=1	Total
P(Dep=1)≤C	68	1	69
P(Dep=1)>C	0	1	1
Total	68	2	70
Correct	68	1	69
% Correct	100.00	50.00	98.57
% Incorrect	0.00	50.00	1.43
Prediction evaluation (cut-off C = 0.25)			
P(Dep=1)≤C	68	1	69
P(Dep=1)>C	0	1	1
Total	68	2	70
Correct	68	1	69
% Correct	100.00	50.00	98.57
% Incorrect	0.00	50.00	1.43
Prediction evaluation (cut-off C = 0.2)			
P(Dep=1)≤C	68	1	69
P(Dep=1)>C	0	1	1
Total	68	2	70
Correct	68	1	69
% Correct	100.00	50.00	98.57
% Incorrect	0.00	50.00	1.43

Table 17. The crisis indicators of the out-of-sample model (2003:01-2008:12) with FDI/PORTINVEST

Dependent Variable: ISP1>3SD / Sample (adjusted): 2003M03 2008M12 – 70 Observations				
Variable	**Coeff.**	**Std. error**	**z-Stat.**	**Prob.**
C	-7.843685	3.381883	-2.319324	0.0204
BUDGET/GDP	-85.06436	59.06183	-1.440260	0.1498
M2/RES	-0.560843	1.818847	-0.308351	0.7578
RER-hpRER	-57.65646	34.80437	-1.152041	0.1728
SHORTDEBT/RES	-2.139991	15.49886	-0.138074	0.8902
FDI/PORTINVEST	0.048669	0.013812	1.762690	0.0456
TOT	-50.00318	31.69397	-1.445460	0.1150
IFF	1.436961	0.838823	1.713069	0.0867
Mean dependent variable	0.028571	Std. deviation of dependent variable		0.167802
Std. error of regression	0.121566	Akaike		0.176770
Log likelihood	-3.186967	Schwarz		0.273135
Restr. log likelihood	-9.081849	Hannan-Quinn		0.185047
Avg. log likelihood	-0.045528	LR stat. (7 variables)		11.78976
Prob. (LR stat.)	0.002754	McFadden R^2		0.649084
Observations: Dep=0 /1	68 / 2	Total		70

Prediction evaluation (cut-off C = 0.5)			
		Estimated prob.	
	Dep=0	Dep=1	Total
P(Dep=1)≤C	68	1	69
P(Dep=1)>C	0	1	1
Total	68	2	70
Correct	68	1	69
% Correct	100.00	50.00	98.57
% Incorrect	0.00	50.00	1.43
Prediction evaluation (cut-off C = 0.25)			
P(Dep=1)≤C	67	0	67
P(Dep=1)>C	1	2	3
Total	68	2	70
Correct	67	2	69
% Correct	98.53	100.00	99.27
% Incorrect	1.47	0.00	2.86
Prediction evaluation (cut-off C = 0.2)			
P(Dep=1)≤C	67	0	67
P(Dep=1)>C	1	2	3
Total	68	2	70
Correct	67	2	69
% Correct	98.53	100.00	99.27
% Incorrect	1.47	0.00	2.86

Figure 10. Evolution of the explanatory variables of the out-of-sample models



The out-of-sample logit model is estimated with six significant indicators of the one-month lagged final model (Table 9). The estimation results presented in Table 16 indicate that only 4 indicators among 6 ($BUDGET/GDP$, $RER-hpRER$, TOT and IFF) are correctly signed and statistically significant at 15% level, contrary to $M2/RES$ and $SHORTDEBT/RES$. However, the model only predicts the occurrence of the October 2008 currency crisis, not the Mai 2006 crisis. It is only after the inclusion of $FDI/PORTINVEST$ that the model reaches to predict the 2006 crisis at 25% threshold level (Table 17). Note that the inclusion of a proxy indicator represents financial contagion might increase the forecast performance of the model.

After showing the 'good' out-of-sample forecast performance of the model estimated with one-month lagged indicators, I aim here to demonstrate how far in advance the model correctly predicts Turkish out-of-sample crisis episodes. In this sense, I estimate successive logit models with three ($t-3$)-, six ($t-6$)- and twelve-month ($t-12$) lagged early warning indicators while the dependent crisis variable remains at t. Note that the model is estimated with only significant indicators of the three-, six- and twelve-month lagged final models (Tables 13, 14 and 15). Firstly, as indicated in Table 18, $BUDGET/GDP$, $RER-hpRER$, $FDI/PORTINVEST$ and TOT remain economically and statistically significant contrary to $M2/RES$, $SHORTDEBT/RES$ and IFF . Moreover, the model reaches to predict the outbreak of the 2008 Turkish crisis, but not the 2006 crisis. Secondly, as indicated in Table 19, $RER-hpRER$, TOT and $NIRUS$ are still significant contrary to $SHORTDEBT/RES$ and IFF . Besides, the model predicts the occurrence of the 2008 crisis, but not the 2006 crisis. Finally, as indicated in Table 20, only two indicators ($NIRUS$ and IFF) are significant at twelve month lag. Furthermore, the probability of the 2008 crisis is again correctly signalled by the model contrary to the probability of the 2006 crisis which remains unpredictable at three-, six- and twelve-month lags. This may be explained by the poor performance of the model, by the self-fulfilling character of this crisis or the transformation of the Turkish economy that the model cannot take into account.

Table 18. The out-of-sample model estimated with three-month lagged crisis indicators (2003:01-2008:12)

Dependent Variable: ISP1>3SD / Sample (adjusted): 2003M05 2008M12 – 68 Observations				
Variable	**Coeff.**	**Std. error**	**z-Stat.**	**Prob.**
C	57.22585	78.86899	0.725581	0.4681
BUDGET/GDP_3	-28.34477	20.86522	-1.387702	0.1350
M2/RES_3	0.430702	1.961427	0.219586	0.8262
RER-hpRER_3	-77.79496	56.91523	-1.466857	0.1117
SHORTDEBT/RES_3	5.766734	11.07589	0.520657	0.6026
FDI/PORTINVEST_3	-0.087160	0.062647	-1.212408	0.1716
TOT_3	-72.77358	58.14690	-1.301241	0.1517
IFF_3	0.684474	0.630666	0.992506	0.3699
Mean dependent variable	0.029412	Std. deviation of dependent variable		0.170214
Std. error of regression	0.141830	Akaike		0.385739
Log likelihood	-5.115111	Schwarz		0.646857
Restr. log likelihood	-9.023017	Hannan-Quinn		0.489202
Avg. log likelihood	-0.045528	LR stat. (7 variables)		7.815812
Prob. (LR stat.)	0.199115	McFadden R^2		0.433104
Observations: Dep=0 /1	66 / 2	Total		68

Prediction evaluation (cut-off C = 0.5)			
		Estimated prob.	
	Dep=0	Dep=1	Total
P(Dep=1)≤C	66	1	67
P(Dep=1)>C	0	1	1
Total	66	2	68
Correct	66	1	67
% Correct	100.00	50.00	98.53
% Incorrect	0.00	50.00	1.47
Prediction evaluation (cut-off C = 0.25)			
P(Dep=1)≤C	65	1	66
P(Dep=1)>C	1	1	2
Total	66	2	68
Correct	65	1	66
% Correct	98.48	50.00	97.06
% Incorrect	1.52	50.00	2.94
Prediction evaluation (cut-off C = 0.2)			
P(Dep=1)≤C	65	1	66
P(Dep=1)>C	1	1	2
Total	66	2	68
Correct	65	1	66
% Correct	98.48	50.00	97.06
% Incorrect	1.52	50.00	2.94

Table 19. The out-of-sample model estimated with six-month lagged crisis indicators

Dependent Variable: ISP1>3SD / Sample (adjusted): 2003M08 2008M12 – 65 Observations				
Variable	**Coeff.**	**Std. error**	**z-Stat.**	**Prob.**
C	61.86529	48.80553	1.267588	0.2049
RER-hpRER_6	-23.35229	18.40712	-1.108020	0.1932
SHORTDEBT/RES_6	-4.677878	9.107810	-0.513612	0.6075
TOT_6	-67.10417	51.98672	-1.490794	0.1068
DNIRUS_6	18.59298	12.59004	1.674361	0.0825
IFF_6	-0.694245	0.997066	-0.696287	0.4862
Mean dependent variable	0.030769	Std. deviation of dependent variable		0.174036
Std. error of regression	0.173417	Akaike		0.417947
Log likelihood	-6.583266	Schwarz		0.652111
Restr. log likelihood	-8.931390	Hannan-Quinn		0.510340
Avg. log likelihood	-0.101281	LR stat. (5 variables)		4.696249
Prob. (LR stat.)	0.283319	McFadden R^2		0.262907
Observations: Dep=0 /1	63 / 2	Total		65

