

Financial Stability and Early Warning Systems: Lessons for I.R. of Iran

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Received: 17 August 2010
Accepted: 15 February 2012

The main purpose of this paper is to overview early warning systems, discussing their importance and relevance for current situations of Iran's financial system and economy. An early warning system generates *ex-ante* warnings of potential problems that may emerge or develop in the future on account of the current risk profile of a financial institution. Although there are various approaches to model warning and prediction of financial and economic risks, the signal extraction approach is the most popular one and gained more attention than any other approaches by financial institutions and policy makers. This approach is explained in detail. The paper will also analyze importance and relevance of early warning systems for Iran's financial system and economy. Pointing out to some leading indicators, the paper suggests that Iranian authorities and in particular economic policy makers need to develop and design an appropriate early warning system to be able to avoid future financial and economic crises or at least take necessary measures to reduce their negative impacts

Keywords: Early Warning Systems, Financial Stability, Signal Extraction Approach, Leading Indicators.

JEL Classification: E00, G00, G01.

1. Introduction

The world economy has witnessed frequent occurrence of financial crises during the last decades. These crises were not restricted to certain geographical regions, level of development or particular banking system structure. Systematic banking crises have been occurring in both developing and developed countries mainly because

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of financial deregulation, innovation, globalization and inadequate or ineffectiveness of rules and regulations. Almost three-quarters of IMF member countries have experienced banking crises over the last two decades. The costs of these crises in terms of GDP were also huge, reaching in some cases to 40%. The bail-out costs were also enormous. The recent financial and economic crisis ignited in the United States in August 2008 and spread in Europe in 2011, caused an unprecedented damage to the global financial system and the global economy.

As a result of frequent financial crises and increasing vulnerability to various kinds of economic and financial risks, financial institutions, economic policy makers, and governments have realized their need for prudent, accurate, risk-based, and quantifiable supervisory processes. In this regard, some economists and financial experts proposed the use of Early Warning Systems (EWS) which were originally designed and developed for warning people of natural hazards such as tsunamis, famine, diseases and military attacks. The main purpose of early warning systems is to generate ex-ante warnings of potential problems and crises that may emerge or develop in the future on account of the current risk profile of a financial institution, financial system or even a country.

The main theoretical and empirical work on early warning systems is attributed to Kaminsky and Reinhart (1999) who have developed the so-called signal extraction approach for finding the causes of twin crises (simultaneous currency and banking crises) in developing countries. Kaminsky, Lizondo and Reinhart (1998), and Goldstein, Kaminsky and Reinhart (2000) did further empirical studies and elaborate on the subject. Although, the signal extraction approach was a major contribution to the literature of financial stability and early warning systems, Bussiere (2001) found that this approach was not without pitfalls.

Iranian Financial institutions and the Central Bank have not yet designed or developed early warning systems for protection of Iran's financial system. Now that Iran's financial system and economy are under numerous domestic and foreign pressures, the need for a well-developed and country-specific early warning system is very urgent. Our purpose in this paper is first to overview the signal extraction approach, hoping financial and economic policy maker's benefit from the subject as a prerequisite for later development of appropriate early

warning systems for the whole economy and financial system as well as for the individual financial institutions. Then, we point out to some of the economic and financial leading indicators which may signal to the fact that why extra caution and care must be, at the moment, paid for protection of Iran's financial system and economy. The paper aims to draw attention of authorities to the importance of early warning systems for the economy and financial system, particularly in current volatile situations.

The paper consists of the following sections. In sections II, the signal extraction approach toward development of an early warning system is explained. In section III, we discuss the importance and relevance of having an early warning system for Iran's financial system and economy, pointing out to some leading indicators which have already started warning authorizes of future financial and economic crises. Finally section IV brings summary and conclusions.

2. Signal Extraction Approach

The signaling approach developed by Kamisky and Reinhart (1999) involves the following steps: a) identifying historical crisis episodes, b) selecting leading indicators as predictors of crisis episodes, c) setting threshold values of the selected leading indicators, d) constructing composite leading indicators, and finally e) watching for red signals and taking appropriate measures.

