



Anticipation of Currency Crisis in Iran Economy with the Use of an Early Warning System

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Abstract

Today, economists have paid much attention to prediction of currency crises due to their very negative effects on the performance of real economies and the consequences of its subsequent recession. The use of an early warning system for currency crises is therefore introduced as an empirical tool for troubleshooting Iran macroeconomic problems. Based on studies conducted in other countries and using conventional methods of extracting symptoms and estimating crisis probability, an early warning system for currency crises is presented to the Iran economy that can warn currency crises beforehand. Using Multi-layer Perceptron Neural Network and Hard-Limit function, the Early Warning System is basically design to consider seasonal data for the period of 2001 to 2015 to anticipate currency crisis of 2019(based on 12-season warning periods). The results predicted show that no currency crisis is threatening Iran economy in 2019. The export index is one of the leading variables in the system which has the greatest impact on currency crises. In addition, according to the previous data and their substitution in this model, the years 1993, 2001 and 2003 are signaled as critical years. It therefore can be concluded that the present research model is reliable.

Keywords: Early Warning System, Currency Crisis, Artificial Neural Network, Perfect Signal.

JEL Classification: G01, G17, E44.

Introduction

There is a financial sector in each country which is providing financial resources and real economic activities. This section can be divided in two parts: monetary market which is mainly administered by banking system of each country and its main duty is to provide short run credits; capital market with its main activity to provide long term financing required for services and production activity. From the empirical findings of research on the relationship between financial development and economic growth over the last decade, there is a positive and meaningful relationship between financial development and economic growth. Policy Recommendation of this empirical finding is the development of financial intermediaries to achieve higher economic growth. Some studies have also emphasized the impact of economic growth on financial development. In spite of these results, another range of empirical research has focused on currency crises and the negative consequences of non-normative development of financial intermediaries. Currency crises are a serious threat to the financial systems due to their negative impact on real sector performance. With regard to negative impacts of currency crises on nominal and real sectors, prediction of these crises has been of interest to some international financial organizations and economic policy makers. Therefore, some recent

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studies in related literature have predicted currency crises; as some researchers tended to introduce various methods, including early warning systems for alarming and prevention of currency crises.

Crisis in the general sense is the state of instability in which the economy faces the point of decline or the lowest point of its basic activity. In general, the emergence of any large none equilibrium in domestic and foreign market economies that is affected by the internal and external factors of the market is considered an economic crisis. Because of the relationship between markets (monetary, capital, labor, goods and services markets), the crisis is spreading from one market to another, and sometimes it affects the whole economy. As long as there is no improvement for a number of activities in economic crises and policy makers do not see things better, expectations are going to worsen the situation. The adverse effects of crises in various forms such as high inflation, low economic growth, widespread recession and declining employment, budget deficit, etc., are emerging and spread internationally into the other countries. The crisis affects the economy from different channels accordingly. Considering that macroeconomic variables, especially national production and inflation rate affecting investment, it is therefore expected that the investment will be affected by emerging of the crisis and so it is reduced. Demand is also decreasing despite the financial crisis and, in this case, it can also affect investment. With the crisis deepening and the spread of uncertainty among investors, it is expected that investments will be made to safer places and, as a result, will be reduced by investment in crisis-hit countries. And because developing countries are looking to attract investment, this will increase the budget deficit and more vulnerability to this investment, and will reduce the investment efficiency in these countries.

The prediction of economic crises is for various reasons of interest to some economic organizations such as the International Monetary Fund, the World Bank and other public or private institutions or organizations. Economic policymakers in each country also need to anticipate crises in order to cope with economic crises. Among the economic crises, currency crises and occurrence of severe fluctuations in the foreign exchange market, especially in developing countries, have been significantly influencing these countries' macroeconomic variables by the dependence of their foreign exchange products on raw, intermediary and foreign capital materials. For example, the recent currency crisis following the large-scale economic sanctions in the country has undergone a number of major macroeconomic variables such as production, employment and inflation. Therefore, the prediction of currency crises due to its wide impact on real economy sectors is of great importance in the country's economy.

Many researchers have introduced early warning systems to inform and deal with economic crises. In this context, a large range of indexes have been identified and tested as leading indicators. Conventional predictive methods in the early warning system include two standard methods called signaling methods or a method for extracting crisis symptoms from leading indicators and another is a probabilistic method or method of Logit or Probit. A newer approach to the early warning system is the signaling method using artificial neural networks. Using this method, it is possible to predict the occurrence of currency crises for the coming years and, with the knowledge of currency crises at a given time by using the necessary policies, such crises can be prevented, or at least the negative effects of these crises could be reduced.

