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ECONOMIC FRAGILITY OF TURKEY: ASSESSMENT OF THE 1998-2012 PERIOD

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Abstract: This study aims to evaluate the vulnerability of the Turkish economy in the context of global crises during the 1998:01-2012:08 period employing signals approach improved by Kaminsky, Lizando and Reinhart (1998) [KLR]. Our study is necessary and timely to assess the fragility of Turkey since the recent crises created a debate on the Turkish economy. We consider more than thirty financial and macroeconomic variables and choose the best performing eighteen variables according to KLR criteria. The real interest rate differential between Turkey and U.S. ranked first according to all the criteria under consideration. Then, we construct composite indices to estimate the probabilities of crises. According to our findings, the probability of a crisis seems very low for Turkey in 2013, as none of the indicators give any signal of a crisis. Even though our study supports the buoyancy of the Turkish economy, it is important to keep monitoring it as global or unexpected developments may create fragilities.

Key Words: Economic Vulnerability, 2008-09 Crisis, Leading Indicators, Signals Approach, Turkey.
***Jel* Classification:** F31, F32, F47, H60

1. Introduction

Economic crises have an extensive history. In the decade of 1990s there was the 1992–1993 crises in the European Exchange Rate Mechanism, the 1992–1994 Mexican banking and currency crisis in Latin America, the Asian Flu of 1997, the Russian Cold of 1998, and the 1999-2002 Argentine economic crisis (Bordo and Schwartz, 1998; Bordo et al., 2001; Dabrowski, 2002). In the late 2000s the 2008 Global Financial Crisis, the worst financial crisis since the Great Depression[1], has occurred and contributed to the still ongoing European Debt Crisis (Rose and Spiegel, 2010; Fender and Gyntelberg, 2008; Lane, 2012). These episodes of turmoil have a deep negative impact on the real economies in which the crises initiated and often their effects spill over to other economies. Therefore, causes, impact and policy implications of economic crises have been examined extensively in the relevant literature.

It is important to assess the vulnerability of the economy to anticipate the crises. An arrival of a crisis can be anticipated through a comprehensive and properly specified early warning system and policy makers can take preemptive measures timely. The aim of our study is to evaluate the vulnerability of the Turkish economy in the context of global crises during the 1998:01-2012:08 period by employing signals approach improved by Kaminsky, Lizando and Reinhart (1998) [KLR hereafter]. In order to find out major leading indicators of financial crises in Turkey, more than 30 variables are tested, and by choosing the best performing 18 variables, composite indices are constructed to estimate the probabilities of crises in the

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[1] http://yaleglobal.yale.edu/content/global-economic-crisis

country. The accuracy of these indices is also controlled by employing the scores proposed by Kaminsky (1998).

This study is necessary and timely to assess the fragility of Turkey since the recent crises created a debate on the Turkish economy. There are opinions supporting that Turkey was resilient during these recent crises episodes. Moody's and Fitch lift Turkey rate to investment grade based on the country's improving debt level, narrowing trade imbalance and diversifying economy.[2] Martin Bruncko, the European Director for The World Economic Forum, stated that: "Turkey have achieved a high rate of growth despite the financial crisis in Europe. It is truly very difficult to achieve growth at this rate. These figures make the Turkish model that much more impressive. As a result, interest in Turkey is on the rise amongst foreign investors."[3] But there are also opposite opinions; Standard and Poor's (S&P) had dropped Turkey's outlook from positive to stable on May.2012, underlying large current account deficit and emphasizing the vulnerability of Turkey to sudden financial account outflows and refinancing risks.[4] Therefore it is crucial to assess objectively the vulnerability of Turkey during the recent periods.

In literature of early warning systems there are a vast number of studies employing KLR approach, but on Turkey there are only a few numbers of country-specific empirical studies. Indeed neither of them does cover the recent crisis episodes according to our knowledge. Thus our study contributes to the literature by filling this gap. Even though we examine only Turkey case, our results can be extended to other emerging market economies with similar macroeconomic structures.

This paper is organized as follows: Section 2 provides a brief background about the economic crises in the post-liberalization era of the Turkish economy. Section 3 provides a literature review. Section 4 introduces the data set. Section 5 describes KLR approach. Section 6 presents the empirical findings of KLR approach, creates composite crises indices following Kaminsky (1998) and estimates crises probabilities. Indeed, the accuracy test results of the composite indices are provided in Section 6. Finally Section 7 concludes the study. In Appendix the graphs of the best performing eighteen indicators are presented.

2. Economic Crises in the Turkish Economy

In this section, we consider the crises in the post liberalization era of the Turkish economy. The financial liberalization of the Turkish economy started at the beginning of the 1980s. The liberalization has been established successfully in terms of removing restrictions on internal and external financial intermediation by 1989. The number of domestic banks increased to 66 in 1990 from 23 in 1980 and the number of foreign banks also rose to 23 from 4. On the other hand, as a result of full capital account liberalization, the interest rate became vulnerable to international monetary movements. Soaring interest rates on government bonds attracted private sector financial investment. The main activities of banks became investing in treasury bonds instead of supporting the real sector. Private banks were raising their funds via short term borrowings on international financial markets. As a result, the non-performing loans of banks rose remarkably. Indeed, foreign borrowing increased the exchange rate risk. Moreover, because of lack of strong regulations and controls in the banking sector, moral hazard infected all sectors. Even though banks were allowed to hold their resources at a deficit position rate of

[2] http://online.wsj.com/article/SB10001424127887324767004578488553027093378.html
[3] http://english.sabah.com.tr/economy/2013/01/23/prime-minister-erdogan-called-on-to-return-to-davos
[4] http://www.bloomberg.com/news/2012-05-01/lira-weakens-after-s-p-revises-turkey-s-outlook-to-stable.html

10 percent, this ratio was exceeded 200 percent on average in 2001. These moral hazard problems and increased exchange rate risk did not work with exchange rate-based IMF stabilization programs.[5] Therefore, the 1990s and the early 2000s were full of crises that took place in 1991 (banking crisis), 1994 (currency crisis), 1998-99 (financial crisis as an infection of Russian cold) and 2000-2001 (financial meltdown). During these periods there were deterioration in macroeconomic balances, high and persistent inflation which had reached to 120 % in 1994[6] and unstable economic growth.

However, these crises episodes resulted in improved regulations and controls for the financial system. The Banking Regulation and Supervision Agency was launched after the 1999 crisis and the Banking Sector Restructuring and Rehabilitation Program was initiated after the 2000-2001 crises. "Istanbul Approach", the voluntary market based framework to facilitate restructuring of the debts of large borrowers, was introduced in January 2002. The number of banks declined to 54 in 2002 from 81 in 1999. Consequently, the financial sector has been strengthened (Boratav and Yeldan, 2001; Macovei, 2009).

The 2002-2008 era was full of distinguished successes in Turkey's recent economic history. GDP per capita increased to current US$ 10379 in 2008 from $3576 in 2002, stable economic growth has been achieved.[7] Unlike previous periods, instead of exchange rate based stabilization programs, inflation targeting has been successfully employed as a framework for monetary policy (Kara, 2006). The chronic inflation problem has been overcome, inflation decreased to one digit (8.9 %) in 2004. However, during this era the current account balance has been deteriorated, which has reached to -40.4 billion in 2008 from -21.4 billion in 2005.[8]

The Turkish financial system has responded to the 2008-09 global financial crisis relatively well. There was a slight decrease in the GDP growth in 2009 but the recovery of the Turkish economy was stronger than that of most other emerging economies. Because of the debt crises in Europe many European Union countries could not fulfill the Maastricht criteria but Turkey does.[9] This was because of the significant capital barriers executed after the 2000-01 banking crisis, more effective fiscal and monetary management, strengthened banking regulation and supervision, and conservative banking practices. Indeed, Turkey's resilience was also due to a rapid bounce back in capital flows and real activity. However, other macro-financial risks have appeared in the economy. Turkey experienced a credit boom through to mid-2011, resulted from easy domestic policies and global monetary conditions, which caused large capital inflows and strong domestic demand, contributed to a sharp widening in the current account deficit and raised the short-term external debt (Macovei, 2009; Kılınç et al., 2012; IMF Country Report, 2012)

[5] Several stabilization programs were announced by the IMF after the crises occurred in the 1987-2001 period. Exchange rate has been used as a nominal anchor for each of these programs.