Prediction evaluation (cut-off C = 0.5)			
		Estimated prob.	
	Dep=0	Dep=1	Total
P(Dep=1)≤C	63	2	65
P(Dep=1)>C	0	0	0
Total	63	2	65
Correct	63	0	63
% Correct	100.00	0.00	96.92
% Incorrect	0.00	100.00	3.08
Prediction evaluation (cut-off C = 0.25)			
P(Dep=1)≤C	61	1	62
P(Dep=1)>C	2	1	3
Total	63	2	65
Correct	61	1	62
% Correct	96.83	50.00	95.38
% Incorrect	3.17	50.00	4.62
Prediction evaluation (cut-off C = 0.2)			
P(Dep=1)≤C	61	1	62
P(Dep=1)>C	2	1	3
Total	63	2	65
Correct	61	1	62
% Correct	96.83	50.00	95.38
% Incorrect	3.17	50.00	4.62

Table 20. The out-of-sample model estimated with twelve-month lagged crisis indicators

Dependent Variable: ISP1>3SD / Sample (adjusted): 2004M02 2008M12 – 59 Observations				
Variable	**Coeff.**	**Std. error**	**z-Stat.**	**Prob.**
C	61.86529	48.80553	1.267588	0.2049
DISE_12	-29.49632	60.89665	-0.484367	0.6281
RER-hpRER_12	0.000340	0.000481	0.707176	0.4795
CA/GDP_12	10.41111	35.59472	0.292490	0.7699
TOT_12	-34.18943	335.0912	-0.102030	0.9187
DNIRUS_12	25.43002	19.71288	1.499135	0.1398
IFF_12	12.18277	7.915082	1.539185	0.1238
Mean dependent variable	0.033898	Std. deviation of dependent variable		0.182521
Std. error of regression	0.147511	Akaike		0.428779
Log likelihood	-5.648995	Schwarz		0.675267
Restr. log likelihood	-8.734493	Hannan-Quinn		0.524998
Avg. log likelihood	-0.095746	LR stat. (6 variables)		6.170996
Prob. (LR stat.)	0.404310	McFadden R^2		0.353254
Observations: Dep=0 /1	57 / 2	Total		59

Prediction evaluation (cut-off C = 0.5)			
		Estimated prob.	
	Dep=0	Dep=1	Total
P(Dep=1)≤C	57	1	58
P(Dep=1)>C	0	1	1
Total	57	2	59
Correct	57	1	58
% Correct	100.00	50.00	98.31
% Incorrect	0.00	50.00	1.69
Prediction evaluation (cut-off C = 0.25)			
P(Dep=1)≤C	56	1	57
P(Dep=1)>C	1	1	2
Total	57	2	59
Correct	56	1	57
% Correct	99.10	50.00	97.31
% Incorrect	0.90	50.00	2.69
Prediction evaluation (cut-off C = 0.2)			
P(Dep=1)≤C	56	1	57
P(Dep=1)>C	1	1	2
Total	57	2	59
Correct	56	1	57
% Correct	99.10	50.00	97.31
% Incorrect	0.90	50.00	2.69

VI. Concluding remarks

This large theoretical and empirical study aimed at presenting the recent "history of crises" of the Turkish economy. After summarizing the stylized facts of the Turkish economy in the last three decades and then the developments of the theoretical and empirical currency crisis literature, I constructed an EWS model which identified very well the determinants of the four severe or less severe Turkish crisis episodes. Besides, the model performed quite well in predicting in-sample and out-of-sample these all four Turkish crises. This very good forecast performance of the model may push more the modelers to adopt one-country EWS approach.

Despite a relatively long 15 years period, i.e. the time between the first crisis occurred in April 1994 and the last one came out in October 2008, I can affirm according to the estimation results of the several logit models that the nearly same factors caused crises in the Turkish economy: excessive budget deficits ($BUDGET/GDP$), high money supply growths ($M2/RES$), real exchange rate overvaluations ($RER-hpRER$) sharp rises in short-term external debt ($SHORTDEBT/RES$), growing riskiness of the banking system (IFF, in particular currency and liquidity mismatches) and external adverse shocks (TOT and $NIRUS$). What may one draw then as a conclusion from these recurrent crisis events? Do not Turkish authorities take necessary pre-emptive economic and political measures? Are the so-called IMF supported structural reforms implemented since the 2001 crisis not enough to prevent repetitive crises in the Turkish economy? Are financial markets too sensitive to changes in the Turkish economy?

Whatever the conclusion or reason, Turkey needs first to reform its either economic and financial structure or political system, second to provide political and economic credibility for domestic and foreign investors with or without support of an external organization such as the IMF or the European Union (EU). In that sense, the Turkish membership perspective to EU gains a great importance. However, there is still considerable uncertainty in certain circles in Europe concerning Turkish membership even in a long-term (10 to 15 years). Note also that the recurrent crisis episodes and the last global financial crisis which has been affecting the whole planet also underline increasing instabilities in international financial markets in the globalization context in which the States' financial regulation and supervision ability has been excessively reduced. One can thus state that the world needs to restructure or redefine the international financial architecture or at least take a range of initiatives to strengthen it.

Appendix I. Descriptive statistics and correlation tests of the explanatory variables (January 1990-December 2002)

Table 21. Descriptive statistics

Indicator	DIPROD	DISE	DINFL	BUDGET /GDP	M2/RES	RER- hpRER	CA/GDP	SHORTDEBT /RES	FDI/ PORTI.	TOT	DNIRUS	BLOAN /BDEPO	BRES/ BASSET	BDEPO /M2	BSHORT POS	CBCRED /BLIAB	IFF
Mean	0.20576	76.6086	1.6203	-0.0223	2.36938	0.00362	-0.0012	1.41334	-5.9533	1.0772	-0.0440	1.716368	0.12528	1.89971	1.15717	0.029592	0.69503
Median	0.18220	6.25667	0.5488	-0.0261	1.69858	-0.0054	-0.0014	1.10625	-0.7878	1.0763	-0.0200	1.630095	0.12486	2.01848	1.13527	0.027875	0.59799
Max.	11.9207	4933.14	13.153	0.03508	5.67195	0.29401	0.00601	4.72112	48.3146	1.2602	0.63000	2.613611	0.20980	2.64664	2.25833	0.167605	8.26937
Min.	-13.470	-3199.7	-0.003	-0.0965	1.06557	-0.1282	-0.0079	0.59990	-277.35	0.9334	-0.8300	0.923075	0.06942	1.16553	0.64628	0.002447	-5.9635
St. Dev.	4.79573	906.685	2.3605	0.02796	1.14839	0.06276	0.00309	0.71441	29.2142	0.0760	0.21655	0.403156	0.03106	0.36003	0.32931	0.024050	1.70147
Skewness	-0.1616	1.81407	2.2643	-0.0567	0.98339	1.44680	0.28006	1.93928	-6.5317	0.1082	-0.4245	0.115002	0.35987	-0.5664	0.51453	2.142725	0.82383
Kurtosis	3.41021	13.6467	8.6623	2.29713	2.72700	6.29533	2.45028	7.75622	54.7992	2.1817	4.97200	2.159691	2.54954	2.23659	2.83647	11.72447	7.81785
Jarque-Bera	1.76219	817.081	339.51	3.27370	25.4638	124.207	3.97794	243.252	18430.9	4.6263	29.7719	4.902014	4.65605	12.0522	7.01202	610.1930	167.441
Sum	31.8942	11874.3	251.15	-3.4704	367.254	0.56160	-0.18952	219.068	-922.76	166.96	-6.8200	266.0370	19.4187	294.455	179.361	4.586768	107.730
Obs.	155	155	155	155	155	155	155	155	155	155	155	155	155	155	155	155	155