The purpose of this paper is to present a warning pattern prior to the occurrence of currency crises in the country. To reach this goal the signaling method is used. The distinction of this paper with previous studies is that, in the present article, the artificial neural network approach is used which in comparison to econometric models; firstly, there is the advantage that the model is not facing serial correlation in time series variables. The second distinguishing feature of the article is that in the present paper, the time series approach is

used, and so this approach is to predict an early warning pattern which is far superior to that of variable-explanatory models.

The paper is presented in five sections. In the next section, we will consider the theoretical literature of the prediction of economic variables and empirical studies of currency crises. In the third section, the method of research and description of the data is presented. The fourth section is dedicated to providing a preliminary warning pattern based on the artificial neural network method of multilayer perceptron, and lastly, a conclusion and suggestion are presented in the final section.

Theoretical Literature and Research Background

The Economic Crisis Concept

In the economic terminology, there are economic upheavals in the sense that the economy sometimes reaches a weak or a peak point at a time. The former point is called the peak and the latter point is called boom. Following a recession there is a recovery period, thereafter, the opening period will begin. Thereby, four stages of the economic period or four stages of the business cycle are completed. There are several stages for the market that are more detailed than the four above. These steps are as follow:

- 1) The crisis, at this stage, the market is about to collapse or there is a possibility of collapse.
- 2) Emergency liquidation, which resulted following to strike stage of a crisis and is a huge bankruptcy.
- 3) A depression, which is a difficult period and production, declines sharply.
- 4) The repression, with prices falling to the lowest level, and the turning point for economic adjustment.
- 5) Recuperation period, in which reserves increase and business conditions are eased.
- 6) The evolutionary period, the more intense recuperation state in the economy.
- 7) The period of over expansion, and high opening that the boom climbs, and the business goes to extreme levels.

So, in short, we can say that the crisis means the collapse of the boom; of course, the crisis should not be confused with the shock. During the shock period, there is a severe financial and credit disorders. It is likely that shock will be created after each crisis and without any doubt industrial recession will come about after any crisis. Specific features of the crisis period include rapid price collapses, reduced production volumes and income, rising unemployment and bankruptcy, and eventually the fall of the stock market. Some economists also focus on the characteristics of the crisis period in terms of unemployment and the duration of the economic downturn, with a recession over three years and an unemployment rate of more than 12 to 20 percent as a characteristic of the crisis period (Batra, 1990).

However, the tides and economic cycles that alternatively occur in macroeconomic variables (the level of prices, employment, gross domestic product, the balance of payments) in capitalist countries are often known as intrinsic characteristics of these systems. But these developments from the distant past, especially with the Great Depression of 1929, attracted the attention of economists. Hence, various theories were presented in order to determine, assess and justify the causes of the crises and recessions that arose in the economies of some countries (Batra, 1990).

According to Keynes's economists, economics is unsustainable, and the main source of instability is the level of investment, and the weakness of investing towards saving which is a cause of recession and crisis. This group believes that in order to stabilize the system, the government must intervene by pursuing appropriate monetary policies and engaging actively

in the economy. In contrast, according to Friedman and advocates of monetary theory, the source of many economic cycles is the monetary sector, not the commodity sector or investment. They believe that there is a strong link between money supply and economic activity. According to Friedman and advocates of monetary theory, the economy is stable at its foundation, and government intervention worsens the situation and may cause instability; they believe that major deficits have always been accompanied by absolute declines in the supply of money.

Accordingly, it is said that the government needs to balance its budget over the economic cycles and allow rising money to grow at an annual rate of 4% or equal to any long-term growth rate of production. Finally, these two perspectives agreed at one point that economic cycles are more based on total demand for goods and services, rather than total supply, but the point that separates these two perspectives is the issue of the main source of total demand fluctuations (consumption + investment + government expenditure). Monetary economists attribute a major factor to money and the other group attributes it to investment. Some other economists attribute the emergence of the crisis to an unequal distribution of income. According to them, as the marginal propensity to save in the wealthy is more than the poor, an unequal distribution of income will increase saving, followed by lower consumption and reduced production. Economists attribute the causes of the crisis to income and wealth concentration (Batra, 1990).