[6] Annual WPI data with base year 1968, obtained from Turkish Central Bank, is used to calculate this inflation rate.

[7] World Bank data: http://data.worldbank.org/indicator/NY.GDP.PCAP.CD.

[8] World Bank data: http://data.worldbank.org/indicator/BN.CAB.XOKA.CD/countries.

[9] In 2012, Turkey's budget deficit to GDP is 1.9% which is below the Maastricht limit of 3%, and debt to GDP ratio is 36.3% which is far below the Maastricht limit of 60%. (source: European Commission European Economic Forecast Report)

3. Literature Review

In the context of the early warning systems KLR approach, probit and logit models are among the most commonly employed methodologies. KLR employs a database of 15 indicator variables considering the external position, the financial sector, the real sector, the institutional structure and the fiscal policy of a particular country. An indicator variable is considered to signal a crisis in period *t* if in that period the indicator exceeds the critical threshold. The estimation of this threshold is crucial; KLR decides it to minimize the noise-to-signal ratio such that the probability of the occurrence of a crisis is at a maximum after exceeding the threshold. Berg and Patillo (1999) compare this signaling method to a panel probit model and are in favor of the probit models. These two main studies paved the way for a huge number of empirical studies. Abiad (2003) and Jacobs et al. (2004) provide an extended literature review on this filed. In this study since we aim to choose a set of early warning indicators for Turkey via KLR methodology, we focus on the country-specific empirical studies on the economic crises in Turkey.

In the post-liberalization era of Turkey since the 1994 currency crisis the studies to identify the indicators of the currency crisis emerged. Ucer et al. (1998) analyzed 1994 crisis by KLR approach based on quarterly data. They examined all indicators in KLR and the new ones, and decided that the best performing indicators were short-term foreign debt/GNP, exports/imports, short-term advances to Treasury/GNP, and (M2+domestic debt)/GNP. Kibritcioglu et al. (1999) examined 1994 crisis investigating the period of 1986:01-1998:12 by the leading indicators approach. They concluded that effective real exchange rate, current account balance/GDP, exports/imports, foreign trade balance/GDP and short-term capital movements/GDP were the leading indicators.

Mariano et al. (2004) applied the Markov regime switching model of exchange rate movements with time-varying transition probabilities to the Turkish economy. Results of monthly and weekly models showed that real exchange rate, foreign exchange reserves and domestic credit/deposit ratio are the most important determinants of financial vulnerability.

Tosuner (2005) developed an early warning system employing KLR for the 1991:01-2004:05 period. He found out that the best performing indicators were deposit banks private domestic credits/GDP, M2/GDP, net international reserves/imports, current account balance/GDP, export/import, real exchange rate. Moreover he emphasized that international capital movements and the international interest rate differences were among crucial factors which increases the country's vulnerability.

Parlaktuna (2005) used a monetary model of exchange market pressure to the Turkish economy via the ordinary least squares regression in the period of 1993-2004 and reached a strong evidence of negative and stable relation between domestic credit and exchange market pressure.

Kaya and Yılmaz (2006) considered 1994-currency crisis and 2001-banking crisis via KLR approach based on the monthly data of the 1990-2002 period. By investigating 29 early warning indicators and they figured out that public sector borrowing requirement/GDP, budget balance/GDP, M2Y/GDP, real effective exchange rate appreciation rate, total external debt stock/GDP were among the best performing indictors.

Cepni and Kose (2006) assessed the vulnerability of Turkey defining a speculative pressure index for the period of 1985Q2-2004Q2. Firstly they found Granger causes of the index which were current account/ GDP ratio, M2/international reserves ratio, real credit growth and current account/foreign direct investment ratio. Then, they forecasted the index employing vector auto regression, probit and logit models and concluded that logit model has better performance in forecasting the vulnerability of the country.

Feridun (2006) used KLR to assess the currency crisis during the 1980:01-2006:06 period and found that short-term debt/international reserves, imports, exports, M2/international reserves, and current account balance/GDP were among the define the best performing indicators. Feridun (2008) employed logit, probit, and limited dependent models to explain the currency crises in the post–liberalization era (1989:09- 2001:04). He concluded that these models created similar results and the currency crises in Turkey were associated with global liquidity conditions, fiscal imbalances, capital outflows, and banking sector weaknesses.

Boduroglu and Erenay (2007) considered the 1994 and 2000 crises and defined a scalar composite index which alerts the financial crisis in Turkey six months before. Ari (2008) investigated the determinants of the financial crisis in by employing binary and multivariate logit models for the 1990:01-2008:12 period and found that excessive budget deficits, high money supply growths, sharp rises in short-term external debt, growing riskiness of the banking system, and external adverse shocks were the major determinants.

In our study we examine the vulnerability of the Turkish economy during the 1998:01-2012:08 period employing the KLR approach. We consider a huge data set, more than 30 variables and select the best performing ones. Thereafter, we estimate the crises probabilities by using composite crises indices of the best indicators. We also investigate the accuracy of these indices employing the scores proposed by Kaminsky (1998). We believe that our study makes a significant contribution to the literature since there are only a small number of country-specific studies on the economic crises in Turkey. Indeed, those studies examine different time spans employing varying methodologies and none of them consider the 2008-09 global crisis episodes according to our research. Furthermore, our results are more extensive since we examine a broad set of financial and macroeconomic variables.

4. Data

The indicator variables used in this study are chosen according to the literature search and availability of the data. Following KLR we have classified the selected thirty-two indicators into four main groups -external, financial, real sector and fiscal- as listed in below:
External: *Current Account:* 1. Exports(in U.S. dollars), 2. imports(in U.S. dollars), 3. exports/imports, 4. trade balance to GDP ratio, 5. terms of trade, 6. real exchange rate, 7. deviations of real exchange rate from trend, 8. ratio of current account to GDP;
Capital Account: 9. Net international reserves (in U.S. dollars), 10. Central Bank's gross exchange reserves, 11. domestic and foreign (U.S.) real interest rate differential, 12. ratio of net foreign direct investment (FDI) to GDP, 13. hot money, 14. ratio of hot money to GDP;
Debt profile: 15. Ratio of external debt stock to exports;
International: 16. U.S. interest rates;
Financial:
Financial Liberalization: 17. Real interest rate on deposits, 18. M2 money multiplier, 19. ratio of total domestic credit to GDP, 20. ratio of deposit banks domestic credit to GDP, 21. domestic debt stock to GDP ratio 22. share price index;

Other Financial: 23. Excess real M1 balances, 24. commercial bank deposits, 25. ratio of broad Money to gross international reserves, 26. ratio of M2 to gross exchange reserve of Central Bank, 27. M1, 28. M2, 29. inflation;
Real Sector: 30. Output index (industrial production index), 31. real GDP growth;
Fiscal: 32. Ratio of fiscal balance to GDP.