Table 22. Correlation matrix

Indicator	DIPROD	DISE	DINFL	BUDGET /GDP	M2/RES	RER- hpRER	CA/GDP	SHORTDEBT /RES	FDI/ PORTI.	TOT	DNIRUS	BLOAN /BDEPO	BRES/ BASSET	BDEPO /M2	BSHORT POS	CBCRED /BLIAB
DIPROD	1.00000	0.0736	0.01345	0.06819	0.00023	-0.0628	-0.0703	-0.057052	0.09899	-0.0402	-0.0495	-0.0802	0.00961	-0.0022	0.05591	-0.10636
DISE	0.07366	1.0000	0.21179	0.01337	-0.0586	-0.0145	-0.0930	-0.067738	0.07126	-0.0125	-0.0759	0.0543	-0.0367	0.0222	-0.0624	-0.01440
DINFL	0.01345	0.2117	1.00000	-0.5178	-0.4358	0.30634	0.26296	-0.396607	-0.0903	-0.5911	-0.2608	0.3433	-0.6230	0.5958	-0.4617	0.470703
BUDGET/GDP	0.06819	0.0133	-0.5178	1.00000	0.57866	-0.2030	-0.2917	0.282522	0.16999	0.60872	-0.0110	-0.3957	0.51743	-0.6665	0.24151	-0.29728
M2/RES	0.00023	-0.058	-0.4358	0.57866	1.00000	-0.0297	-0.1439	0.683882	-0.1146	0.48830	-0.1404	-0.4204	0.65145	-0.7500	0.33771	0.056499
RER-hpRER	-0.0628	-0.014	0.30634	-0.2030	-0.0297	1.00000	0.51112	0.194401	-0.1533	-0.2369	-0.0023	0.0970	0.00610	0.2123	0.10267	0.088186
CA/GDP	-0.0703	-0.093	0.26296	-0.2917	-0.1439	0.51112	1.00000	0.043372	-0.0533	-0.2155	-0.0878	0.0328	-0.0481	0.2648	0.19325	0.039641
SHORTDEBT/RES	-0.0570	-0.067	-0.3966	0.28252	0.68388	0.19440	0.04337	1.000000	-0.0230	0.51382	0.12341	-0.1534	0.40460	-0.4486	0.25767	0.030128
FDI/PORTINVEST	0.09899	0.0712	-0.0903	0.16999	-0.1146	-0.1533	-0.0533	-0.023021	1.00000	0.08419	0.19508	-0.0389	-0.0225	0.1171	0.03545	-0.36473
TOT	-0.0402	-0.012	-0.5911	0.60872	0.48830	-0.2369	-0.2155	0.513821	0.08419	1.00000	0.10420	-0.0951	0.37603	-0.5108	0.05810	-0.14332
DNIRUS	-0.0495	-0.075	-0.2608	-0.0110	-0.1404	-0.0023	-0.0878	0.123413	0.19508	0.10420	1.00000	-0.0950	0.11853	0.1034	0.12312	-0.28266

BLOAN/BDEPO	-0.0802	0.0543	0.34331	-0.3957	-0.4204	0.09704	0.03284	-0.153446	-0.0389	-0.0951	-0.0950	1.0000	-0.6817	0.5416	-0.6301	0.527383
BRES/BASSET	0.00961	-0.036	-0.6230	0.51743	0.65145	0.00610	-0.0481	0.404607	-0.0225	0.37603	0.11853	-0.6817	1.00000	-0.7749	0.75909	-0.35527
BDEPO/M2	-0.0022	0.0222	0.59583	-0.6665	-0.7500	0.21235	0.26482	-0.448686	0.11717	-0.5108	0.10341	0.5416	-0.7749	1.0000	-0.4679	0.060189
BSHORTPOS	0.05591	-0.062	-0.4617	0.24151	0.33771	0.10267	0.19325	0.257673	0.03545	0.05810	0.12312	-0.6301	0.75909	-0.4679	1.00000	-0.46722
CBCRED/BLIAB	-0.10636	-0.014	0.47070	-0.2972	0.05649	0.08818	0.03964	0.030128	-0.3647	-0.1433	-0.28266	0.5273	-0.35527	0.0601	-0.46722	1.000000

Table 23. Correlation matrix with IFF

Indicator	DIPROD	DISE	DINFL	BUDGET/GDP	M2/RES	RER-hpRER	CA/GDP	SHORTDEBT/RES	FDI/PORTI.	TOT	DNIRUS	IFF
DIPROD	1.000000	0.073665	0.013456	0.068194	0.00023	-0.062845	-0.070381	-0.057052	0.098993	-0.040256	-0.049574	0.07258
DISE	0.073665	1.000000	0.211790	0.013370	-0.05866	-0.014562	-0.093000	-0.067738	0.071266	-0.012593	-0.075983	-0.13418
DINFL	0.013456	0.211790	1.000000	-0.517853	-0.43582	0.306342	0.262969	-0.396607	-0.090306	-0.591115	-0.260879	-0.26660
BUDGET/GDP	0.068194	0.013370	-0.517853	1.000000	0.57866	-0.203071	-0.291772	0.282522	0.169997	0.608729	-0.011019	-0.02581
M2/RES	0.000231	-0.058665	-0.435829	0.578667	1.00000	-0.029737	-0.143946	0.683882	-0.114627	0.488308	-0.140430	0.05363
RER/HPRER	-0.062845	-0.014562	0.306342	-0.203071	-0.02973	1.000000	0.511129	0.194401	-0.153339	-0.236957	-0.002345	-0.08278
CA/GDP	-0.070381	-0.093000	0.262969	-0.291772	-0.14394	0.511129	1.000000	0.043372	-0.053311	-0.215559	-0.087882	-0.21456
SHORTDEBT/RES	-0.057052	-0.067738	-0.396607	0.282522	0.68388	0.194401	0.043372	1.000000	-0.023021	0.513821	0.123413	0.18140
FDI/PORTINVEST	0.098993	0.071266	-0.090306	0.169997	-0.11462	-0.153339	-0.053311	-0.023021	1.000000	0.084190	0.195082	-0.03055
TOT	-0.040256	-0.012593	-0.591115	0.608729	0.48830	-0.236957	-0.215559	0.513821	0.084190	1.000000	0.104206	0.05861
DNIRUS	-0.049574	-0.075983	-0.260879	-0.011019	-0.14043	-0.002345	-0.087882	0.123413	0.195082	0.104206	1.000000	-0.00701
IFF	0.072580	-0.134188	-0.266604	-0.025811	0.05363	-0.082783	-0.214566	0.181405	-0.030555	0.058615	-0.007011	1.00000

Appendix II. Descriptive statistics and correlation tests of the explanatory variables (January 2003-December 2008)

Table 24. Descriptive statistics

Indicator	DIPROD	DISE	DINFL	BUDGET/GDP	M2/RES	RER-hpRER	CA/GDP	SHORTDEBT/RES	FDI/PORTI.	TOT	DNIRUS	IFF
Mean	-0.001859	210.6325	2.991789	-0.012393	2.826996	-0.008900	-0.004236	0.720288	1.206710	0.948975	0.006761	1.049386
Median	0.785000	529.9323	2.839000	-0.027335	3.082499	-0.008457	-0.004814	0.710432	-1.950786	0.948582	0.030000	0.877376
Max.	17.74400	5976.645	11.87300	0.069156	4.327765	0.069859	0.002973	0.962977	234.0564	1.007840	0.800000	5.376024
Min.	-19.55400	-8393.082	-2.990000	-0.106026	1.389426	-0.074683	-0.009389	0.545467	-147.0232	0.866511	-1.960000	-2.764689
St. Deviation	6.626495	2590.973	2.802100	0.048402	0.892763	0.035234	0.002483	0.108236	36.75010	0.030485	0.348100	1.470265
Skewness	-0.352747	-0.706926	0.339172	0.215208	-0.000494	0.137993	0.712663	0.298114	2.679192	-0.415434	-3.092053	0.450164
Kurtosis	4.402079	4.316412	3.260710	2.133916	1.578985	2.780914	3.356327	2.177836	27.57263	2.995680	17.94256	4.030551
Jarque-Bera	7.287988	11.04026	1.562355	2.767105	5.973721	0.367327	6.385629	3.051349	1871.223	2.042316	773.6727	5.539853
Sum	-0.132000	14954.90	212.4170	-0.879881	200.7167	-0.631878	-0.300749	51.14044	85.67643	67.37724	0.480000	74.50643
Observations	71	71	71	71	71	71	71	71	71	71	71	71