In fact, as a result of the concentration of wealth, there are three phenomena:

- 1) The demand for loans will increase as the number of low-income or poor people will increase.
- 2) The number of loan takers who do not have the necessary credit increases and so the number of banks with relatively insecure loans increases.
- 3) An unequal increase in wealth increases investment in speculative activities, the fast and high profits from speculation encourage more people to do so, and ultimately lead speculating people from ordinary and wise behavior to extremism and madness.

In other words, the concentration of wealth by increasing the number of banks with insecure loans and the growth of madness speculation will ultimately lead to a crisis (Batra, 1990).

Types of Crises

Financial Crisis

The financial crisis is a sudden and fast change in all or most of the financial indicators - including short-term interest rates and asset prices (securities, stocks, real estate, land) - and the bankruptcy and collapse of financial institutions. Creating price bubbles for an asset or even a range of assets is related to the nature of the asset market. The risk begins when the bubble is transferred from one asset to another and spreads from one country to another and stops the financial structural function (Neely, 2005).

Monetary Crisis (Currency Crisis)

A monetary crisis or a balance of payments crisis is a sudden currency value drop, which often ends with an aggressive policy on the foreign exchange market. The monetary crisis may be due to a severe deficit in balance of payments or hoarding in the market. In other words, a sudden and unexpected fall in the value of the national currency creates a currency crisis. This issue may occur in the fixed and float exchange rate system, and the system between them. If the foreign exchange system is stable, the crisis will lead to the loss of

international reserves, and once the reserves appear to end, it will reduce the value of the national currency. If a country has a floating exchange rate system, the exchange rate crisis will include a reduction in the immediate and uncontrollable value of the national currency (Galbraith, 1975). Also, a currency crisis is a situation in which serious doubt exists as to whether a country's central bank has sufficient foreign exchange reserves to maintain the country's fixed exchange rate. The crisis is often accompanied by a speculative attack in the foreign exchange market. A currency crisis is a type of financial crisis, and is often associated with a real economic crisis. A currency crisis raises the probability of a banking crisis or a default crisis. During a currency crisis the value of foreign denominated debt will rise drastically relative to the declining value of the home currency. Financial institutions and the government will struggle to meet debt obligations and economic crisis may ensue. Causation also runs the other way. The probability of a currency crisis rises when a country is experiencing a banking or default crisis (Kaminsky and Reinhart, 1999). To offset the damage resulting from a banking or default crisis, a central bank will often increase currency issuance, which can decrease reserves to a point where a fixed exchange rate break. The linkage between currency, banking, and default crises increases the chance of twin crises or even triple crises, outcomes in which the economic cost of each individual crisis is enlarged (Reinhart, 2002). It should be noted that FPI is at first considered as an indicator of currency crises, but given that an increase in the exchange rate, can cause a fall in the value of the national currency and, consequently, can impact on the bank's debt, the FPI can be as an indicator for predicting monetary crises.

Bank Crisis

The banking crisis occurs when banks lose the ability to carry out normal lending and all banks (or some of them) are facing bankruptcy in a country. Like other economic units, banks are considered bankrupt when their assets are less than their debts, or, in other words, they have a special negative value (Neely and Kanaani, 2005).

Internal Studies

- Motahari et al. (2015) in an article entitled "Presenting an early warning system before the occurrence of Currency fluctuations in the Iranian Currency Exchange Market: Markov Switching GARCH Method " An early warning system is introduced before the onset of extreme fluctuations in the foreign exchange market. For this purpose, the free market exchange rate fluctuations are modeled by estimating Markov Switching GARCH model. By estimating this model, the matrix of the probability transfer is calculated for two conditions of a high and low fluctuation exchange rate. Using this matrix, it is possible to predict the market situation with severe fluctuations in any future period, thus providing an appropriate pattern for predicting severe fluctuations. The results of this model show that the probability of staying in a highly fluctuating regime, the probability of a transition from a fluctuating regime to a low exchange rate regime, the probability of a transition from a low-fluctuation regime to a highly fluctuating exchange-rate regime and the probability of staying in a low-swing regime is respectively, 0 and 39/38, 80/0, 51/0.
- SayedNia Tayebi (2011) in an article entitled "Explaining a warning system for identifying financial crises in Iran" provides a warning system for explaining financial crises in a way that this warning system should be able to send a signal at the moment on the possibility of a future crisis. The results of this study indicate that the years 1980, 1987, 1994 and 1995 were selected as critical years, and indicators such as GDP growth

