

## Predictability of Financial Crisis in Developing Countries: Turkey, Argentina and Thailand

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### **Abstract**

Since 1980's, financial liberalization policies that implemented without adequate infrastructure in order to decrease inflation and interest rates also construct a sustainable growth process led to many financial crisis which have significant effects throughout the world. Therefore many models have developed to explain these crises. Main purpose of these models is to increase the predictability of financial crisis by identifying the factors that affecting the formation of crisis. Determining factors affecting the formation of financial crisis and trying to predict the crisis is very important in preventing crisis. In this context the aim of this study is analysis the predictability of financial crisis that occurred in developing countries which are Turkey, Argentina and Thailand 1990-2010 periods, by using Markov Regime Chance Model. In generated models, indices of financial pressure were calculated as dependent variable and fifteen different indicators were chosen from the literature to describe these indices. Successful indicators in predicting financial crises are: for Turkey; trend deviation of real exchange rate, domestic credits/industrial production, inflation and M2/reserves, for Argentina; stock price, difference in real interest rate, inflation and M2/reserves and for Thailand; trade balance, terms of trade, M2/reserves and oil prices. As a result of this study, financial crises such as 1994 and 2001 crises in Turkey, 1994, 2002 and 2009 crises in Argentina and 1997 and 2009 crises in Thailand were successfully predicted.

**Keywords:** Financial Crisis, Financial pressure, Markov Regime Chance Model, Predictability

### **Introduction**

Since 1980, financial liberalization policies implemented in order to create a sustainable process of growth and decrease the inflation and interest rate in developed and developing countries, led to the financial crisis become a commonly experienced phenomenon because of inadequate infrastructure. As a result of these and other policies that were implemented since 1990's have a significant impact, especially in developing countries, a large number of world-wide financial crisis experienced. Just a few of these crises are; Latin America in 1994, South-East Asia in 1997, Russia in 1998, Brazil in 1999, Turkey in 1994, 2001, Argentina in 2002 and the United States in 2008 which led to global financial crisis spread

around the world. The 2008 global financial crisis vary from the other crisis in terms influence firstly developed countries.

The increase in the number of financial crises, has led to the development of the more financial crisis model. The main purpose of the developed models is to determine the factors affecting the formation of the crises and to increase the predictability of financial crises. Prescribing the financial crisis are important to minimize the costs of the crisis and also important in terms of the probable crisis prevention. Applied models of the financial crisis in the literature are examined under the headings of standard models and new models that are often developed as alternative to these models. Standard models are the signal approach (Kaminsky et al., 1998), and limited dependent regression (Logit-Probit) models (Frankel and Rose, 1996). On the other hand in recent years a large number of analysis techniques used in the prediction of financial crises. Markov regime change (MRD) model (Hamilton, 1989) and classification and regression trees (CART-Classification and Regression Trees) model (Breiman, 1984) are example of these models which are also used in this study. Furthermore, the artificial neural network model (Nag and Mitra, 1999), and limited VAR model (Krokoska, 2000) may be mentioned. The main purpose of this study is to identify the leading indicators of financial crises in Turkey, Argentina and Thailand during the period 1990-2010 and to analyze the predictability of these crises by using MRD model.

## **Literature Review**

MRD model is one of the new models used for the prediction of financial crises, therefore the literature is limited. Some of the works can be reached in the research literature on the subject are as follows:

Abiad (2003), were analyzed five Asian countries that were much affected in South-East Asia crisis period of 1972-1999 using MRD model. Dependent variable was crisis variable that was obtained monthly changes in international reserves, the nominal exchange rate and interest rates. Independent variables were total of 22 indicators under the various main headings. Model was superior compared to standard transmission method in terms of providing fewer false signals as well as to anticipate the current crisis.