The monthly data of indicators for the 1998:01-2012:08 period is obtained from the IMF's international financial statistics data set (IFS), Central Bank of Turkish Republic (TR), Turkish Statistical Institute (TurkStat) and Treasury. Almost all indicators are in the form of monthly percentage change except seven of them: (3),(4), (7), (8),(11), (14) and (23). The excess real M1 supply (23) is defined as the residuals from a regression of real M1 balances on real GDP, inflation, and a deterministic time trend. The money multiplier of M2 (18) is obtained from the ratio of M2 to the reserve money which is used as a proxy of monetary base since in the IFS monetary base data starts from 2001. The percentage change of the consumer price index (CPI, 2005=100) is the index for inflation (29). The U.S. bilateral exchange rate (TL/$) is employed to define the real exchange rate, RER, (6) which is constructed such a way that an increase in the RER indicates real depreciation. The terms of trade (5) is defined as the unit value of imports divided by the unit value of exports. To calculate the real interest rates differential (11) money market rates employed, monthly rates are deflated by CPI and measured in percentage points. Hot money (13) is constructed as the sum of portfolio investment liabilities and other liabilities (short-term credits), which are obtained from the Central Bank of Turkey. As share price index (22) inflation adjusted Istanbul Stock Exchange Index (IMKB100) is employed.

e-view version 6 and Matlab *R*2006*b* version 7.3 are employed in our analyses. Firstly, the seasonality of indicators has been controlled and if necessary adjusted by TRAMO-SEATS in *e*-views version 6. Then, non-stationarities of indicators are controlled by Augmented Dickey Fuller (ADF) tests.[10] As presented in Table 1 all indicators are found as stationary in their level, that means all indicators are *I*(0).

[insert Table 1]

5. KLR (1998) Approach

5.1 Construction of Speculative Pressure Index

A crisis is defined as a period of extreme pressure in the foreign exchange market. Following the work of others (Kaminsky, Lizondo and Reinhart, 1998; Eichengreen, Rose and Wyplosz, 1995, 1996), a speculative pressure index is constructed. The indices are calculated as the weighted average of percentage changes in the bilateral nominal exchange rate and the percentage change in foreign reserves and the change in the interest rate. Thus, the speculative pressure index is as follows:

$$SPI_t = \alpha\% \Delta e_t + \beta \Delta i_t - \gamma\% \Delta r_t$$

where e_t denotes the nominal exchange rate per US dollars at time t, r_t denotes net international reserves, i_t denotes the short-term nominal interest rate. α, β, γ are the weights chosen such that the three components of the index have equal sample volatility such that α is

[10] ADF test is a very well-known non-stationarity test, thus we do not explain it explicitly. Please see Dickey and Fuller (1981) for detailed discussion on the ADF test.

the inverse of the standard deviation of the rate of change of exchange rate, β is the inverse of the standard deviation of the change of interest rate and γ is the inverse of the standard deviation of the rate of change of net international reserves.

A crisis occurs if the speculative price index is higher than a threshold value. A threshold value is defined as μ + kσ here is the sample mean of SPI and is the standard deviation of it and k is a constant. The crisis index is defined in following way:

$$Crisis = \begin{Bmatrix} 1 \ \ if \ \ SPI_t \geq \mu + k\sigma \\ 0 \ \ if \ \ SPI_t < \mu + k\sigma \end{Bmatrix}$$

As k increases, threshold value increases. Thus with smaller k value we observe more crisis and as k increases number of crises decreases. The crises periods according to different *k* thresholds for Turkey are given in Table 2 and showed in Figure 1.

[insert Table 2]

[insert Figure 1]

In literature the choice of *k* is somewhat random; KLR took *k* as 3, Edison (2003) as 2.5. Eichengreen et al. (1995) as 2, Eichengreen et al. (1996) as 1.5. Here, we took *k*=1.5 to identify of more crises.

5.2 Signals of Early Warning Indicators and A Crisis

If an indicator takes higher (or lower) value than its threshold value this is considered as a signal which warns about the crisis within a specified period of time. In our study, this specified period of time, i.e. the signaling horizon, is taken as 24 months following KLR. Let *Y* is an indicator variable. *Y* issues a signal of a crisis in period t if in that period the indicator passes the critical threshold, *TH*. If *Y* does not exceed this threshold then there is no signal. The signaling state, S_t, is presented by

$$S_t = \begin{Bmatrix} 1 \ if \ |Y_t| \geq |TH| \\ 0 \ if \ |Y_t| < |TH| \end{Bmatrix} \quad (1)$$

If the expected sign of the relationship is negative then for that indicator taking values less than the threshold increases the probability of crisis, and if the expected sign of the relationship is positive for that indicator taking values higher than the threshold rises the probability of crisis. Therefore, in (1) expressions are written in absolute form. The information about the expected sign of each variable is presented in Table 3.(*See* Table 3). For example, a decline in export growth is a sign for a loss of competitiveness in international good market, which could be caused by an overvalued domestic currency or evenif it occurs due to reasons unrelated to the exchange rate it would create devaluation pressure. In both cases, declining export growth increases the probability of crisis. Thus the expected impact of export growth is negative. Logically, since there is a positive relationship between the crisis and import growth the expected sign of imports is positive. As last example, an increase in hot money which means increased short-term capital inflows causes credit expansion and that would lead to currency overvaluation. Thus huge growth in hot money would lead to worsening in the current account and have been often related with financial instability and currency crises. Thus the expected sign of hot money growth is positive.

If an indicator issues a signal and a crisis occurs within 24 months then it is called as a good signal. But if issued signal is not followed by crisis within a signaling horizon, it is called as a bad signal or noise. KLR assigns the optimal threshold is as the one which minimizes the noise to good signals ratio.

5.3 Effectiveness of the Indicator

The effectiveness of the variable is evaluated considering the matrix below:

	Crisis within 24 months	No Crisis within 24 months
Signal was issued	A	B
No Signal was issued	C	D

here *A* counts the number of months in which the indicator produces a good signal, *B* counts the number of months in which a bad signal (noise) is issued, *C* is the number of months in which the indicator botched to produce a signal and *D* is the number of months in which no signal is produced and no crisis occurred within 24 months. Perfect indicator issues only *A* and *D*. In order to assess the performance of the indicator the following concepts are considered: the percentage of possible good signals ($A/(A+C)$); the percentage of possible bad signals ($B/(B+D)$); the ratio of *Noise to Signal* ($B/(B+D)$)/($A/(A+C)$); the difference between the conditional probability of crisis and the probability of crisis (i.e. $p(crisis/signal)$-$p(crisis)$ = $A/(A+B)$ - $[(A+C)/(A+B+C+D)]$); *Average Lead Time* that is the average number of months prior to a crisis when the first good signal occurs; *Persistence of Signals* that is the persistence of the indicator's signals prior to crises relative to tranquil times. An indicator which produces more persistent signals prior to crises time than at other times is preferred. The persistence of signal is calculated as the inverse of the ratio of noise to signal. p(crisis/signal)-p(crisis) difference is called as an "*Improvement Ratio*". The variable provides correct priori information about the crisis if p(crisis/signal) is greater than p(crisis) which means a positive improvement ratio.