- rate, real interest rate, inflation rate and currency deviations have been introduced as warning indicators.
- Shajari and Mohebikhah (2010) in an article entitled "Banking Crisis Forecasts and Balance of Payments Using the KLR Marking Method (Case Study: Iran)", provide a Possible Model for Predicting Bank and Balance of Payments Crises for the Iranian economy using the signaling method and examine the possibility of overlapping the twin crisis. According to the results of this study, two variables of stock price and real interest rates are respectively the most reliable indicators for predicting the crisis.
 - Neely and Kanaani (2005) in an article entitled "Forecasting Currency Crises in affiliated Oil Resources Economies (with the KLR Approach)", evaluate the role of variables such as real exchange rate changes, changes in exchange resource volumes, changes in monetary variables towards foreign exchange reserves alongside oil shocks in countries with oil reserves. In this paper, the vulnerability of the Iranian foreign exchange market has also been analyzed. The results of this paper indicate that if the changes in the price of oil, changes in foreign exchange reserves, and changes in the ratio of the amount of money to the volume of foreign exchange reserves simultaneously trigger the announcement, the probability of a crisis would reach 100%.
 - Naderi (2003), in a paper entitled "Providing an early warning system for financial crises in the Iranian economy, relying on the financial crisis of 1993", simulates a system that could be used to cope with the crisis in other years. In this paper, firstly through a signaling method, the important indicators affecting the financial crisis years of the Iranian economy have been identified, and then by providing a probability function of a financial crisis through logit, the critical years in Iran economy were identified. The results of this study indicate that the real exchange rate, the growth rate of international reserves, the growth rate of value added of the industries and mines, the ratio of foreign currency debt to international reserves, inflation rate, export growth rate, the growth rate of terms of trade and foreign currency debt are the most effective indicators of financial crisis.

Foreign Studies

- Bali et al. (2014), in an article entitled "Developing a warning system for predicting currency crises" used 32 independent variables and a complete signal as a dependent variable for predicting currency crises for Turkey over the years 1992 to 2011. In this research, using the neural network, leading indicators are ranked according to their importance in prediction. The results indicate that the years of 1994 and 2001 are the years of the Turkish crisis that was warned 12 months earlier.
- Davis and Delrba (2008), in an article entitled "Comparison of a Bank Warning System" try to evaluate the warning system with a logit model and a signaling approach for the banking crisis. By reviewing 60 countries, they found that the growth of real GDP and exchange rates are the most influential indicators of the banking crisis.
- Lin et al. (2006), in an article entitled "A new approach to modeling early warning systems for currency crises: Can a machine-learning fuzzy expert system predict the currency crises effectively?" have been investigating the currency crisis. In this study, first, the relationship between the currency crisis and political variables was investigated and then, by comparing the three methods of fuzzy logic, Logit and, the signal approach, it has been concluded that fuzzy logic, despite the defect, has more power in prediction, and the predictive power of this method is estimated to be 86%.
- Kibritcioglu (2004), in an article entitled "An Analysis of the Early Warning Signals of Foreign Currency Crises in Turkey from 1996-2004", relying on the findings of

Kaminsky and Reinhart in the framework of the signal approach to explain the early warning system in order to identify the currency crisis, use the currency market pressure indicator to determine the currency crisis. Combining 46 economic variables, he identified five critical economic periods in his 2000 study, 4 of which were prior to 2000 and one relates to 2001, and almost all his predictions have been successful.

- Bussiere and Fratzscher (2002), in a paper titled “Towards a New Warning Financial Crisis Identification System”, published by the European Central Bank, have tried to provide a new warning system through the Logit Model to identify financial crises of 32 emerging economies with open economies from 1993 to 2002. The results of the model indicate that Logit model has been predicting the crisis well.

Comparing internal and foreign studies, one can conclude that the similarity of these studies to predict the types of crises is the use of econometric methods, such as Logit and Probit methods, and methods for extracting signals. It can also be seen that in foreign studies, contrary to internal studies, it is necessary to have an early warning system for predictions, but it does not consider this tool sufficiently accurate in predicting crises, especially currency crises.