Table 25. Correlation matrix

Indicator	DIPROD	DISE	DINFL	BUDGET/GDP	M2/RES	RER-hpRER	CA/GDP	SHORTDEBT/RES	FDI/PORTI.	TOT	DNIRUS	IFF
DIPROD	1.000000	-0.127825	0.062666	0.107642	-0.067369	-0.137815	-0.111994	0.003025	-0.003021	0.113124	-0.008392	0.071904
DISE	-0.127825	1.000000	-0.229499	-0.109868	-0.196528	-0.268987	0.101996	0.044771	0.129318	0.305499	0.130491	-0.42963
DINFL	0.062666	-0.229499	1.000000	0.074682	-0.016929	0.166442	-0.033094	-0.038307	0.104438	-0.258504	-0.004645	0.181206
BUDGET/GDP	0.107642	-0.109868	0.074682	1.000000	0.009270	-0.003096	0.051960	-0.012716	-0.125058	-0.074608	-0.153614	-0.11007
M2/RES	-0.067369	-0.196528	-0.016929	0.009270	1.000000	0.305257	-0.368134	-0.372079	0.056881	-0.726612	-0.235606	-0.00269
RER-hpRER	-0.137815	-0.268987	0.166442	-0.003096	0.305257	1.000000	-0.068486	0.128662	-0.223383	-0.581183	-0.014536	0.290281
CA/GDP	-0.111994	0.101996	-0.033094	0.051960	-0.368134	-0.068486	1.000000	0.196567	-0.063707	0.139481	-0.004203	-0.10431
SHORTDEBT/RES	0.003025	0.044771	-0.038307	-0.012716	-0.372079	0.128662	0.196567	1.000000	-0.018407	0.202048	0.305593	0.179975
FDI/PORTINVEST	-0.003021	0.129318	0.104438	-0.125058	0.056881	-0.223383	-0.063707	-0.018407	1.000000	-0.052661	0.015822	-0.14327
TOT	0.113124	0.305499	-0.258504	-0.074608	-0.726612	-0.581183	0.139481	0.202048	-0.052661	1.000000	0.244214	-0.05943
DNIRUS	-0.008392	0.130491	-0.004645	-0.153614	-0.235606	-0.014536	-0.004203	0.305593	0.015822	0.244214	1.000000	0.239513
IFF	0.071904	-0.429631	0.181206	-0.110074	-0.002698	0.290281	-0.104310	0.179975	-0.143272	-0.059430	0.239513	1.000000

Appendix III. Forecast performance of the consecutive logit models

Figure 11. Forecast performance of the logit model estimated only with public and real sector variables

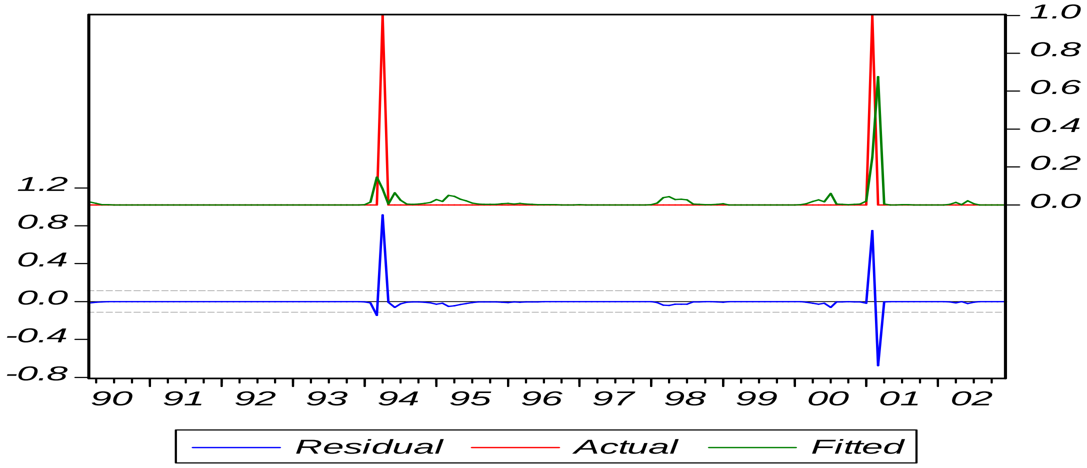


Figure 12. Forecast performance of the logit model estimated only with external balance and capital flows variables

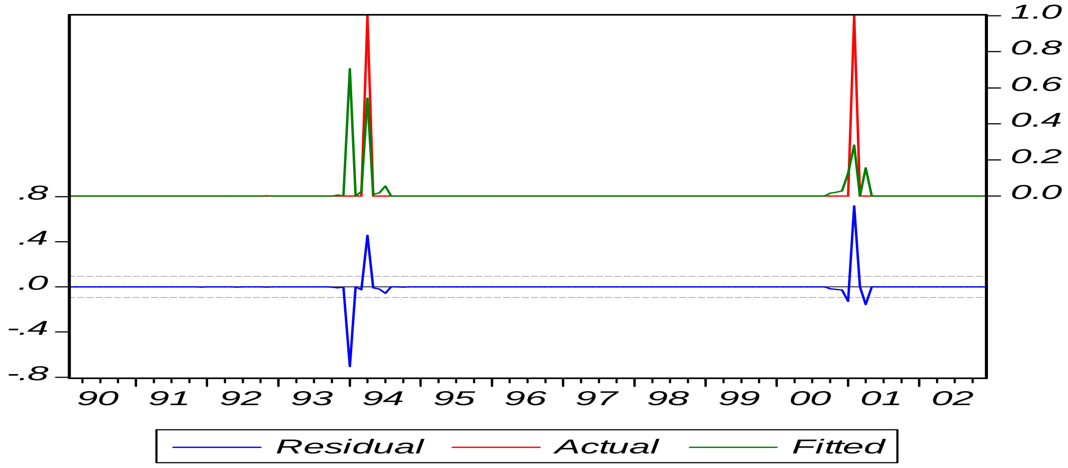


Figure 13. Forecast performance of the logit model estimated only with financial sector variables