6. Empirical Findings

6.1 Best Performing Indicators

Among the 32 potential early warning indicators we choose the best performing ones evaluating the effectiveness of them. First of all we decided the optimal threshold for each indicator employing a grid analysis. In KLR the thresholds are assigned regarding percentiles of the distribution of the indicator's observations. If the expected sign of a relationship is negative, for example, export growth is considered to issue a signal if its values fall in the bottom 10% of its distribution. Taking the observation at the bottom 10% as a threshold, the ratio of noise to good signal is calculated. This analysis is repeated using a grid of reference percentiles between bottom 10% and 20%, and the optimal threshold is defined as the one which minimizes the noise to good signals ratio. If the expected sign of a relationship is positive, for example, import growth is considered to issue a signal if its values cross the upper 10% of its distribution. Then upper 10% (i.e. 90%) and 20% (i.e. 80%) will be considered in a grid search to obtain the optimal threshold which minimizes the noise to good signal ratio. The optimal threshold percentile, the noise to signal ratio and its calculation, and the improvement ratio for each indicator are provided in Table 3, in which all variables are in ascending order according to noise to signal ratios.

[insert Table 3]

If an indicator contains accurate information, the improvement ratio should be bigger than zero and noise to signal ratio should be below "1". As a result, TR-U.S. real interest rate differential and excess real M1 supply are ranked the top performers whereas the variables with noise to signal ratio greater than 1 and non-positive improvement ratio cannot be considered as potential indicator anymore which are: (14) Hot Money/GDP, (12) Net FDI/GDP, (6) Real Exchange Rate, (16) U.S. 3-Month T-Bill Interest Rate, (9) Net International Reserves, (7) Deviations of RER From Trend, (18) M2 Money Multiplier, (24) Commercial Bank Deposit, (4) Trade Balance/GDP, (8) Current Account Balance /GDP. Four of these variables are current account indicators (4, 6, 7, 8), three of capital account (9, 12,14), one of international (16), one of financial liberalization (18), and one of other financial (24). Hot money/GDP indicator just in the border with noise/signal equal to 1.2 and improvement ratio 0. However, the growth of hot money is still among the good performing indicators with noise/signal equal to 0.64 and improvement ratio 0.11.

We have examined the performance of the indicators focusing how few false signals they produce. But this criterion is not enough alone to decide on best performers. We should also consider the average lead time of the signals - the average number of months before the crisis when first signal occurs- for each indicator. An indicator which signals sufficiently before the crisis is preferred to one gives signals when the crisis is imminent, since it provides enough time to policymaker to apply preemptive measures. Table 4 presents the results.

[insert Table 4]

The indicators, on average, send their first signal almost fourteen months before the crisis erupts with TR-U.S. real interest rate differential having the longest lead time and deviations of RER from trend having the shortest. Hence, we can claim that all the variables are leading rather than concurrent and can be employed as early warning indicators. Generally, indicators performed under first criterion-few false signals- also performed well under the second criterion-longer lead time-. But there exceptions, eventhough U.S. 3-month T-bill interest rate ranked fourth among the good performers under the second criterion we cannot consider it among the best leading indicators since it has noise to signal ratio greater than one with negative improvement ratio.

The third criterion that potential leading indicator should fulfill is persistence of the signals during the pre-crisis period (i.e. during the 24-month window) relative to tranquil times.[11] Table 5 establishes the results, in which the indicators are ranked according to their performance.

[insert Table 5]

The indicator issuing the most persistent signals is the TR-U.S. real interest rate differential whose signals are twenty five times more persistent prior of crises than in tranquil times and the one with the least persistent signals is the current account balance /GDP. As seen that the indicators performances with first and third criteria are parallel since the third criterion is nothing but another way of interpreting the noise to signal ratio.

Hence, we have decided the best performing indicators by employing KLR methodology. Now we combine the information on the different indicators to estimate the probability of a

[11] Following KLR we have measured the indicator's signals persistence as an inverse of the noise to signal ratio.

crisis conditional on simultaneous signal from any subset of best performing indicators. To combine the information on the various indicators we will employ composite indicators suggested by Kaminsky (1998). First we select a subset[12] of the best performing indicators which is composed of eighteen variables as follows: TR-U.S. real interest rate differential, excess real M1 supply, external debt stock/exports, output index, inflation, M2, hot money, budget balance/GDP, exports, imports, terms of trade, M1, domestic debt stock/GDP, deposit banks domestic credit/GDP, real GDP growth, IMKB100, broad money/gross international reserves and total domestic credit/GDP. The graphs of the selected indicators are given in Appendix. The shaded areas in the graphs indicate the 24-month window for the crises. (*See* Appendix).

6.2 Construction of Composite Crisis Indicators

Kaminsky (1998) proposes different composite indicators of crisis to capture the vulnerability of the economy to a crisis. In our study we use two of them to construct the composite index of our selected 18 indicators. Firstly, we define a composite index (I_t^1), which is the sum of the number of indicators signaling that there is a crisis at period t, as follows:

$$I_t^1 = \sum_{j=1}^{18} S_t^j$$

here S_t equals to one if the indicator j exceeds its threshold value in period t and zero otherwise. Since we have 18 univariate indicators I^1 can be at most 18 if all signals are flashing at the same time and at least zero if there is no signal.

The first index gives equal importance to each indicator. However it is logical to give more importance to the better performing indicators. The second composite index assigns the inverse of the noise to signal ratio of the univariate indicators as a weight so the indicators with low noise-to-signal ratios receive a larger weight than the ones with a high noise-to-signal ratio, as follows:

$$I_t^2 = \sum_{j=1}^{18} \frac{S_t^j}{\omega^j}$$

here ω^j is the ratio of noise to signal for variable j. In our case, the maximum value for I^2 can be at most 105, the sum of the signal-to-noise ratio when all signals are flashing.

Figure 2 and 3 exhibit the evolution of these composite indicators I^1 and I^2. The shaded areas in the graphs indicate the 24-month window before crises. The behaviors of both indices are in tandem. As it is seen both of them are more signaling during pre-crises periods. The larger value of the composite index and the greater incidence within these windows indicate that the economy is becoming more vulnerable to a crisis.

[insert Figure 2 and Figure 3]

Eventhough the composite indicators are informative in identifying the fragility of the economy, it is difficult to infer from their values the probability that a country will experience

[12] This subset of the best performing indicators is decided by considering indicators' ranks under three criteria simultaneously.

a crisis. Therefore, we calculate for each value of the composite index an associated probability of crisis and treat these probabilities as forecasts of crises.

6.3 Probabilities of a Crisis

Following to Kaminsky (1998) we construct the sets of probability of future crises conditional on composite indicator value intervals as follows:

$$P\left(C_{t,t+h}\middle|I_i^k < I_t^k < I_j^k\right) = \frac{\sum Months\ with\ I_i^k < I_t^k < I_j^k\ given\ a\ crisis\ occurs\ within\ h\ months}{Months\ with\ I_i^k < I_t^k < I_j^k}$$

where P denotes probability, $C_{t,t+h}$ denotes the occurrence of a crisis in the interval $[t, t+h]$, h is the signaling period (24 months) and k=1,2. Thus, $P\left(C_{t,t+h}\middle|I_i^k < I_t^k < I_j^k\right)$ represents the probability of a crisis which may happen within h months at time t conditional on that I_t^k lies in between $I_i^k\ and\ I_j^k$.

Table 6 and Table 7 report the conditional probabilities of financial crises that are associated with different values of the first composite index, I^1, and the weighted composite index, I^2, respectively. According to our results if I^1 is greater than 8, then certainly (with 100%) there will be a crisis in 24 month. Indeed, evenif only two indicators are signaling, i. e. I^1=2, the crisis probability in the succeeding months is so high which is 53.12%. These results indicate that the Turkish economy is very fragile and any signaling indicator could be a significant sign of coming crisis.