Knedlik (2007) tried to predict the financial crisis in South Africa by using the signal, probit and MRD models. Exchange rate pressure index used in this study was the dependent variable and independent variables are composed of from 15 different indicators. Based on the results in signal approach years 1996 and 1998, in the probit model years 1996, 1998 and 2001 and in the MRD model, 1996, 1998, 2001 and 2006 were foreseen as a period of crisis.

Brunetti et al. (2007) examined the 1984-2001 period in Malaysia, Singapore, Finland and Thailand by using MRD model. Indicators used in the study were M2/reserves, the real exchange rate, domestic credit / GDP, foreign exchange gains / devaluation, interest rate differential, the general and the banking sector stock index returns and volatility. According to the results of the analysis, the real effective exchange rate, M2/reserves, general and the banking sector index and stock returns indicators were significant indicators in explaining the crisis in these countries.

Yılmazkuday and Akay (2008) have analyzed the period from 1986 to 2001 in Turkey by using monthly data with MRD model. The variables used in this study to predict crises were the nominal exchange rate, net international reserves and domestic loans. According to the analysis 1991, 1994 and 2001 crises were successfully proposed.

### Model, Data and Variables

MRD model, developed by Hamilton (1989), commonly used estimation of non-linear model in time series analysis. MRD model examine the relationships between regimes in the periods  $t$  and  $t-1$  and is stated as;

$$y_t = \alpha_{s_t} + x_t' \beta_{s_t} + \varepsilon_t \varepsilon_t \sim i. i. d. N(0, \sigma_{\varepsilon, s_t}^2) \quad (1)$$

Here;  $y_t$  is crisis press index,  $x_t$  is dependent variables and  $s_t$  is regime variable. In MRD model regime change is described as a probability function and the periods of regime is determined by a random variables  $s_t$ . In this case, the probability value of the  $s_t$  variable is depending on the previous regime period is shown as:

$$P\{s_t = j | s_{t-1} = i\} = P\{s_t = j | s_{t-1} = i, s_{t-2} = k, \dots\} = p_{ij} \quad (2)$$

The above equation indicates transition probabilities regime  $i$  to the regime  $j$  that fits the first-order Markov chain. MRD model is estimated by maximum likelihood method.

In general, to predict the financial crisis, in the literature primarily financial pressure indices calculated and relationships between these indices and variables which is considered to be the effect of the crisis are examined. In the calculation of FBE, usually the the nominal exchange rate, interest rate and net international reserves are used. In analysis, the FBE formula in Eichengreen et al. (1995) articles was used. The formula is as follows:

$$FBE = \left( \frac{\Delta e}{e_{t-1}} \right) - \left[ \left( \frac{\sigma \Delta e}{\sigma \Delta r} \right) * \left( \frac{\Delta r}{r_{t-1}} \right) \right] + \left[ \left( \frac{\sigma \Delta e}{\sigma \Delta f} \right) * \Delta f \right] \quad (3)$$

Wherein the  $e$ ; nominal exchange rate,  $r$ , net international reserves,  $f$ ; interbank overnight interest rate,  $\Delta$ , change, and  $\sigma$  is the standard deviation.

In the literature, the current account, capital account and a large number of variables under the main headings of the the financial sector, the corporate sector and the public sector variables were used as indicators of the financial crisis. In this study 15 of them is used which are most commonly used and most meaningful in the literature to create significant and high explanatory power models. The used variables are; the industrial production, stock price, inflation, M2 multiplier, M2/Reserves, M2/Reserves level, the oil price, money market pressure index (PPBE), the real exchange rate deviation from trend (RDKTS), the real interest rate (RFO), the real interest rate differential (RFOF), real deposit stock (RMS), the terms of trade, trade balance, domestic credit / industrial production.

PPBE was calculated as follows (Hagen and Hoo, 2004, p.4).

$$PPBE = \left( \frac{\Delta\gamma}{\sigma\Delta\gamma} \right) + \left( \frac{\Delta f}{\sigma\Delta f} \right) \quad (4)$$

Wherein  $\gamma$  is the ratio of central bank loans given to banks to total deposits,  $f$ ; interbank overnight interest rate,  $\Delta$ , refers to the exchange and  $\sigma$ , standard deviation.