Method of Research and Description of Data

Research Method

Models in the early warning system are divided into two general types of structural models and non-structural models. Structural models include logit, Probit and fuzzy logic, while non-structural models include a signal approach. In practice, Logit and Probit methods are more applicable and these methods allow for a more meaningful statistical analysis of explanatory variables (Lin et al., 2006). These types of models need larger samples so that they can relate only a limited number of explanatory variables without correlation. The signaling method is most commonly used for single-variable models; these models are more reliable with fewer samples (Beaver, 2005). Using artificial neural networks, Signal techniques can predict crises easier. Among the neural networks, the perceptron neural network is of great importance for prediction; furthermore as the use of neural networks does not have problems of econometric models such as self-correlation and serial correlation errors, prediction of crises can be done better (Bali et al., 2014).

In this study, the data were first compiled from valid official sources such as the CBI¹, and then the financial pressure index (FPI) were calculated as the dependent variable by forming the data matrix.

According to Bali et al. (2014), the main reason for using this indicator in currency crises is the use of variables such as foreign exchange rates, foreign gross exchange reserves and inflation, which are somewhat reflective of the currency crisis. It should be noted, however, that the FPI is at first glance an indicator of currency crises, but given the collapse of the foreign currency, the fall in the value of the national currency and consequently its impact on the banks' debt; it can be regarded as an indicator to predict currency crises. The financial pressure index includes three main variables as the percentage of changes in the dollar exchange rate (e_t), the central bank's gross foreign currency reserves (r_t), and the overnight interest rate or inflation rate (i_t) (Bali et al., 2014).

$$FPI_t = f(e_t, r_t, i_t) = \frac{\left(\frac{e_t - \mu_e}{\sigma_e}\right) - \left(\frac{r_t - \mu_r}{\sigma_r}\right) + \left(\frac{i_t - \mu_i}{\sigma_i}\right)}{3} \quad (1)$$

1. Central Bank of Iran

In the above relation, μ shows the mean and σ is the standard deviation. Also, the variables used in the FPI index come from the following relationships, which show the period t , the current year, and the period $t-1$ as the previous year.

$$e_t = \frac{E_t - E_{t-1}}{E_{t-1}} \quad (2)$$

$$r_t = \frac{R_t - R_{t-1}}{R_{t-1}} \quad (3)$$

$$i_t = \frac{I_t - I_{t-1}}{I_{t-1}} \quad (4)$$

Given the data matrix, the input and output of the neural network system are determined and using the Perceptron neural network, a currency crisis will be predicted. Some of the variables used as independent variables (system inputs) are: percentage of budget deficit to gross domestic product, index of production of large industrial workshops, current account balance, export of goods, import of goods, government debt to central bank, bank debt, etc. which will be predicted by these variables. In this kind of neural network, weights and biases can be trained to produce a specific target. The learning rules used in this regard are called "perceptron training rules". These networks are noteworthy because they are capable of evolution by input vectors (Kia, 2011). This method therefore is used in this study to predict currency crises due to the fact that they are reliable and very fast to resolve issues. The perfect signal used as the target in the neural network is calculated from the following equation:

$$PS_i = \begin{cases} 1 & \text{if } FPI > (\mu + \alpha\sigma) \\ 0 & \text{Otherwise} \end{cases} \quad (5)$$

The perceptron neural network used in this study has three layers, the input, the hidden and the output layers. The input layer has the number of independent variables of the neuron model; the hidden layer and the output layer have two and one neurons respectively. In the hidden layer, the transfer function HL (hard-limit) has been used. According to the data matrix and the perceptron neural network after performing the predictive calculations of currency crises, if the output of the model is "1", it means that the crisis has occurred in the desired season and if the output of the number "0" is displayed we will not have a crisis.

Data Description

According to Bali et al. (2014); Davis and Delrba (2008); Lin et al. (2006); Bussiere and Fratzscher (2002); Motahari et al. (2015), and SayedNia Tayebi (2011) The selected variables are as Table (1), which were selected for the period of 2001 to 2015 seasonally as economic indicators of the central bank.