[insert Table 6]

The estimated probabilities of crises based on I^1 are plotted in Figure 4. According to our composite index the probability of a crisis within 24 month from August.2012 is 13.79% or with 86.21% probability there will not be a crisis in Turkey. Actually, none of the indicators give any signal of crisis in August.2012. The conditional probabilities of crises based on the weighted composite index, I^2, are presented in Table 7 and plotted in Figure 5. As it is seen from Figure 5 the probability of a financial crisis increases as the signs of vulnerability of the economy increase. Our forecasts on the Turkish economy based on I^2 are just parallel to predictions of I^1.[13]

[insert Figure 4 & Figure 5]

[insert Table 7]

6.4 Accuracy of Composite Indicators

To evaluate accuracy of composite indicators we again follow Kaminsky (1998). First we construct Quadratic Probability Score (QPS): $QPS^k = 1/T \sum_{t=1}^{T} 2(P_t^k - R_t)^2$ here (P_t^k) is a series of probability forecasts t:1,…,T, P_t^k :the probability of crisis in $[t,t+24]$ conditional on information provided by the composite indicator I^k in period t. (R_t) is a corresponding time series of realizations, R_t equals to 1 if crisis occurs between t and t+24 and 0 otherwise. QPS

[13] Since there is no signaling indicator in August.2012 -see Figure 3- the weighted composite indicator I^2 equals to zero which implies that we do not expect a financial crisis within 24-month window with 86.21% probability.

ranges from 0 to 2, with a score of 0 corresponding to perfect accuracy. We find that QPS values for our composite indicators I^1 and I^2 are respectively 0.6472 and 0.6753.

Next, we define the log probability score (LPS) as follows:
$LPS^k = 1/T \sum_{t=1}^{T}[(1 - R_t)ln(1 - P_t^k) + R_t ln(P_t^k)]$. LPS ranges from 0 to ∞, with a score of 0 corresponding to perfect accuracy. We find for index I^1 and I^2 LPS values are respectively 1.1301 and 1.1129.

Finally, overall forecast calibration which refers to closeness of forecast probabilities and observed relative frequencies is measured by the global squared bias (GSB):
$GSB^k = 2(\bar{P} - \bar{R})^2$. The GSB ranges from 0 to 2 with a score of 0 corresponding to *prefect global calibration*. It is received that GSB for I^1 and I^2 are 0.4757 and 0.4632, respectively.

Hence, we can conclude that the performances of both composite indicators are reasonably good and very similar to each other.

7. Conclusion

In this study we analyze the vulnerability of the Turkish economy for the 1998:01-2012:08 period using KLR methodology. First, we construct the speculative pressure index and examine the relationship between the index and 32 nominated early warning indicators of financial crises. Among these indicators, we have chosen the best performing ones by evaluating their noise to signal ratio, improvement ratio and average leading time. The real interest rate differential between Turkey and U.S. ranked first according to all criteria. Among the major indicators we have excess real M1 supply, hot money, IMKB 100, external debt stock/exports, output index, inflation, budget balance/GDP, exports, imports, terms of trade, M1 & M2, and real GDP growth. Our results are generally consistent with the previous studies in the literature. Although we do not have current account/GDP among the best performing indicators we still have other current account variables such as exports, imports and terms of trade.

The three big rating agencies, (S&P, Moody's and Fitch) use a combination of several quantitative and qualitative variables (economic, social and political) to assign a credit rating to a debtor. According to literature the real GDP Growth, external debt stock/Exports, current account balance /GDP, inflation, budget balance/GDP have around 80-90% of explanatory power of credit rating agencies rates (Cantor and Packer, 1996). Our results show that all of these variables are among the best performing indicators, except (current account balance /GDP). Thus our results also support the rating methodology of the rating agencies.

In our analysis following Kaminsky (1998) we have created composite crises indices and calculated the probability of a crisis during the 1998-2012 period. Although, in literature in multi-country studies researchers generally obtain quite low estimated probabilities, our estimated probabilities are quite high similar to Feridun (2006) who only examines Turkey case. One reason for our finding is that during the period we examine indicators are frequently signaling and a crisis follows. The other possible reason is that those studies are generally multi-country studies where the outcomes may not be consistent for the different countries under different time span.

According to our results with 86.21% probability there will be no crisis in Turkey within 24 month from August.2012. Actually, none of the indicators give any signal of crisis in

August.2012. Eventhough the probability of crisis seems very low for Turkey for the next periods, global or unexpected developments may create fragilities in the Turkish economy.

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Table 1. Non-Stationarity Test Results for the Indicators

NO	INDICATOR NAME	TRANSFORMATION	ADF TEST I(0)
	External		
	Current Account:		
1	Exports+	Monthly % Change	-5.65***(0)
2	Imports+	Monthly % Change	-9.92***(0)
3	Exports/Imports+	Level	-3.37***(1)
4	Trade Balance/GDP+	Level	-2.54*(3)
5	Terms of Trade+	Monthly % Change	-10.74***(1)
6	Real Exchange Rate (RER)	Monthly % Change	-9.65***(1)
7	Deviations of RER From Trend	Level	-5.21***(1)
8	Current Account Balance /GDP+	Level	-3.21*(1) TR&C
	Capital Account:		
9	Net International Reserves+	Monthly % Change	-4.54***(3)
10	Gross Exchange Reserves	Monthly % Change	-10.92***(0)
11	TR-U.S. Real Interest Rate Differential	Level	-3.04**(2)
12	Net FDI/GDP+	Monthly % Change	-6.11***(2)
13	Hot Money	Monthly % Change	-13.39***(0)
14	Hot Money/GDP+	Level	-3.61***(2)
	Debt Profile:		
15	External Debt Stock/Exports+	Monthly % Change	-12.94***(0)
	International:		
16	U.S. 3-Month T-Bill Interest Rate	Monthly % Change	-11.84***(0)
	Financial		
	Financial Liberalization:		
17	Real Interest Rate on Deposits+	Monthly % Change	-4.83***(2)
18	M2 Money Multiplier+	Monthly % Change	-11.46***(0)
19	Total Domestic Credit/GDP+	Monthly % Change	-5.22***(2)
20	Deposit Banks Domestic Credit/GDP+	Monthly % Change	-5.22***(2)
21	Domestic Debt Stock/GDP+	Monthly % Change	-3.62***(3)
22	IMKB100	Monthly % Change	-9.88***(0)
	Other Financial:		
23	Excess Real M1 Supply+	Level	-5.86***(3)
24	Commercial Bank Deposit+	Monthly % Change	-7.35***(0)
25	Broad Money/Gross International Reserves	Monthly % Change	-13.19***(0)
26	M2/Exchange Reserve Ratio	Monthly % Change	-11.24***(1)
27	M1+	Monthly % Change	-15.79***(0)
28	M2+	Monthly % Change	-12.42***(0)
29	Inflation	Monthly % Change	-6.81***(0)TR&C
	Real Sector		
30	Outputindex+	Monthly % Change	-10.87***(0)
31	Real GDP Growth+	Monthly % Change	-13.77***(0)
	Fiscal		
32	Budget Balance/GDP+	Monthly % Change	-12.90***(0)

Notes: +: States that the indicator is seasonally adjusted by Tramo/Seats. ***, **, * denote significance at 1%, 5%, 10% levels respectively. In ADF regression the lagged differences introduced into the model to make the residuals white noise process. The number in parenthesis denotes the significant lagged differenced terms, decided by Schwarz Criterion. Only the constant employed in all ADF tests unless otherwise indicated.TR& C: Trend and constant are included in ADF test.