All data used in the analysis except M2/Reserves (level) data are monthly and with the purpose of purification from seasonally annual percentage changes were used. The difference of M2/Rezervler (level) from M2/Rezervler is calculation without taking annual percentage change. These two indicators are also included because both were commonly used in the literature. Although the period of 1990:01-2010:12 was stated as the period of analysis, for each country data for this period could not be obtained. Therefore, the analysis period is different for each country. Monthly values of some of the data could not be reached in this study. Periods of countries and indicators that could not be used for analysis are shown in Table 1.

Table 1: Analysis period of countries and unavailable indicators

Turkey	1991:1-2009:7	-
Argantina	1992:1-2010:12	RDKTS, terms of trade
Thailand	1990:1-2009:8	RDKTS,Ind. Prod.,Stock price

## Model Applications

Selection of the data in the MRD model, general to the specific method is applied in literature as an approach to Hendry (Hendry and Richard, 1983, p.3-32). for each country a large number of model is implemented and model that has highest explanatory power and overlapping theories have been selected. Pc-Give program was used for analysis. In models, it is assumed that there is two regimes as normal regime and the crisis. While normal regime has considered with low average and low-volatility, the crisis regime considered with the higher average, high volatility. As a result of prediction of the models, obtained filtered probability values, shows estimates of the probability for  $t =$  time based on the information that we have until the time  $t$ . Predicted probability values based on the information for the entire sample are estimated to be a step forward.

In this study, discussed model is in a non-linear structure. Not linear of the model was decided according to the results of LR (Likelihood Ratio) linearity test.

The result of the analysis for each country is going to be interpreted with a figure and two tables. MRD model prediction results for each country will be evaluated separately.

## MRD Model: Turkey Application

MRD model results on Turkey are provided in Figure 1, Table 2 and Table 3. In the model, the "regime 0" refers to the process experiencing financial crises (FBE tend to rise), "regime 1" refers to the process of the economy is stable (FBE tends to fall). According to the Table 2 except the dom. cred./ind. prod. (0) all the variables were statistically significant. Model is not linear according to Likelihood ratio.

If we look at the characteristics of regimes according to Table 3, 13 of the 222 observation in the process belongs to “regime 0”, the 222 is belongs to “regime 1”. The periods regime 0 valid are periods 1994:2-1994:5, 1995:2-1995:5, 2000:11-2001:2 and 2002:1-2002:1. While the probability of regime 0 is 5.53, the probability of regime 1 is 94.47. Both regimes shows a high persistence as shown in regime probability matrix. If we look at the probability of the regime transition, the transition possibility of a stable period to the crisis period was 0.32.