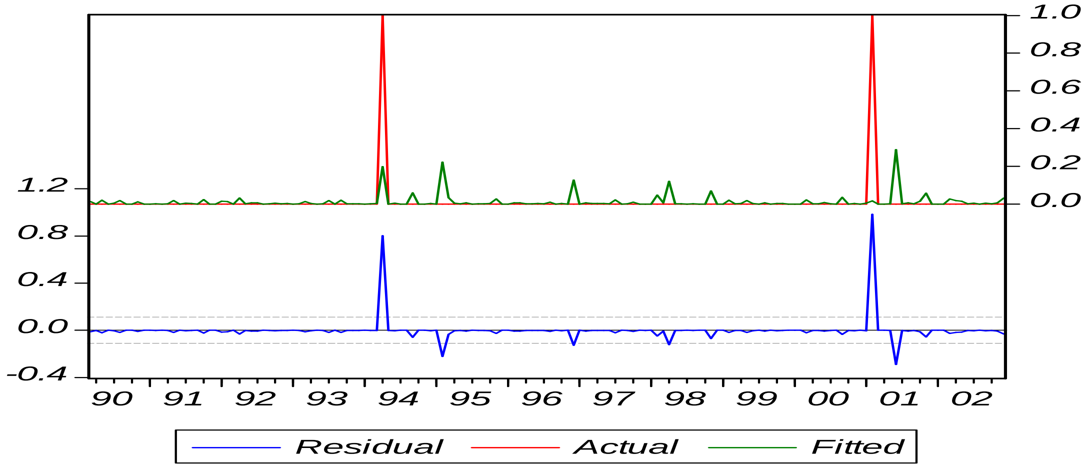


Figure 14. Forecast performance of the final logit model

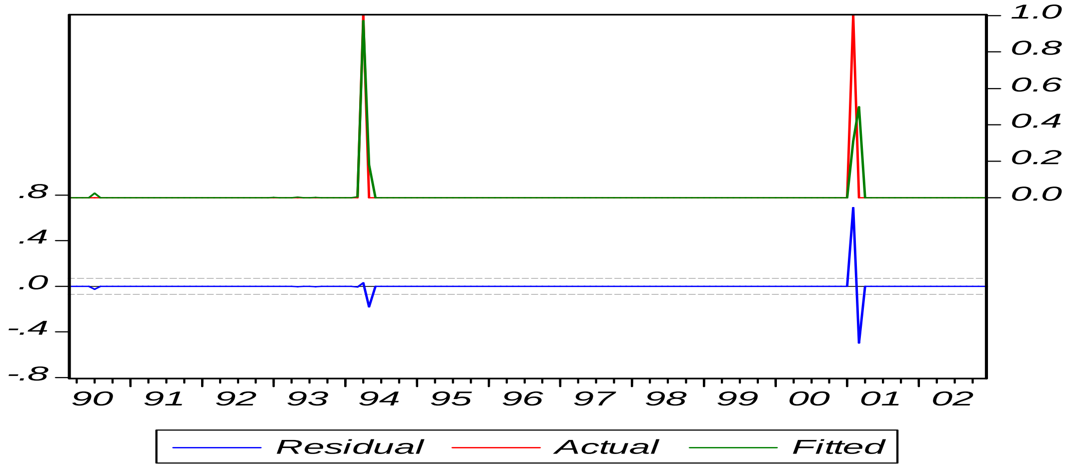


Figure 15. Forecast performance of the final logit model with three-month lagged indicators

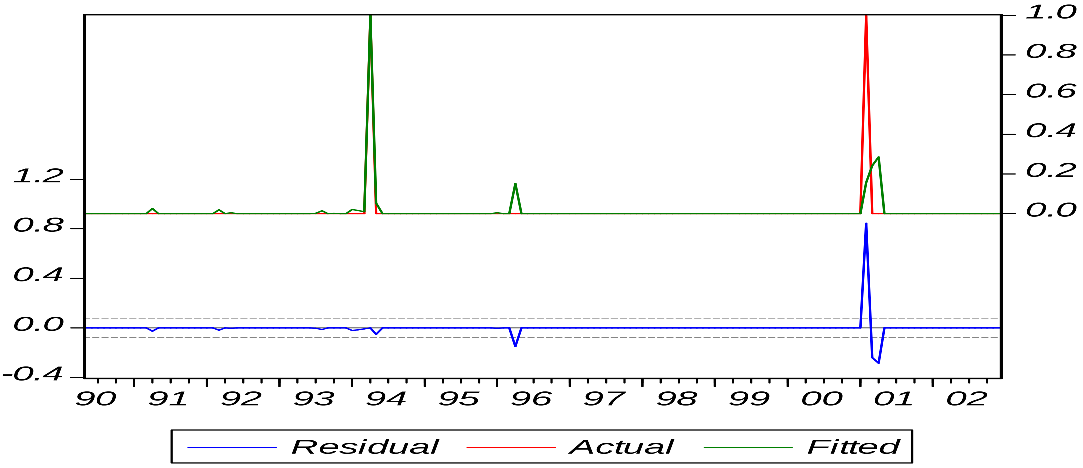


Figure 16. Forecast performance of the final logit model with six-month lagged indicators

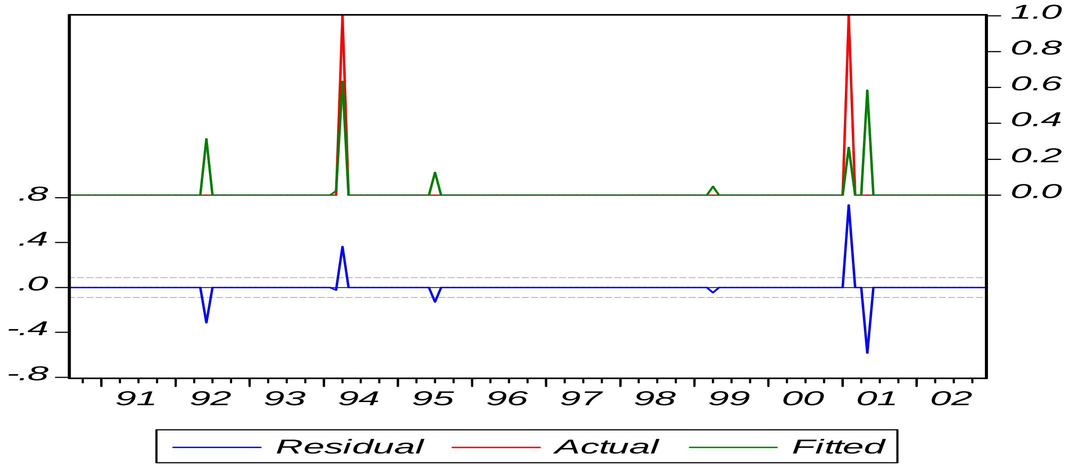


Figure 17. Forecast performance of the final logit model with twelve-month lagged indicators

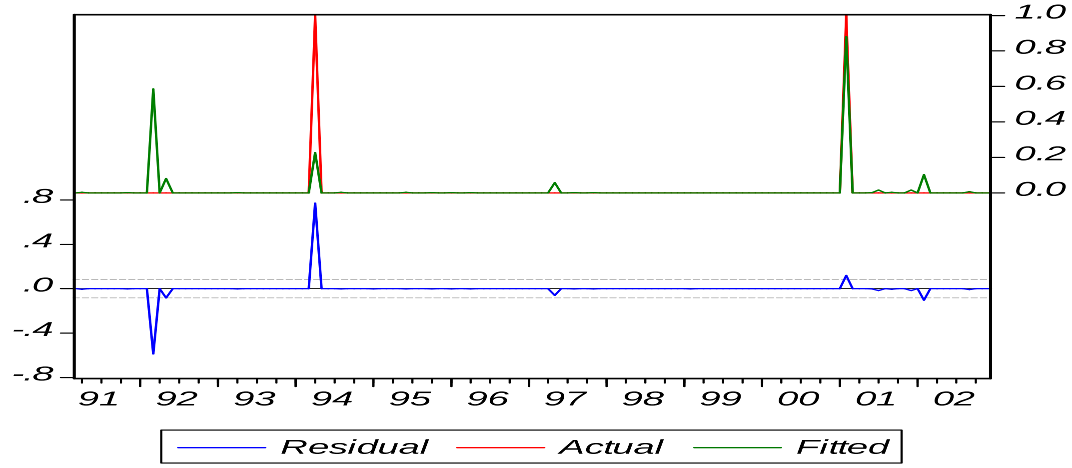


Figure 18. Forecast performance of the out-of-sample logit model

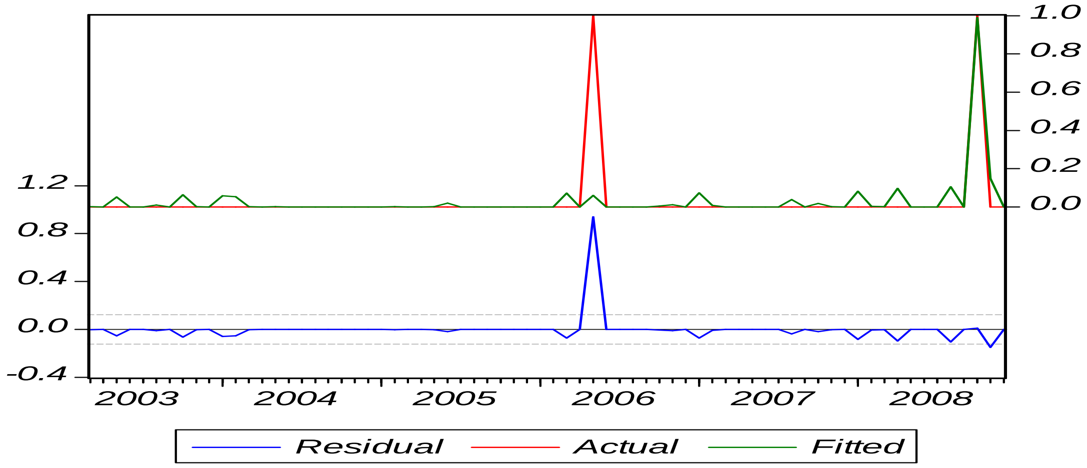


Figure 19. Forecast performance of the out-of-sample logit model with FDI/PORTINVEST