Table 2. Crises Periods as k changes

k=1.5	k=2	k=2.5	k=3
Aug.1998			
Oct.1998			
Nov.2000			
Feb.2001	Feb.2001	Feb.2001	Feb.2001
Apr.2001	Apr.2001	Apr.2001	Apr.2001
Jun. 2001			
Oct.2001			
Jun.2006			
Oct.2008	Oct.2008	Oct.2008	

Table 3. Indicators Performances : Noise-to-Signal & Improvement Ratio

NO	INDICATOR NAME	Expected Sign	Threshold in percentile	Good signals as a % of possible good signals: A/(A+C)	Bad signals as a % of possible bad signals: B/(B+D)	Noise/Signal (adjusted): (B/(B+D))/(A/(A+C))	Improvement Ratio: p(crisis/signal)-p(crisis) = A/(A+B) - [(A+C)/(A+B+C+D)]
	Potential Early Warning Indicators with Noise/Signal<0.5						
11	TR-U.S. Real Interest Rate Differential	+	83	0.32	0.01	0.04	0.45
23	Excess Real M1 Supply	+	87	0.24	0.01	0.05	0.44
15	External Debt Stock/Exports	+	85	0.26	0.02	0.09	0.4
30	Outputindex	-	13	0.23	0.02	0.10	0.39
28	M2	+	81	0.33	0.04	0.11	0.39
29	Inflation	+	85	0.24	0.05	0.2	0.33
32	Budget Balance/GDP	-	17	0.26	0.07	0.27	0.28
1	Exports	-	17	0.24	0.1	0.39	0.21
5	Terms of Trade	-	11	0.15	0.06	0.39	0.22
27	M1	+	90	0.14	0.06	0.42	0.2
	Potential Early Warning Indicators with 0.5≤ Noise/Signal<1						
3	Exports/Imports	-	16	0.21	0.11	0.51	0.16
21	Domestic Debt Stock/GDP	+	83	0.22	0.12	0.54	0.15
19	Total Domestic Credit/GDP	+	85	0.19	0.11	0.57	0.13
17	Real Interest Rate on Deposits	+	89	0.13	0.08	0.63	0.11
26	M2/Exchange Reserve Ratio	+	81	0.23	0.15	0.63	0.11
31	Real GDP Growth	-	11	0.13	0.08	0.63	0.11
13	Hot Money	+	80	0.24	0.15	0.64	0.11
20	Deposit Banks Domestic Credit/GDP	+	80	0.24	0.15	0.64	0.11
22	IMKB100	-	19	0.22	0.15	0.7	0.09
10	Gross Exchange Reserves	-	11	0.12	0.1	0.79	0.06
25	Broad Money/Gross International Reserves	+	82	0.19	0.17	0.91	0.02
2	Imports	+	89	0.11	0.11	0.98	0.01
	Potential Early Warning Indicators with Noise/Signal ≥1						
14	Hot Money/GDP	+	81	0.19	0.19	1.02	0
12	Net FDI/GDP	-	20	0.19	0.21	1.15	-0.03

6	Real Exchange Rate (RER)	+	85	0.13	0.17	1.26	-0.06
16	U.S. 3-Month T-Bill Interest Rate	+	80	0.18	0.23	1.29	-0.06
9	Net International Reserves	-	10	0.09	0.12	1.35	-0.08
7	Deviations of RER From Trend	+	81	0.15	0.23	1.47	-0.1
18	M2 Money Multiplier	+	90	0.08	0.13	1.7	-0.13
24	Commercial Bank Deposit	-	20	0.13	0.27	2.08	-0.18
4	Trade Balance/GDP	-	20	0.1	0.31	3.13	-0.26
8	Current Account Balance /GDP	-	20	0.1	0.31	3.13	-0.26

Table 4. Indicators Performances: Average Lead Time

NO	INDICATOR NAME	Average number of months prior to crises first good signal occurs
11	TR-U.S. Real Interest Rate Differential	19.1
29	Inflation	18.9
13	Hot Money	17.8
16	U.S. 3-Month T-Bill Interest Rate	17.7
2	Imports	17.6
1	Exports	17.4
5	Terms of Trade	17.4
14	Hot Money/GDP	17
15	External Debt Stock/Exports	17
20	Deposit Banks Domestic Credit/GDP	17
26	M2/Exchange Reserve Ratio	16.9
21	Domestic Debt Stock/GDP	16.8
30	Outputindex	16.7
23	Excess Real M1 Supply	16.1
28	M2	16
25	Broad Money/Gross International Reserves	15.9
24	Commercial Bank Deposit	15.5
31	Real GDP Growth	15.4
12	Net FDI/GDP	15.1
32	Budget Balance/GDP	14.5
27	M1	14.2
22	IMKB100	14.1
19	Total Domestic Credit/GDP	14
8	Current Account Balance /GDP	12.5
17	Real Interest Rate on Deposits	12.3
3	Exports/Imports	12.1
6	Real Exchange Rate (RER)	11.4
9	Net International Reserves	10.5
18	M2 Money Multiplier	10.5
4	Trade Balance/GDP	9.7
10	Gross Exchange Reserves	9.1
7	Deviations of RER From Trend	8.2

Table 5. Indicators Performances: Persistence

NO	INDICATOR NAME	Persistence of Indicator
11	TR-U.S. Real Interest Rate Differential	25.00
23	Excess Real M1 Supply	20.00
15	External Debt Stock/Exports	11.11
30	Outputindex	10.00
28	M2	9.09
29	Inflation	5.00
32	Budget Balance/GDP	3.70
1	Exports	2.56
5	Terms of Trade	2.56
27	M1	2.38
3	Exports/Imports	1.96
21	Domestic Debt Stock/GDP	1.85
19	Total Domestic Credit/GDP	1.75
17	Real Interest Rate on Deposits	1.59
26	M2/Exchange Reserve Ratio	1.59
31	Real GDP Growth	1.59
13	Hot Money	1.56
20	Deposit Banks Domestic Credit/GDP	1.56
22	IMKB100	1.43
10	Gross Exchange Reserves	1.27
25	Broad Money/Gross International Reserves	1.10
2	Imports	1.02
14	Hot Money/GDP	0.98
12	Net FDI/GDP	0.87
6	Real Exchange Rate (RER)	0.79
16	U.S. 3-Month T-Bill Interest Rate	0.78
9	Net International Reserves	0.74
7	Deviations of RER From Trend	0.68
18	M2 Money Multiplier	0.59
24	Commercial Bank Deposit	0.48
4	Trade Balance/GDP	0.32
8	Current Account Balance /GDP	0.32

Table 6. Probabilities of a Crisis for composite indicator I^1

Value of Indicator (I^1)	0	1	2	3	4	5	6	7	8	≥9
Prob. of Crisis	0.1379	0.3409	0.5312	0.5333	0.7857	0.9167	0.875	1	0.8	1

Table 7. Probabilities of a Crisis for composite indicator I^2

Value of Indicator (I^2)	≤0	$0< I_t^2 \leq 2.5$	$2.5< I_t^2 \leq 5$	$5< I_t^2 \leq 10$	$10< I_t^2 \leq 17$	$17 < I_t^2 \leq 35$	> 35
Prob. of Crisis	0.1379	0.2333	0.5	0.4667	0.6875	0.9231	0.9677