Table 2. MRD Model Results 1: Turkey

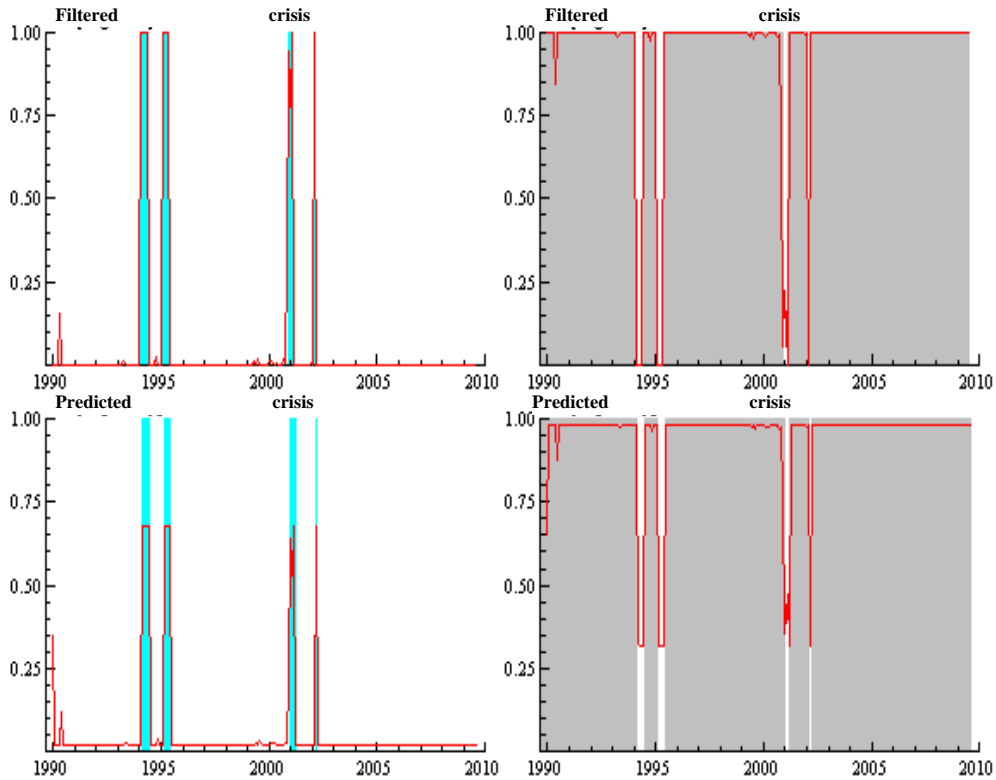
Constant (0)	198.38	112.20	1.77	0.08
Constant (1)	-63.34	8.75	-7.24	0.00
RDKTS(0)	-11.4	1.84	-6.19	0.00
RDKTS(1)	-0.65	0.31	-2.11	0.04
Terms of trade (0)	1.38	0.14	9.72	0.00
Terms of trade (1)	0.29	0.03	9.93	0.00
Trade balance (0)	-30.41	2.71	-11.20	0.00
Trade balance (1)	-2.24	0.44	-5.07	0.00
dom. cred./ind. prod. (0)	0.78	0.79	0.99	0.32
dom. cred./ind. prod. (1)	0.69	0.11	6.06	0.00
Inflation(0)	-11.55	0.74	-15.70	0.00
Inflation (1)	0.57	0.14	4.02	0.00
M2/Res.(level)(0)	267.75	22.45	11.90	0.00
M2/Res.(level)(1)	9.11	2.28	4.00	0.00
Likelihood ratio (LR)	97.62			0.00

Table 3: MRD Model Results 2: Turkey

	Number of obs.	Prob.	Time	Regime 0*	Regime 1	1994:2 - 1994:5 (4 ay)	1990:1 - 1994:1	-
Regime 0*	13	5.53	3.25	0.68	0.02	1995:2 - 1995:5 (4 ay)	1994:6 - 1995:1	-
Regime 1	222	94.47	44.4	0.32	0.98	2000:11 - 2001:2 (4 ay)	1995:6 - 2000:10	-
						2002:1-2002:1 (1 ay)	2002:3-2009:7	-

\*Crisis Regime

Figure 1: Filtered and Predicted Crisis Probabilities: Turkey



According to Table 3 and Figure 1, transition to the regime 0 which we accept as a crisis period, first took place in February 1994 and April 1994 crisis was predicted two months in advance. The second regime transition in Turkey took place in February 1995 and continues four months. Cause of this regime change is thought to be crisis that started in Mexico in December 1994. The third regime change began in November 2000 and took four months. Model is successful in predicting the crisis of February 2001. Last regime change was a monthly change in January 2002. Cause of this regime change can be Argentine crisis started in January 2002.

### MRD Model: Argentina Application

MRD model results on Argentina are provided in Figure 2, Table 4 and Table 5. In the model, the "regime 0" refers to the process of the economy is stable, "regime 1" refers to the process experiencing financial crises. According to Table 4 except the ind. prod. (0) all the variables were statistically significant. Model is not linear according to Likelihood ratio.