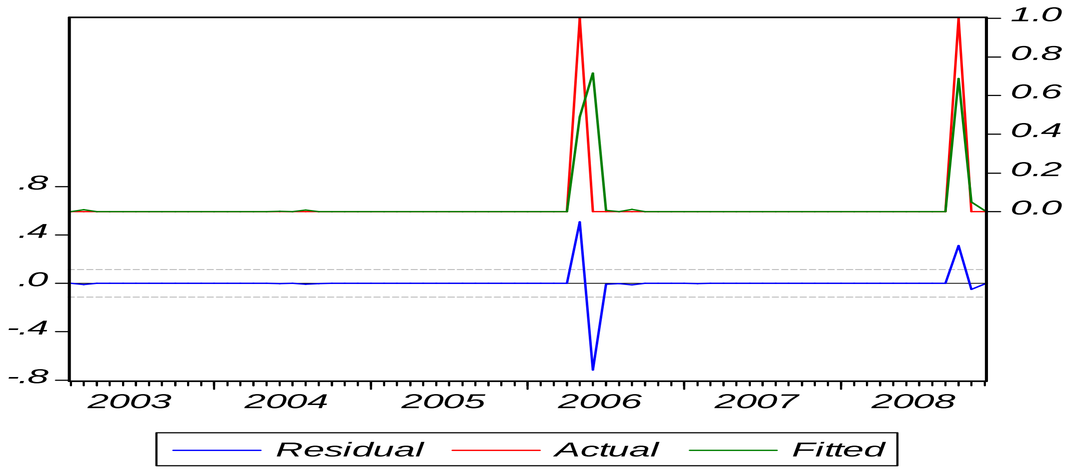


Figure 20. Forecast performance of the out-of-sample logit model with three-month lagged indicators

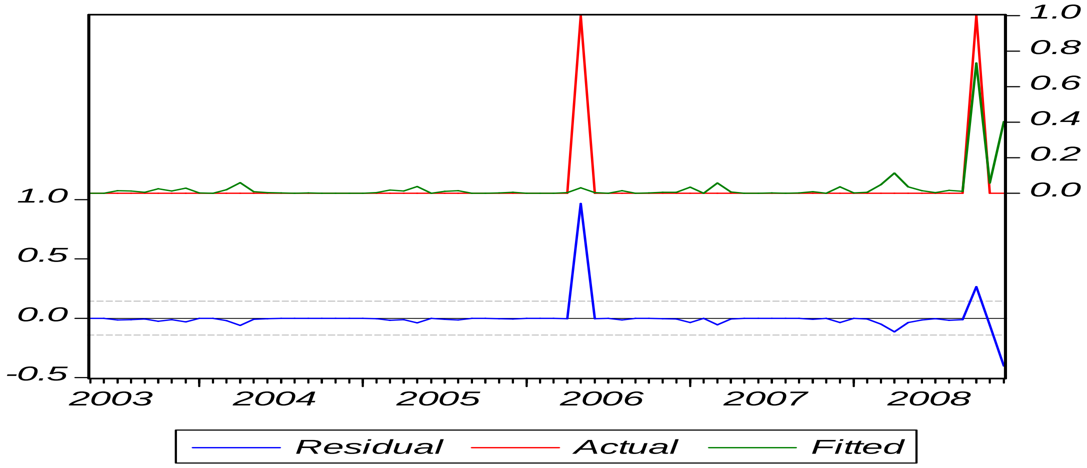


Figure 21. Forecast performance of the out-of-sample logit model with six-month lagged indicators

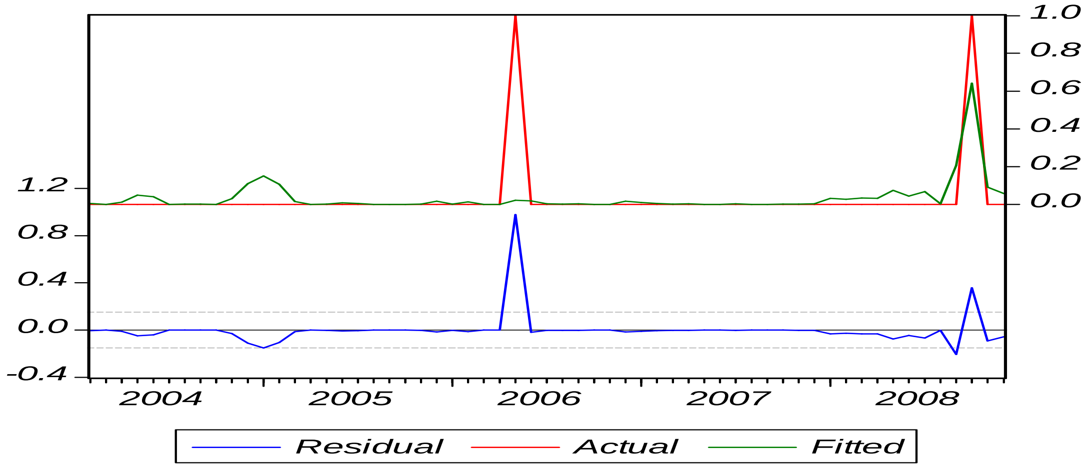
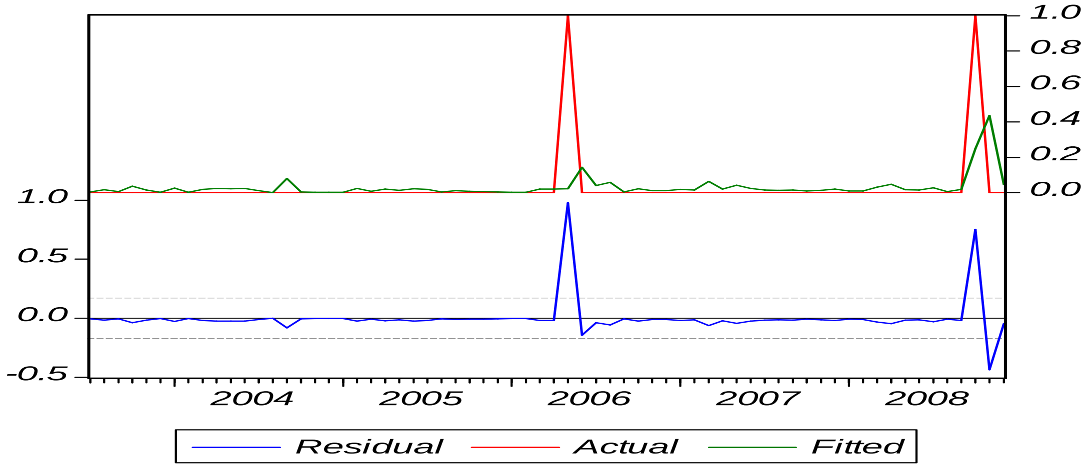


Figure 22. Forecast performance of the out-of-sample logit model with twelve-month lagged indicators



References

Abiad A.G. (1999), Early warning systems for currency crises: A Markov-switching approach with application to South Asia, *Mimeo,* University of Pennsylvania.

Abiad A.G. (2003), Early warning systems: A survey and a regime-switching approach, *IMF Working Paper,* 03-32.

Agénor P.R., Bhandari J.S. and Flood R.P. (1992), Speculative attacks and models of balance of payments crises, *NBER Working Paper,* 3919.

Agénor P.R., McDermott C.J. and Ucer E.M (1997), Fiscal imbalances, capital inflows, and the real exchange rate: The case of Turkey, *IMF Working Paper*, 97-1.

Aghion P., Bacchetta P. and Banerjee A. (2000), A simple model of monetary policy and currency crises, *European Economic Review,* 44, pp.728-738.

Aghion P., Bacchetta P. and Banerjee A. (2001), A corporate balance sheet approach to currency crises, *Studienzentrum Gerzensee Working Paper,* 01-05.

Akcay C. O., Alper C. E. and Ozmucur S. (2001), Budget deficit, inflation and debt sustainability: Evidence from Turkey (1970-2000), *Bogazici University Discussion Paper,* 01-12.