2.1. Identification of Historical Crisis Episodes

Without having observed a number of patients with heart attacks, doctors could have reached the medical conclusion that high levels of cholesterol, blood pressure and sugar would signal possible heart attacks. Similarly, without experiencing several financial crises in the past, no early warning system could be made to warn policy makers and governments of future crises. Therefore, the first step in designing an early warning system is to identify past financial crises. In this regard, it is necessary to determine what constitute a crisis and how it is defined as a dependent variable. The word "crisis" is very subjective and needs to be proxied by some measurable variables. Unfortunately, the most common-cited problem with all early warning systems developed so far is the inconsistency in the financial or banking crisis variable. There is no unique quantitative variable for banking or financial crisis. The problem lies in the fact that financial

or banking crisis is an event, so proxies for these crises would not necessarily be perfectly correlated with the crises themselves. Another problem is that a single proxy variable may not pick up all crisis events.

In addition, systematic crisis has to be distinguished from non-systematic one. According to Kaminsky and Reinhart (1999), a banking crisis is systematic if banks runs result in closure or nationalization of at least one bank, or if there are no runs, large-scale government intervention, merging or nationalization of one bank marks the beginning of the same for other banks. Lindgren, Garcia and Saal (1996) classify systematic banking crises on the basis of whether bank runs, portfolio shifts, bank collapses or large-scale government intervention, as in the case of the recent financial crisis in the US and Europe, occur. Any other episodes of financial stability are classified as non-systematic crises.

Demirguc-Kunt and Detragiache (1998a) use a more specific set of four criteria where achievement of at least one of the conditions is a requirement for systemic banking crisis, otherwise bank failure is considered to be non-systemic. The proportion of non-performing loans to total banking system assets exceeds 10%, or the public bailout cost exceeds 2% of GDP, or systemic crisis causes large scale bank nationalization, or extensive bank runs are visible and if not, emergency government intervention is visible.

Even if systemic crises unambiguously occur, identifying their starting and ending dates is important as the same episode may have a different duration in different studies. Where bank runs do not occur and banking system data are either unavailable or unreliable, locating the exact time when the system became insolvent is impossible. Even if bank runs do occur, this may be a culmination of a prolonged period of systemic insolvency, which was either unknown to depositors or supported by government assistance at an earlier stage. Kaminsky and Reinhart (1999) note that crises can also be dated too early, since the worst of the crisis could unfold after the subjective start date. Dating is also problematic when there are successions of crises episodes; in many such instances it is arguable that later crises are extensions or re-emergences of previous financial distress as opposed to distinct crises events (Caprio and Klingebiel, 1996).

2.2. Selecting Leading Indicators

According to medical doctors, heart attacks have various signals such as level of cholesterol, blood pressure, blood sugar level, stress, chest pain, etc. Doctors use these signals to evaluate a patient's conditions. Similarly, financial and economic crises are characterized by signals and leading indicators. These indicators as predictors of financial, banking and currency crises are often chosen based on economic rationales, characteristics of crisis, country specifics as well as the availability of data. Kaminsky, Lizondo, and Reinhart (1998) made a comprehensive survey of various types of indicators used in empirical studies of EWS models. IMF has also provided a comprehensive list of financial soundness indicators. Some of the indicators and variables proposed by financial and economic experts are as follows:

1. Capital Account Indicators: international reserves, capital flows, short-term capital flows, foreign direct investment, and differential between domestic and foreign interest rates.
2. Debt Profile Indicators: public foreign debt, short-term debt, share of debt classified by type of creditor and by interest structure, debt service, and foreign aid.
3. Current Account Indicators: real exchange rate, current account balance, trade balance, exports, imports, terms of trade, price of exports, savings, and investment.
4. International Variables: foreign real GDP growth, interest rates, and price level.
5. Financial Liberalization Variables: credit growth, change in the money multiplier, real interest rates, and spread between bank lending and deposit interest rates.
6. Other Financial Variables: central bank credit to the banking system, gap between money demand and supply, money growth, bond yields, domestic inflation, "shadow" exchange rate¹, parallel market exchange rate premium², central exchange rate parity, position of the exchange rate within the official band, and M_2 /international reserves.
7. Real Sector Variables: real GDP growth, output, output gap, employment/unemployment, wages, and changes in stock prices.