Figure 1. Crises Periods as k changes

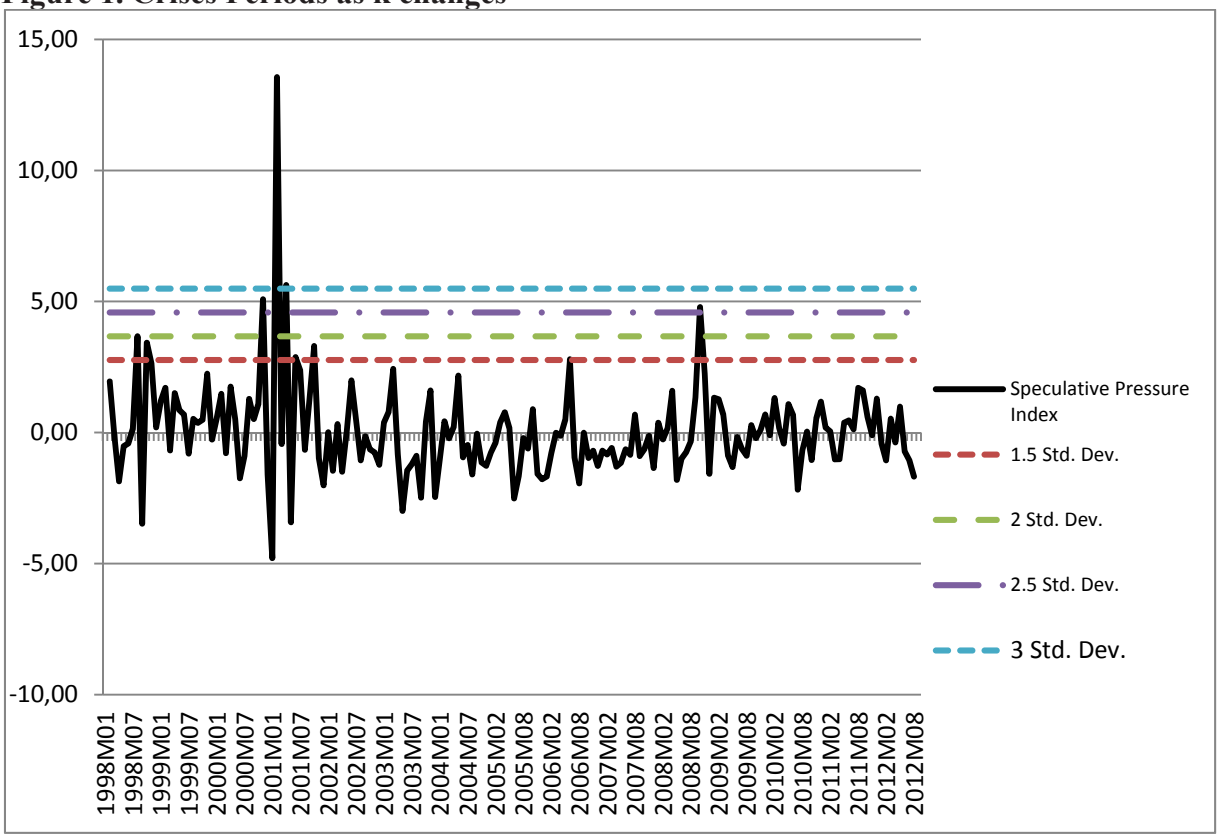


Figure 2. Composite Index I^1

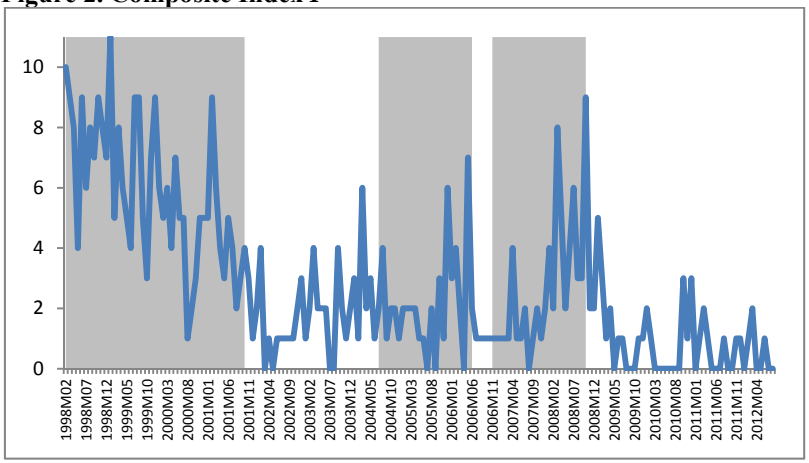


Figure 3. Composite Index I^2

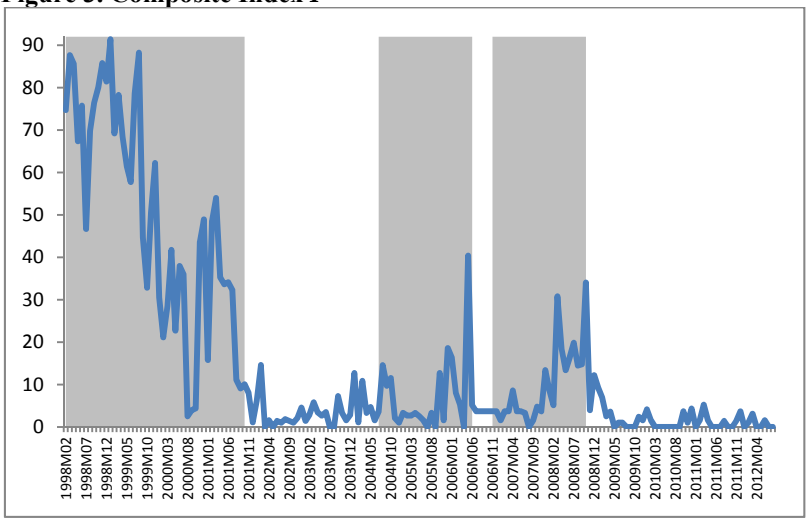


Figure 4. Estimated Probabilities of Crises: Composite Indicator I^1

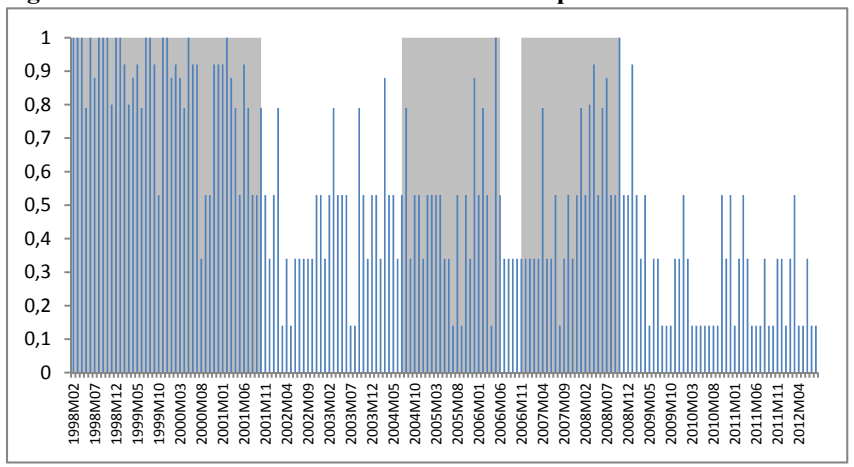
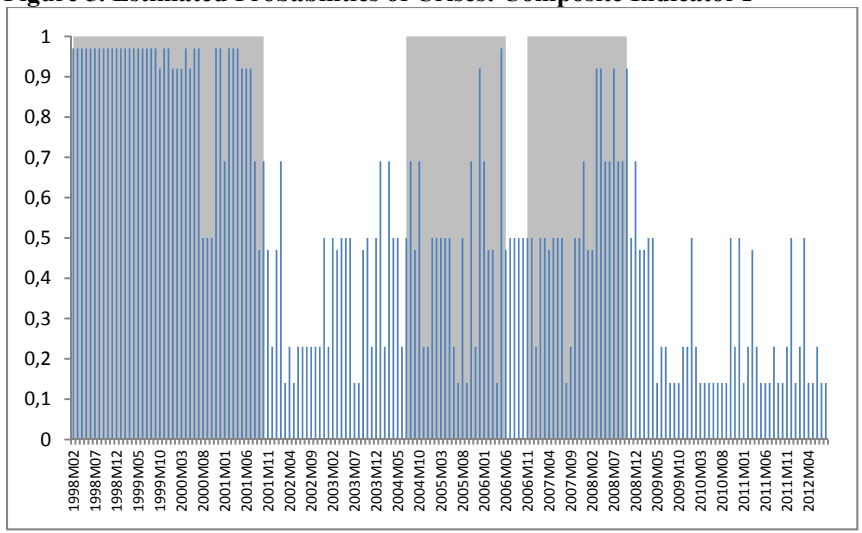
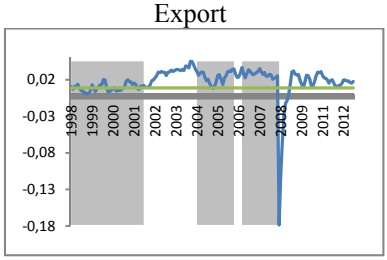