Akyuz Y. and Boratav K. (2003), The making of the Turkish financial crisis, *World Development,* 31-9, pp.1549-1566.

Antczak R. (2000), Theoretical aspects of currency crises, *CASE Studies & Analyses,* 211.

Ari A. and Dagtekin R. (2007), Les indicateurs d'alerte de la crise financière de 2000-2001 en Turquie : Elaboration d'un modèle de prévision de crise jumelle, *Région et Développement,* 26, pp.35-51.

Ari A. and Dagtekin R. (2008), Early warning signals of the 2000/2001 Turkish financial crisis, *International Journal of Emerging and Transition Economies,* 1-2, pp.191-218.

Arias G. (2003), Currency crises: What we know what we need to know, *CEFI Working Paper,* 2003-13.

Aricanli T. and Rodrik D. (1990), « The political economy of Turkey: Debt, adjustment and sustainability », London, *Palgrave MacMillan*.

Aziz J., Caramazza F. and Salgado R. (2000), Currency crises: In search of common elements, *IMF Working Paper,* 00-67.

Berg A. and Pattillo C. (1998), Are currency crises predictable? A test, *IMF Working Paper,* 98-154.

Berg A. and Pattillo C. (1999), Predicting currency crises: The indicators approach and an alternative, *Journal of International Money and Finance*, 18, pp.561-586.

Berg A., Borensztein E. and Pattillo C. (2004), Assessing early warning systems: How they worked in practice?, *IMF Working Paper*, 04-52.

Blackburn K. and Sola M. (1993), Speculative currency attacks and balance of payments crises, *Journal of Economic Surveys*, 7, pp.119-144.

Blanco H. and Garber P.M. (1986), Recurrent devaluation and speculative attacks on the Mexican peso, *Journal of Political Economy*, 94, pp.148-166.

Boratav K. (2001), 2000-2001 krizinde sermaye hareketleri, *Iktisat, Isletme ve Finans*, 186, pp.7-18.

Boratav K. and Yeldan E. (2002) Turkey, 1980-2000: Financial liberalization, macroeconomic (in)stability and patterns of distribution, *Mimeo*, CEPA New School for Social Research.

Burkart O. and Coudert V. (2000), Currency crises in the emerging economies, *Bulletin de la Banque de France*, 74, pp.21-32.

Burkart O. and Coudert V. (2002), Leading indicators of currency crises for emerging economies, *Emerging Markets Review*, 3, pp.107-133.

Burnside C., Eichenbaum M. and Rebelo S. (2004), Government guaranties and self-fulfilling speculative attacks, *Journal of Economic Theory*, 119-1, pp.31-63.

Bussière M. (2007), Balance of payment crises in emerging markets: How early were the “early” warning signals, *European Central Bank Working Paper Series*, 713.

Bussière M. and Fratzscher M. (2002), Towards a new early warning system of financial crises, *European Central Bank Working Paper Series*, 145.

Bussière M. and Mulder C. (1999a), Political instability and economic vulnerability, *IMF Working Paper*, 99-46.

Bussière M. and Mulder C. (1999b), External vulnerability in emerging market economies: How high liquidity can offset weak fundamentals and the effects of contagion, *IMF Working Paper*, 99-88.

Calvo G.A. (2000), Balance of payments crises in emerging markets: Large capital inflows and sovereign governments, in Krugman P. (Ed.) “Currency Crises”, Chicago IL, *University of Chicago Press*.

Calvo G.A. and Vegh C.A. (1999), Inflation stabilization and BOP crises in developing countries, *NBER Working Paper*, 6925.

Caramazza F., Ricci L. and Salgado R. (2000), Trade and financial contagion in currency crises, *IMF Working Paper,* 00-55.

Caramazza F., Ricci L. et Salgado R. (2004), International financial contagion in currency crises, *Journal of International Money and Finance,* 23, pp.51-70.

Cartapanis A. (2004), Le déclenchement des crises de change : Qu'avons-nous appris depuis dix ans?, *Économie Internationale,* 97, pp.5-48.

Cartapanis A., Dropsy V. and Mametz S. (1998), Crises de change et indicateurs de vulnérabilité : Le cas des pays émergents d'Amérique latine et d'Asie, *Economie Internationale,* 76, pp.69-93.

Chang R. and Velasco A. (1998), Financial crises in emerging markets: A canonical model », *New York University Economic Research Reports,* 98-21.

Chang R. and Velasco A. (2001), A model of financial crises in emerging markets, *The Quarterly Journal of Economics,* 116-2, pp.489-517.

Chui M. (2002), Leading indicators of balance-of-payments crises: A partial review, *Bank of England Working Paper,* 171.

Civcir I. (2003), Dollarization and its long-run determinants in Turkey, *Middle East Economic Series,* 6.

Cole H.L. and Kehoe T.J. (1996), A self-fulfilling model of Mexico's 1994-1995 debt crisis, *Journal of International Economics,* 41, pp.309-330.

Corsetti G., Pesenti P. and Roubini N. (1999), Paper tigers? A model of the Asian crisis, *European Economic Review,* 43-7, pp.1211-1236.

Davidson R. and MacKinnon J.G. (1999), Econometric theory and methods, New York, *Oxford University Press*.

Dehove M. (2003), Crises financières : Deux ou trois choses que nous savons d'elles. Que nous apprend l'approche statistique des crises financières ?, *CAE Working Paper*.

Demir F. (2004), A failure story: Politics and financial liberalization in Turkey, revisiting the revolving door hypothesis, *World Development,* 32-5, pp.851-869.

Demirguc-Kunt A. and Detragiache E. (1998), The determinants of banking crises: Evidence from developing and developed countries, *IMF Staff Papers*, 45-1, pp.81-109.

Demirguc-Kunt A. and Detragiache E. (2000), Monitoring banking sector fragility: A multivariate logit approach, *The World Bank Economic Review*, 14-2, pp.287-307.

Diamond D. W. and Dybvig P. H. (1983), Bank runs, deposit insurance and liquidity, *Journal of Political Economy,* 91, pp.401-419.

Dooley M. (2000), A model of crises in emerging markets, *The Economic Journal,* 110-460, pp.256-272.

Edison H.J. (2003), Do indicators of financial crises work? An evaluation of an early warning system, *International Journal of Finance and Economics,* 8, pp.11-53.

Eichengreen B., Rose A.K. and Wyplosz C. (1994), Speculative attacks on pegged exchange rates: An empirical exploration with special reference to the European Monetary System, *NBER Working Paper*, 4898.

Eichengreen B., Rose A.K. and Wyplosz C. (1995), Exchange rate mayhem: The antecedents and aftermath of speculative attacks, *Economic Policy,* 21, pp.249-312.

Eichengreen B., Rose A.K. et Wyplosz C. (1996), Contagious currency crises, *NBER Working Paper,* 5681.

Ertugrul A. and Selcuk F. (2001), A brief history of the Turkish economy, 1980-2000, *Russian and East European Finance and Trade,* 2001, 37-6, pp.6-28.

Esquivel G. and Larrain F. (2000), Explaining currency crises, *El Trimestre Economico,* 67-2, pp.191-237.

Flood R.P. and Garber P.M. (1984), Collapsing exchange rate regimes: Some linear examples, *Journal of International Economics,* 17, pp.1-13.

Flood R.P. and Marion N. (1998), Perspectives on the current currency crisis literature, *IMF Working Paper,* 98-130.

Frankel J.A. and Rose A.K. (1996), Currency crashes in emerging markets: An empirical treatment, *Journal of International Economics,* 41, pp.351-366.

Furman, J. and Stiglitz, J.E. (1998), Economic crises: Evidence and insights from East Asia, *Brookings Papers on Economic Activity,* 2, pp.1-135.

Gilles Ph. (2007), Vulnérabilité et crises financières : Enseignements pour une architecture financière internationale, *Région et Développement,* 26, pp.5-12.

Goldstein M., Kaminsky G.L. and Reinhart C.M. (2000), Assessing financial vulnerability: An early warning system for emerging market, Washington, DC, *Institute for International Economics*.

Green W.H. (2003), Econometric analysis, New Jersey, *Prentice-Hall,* 5th edition.

Gujarati D.N. (2004), Basic econometrics, New York, *McGraw-Hill,* 4th edition.