1. What the market exchange rate would be in the absence of various market imperfections.
 2. The difference between the parallel market exchange rate and the official exchange rate as a percentage of the official exchange rate.

8. Institutional/Structural Factors: openness, trade concentration, dummies for multiple exchange rates, exchange controls, duration of the fixed exchange rate periods, financial liberalization, banking crises, past foreign exchange market crises, and past foreign exchange market events.
9. Political Variables: dummies for elections change of government, legal and illegal executive transfers, change of finance minister, and degree of political instability.
10. Underground Economy Variables: public and private corruption, fraud, rent-seeking activities, bribery, and money laundering.

2.3. Setting Leading Indicators' Thresholds

To prevent heart attacks, doctors recommend people to control their cholesterol level, blood pressure, blood sugar level and stress. Similarly, to prevent financial and economic crises, signal extraction approach involves monitoring a set of leading indicators, such as those introduced in section b) above, that tend to behave differently prior to a crisis and examining whether they individually or collectively have reached "threshold" values that are historically associated with the onset of a financial crisis. The logic is that if aberrant behavior of a variable can be quantitatively defined then whenever that variable moves from tranquil to abnormal activity, crisis is forewarned.

Let X_i be an indicator variable relating to indicator i and X_i^* denotes the threshold for this indicator. A signal variable relating to indicator i is denoted by S_i . S_i is a binary variable which takes two values; $S_i = \{0, 1\}$. If the variable crosses the threshold, a signal is emitted and $S_i = 1$. Therefore, we have:

$$(1) \quad \{ S_i = 1 \} = \{ |X_i| > |X_i^*| \}$$

If the variable remains within its threshold boundary, it behaves normally and does not issue a signal, so $S_i = 0$. Thus we have:

$$(2) \quad \{ S_i = 0 \} = \{ |X_i| < |X_i^*| \}$$

Notice the directional sign may vary depending on whether the indicator has an upper or lower bound; hence the variables and thresholds in above equations are expressed in absolute terms. For a time series of T observations for indicator i we can obtain a binary

time series of signal or no-signal observations. This series is then checked against actual events to construct a measure of predictive accuracy. Given that there are two cases of signal and no-signal and two actual events of crisis and no-crisis, we have four possible scenarios as shown in table 1.

Table 1. True and False Warning Signals

	Crisis	No Crisis
Signal	A	B
No Signal	C	D

If the indicator signals crisis and this correlates with an actual crisis, the outcome is denoted 'A'. If the signal is not matched by a crisis in reality, the outcome is denoted 'B'. If no signal is emitted by the indicator but there was an actual crisis, the outcome is called 'C'. If no signal is emitted and there there is no crisis in reality, the outcome is 'D'. A perfect indicator would produce only outcomes A and D; it would correctly call all crises and would not issue signals unnecessarily. Outcome C represents a failure to call a crisis (Type I error) and outcome B generates a false alarm (type II error).

There is an inherent trade-off between Type I and Type II errors which are functions of the threshold X^* . Changing the threshold to allow more crises to be detected (lowering Type I error) necessarily raises the likelihood of false alarms (increasing Type II error). So, depending on preferences of the EWS user over Type I and Type II errors, a measure of signaling accuracy can be constructed for each indicator, based on the proportion of false alarms and missed crises. A policy maker concerned with avoiding crises at all costs may choose to minimize Type I errors even if this entails unnecessary intervention due to more Type II errors. In countries with high record of unstable financial positions, policy makers may prefer to use a EWS model with wider thresholds giving them time to take necessary measures. On the other hand, policy makers with relatively stable financial systems may prefer avoiding Type II errors and undue intervention.