Table 1. Introducing Model Variables

Variable Name	Variable Symbol	Reference	Type of Variable
Exchange rate (Rail/USD)	X11(et)	Lin et al. (2006), Bali et al. (2014), Neely and Kanaani (2005), Edison (2000), Kaminsky and Reinhart (1999)	Actional (used to construct the FPI dependent variable)
Inflation rate	X2(it)	Bali et al. (2014), Kaminsky and Reinhart (1999)	Actional (used to construct the FPI dependent variable)
Change in international reserves	X23(rt)	Kaminsky and Reinhart (1999), Shajari and Mohebikhah (2010), Edison (2000), SayedNia Tayebi (2011), Naderi (2003), Bali et al. (2014)	Actional (used to construct the FPI dependent variable)

Variable Name	Variable Symbol	Reference	Type of Variable
Changes in budget deficit to GDP	X1	Bali et al. (2014), SayedNia Tayebi (2011)	Independent
Liquidity volume (M2)	X3	Kaminsky and Reinhart (1999), Shajari and Mohebikhah (2010), Edison (2000), Bali et al. (2014)	Independent
Money volume (M1)	X4	Kaminsky and Reinhart (1999), Shajari and Mohebikhah (2010), Edison (2000), Bali et al. (2014)	Independent
Growth of non-government sector deposits	X5	Motahari et al. (2015), Kibritcioglu (2004), Bussiere and Fratzscher (2002)	Independent
Production of large industrial workshops index	X6	Kaminsky and Reinhart (1999), Shajari and Mohebikhah (2010), Edison (2000), Bali et al. (2014)	Independent
Consumer Price Index (CPI)	X7	Lin et al. (2006), Bali et al. (2014), Neely and Kanaani (2005)	Independent
Export of goods	X8	Lin et al. (2006), Bali et al. (2014), Neely and Kanaani (2005), Edison (2000), Kaminsky and Reinhart (1999)	Independent
Import of goods	X9	Lin et al. (2006), Bali et al. (2014), Neely and Kanaani (2005), Edison (2000), Kaminsky and Reinhart (1999)	Independent
Current account balance	X10	Lin et al. (2006), Bali et al. (2014), Neely and Kanaani (2005), Edison (2000), Kaminsky and Reinhart (1999), Motahari et al. (2015)	Independent
Foreign Central Bank Debt	X11	Motahari et al. (2015), Lin et al. (2006), Bali et al. (2014), Neely and Kanaani (2005), Naderi (2003)	Independent
Budget / surplus deficit	X12	Lin et al. (2006), Bali et al. (2014), Neely and Kanaani (2005), Edison (2000), Kaminsky and Reinhart (1999), Motahari et al. (2015), Naderi (2003)	Independent
Total non-government sector deposits	X13	Bali et al. (2014), Bussiere and Fratzscher (2002)	Independent
Net foreign assets of Central Bank	X14	Kaminsky and Reinhart (1999), Shajari and Mohebikhah (2010), Bali et al. (2014), Edison (2000)	Independent
Non-government sector debt to banks	X15	Lin et al. (2006), Bali et al. (2014), Neely and Kanaani (2005), Edison (2000), Kaminsky and Reinhart (1999), Naderi (2003), Sayyadnia Tayebi (2011)	Independent
Government debt to banking system	X16	Bali et al. (2014), Bussiere and Fratzscher (2002)	Independent
Government deposits at banking system	X17	Bali et al. (2014), Bussiere and Fratzscher (2002)	Independent
Government debt to central bank	X18	Lin et al. (2006), Bali et al. (2014), Neely and Kanaani (2005), Edison (2000), Kaminsky and Reinhart (1999), Naderi (2003), SayedNia Tayebi (2011)	Independent
Bank debt to central bank	X19	Lin et al. (2006), Bali et al. (2014), Neely and Kanaani (2005), Edison (2000), Kaminsky and Reinhart (1999), Naderi (2003), SayedNia Tayebi (2011)	Independent
(Total) bank	X20	Bali et al. (2014), Bussiere and Fratzscher (2002)	Independent

Variable Name	Variable Symbol	Reference	Type of Variable
deposits to the central bank			
(Total) stock price index	X21	Kaminsky and Reinhart (1999), Shajari and Mohebikhah (2010), Bali et al. (2014), Edison (2000)	Independent
(Total) bank deposits at central bank	X22	Bali et al. (2014), Bussiere and Fratzscher (2002)	Independent
Oil price	X24	Bali et al. (2014), Bussiere and Fratzscher (2002)	Independent
Value added of industries and mines	X25	Bali et al. (2014), Bussiere and Fratzscher (2002)	Independent
Gross domestic product (GDP)	X26	Lin et al. (2006), Bali et al. (2014), Neely and Kanaani (2005), Edison (2000), Kaminsky and Reinhart (1999), Naderi (2003), SayedNia Tayebi (2011)	Independent

Source: Subject literature and related studies¹.