Table 4: MRD Model Results 1: Argentina

Constant (0)	14.98	4.18	3.59	0.00
Constant (1)	105.83	10.80	9.80	0.00
Stock price(0)	-0.69	0.05	-12.90	0.00
Stock price (1)	-0.95	0.11	-8.83	0.00
RFOF(0)	-0.02	0.01	-1.69	0.09
RFOF(1)	0.04	0.02	1.83	0.07
M2/Res.(0)	0.38	0.19	2.00	0.05
M2/Res.(1)	-1.30	0.39	-3.37	0.00
RMS (0)	-2.37	0.23	-10.20	0.00
RMS (1)	-3.56	0.44	-8.17	0.00
Inflation(0)	-2.08	0.44	-4.70	0.00
Inflation (1)	2.63	0.95	2.76	0.01
Ind. prod. (0)	-0.24	0.43	-0.56	0.58
Ind. prod. (1)	-2.32	1.31	-1.77	0.08
Likelihood ratio (LR)	214.44			0.00

Table 5 shows the characteristics of the regimes.

Table 5: MRD Model Results 2: Argentina

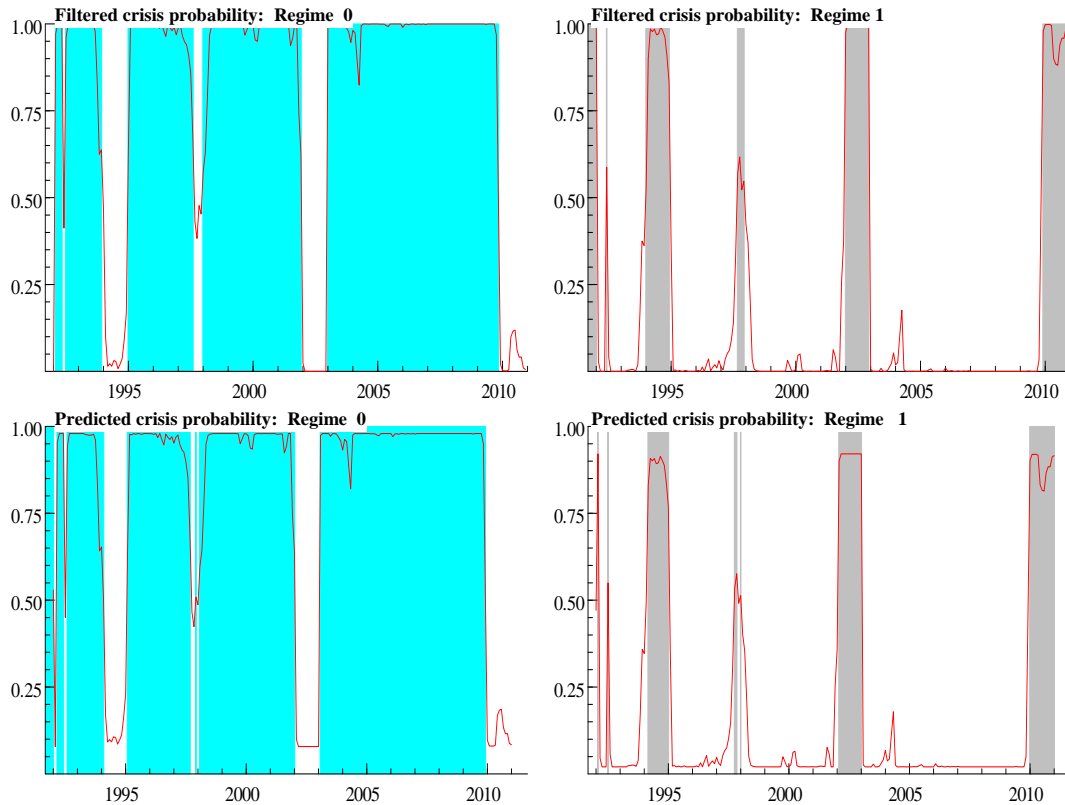
	Number of obs.	Prob.	Time	Regime 0	Regime 1*	1992:2-1993:9	1992:1-1992:1(1 ay)
Regime 0	184	80.7	61.33	0.98	0.08	1994:12-2001:10	1993:10-1994:11(14 ay)
Regime 1*	44	19.3	11	0.02	0.92	2003:1-2009:9	2001:11-2002:12(14 ay) 2009:10-2010:12(15 ay)

