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Predictability of financial crises by KLR method: Turkey case (Period of 1990:01-2018:09)

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Abstract. As a result of global integration and financial liberalization, financial crises have been experienced quite frequently in the world since the 1980s. The effects of the financial crises in the international arena are severe and rapidly spreading. For this reason, in the studies on the crisis, various methods for early warning models have been developed on the prediction of crises. The aim of this study was to estimate the financial crisis for Turkey case by "KLR Signal Approach" that was developed by Kaminsky and Reinhart Lizondo in 1998. In this study, 7 macroeconomic variables belong to the period of 1990:01 and 2018:9 were examined. The difference of this study from other studies is that a new crisis variable has been created. It was found at the end of the study that the selected variables were successful in catching the crisis signal.

Keywords. Financial crisis, Signal approach, KLR signal approach, Early warning methods.
JEL. G01, C10, C29, F30.

1. Introduction

Much as seeing an uncertain future is quite difficult, many of the economists are intensely interested in this topic. The increase in the number and frequency of the crisis that has been experienced as from the 1980s caused foresee ability of crises to be questioned. Because the crises today spread into nearby countries from the root country by contagion effect. Furthermore, the crises have grown and accelerated by developments in. This is because the studies that have been conducted to predetermine the developments relating to the economic events triggered various economic forecast methods to be gained to the literature.

On the other hand, some problems can be observed when it is considered that many of the countries rapidly make progress in liberalization and foreign expansion process. Being passed into financial liberalization by developing countries before providing the macroeconomic stability may cause financial crises to be experienced.

Financial crises have a problematic characteristic that arising from different reasons. Therefore, the financial crisis has not a single definition that is characterized. The common trait that is attributed to the crisis is that the crisis is an unpredictable and nonlinear event (Mishkin, 1996: 39; Kibritçioğlu, 2000: 5; Stubbart, 1987: 89). Globally damages which have been inflicted by crises revealed the necessity to take precautions by determining the factors cause crises. Using several empirical methods is discussed by improving the literature to estimate the financial crises.

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Following items are the methods to estimate the crises; Signal Approach that was developed by the help of the macroeconomic indicators; Artificial Neural Networks that has just been started to be used; Regression (logit-probit) models. Logit and probit models are the techniques preferred in regression analyses in which the dependent variable is double-edged (there is/there is not) (Gujarati, 1995: 561). Artificial Neural Networks is a method that is established on the approach of learning by experiences. This method that is used in many of social sciences is also utilized to estimate the economic crises. It is aimed in this direction to make crisis predictions relating to the future from internal values by generalizing by using inputs relating to the economy (Silva *et al.*, 2016: 26). The method in this study is “Kaminsky, Lizondo, and Reinhart (KLR) Signal Approach” that is commonly used to estimate the financial crises and accepted as the first of the signal methods.

In this model, the factors that cause the crisis are analyzed by establishing a crisis dependent variable. Within this framework, first of all, the literature review can be seen in this paper. Afterward, the method was explained; the data set of the research was established. Finally, the findings were evaluated by performing the empirical analysis.

2. Literature review

It is seen in the literature that three different methods have been used relating to the early warning system. This paper only mentioned on the studies in which the method in question was used to set up a substructure for KLR approach.

Berg & Pattillo (1999) made a comparison with a probit regression-based KLR model as an alternative to the KLR model. The study surveyed foreseeability of the 1997 crisis happened in Far East countries. The difference of probit-based KLR model from the original KLR model is that measuring the crisis signal within 24 months and following periods via an independent crisis variable. It was found in their research that the probit-based KLR model which was developed as an alternative to the KLR model gives better results. It was also argued that both two models give better results than expected.