IMF (1998), World Economic Outlook, may, Washington, DC.

Irwin G. and Vines D. (1999), A Krugman-Dooley-Sachs third generation model of the Asian financial crisis, *CEPR Discussion Paper,* 2149.

Irwin G. and Vines D. (2003), Government guarantees, investment, and vulnerability to financial crises, *Review of International Economics*, 11-5, pp.860-874.

Jeanne O. (1997), Are currency crises self-fulfilling? A test, *Journal of International Economics,* 43, pp.263-286.

Jeanne O. (2000), Currency crises: A perspective on recent theoretical development, *Special Papers on International Economics*, 20.

Kamin S.B., Schindler J.W. and Samuel S.L. (2001), The contribution of domestic and external factors to emerging market devaluation crises: An early warning systems approach, *International Finance Discussion Papers,* 711.

Kaminsky G.L. (1999), Currency and banking crises: The early warning of distress, *IMF Working Paper,* 99-178.

Kaminsky G.L., Lizondo S. and Reinhart C.M. (1998), Leading indicators of currency crises, *IMF Staff Papers,* 5-1, pp.1-48.

Kaminsky G.L. and Reinhart C.M. (1999), The twin crises: The causes of banking and balance-of-payments problems, *American Economic Review,* 89-3, pp.473-500.

Kansu A. (2004), Türkiye 1994 ve 2001 krizleri, Istanbul, *Derin Yayinlari.*

Kibritcioglu A. (2003), Monitoring banking sector fragility, *The Arab Bank Review*, 5-2, pp.51-66.

Komulainen T. and Lukkarila J. (2003), What drives financial crises in emerging markets?, *Emerging Markets Review,* 4, pp.248-272.

Krugman P. (1979), A model of balance of payments crises, *Journal of Money, Credit and Banking,* 11, pp.311-325.

Krugman P. (1996), Are currency crises are self-fulfilling, in Bernanke B.S. and Rotemberg J.J. (Eds.) “NBER Macroeconomics Annual”, *MIT Press,* pp.345-407.

Krugman P. (1998), What happened to Asia, *Mimeo,* MIT.

Krugman P. (1999), Balance Sheets, the transfer problem, and financial crises, *International Tax and Public Finance*, 6, pp.459-472.

Krugman P. (2001), Crises: The next generation?, Paper presented at the *Razin Conference,* Tel Aviv University, 25-26 March.

Kumar M., Moorthy U. and Perraudin W. (2002), Predicting emerging market currency crashes, *IMF Working Paper*, 02-7.

Lestano L. and Jacobs J. (2007) Dating currency crisis with *ad hoc* and extreme value-based thresholds: East Asia 1970-2002, *International Journal of Finance and Economics,* 12, pp.371-388.

Lestano L., Jacobs J. and Kuper G. (2003) Indicators of financial crises do work! An early-warning system for six Asian countries, *CCSO Working Papers,* 2003-13.

Maddala G.S. (1983), Limited-dependent and qualitative variables in econometrics, Cambridge, Econometrics Society Monographs, 3, *Cambridge University Press*.

Masson P.R. (1998), Contagion: Monsoonal effects, spillovers, and jumps between multiple equilibria, *IMF Working Paper,* 98-142.

McKinnon R.I. and Pill H. (1996), Credible liberalizations and international capital flows: The “overborrowing syndrome” in Ito T. and Krueger A.O. (Eds.), “Financial deregulation and integration in East Asia”, Chicago, IL, *The University of Chicago Press,* pp.7-42.

Milesi-Ferretti G.M. and Razin A. (1998) Current account reversals and currency crises: Empirical regularities, *IMF Working Paper,* 98-89.

Mulder C., Perelli R. and Rocha M. (2002), The role of corporate, legal and macroeconomic balance sheet indicators in crisis detection and prevention, *IMF Working Paper,* 02-59.

Mulder C., Perelli R. and Rocha M. (2007), New strategies for currency crises early warning systems: A balance sheet approach, Paper presented at the *24èmes Journées Internationales d’Economie Monétaire et Bancaire,* GDRE, Rennes, 14-15 June.

Nag A. and Mitra A. (1999), Neural networks and early warning indicators of currency crisis, *Reserve Bank of India Occasional Papers,* 20-3, pp.183-222.

Nitithanprapas I. et Willett T.D., (2000), A currency crises model that works: A payments disequilibrium approach », *Claremont Colleges Working Papers,* 2000-25.

Obstfeld M. (1986), Rational and self-fulfilling balance of payments crises, *American Economic Review,* 76, pp.72-81.

Obstfeld M. (1994), Logic of currency crises, *NBER Working Paper,* 4640.

Obstfeld M. (1996), Models of currency crises with self-fulfilling features, *European Economic Review,* 40-3, pp.1037-1047.

Obstfeld M. (1997), Destabilizing effects of exchange rate escape clauses, *Journal of International Economics,* 43-1, pp.61-77.

Onis Z. and Rubin B. (Eds.) (2003), The Turkish economy in crisis, London Portland, OR, *Frank Cass.*

Ozatay F. (1996), The lessons from 1994 crisis in Turkey: Public debt (mis)management and confidence crisis, *Yapi Kredi Economic Review,* 7-1 pp.21-37.

Ozatay F. (1999), The 1994 currency crisis in Turkey, *Yapi Kredi Discussion Paper Series,* 99-01.

Ozatay F. and Sak G. (2003), Banking sector fragility and Turkey's 2000-01 financial crisis, in Collins S. M. and Rodrik D. (Eds.) "Brookings Trade Forum 2002", *Brookings Institution Press*, pp.121-160.

Ozkan F.G. (2005), Currency and financial crises in Turkey: Bad fundamentals or bad luck?, *The World Economy,* 28-4, pp.541-572.

Parasiz I. (2002), Enflasyon, kriz, ayarlamalar, Bursa, *Ezgi Kitabevi,* 2nd edition.

Radelet S. et Sachs J. (1998), The onset of the East Asian financial crisis, *NBER Working Paper,* 6680.

Rodrik D. (1990), Premature Liberalization, incomplete stabilization: The Özal decade in Turkey, *NBER Working Paper,* 3300.

Rodrik D. and Velasco A. (1999), Short-term capital flows, *NBER Working Paper,* 7364.

Sachs J. Tornell A. and Velasco A. (1996), Financial crises in emerging markets: The lessons from 1995, *Brookings Papers on Economic Activity,* 1, pp.147-215.

Sak G. (1995), Public policies towards financial liberalization: A general framework and an evaluation of the Turkish experience in the 1980s, Ankara, *Capital Markets Board Publications*.

Schnatz B. (1998), Macroeconomic determinants of currency turbulences in emerging markets, *Deutsche Bundesbank Discussion Paper,* 3-98.

Schneider M. and Tornell A. (2000), Balance sheet effects, bailout guarantees and financial crises, *NBER Working Paper*, 8060.

Tornell A. (1999), Common fundamentals in the Tequila and Asian crises, *NBER Working Paper,* 7139.

Uygur E. (2001), Krizden krize Turkiye: 2000 Kasim ve 2001 Subat Krizleri, *Turkiye Ekonomi Kurumu Tartisma Metni,* 2001-1.

Vlaar P.J.G. (2000), Currency crisis models for emerging markets, *De Nederlandsche Bank WO Research Memoranda,* 595.

Wooldridge J.M. (2002), Introductory Econometrics: A modern approach, Cincinnati, Oh, *South-Western College Publishing,* 2nd edition.

Wyplosz C. (2001), How risky is financial liberalization in the developing countries?, *G-24 Discussion Paper Series*, 14.

Yeldan E. (1994), Turk ekonomisinde krizin olusumu 1990-1993: Bir denge genel analizi, Ankara, *Turk Harb-Is Sendikasi Yayinlari*.

Yeldan E. (2001), On the IMF-directed disinflation program in Turkey: A program for stabilization and austerity or a recipe of impoverishment and financial chaos?, *Bilkent University Working Paper*, 01-10.

Yeldan E. (2002), Behind the 2000/2001 Turkish crisis: Stability, credibility and governance for whom?, *Mimeo*, Bilkent University.

Zhang Z. (2001), Speculative attacks in the Asian crisis, *IMF Working Paper*, 01-189.