\* Crisis Regime

According to Table 5 and Figure 2, transition to the regime 1 which we accept as a crisis period, first took place in February 1994 and took one month. The reason of this regime change may be the effect of financial liberalization practices implemented during 1990-1992. The second regime transition took place in October 1993 and took 14 months. The cause of this regime change is thought to be instability in Mexico and ERM crisis beginning towards the end of 1992. The third regime change began in December 2001 and took 14 months. Model is successful for predicting the crisis in Argentina beginning in January 2002. The last regime change began in October 2009 and took 15 months to

December 2010 which is the last month of the analysis period. The cause of this regime change is thought to be the global financial crisis that started in 2008.

Figure 2: Filtered and Predicted Crisis Probabilities: Argentina



### MRD Model: Thailand Application

MRD model results on Thailand are provided in Figure 3, Table 6 and Table 7. In the model, the "regime 0" refers to the process of the economy is stable; "regime 1" refers to the process experiencing financial crises. According to Table 6 except RFOF (0) and the oil price (1), all variables were statistically significant. Model is not linear according to Likelihood ratio.

According to Table 7 and Figure 3, , transition to the regime 1 which we accept as a crisis period, first took place in July 1997 and took 22 months. Model was failed to predict the crisis in Thailand began in July 1997. Another feature of this first regime transition is continuing for a long time of 22 months. The reason for this crisis is believed that crisis in August 1998 in Russia and in January 1999 in Brazil began with the same period of Thailand crises. Repeatedly crisis in the world economy has led to the crisis a long time in Thailand. Second regime change in Thailand started in January 2009 and lasted four months. The cause of this regime change is thought to be the global financial crisis that started in 2008.



Table 6: MRD Model Results 1: Thailand

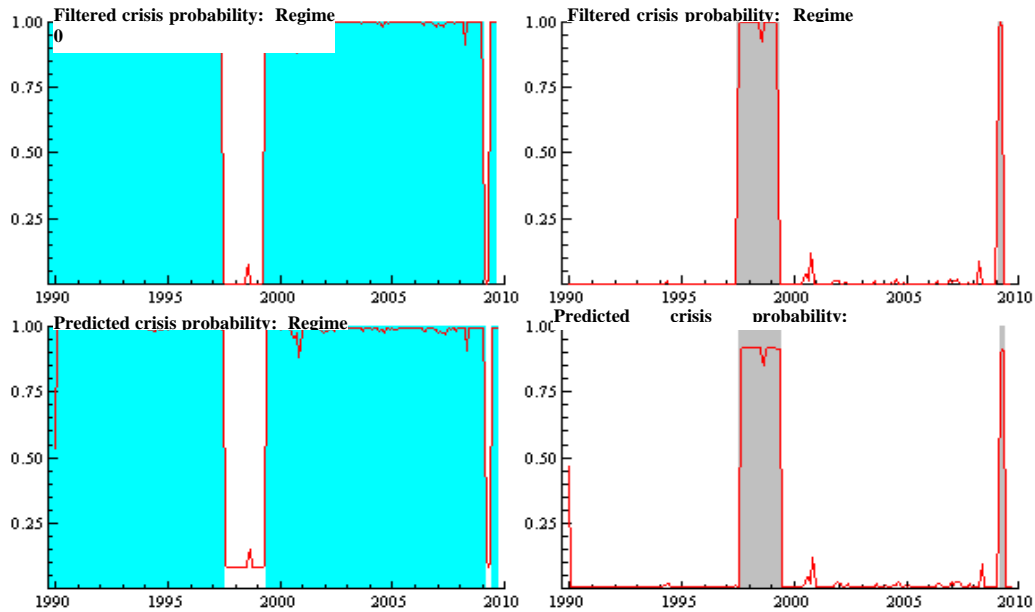
Constant (0)	-4.27	1.97	-2.17	0.03
Constant (1)	-124.63	15.28	-8.16	0.00
Trade balance(0)	-0.01	0.00	-2.28	0.02
Trade balance (1)	-0.04	0.01	-3.69	0.00
Terms of trade (0)	-1.99	0.26	-7.54	0.00
Terms of trade (1)	-11.74	0.65	-18.20	0.00
M2/Res.(0)	1.40	0.12	11.20	0.00
M2/Res.(1)	-1.63	0.21	-7.72	0.00
RFOF(0)	0.00	0.00	-0.35	0.73
RFOF(1)	0.09	0.01	10.10	0.00
RMS (0)	-1.18	0.19	-6.39	0.00
RMS (1)	24.68	1.39	17.70	0.00
Oil price (0)	-0.09	0.04	-2.68	0.01
Oil price (1)	0.15	0.25	0.61	0.54
Likelihood ratio (LR)	362.6			0.00