Šonje & Babić (2003) surveyed whether two crises happened in 1999 and 2001 in Croatia could be forecasted by using KLR method. It was concluded in research with 28 macroeconomic variables that variables give correct signals before the crisis

Peng & Bajona (2008) researched to foresee the financial crises by using KLR approach through China case. They analyzed 5 past financial crises in China by using 14 variables from the financial sector, the external sector, and the real sector. These variables as follows; M2 multiplier, local real interest rate, credit-deposit ratio, the ratio of domestic credits to GDP, M1 money supply balance, the ratio of M2 to the reserves, bank deposits, import, export, real exchange rate, reserves, difference of the real interest rate, terms of trade and industrial production. It is pointed out that the KLR method is successful in foreseeing the crisis.

Avcı & Altay (2013) measured the success of KLR approach by reviewing the financial crises in Turkey, Argentina, England, and Thailand. They analyzed the financial crises between the years of 1990 and 2010. It was emphasized in the study that the variables vary in forecasting the financial crises. Money market pressure index, real interest rate, deviation of real exchange from the trend, share prices, the ratio of domestic credits to industrial production are the most successful indicators for Turkey. The most successful indicators for Thailand are inflation, terms of trade, money market pressure index and the ratio of domestic credits to the industrial production. The most successful indicators for England are inflation, deviation of the real foreign exchange rate from the trend, the ratio of domestic credits to the industrial production, industrial production. About Argentina, the most successful indicators are industrial production, real interest rate, a difference of real interest rate, trade balance, the ratio of M2 to the reserves.

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Balaga & Padhi (2017) analyzed the money crisis happened between the years of 1986 and 2015 by using the KLR model. Entirely 19 variables were used in the research. There could not found a common variable to foresee the crises analyzed in the research. One of the variables that signal in the period close to the crisis was different from another variable. Accordingly, the study is different from other studies.

3. Method and methodology of research: KLR approach

In this research, the KLR signal approach is the method that was selected to foresee the financial crisis. The reason for being preferred this model is that the effect of each of the leading variables is analyzed in the KLR method.

This method was developed by Graciela Kaminsky (1998). It is called as KLR approach in the literature because of much contributions of Lizondo and Reinhart. KLR approach is based on reviewing changes in data groups belong to the economy before the crises. The study that they published in 1998 was fictionalized on money and bank crises. They researched foreseeability of the crisis by using monthly data of 15 developing and 5 developed countries between the years of 1970 and 1995. Following items were the variables used in research; real exchange rate, M2/gross international reserves, capital market index, production, export increase, M2 money multiplier, M1 surplus, domestic loans/GDP, real interests, international reserves and international terms of trade (Kaminsky *et al.*, 1998: 2).

The method can be explained by fictionalizing under three main parts. Financial Pressure Index (FPI) that is known as speculative or financial pressure as the crisis indicator was established in the first stage. FPI is calculated as follows Avcı & Altay, (2013: 52);

$$\begin{aligned} Et &: \% \text{ change in the exchange rate} \\ Rt &: \% \text{ change in gross foreign exchange reserve} \\ It &: \% \text{ change in overnight interest rate} \end{aligned}$$

Absence or presence of the crisis can be known by using the 1st and 2nd equation after establishing FPI.

$$FPI \geq \mu + 1,5 \sigma \rightarrow \text{There is a financial crisis, } D=1 \quad (1)$$

$$FPI < \mu + 1,5 \sigma \rightarrow \text{There is no financial crisis, } D=0 \quad (2)$$

μ shows the average of FPI; σ is the standard deviation. After calculating the percentage change in raw data of FPI, the data are standardized ¹before computing the absence or presence of the crisis. Afterward, the data are inserted in the analysis.

In the second stage of the method, threshold values are computed for each of the economic variables. The threshold value that is computed for a variable is determined by the help of specifying 10% of the observations so as to exceed this value (Kaminsky *et al.*, 1998: 17-18). More clearly, percentiles are utilized in calculating the aberration for the data set belongs to each variable.