Provide an Early Warning Pattern for Currency Crises

In this study, the perfect signal is considered as the dependent variable (model output), which is a multilayer perceptron neural network for constructing a neural network of the research model with an input layer of 26 neurons (each neuron identifies an independent variable). The hidden layer consists of two neurons that follow the transmission function of the tangent of hyperbolicity and the output layer consists of a neuron.

According to Table 2, it can be seen that different studies have used different values for α coefficient. Therefore, in this study, according to previous studies, the same coefficients were used to extract the appropriate coefficient for Iran.

Table 2. Different Amounts of α in Previous Studies

Different values of the coefficient α	$\alpha = 1.5$	$\alpha = 2$	$\alpha = 2.5$	$\alpha = 3$
Studies using the α coefficient	Tambunan (2002)	Eichengreen et al. (1995), Park (2002)	Yap (2002)	Kaminsky and Reinhart (1999), Berg and Pattillo (1999)
	Adiningsih, Setiawati, and Sholihah (2002) Tinakorn (2002)	Kamin and Bobson (1999)	Edison (2003)	
	Kibritcioglu et al. (2001)	Bussiere and Fratzscher (2006)		Peng and Bajona (2008)

Source: Bali et al. (2014).

The amount of signal range of a crisis is obtained by the following equation:

$$TV = \mu + \alpha\sigma \quad (6)$$

Given the Binary variable K, when the value of this variable gets "1", crisis happens in that season and if it shows "0" we will not have any crises:

$$k = \begin{cases} 1 & \text{if } FPI > TV \\ 0 & \text{otherwise} \end{cases} \quad (7)$$

Perfect Signal

1. The data related to the variables are collected from the central bank of Iran and the data length is 60.

A perfect signal is an ideal series of signals that warns in a period of 12 seasons before crisis. This signal shows the value of "1" in the 12 seasons before the critical season.

$$PS_i = \begin{cases} 1 & \text{if } \exists i=1.2.....12 \text{ subject to } FPI_{i+k} > (\mu + \alpha\sigma) \\ 0 & \text{otherwise} \end{cases} \quad (8)$$

It should be noted that the purpose of perfect signal is to give warning before crisis occurs.

The purpose of the study is to investigate the occurrence of a currency crisis in the first season of 1398 (based on warning periods of 12 seasons) based on MATLAB, which can be estimated by the following table.

Table 3. Perfect Signaling Results of the Present Study

Period	Crisis	Perfect signal (PS)
Q195	-	.
Q295	.	.
Q395	.	.
Q495	.	.
Q196	.	.
Q296	.	.
Q396	.	.
Q496	.	.
Q197	.	.
Q297	.	.
Q397	.	.
Q497	.	.
Q198	.	.

Source: Research findings.

It is also evident in Figure (1) that during different levels of the 20 upcoming periods i.e., from the first season of 2016 to the end of 2020, the currency crisis will not impair Iran.