What level of threshold a policy-makers wishes to choose for each signaling variable, depends on the form of his objective function. Assume that missing a crisis as well as issuing a signal that requires taking preemptive action both have a cost for the policy-maker, which

he wants to minimize. Therefore the loss function of the policy-maker is formulated as

$$(3) \quad L(X^*) \equiv \theta L_{NS/C}(X^*) + (1-\theta) L_S(X^*)$$

With $L_{NS/C}$ as the probability of a missed crisis, i.e. the joint probability that the EWS model issues no signal and a crisis occurs, and L_S as the probability of issuing a signal that a crisis will occur. θ can be interpreted as the relative cost of missing a crisis, or the policy-maker's degree of relative risk aversion towards missing a crisis, whereas $(1 - \theta)$ can analogously be understood as the cost of taking pre-emptive action.

Kaminsky and Reinhart (1999) introduce a specific criterion for the choice of thresholds in EWS models. According to this, the probability of failing to call crisis and the probability of false alarms are minimized simultaneously. For this purpose, they propose the Noise to Signal Ratio (NSR) which is given by

$$(4) \quad \begin{aligned} \text{NSR} &= \text{Type II error} / (1 - \text{Type I error}) \\ &= [B/(B + D)]/[A/(A + C)]. \end{aligned}$$

The NSR measure takes the trade-off between Type I and Type II errors into account. The optimal threshold (X^*) will minimize the numerator and maximize the denominator of the NSR. Empirically, the minimum NSR and the associated threshold of each indicator are estimated using a grid search procedure. This involves calculating NSRs assuming different threshold levels and finding the minimum one. In their empirical study, Kaminsky and Reinhart limited the grid search to a region between the 10th and 20th percentile of an indicator's frequency distribution: at the upper tail if the indicator is positively correlated with the crisis probability, and lower tail if the two are negatively correlated. They also assumed that the frequency distribution to be country-specific for each indicator, but the same percentile was applied to all countries in the panel data.

2.4. Constructing Composite Leading Indices

Normally, there is more than one indicator in the signal-extraction-based EWS model and not all of them signal crisis at the same time. For policy makers to respond to various signals and no-signals, a composite leading index is required. Creating a composite indicator

increases the likelihood of correctly calling crises compared to the univariate approach but raises the chances of false alarms. Although the general approach benefits in terms of crisis prediction, it is penalized by the higher level of Type II errors and the NSR is correspondingly higher than when single variables act as signalers using the same approach. Bario and Lowe (2002) have found that composite indicators increase gains in crisis identification and efficiency of EWS models.

Selection of optimal composite threshold is similar to selection of optimal threshold for a single indicator. This is usually done by a grid search to identify the minimum NSR. However, in empirical studies different thresholds may be chosen by different researchers depending on their given weights to Type II and Type I errors. Some researchers give more weight to Type II errors since they consider the failure to predict a crisis outweighs the costs of unnecessary intervention.

Using the Kaminsky and Reinhart procedure, Borio and Lowe (2002) developed constructing composite indicators to extract signals of crisis. They first select indicators which a priori are thought to contain information for crisis prediction. They then aggregate these variables to generate a composite signal whereby the indicator is switched on if all constituent variables cross their respective thresholds simultaneously.

Based on the assumption that the greater the number of leading indicators signaling a crisis, the higher the probability that such a crisis would actually occur, Kaminsky (2000) proposed a number of composite leading indices. One such composite index (I_t) is a weighted average of zero/one signals by individual indicators, S_{it} , with weights being inverses of their respective minimum NSRs. So, it is defined as

$$(6) \quad I_t = S_{it}/e_i$$

where e_i is the minimum NSR of the leading indicator i . This composite index gives more weights to better performing (with smaller minimum NSRs) indicators.