In the third stage, a crisis matrix is created for threshold values calculated. The time elapsed between the signal of the indicator and the crisis determined is specified as 24 months. The performance review is actualized based on whether there is crisis after the indicator signals. Table 1 shows the crisis matrix.

¹Standardizing process is to proportion each of the variables to the standard deviation by subtracting from the arithmetic mean.

For X variable is $\frac{x-\mu}{\sigma}$ this process is separately calculated for three of the variables in this index (Jia & Li, 2015: 587)

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Table 1. *Crisis signal matrix*

Signal Existence	There is crisis (Within 24 months)	There is no crisis (Within 24 months)
There is crisis (if threshold opens)	A (correct signal)	B (noise)
There is no crisis (if threshold does not open)	C (unanticipated signal)	D (incorrect signal)

Source: Reinhart, Goldstein & Kaminsky, (2000).

As is seen in Table, the state of exceeding the threshold computed is accepted as the correct signal (A); namely, there is a crisis. The absence of a crisis in spite of exceeding the threshold value at the end of comparing the indicators with crises is accepted as noise; namely, there is no crisis (B). If there is a crisis (C) in spite of absence of deviation from a threshold value, it is accepted as an unanticipated signal. On the other hand, if there is no crisis and the threshold is not exceeded (D), it is accepted as the correct result and missing signal (Kaminsky, Lizondo & Reinhart, 1998: 18).

Inferences from Table 1 about the crisis possibility as follows (Kaminsky, Lizondo & Reinhart, 1998:29-31);

- The ratio of the probability of absolute crises happened in a country is the ratio of the total crises to the total number of period (A+B+C+D)
- The probability of bad signal is the ratio of a wrong signal caught (B) to all the bad signal (B+D)
- Conditional probability is the ratio of the correct signal caught to the number of signals caught (A+B).

3.1. Data set of research

In this research, it was studied by monthly data of 1990:01-2018:09 period by considering the KLR method and Financial crises history of Turkey. It is thought that using monthly data in period closes to the crisis will provide an advantage by submitting more number of observation. The dataset in this paper was constituted by literature review and analyzing the crises history. TL interest rate, composite leading indicators, consumer price index, import, and export were obtained from Economic Co-operation and Development. Gross foreign exchange reserves, exchange rate, BIST closure index, M2 money supply, total commercial bank deposits were obtained from the Central Bank of the Turkish Republic. The real interest rate was acquired from International Financial Statistics (IFS) in the data page of the International Monetary Fund (IMF).

3.2. Empirical analysis and research findings

The analysis was completed by three stages. In the first stage, a crisis variable was derived by the help of FPI; the threshold value of each of the variables was computed by constituting speculative pressure index. In the second stage, absence or presence of the crisis within 24 months was specified by the threshold value. In the last stage, crisis matrixes were established for the variables.

History of Turkey financial crisis was not specifically discussed in the first stage differently from other studies. A crisis variable was derived for the periods in question by establishing the Financial Pressure Index instead of reviewing the available crisis periods. The threshold value of FPI was calculated as 2,76 for the period between 1990:1 and 2018:05. The periods that exceed this value are called the crisis period based on the index value.

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Table 2. *Finansal Pressure Index Crisis Periods*

FPI Value: 1,92		
Period	Value	D: 1
Feb.94	3,50	There is crisis
Mar.94	7,15	There is crisis
Apr.94	5,09	There is crisis
May.94	5,14	There is crisis
Nov.00	2,03	There is crisis
Dec.00	4,03	There is crisis
Feb.01	9,01	There is crisis
Mar.01	1,95	There is crisis
Apr.01	2,05	There is crisis
July.18	2,06	There is crisis
Aug.18	2,28	There is crisis
Sep.18	2,46	There is crisis

As is seen in Table 2, the periods in which the threshold value (1,92) is exceeded refer to the crisis in the country. With reference to the index, ($Y=1$) values that are evaluated as crisis period are given. The periods in which the index value is not exceeded and there is no crisis were inserted in the research as ($Y=0$) with the dummy variable. The graphics for the index is shown below (Graphics 1).