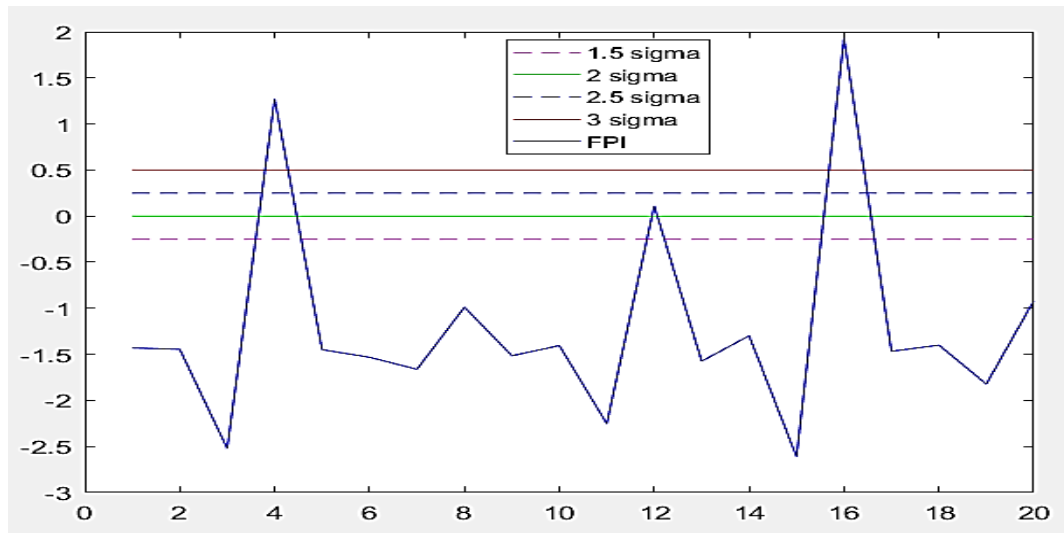


Figure 1. FPI Fluctuations Relative to Different Standard Deviations

Source: Research findings.

Figure (2) shows the results obtained from the signals determine the most effective independent variables of the model. Export, import, total government sector deposits, CPI, and current account balance are the most important indicators of the system for forecasting currency crises, respectively.

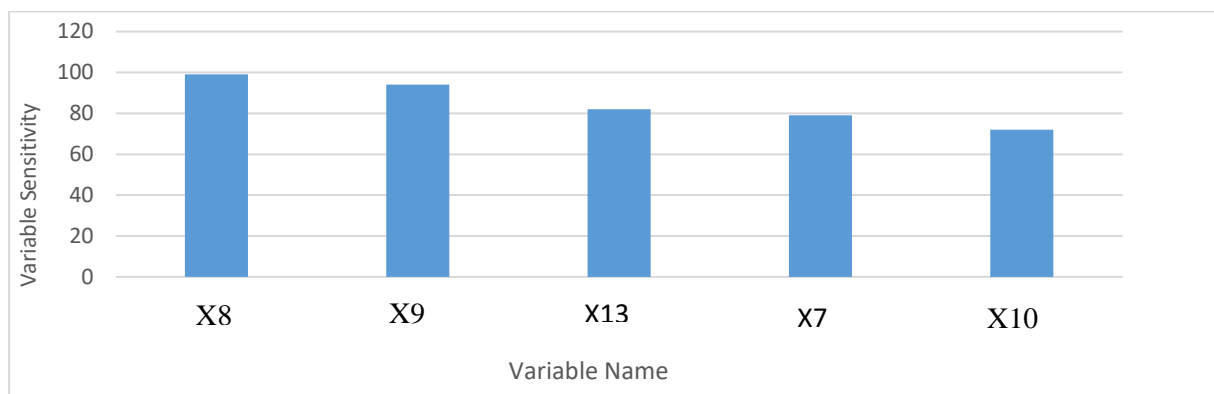


Figure 2. The Most Effective Model Variables

Source: Research findings.

Conclusions

Prediction is a quantitative estimate of the probability of occurrence based on current and past information in the future. For this purpose, other than econometric methods, another approach like artificial neural networks can be used.

Econometric methods are suitable for prediction, but due to their serial correlation, prediction error in these methods is higher, whereas in the artificial neural network method (implemented with MATLAB software), these errors are often less. Particularly in anticipating the currency crises that are taking place to provide an early warning system for these crises in Iran, due to the use of time-series money variables that are likely to have a serial correction error, the use of the artificial neural network will be more precise, and there is no need to carry out various related tests and the implementation of econometric methods to eliminate these errors.

Using the 26 independent variables and one dependent variable according to the previous sections as presented in Table 1, the construction of an early warning system was introduced

which based on the 12 seasonal warning periods, the subsequent results indicate that Iran will not be facing any currency crisis in 2019.

However, a review of previous studies on crises prediction methods including SayedNia Tayebi (2011), in a study titled "Explaining a warning system for identifying financial crises in Iran" and Shajari and Mohebikhah (2010) in an article entitled "Banking Crisis Forecasts and Balance of Payments Using the KLR Marking Method (Case Study: Iran)", It can be understood that the optimal predictive percentage of this system is comparatively higher than that in the previous methods. The optimal predictive percentage in the present study is 97%, while in previous studies fluctuates from 85% to 95%.

It is further concluded in this model that the signals mostly will occur before the crisis, which in Iran, until 2020, no crises can be observed. In addition to the above results, according to Figure 2, the independent variables with more influences in this model can be observed and the export index is of course the leading indicator of Iran's currency crisis.

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