2.5. Watching for Red Signals and Taking Appropriate Measures

When a patient's important blood variables such as cholesterol level, sugar level and blood pressure pass their respective standard

thresholds, his doctor will definitely warn him of future heart problems if his current conditions remain unchanged. Therefore, he recommends his patient to take appropriate measures such as having low-fat and low-sugar diet and, more daily exercise to prevent heart attack. Similarly, once the early warning system with optimal thresholds for leading indicators is setup, financial authorities have to be on alert, frequently monitoring the system and be ready to take necessary measures in the case thresholds are passed. In this regard, authorities have to explicitly reveal their preferences over type I error and type II error. Taking measures to avoid financial risks will necessarily be costly, but doing nothing may even be more costly if the crisis occurs. The accuracy and predictive efficiency of early warning systems depends, *inter alia*, on frequency of financial crises in the past as well as preferences of decision makers regarding the choice between more crisis avoidance and false alarms.

3. Importance and Relevance of EWSs for Iran's Financial System and Economy

Our attempt in this section is not to develop or design early warning systems for Iran's financial system and economy, but rather, to explore more fundamental issues regarding the importance and relevance of such systems for current financial and economic situations. We always need to have a warning system for protection of the financial institutions, the whole financial system and economy against various domestic and foreign risks. But, the need for an early warning system at the moment in which the commercial banks, central bank, firms and the whole economy are under unprecedented pressures is more urgent than ever. In comparison to costs, the benefits of developing and designing a prudent, accurate, risk-based and country-specific early warning system for the country in general and the financial system in particular are overwhelming.

Before pointing out to some of the relevant indicators which may have already started warning the authorities and policy makers of near future financial and economic crises, it is informative to explore, based on the past experiences and the nature of Iranian economy and financial system, some general issues and limitations of developing an appropriate early warning system for Iran's financial system and economy. We hope that this paper paves the way for further research

in this area, contributing to strengthening of the stability of Iran's financial system.

3.1. Limitations of Current Early Warning Systems

Since Iran's financial system has experienced very few distress and problems in the past, designing and developing an early warning system with relevant leading indicators is problematic. One possibility is to rely on experiences of other financial institutions and other countries. Several financial and macroeconomic indicators can be constructed by which policy makers and in particular Iran's central bank may regularly check Iran's financial and economic stability by monitoring levels and volatility of these indicators compare to some predetermined thresholds. Whenever a composite of these indicators reaches its threshold, it may be considered as crisis signal, necessitating appropriate measures.

But, this approach is not very accurate for predicting future financial crises for Iran's financial system because it is built on historical data obtained from other financial systems. The latter may fundamentally be different from the former in many ways and in particular in terms of risks involved. In addition, the impacts of qualitative factors such as management quality, internal control and other specific factors may easily be ignored in the final stability assessment of the system. It is widely acknowledged that these qualitative factors, particularly the efficiency or inefficiency of management, can also be significant causes of financial crises. Incorporating qualitative factors into early warning system is of crucial importance for Iran's financial system and economy.

Another important issue is the trade-off between two types of errors. A Type I error occurs when a model incorrectly identifies a weak financial situation as a strong financial situation, and a Type II error occurs when a strong financial situation is mistakenly identified as a weak financial situation. For Iranian financial institutions, a Type I error may potentially be more serious than a Type II error. This is because Iran's financial system is based on *Islamic Jurist Prudence* and a weak financial situation that may escape supervision entails a higher risk in terms of giving bad impression about Islamic finance. Therefore, supervisory authorities may aim at minimising the Type I error rate. However, this also means that they will have a high Type II error and will incorrectly classify a number of strong financial

situations as weak. The level of the actual trade-off will depend upon the model accuracy and the extent to which the supervisory authority is willing and able to undertake increased examination and surveillance of strong financial situations to identify a greater proportion of weak financial situations. In the case of Iran, the costs of failure to prevent financial and economic crises are huge for both financial institutions and government. To minimize these costs, it is necessary to pay more attention to check and balance of financial institutions. Also, giving more weight to Type I error implies that Shariah rules and principles are more respected by the supervisory board of financial institutions.