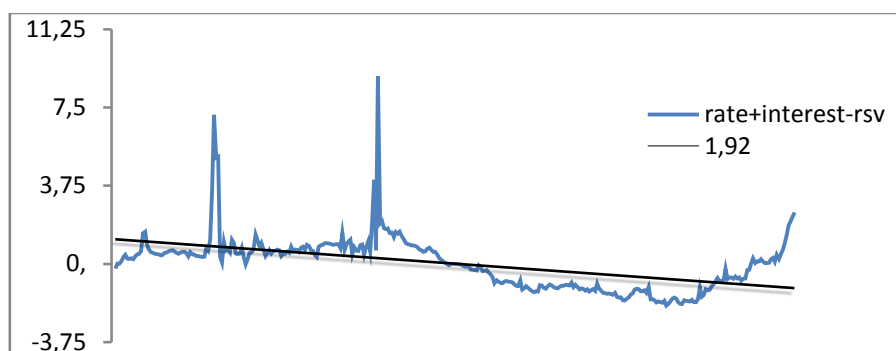


Figure 1. *Financial Pressure Index for Turkey (1990:01 - 2018:09)*

The proper threshold values for the variables were specified by using statistical calculations. The periods that exceed the threshold were accepted as the warning signals. Table 3 shows the research findings.

Table 3. *Signal Approach Estimation Results*

Indicator	Threshold Values	Correct Signal (A)	Noise (B)	Lost Signal (C)
Cpi (+)	22%	15	No signal	No signal
BIST (-)	17%	10	No signal	2
Bank deposit (-)	12%	13	2	5
M2 (+)	7%	9	1	6
Composite Leading Indicators	7%	Sinyal yok	3	14
Import (-)	13%	9	No signal	4
Export/imp.(-)	15%	12	5	3

Not: Marks of (-), (+) in brackets on indicator column express the state in which the variable signals. For example, an increasing consumer price index that is used in calculating inflation may make the economy fragile by affecting it in many aspects. Moreover, theories and several studies in literature were utilized to determine the direction of the variables.²

As is seen in Table 3, the successful variables in estimating the possible crises in Turkey are BIST, CPI, bank deposits, the ratio of export to import. They gave better signals in comparison with other signals in catching the signals. Composite leading indicators index gave no correct signals. The correct signal ratio of the M2 money supply is close to the ratio of signals caught by M2 money supply. According to these findings, there are results relating to the financial crises

² See: Šonje & Babić, (2003: 12); Avcı & Altay, (2013: 53).

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experienced in Turkey in 1994, 2000, 2001 and 2018. All these developments is a status that coincides with the happenings as well.

4. Conclusion

Becoming frequent the financial crises and also the results of the crises all around the world have increased the number of studies about the financial crises. Thus, the crisis literature has become rich and the models were developed by various early warning signal models.

This research used the crisis estimation method that is also known as “KLR Signal Approach”. We tested the predictability of the financial crises experienced in the Turkish economy. It was worked with entirely 7 variables and the monthly data belong the period of 1990:01-2018:09. At the end of the study, while BIST, cpi, bank deposits, the ratio of export to the import gave successful signals, composite leading indicators index gave no correct signal. We also found that the correct signal ratio of the M2 money supply is close to the ratio of signals caught by M2 money supply. It is concluded with reference to change in exchange rates in the last period that there was a crisis in Turkey by July, August, and September.

We see when the research results are evaluated that the variables are significant in explaining the financial crises; this conclusion is compatible with many of the studies in the literature. However, restricting the signals by 24 months cannot submit a certain information on the realization time of the crisis. Moreover, it can also be concluded when the complex structure of the crises is considered that the variables were not simultaneously inserted in the model by analyzing one by one. As is known, a decay in a macroeconomic indicator can affect other indicators and also stimulate the crisis.

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