Figure 5. Estimated Probabilities of Crises: Composite Indicator I^2

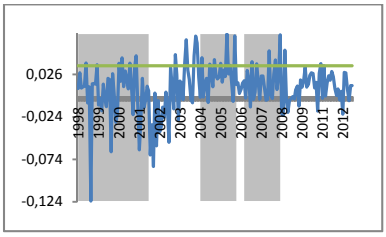


Appendix

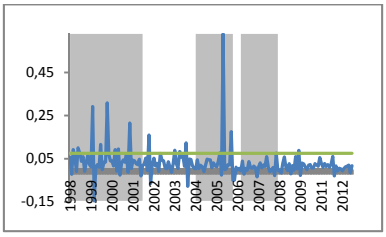
Export



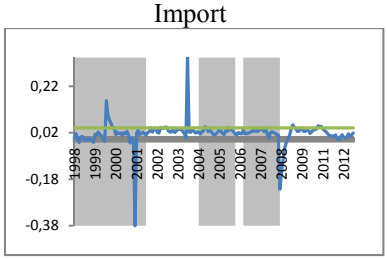
Total Domestic Credit/GDP



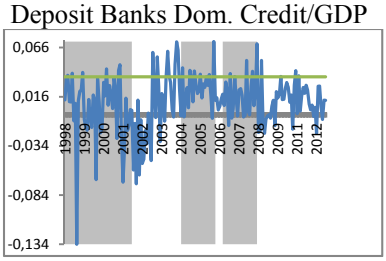
M1



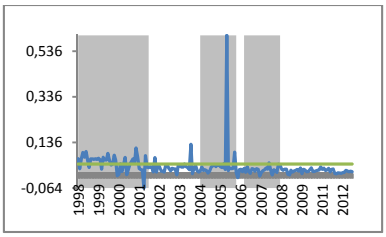
Import



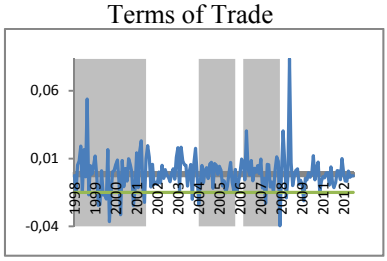
Deposit Banks Dom. Credit/GDP



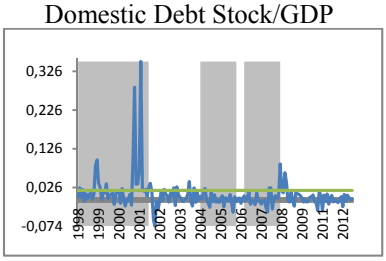
M2



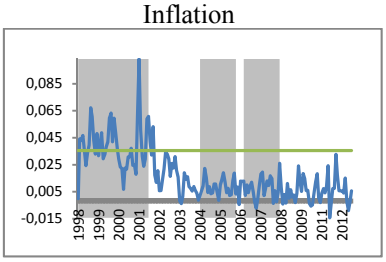
Terms of Trade



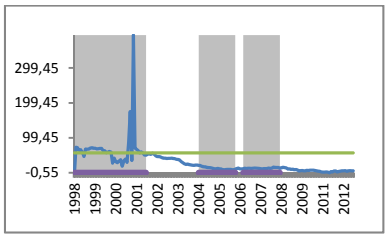
Domestic Debt Stock/GDP



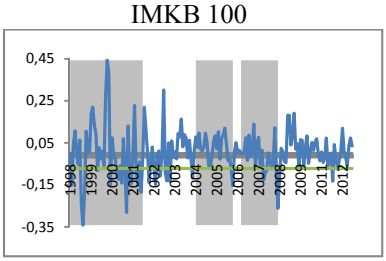
Inflation



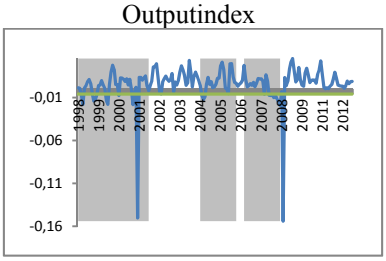
Real Interest Rate Diff. TR-U.S.



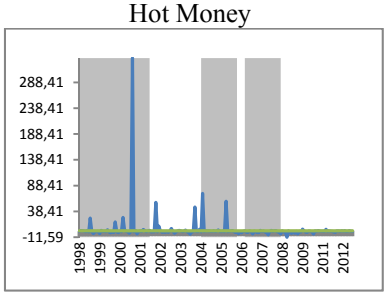
IMKB 100



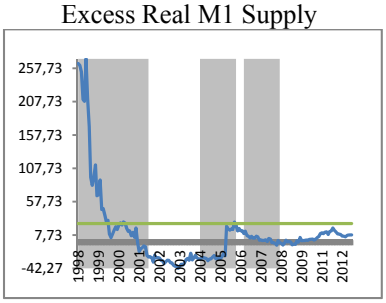
Outputindex



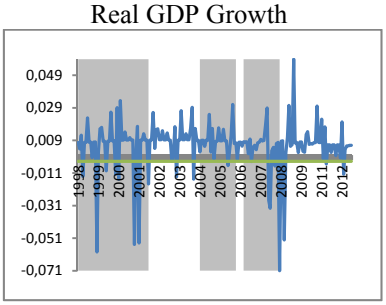
Hot Money



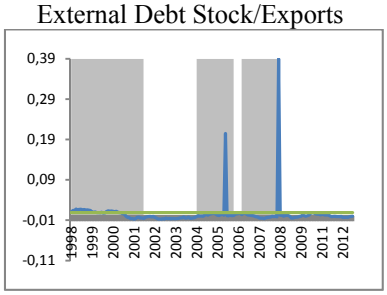
Excess Real M1 Supply



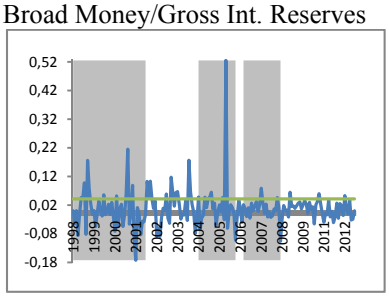
Real GDP Growth



External Debt Stock/Exports



Broad Money/Gross Int. Reserves



Budget Balance/GDP