3.2. Relevant Indicators

It is very important to undertake an assessment of the financial institutions, the whole financial system and the economy, identifying their strengths, weaknesses, opportunities, and constraints. Although there is no well-established early warning system at the moment to rely on its signals, some economic and socio-economic indicators may signal potential financial and economic problems ahead. Ignoring these signals as well as overestimation of strengths and underestimation of weaknesses will impose unexpected costs on the financial system and economy. Some of these indicators and issues for concern are briefly explained.

1. **Excessive Money Supply:** Money in any economy is more or less like blood in our body. Blood will circulate in the whole body, carrying vitamins and minerals to all cells and organs. The level of blood increases as our body grows. But if too much blood is injected into our body, it will cause many diseases. Similarly, money should circulate within economy, reaching all individuals, firms, and sectors proportionately. In a growing economy, money supply increases to finance real economic growth. Excessive injection of money into economy more than the needs of a growing economy creates many problems including high inflation, unjust distribution of wealth and income, corruption, poverty, and many other social problems.

Since end of the war in 1368, Iran has annually increased its money supply excessively beyond the needs of real economic growth. In comparison with other developing countries, Iran's annual money

supply growth is extremely high, despite the fact that its performance in terms of real economic growth has not been satisfactory. Figures 1 and 2 compare Iran's money supply with those of Qatar, Saudi Arabia, United Arab Emirates, Kuwait (Figure 1), India, South Korea, Pakistan and Malaysia (Figure 2). Data were normalized by the first year, 1990. It goes without saying that Iran's money supply follows an exponential path while those of others follow linear path with mild growth. This excessive growth has created numerous economic and social problems within the economy during the last two decades.

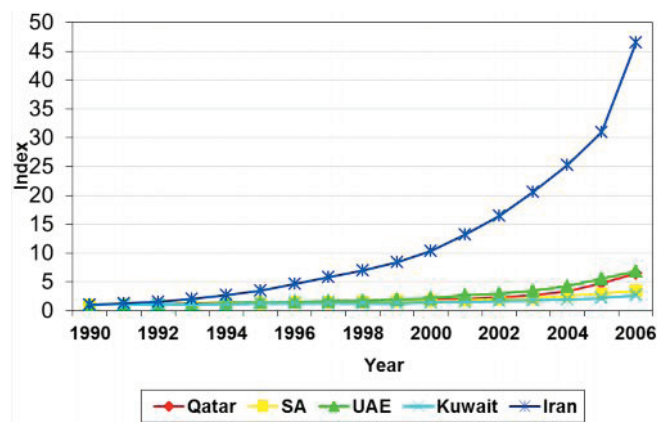


Figure 1. Money Supply Index in Selected Countries (1990=1)

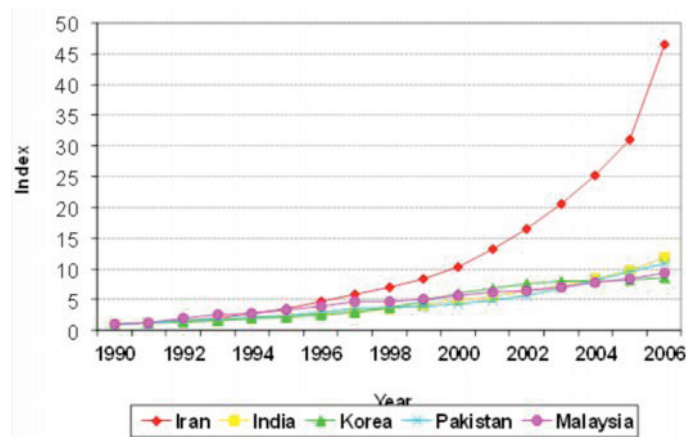


Figure 2. Money Supply Index in Selected Countries (1990=1)

As long as this path of money supply continues into the future, Iranian authorities and policy makers should be expecting volatilities

and misalignments in asset prices, exchange rates, banks profit rates, and relative prices and as a result liquidity circulates more proportionately among non-productive assets such as gold, foreign exchange and land rather than be directed toward productive investments.