Table 7: MRD Model Results 2: Thailand

	Number of obs.	Prob.	Time	Regime 0	Regime 1*	1990:1- 1997:6	1997:7- 1999:4(22ay)
Regime 0	210	88.98	70	0.99	0.08	1999:5- 2008:12	2009:1- 2009:4(4ay)
Regime 1*	26	11.02	13	0.01	0.92	2009:5- 2009:8	

\*Crisis regime

Figure 3: Filtered and Predicted Crisis Probabilities: Thailand



## Conclusion

In this study, financial crises for the period 1990-2010 occurred in Turkey, Argentina and Thailand which are selected developing countries, were tried to predict with MRD model and investigated the determinants of these crises. The following findings can be made from the results of MRD. Most successful indicators of financial crisis in Turkey are RDKTS (the real exchange rate deviation from trend), terms of trade, trade balance, rate of domestic credits to industrial production, inflation and M2/reserves (level), respectively. 1994 and 2001 crises in Turkey were predicted but 2008 Global Financial Crisis was not. In FBE's that is obtained in order to determine the financial crisis period for Turkey, the 2008 global financial crisis is not included in the crisis period. However, the analysis of individual data for Turkey has shown crisis signals of indicators such as money market pressure index, industrial production, the oil price, the trade balance and the real exchange rate deviation from trend. In spite of some of the indicators gave significant signal, unpredictability of financial crises in Turkey is due to two reasons. The first is nondetermination of these crisis periods because of financial pressure indices. This problem can be solved by using different financial pressure indices. The second reason is that although important changes in some indicators of crisis, the signal does not pose much of a mobilization on overall indicators.

Most successful indicators of the predicting financial crisis in Argentina are the stock price, RFOF, M2/reserves, RMS, inflation and industrial production. Financial crisis occurred in Argentina in 1994, in 2002 and in 2009 have been foreseen successfully.

The most successful indicators predicting the financial crisis in Thailand are trade balance, terms of trade, M2/reserves, RFOF, RMS and oil prices. Crises that occurred in Thailand in 1997 and 2009 were successfully predicted. MRD model has been more successful in predicting the financial crises for Argentina and Thailand than Turkey.

Successfully indicators in predicting the financial crisis vary from country to country. Therefore, the determination of leading indicators in predicting the financial crisis and to achieve more successful outcomes we recommend single country-based analysis rather than analyzes for groups of countries and increase the reliability of the results using a

combination of more than one model. In order to obtain the necessary measures in time by authorities and central banks, monitoring of indicators of financial crises across countries and successful indicators separately for each country should be continuously monitored as an important economic policy option.

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