2. **Unprecedented Growth of Financial Institutions:** Iran's Central Bank has recently increased number of licensed financial institutions and banks. Financial institutions have been able to some extent to attract deposits away from public banks by provision of more favourable short and long term profits rates on saving accounts. Some of these financial institutions provide profit rates to depositors much beyond the rates public banks offer. Although increasing the number of financial institutions will promote competition and help financial deepening, there is a fear that these institutions not regularly being supervised and their balance sheets (assets and liabilities) not transparent enough to ensure financial stability. More importantly, these financial institutions are growing so fast in circumstances in which real economic growth is sluggish and non-financial firms are struggling with mounting problems. If financial growth is neither consistent with nor proportional to real economic activity and this gap persists over time, policy makers should be worried about a potential financial crisis. This was the case in 2008 financial crisis.
3. **Unprecedented Level of Corruption:** Corruption exists in almost all countries of the world, but the level of corruption varies across countries. The level of corruption is normally higher in developing than in developed countries mainly because of less transparent governments, insufficient legal and institutional framework, inadequate law enforcement, lack of effective and accurate supervisory process and many other socio-economic factors. Within developing countries, resource-based countries in general and oil exporting countries in particular face with huge rent-seeking activities and corruption. Unfortunately, the levels of corruption and rent-seeking activities have, as claimed by many Iranian officials, been increasing since end of the war and in particular in recent years. An unprecedented case of corruption was recently

disclosed in 1390. High level of corruption may signal potential economic and social problems in future.

4. **Increasing Parallel Exchange Market Premium:** Parallel exchange market premium has recently increased significantly as a result of speculation of market exchange rates, foreign exchange rationing policies, and political tensions in the region. The increasing gap between market exchange rates and the government-based fixed rate may lead, as was witnessed before, to diversion of resources away from production toward rent seeking activities. This will in return cause inefficient allocation of resources and signal further decline in real output.

Given the above facts and many other concerns induced from numerous reports, Iran needs regular financial and economic risk assessment. To avoid future financial and economic crises or to at least reduce the negative impacts of these crises, policy makers need to design and develop suitable early warning systems for financial institutions and the whole financial system and economy. In this system, all relevant qualitative and quantitative factors should be taken into account. In addition, the system should be revised and adjusted on the base of risk factors surrounding the financial system and economy.

4. Conclusion

This paper tried to explain how the early warning system based on the signal extraction approach work and what lessons can be learned. Overviewing the signal extraction approach as well as its weaknesses and strengths, the paper discussed various steps involving in the construction of an early warning system. Particular attention was paid to the trade-off between the type I and type II errors. It was also argued that policy makers preferences over these errors are very crucial, indicating how much they are willing to avoid financial and economic crises.

More importantly, our purpose was to convince Iran's policy makers and authorities that early warning system is a necessary tool for protecting the stability of financial institutions and the whole financial system. Pointing out to some important leading indicators, we discussed that Iran's policy makers should be alert about Iran's current financial and economic conditions. Some leading indicators

such as excessive money supply, high parallel market premium, increasing number of financial institutions and high corruption have already started warning us of possible future problems for the financial system and economy.

We have also argued that a comprehensive early warning system for Iran's financial system should take into consideration all qualitative and quantitative risk factors. Many of these risk factors have well known indicators and can be constructed for individual financial institutions and aggregated for the whole system. However, many of other qualitative risk factors including institutional and managerial factors are yet to be constructed and incorporated into the early warning system.

While lessons learnt from the signal extraction approach to early warning systems can be informative for Iran's financial institutions, they have various limitations due to specific features of Iran's financial system and lack of data on previous financial distress or crises. Further theoretical and empirical research is needed to develop a more suitable early warning system for Iran's financial system and economy.

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