Adv. Math. Fin. App., 2023, **8**(4), P. 1429-1448

Advances in Mathematical Finance & Applications
www.amfa.iau-arak.ac.ir
Print ISSN: 2538-5569
Online ISSN: 2645-4610
Doi: 10.22034/AMFA.2021.1941377.1636

Applied-Research Paper

Providing an Intelligent Credit Risk Management System of the Bank Based on the Macroeconomic Indicators in the Country's Stock Exchange Banks

Mohsen Ziaee Bidhendy*, Mehrzad Minooee, Mirfaz Fallah Shams

[a] *Financial Department, Faculty of Management, Central Tehran Branch, Islamic Azad University, Tehran, Iran*

ARTICLE INFO

Article history:
Received 2021-07-28
Accepted 2021-10-31

Keywords:
Financial risk management
Economic and financial crisis
Exchange Banks
MATLAB programming environment

ABSTRACT

This study is focused on establishing an intelligent credit risk management system for banks, incorporating macroeconomic indicators through a combined methodology of econometrics and artificial intelligence. In addition to reviewing scientific documents and reports, panel data from annual reports and datasets of stock exchange banks are analyzed within the MATLAB programming environment. One of the most significant findings of this research is the approach, which is based on calculations derived from the GARCH economic model. In this approach, the input values for the component "Inflation rate factor (A4)" carry a weight of 0.943734, equivalent to the "High H" membership function. The component "Bank deposit rate factor (B4)" holds a weight of 0.959346, also equivalent to the "High H" membership function. The component "Unemployment rate factor (A3)" is weighted at 0.990343, again corresponding to the "High H" membership function. Similarly, the component "Exchange Rate Factor (B2)" bears a weight of 0.990413, denoting the "High H" membership function. Lastly, the component "GDP growth rate factor (A1)" is weighted at 0.959256, corresponding to the "High H" membership function. In essence, these results indicate that the total score amounts to 5.46 within a range of 6, positioning the target variable at the 91st level, which is the fifth level of the system output, signifying an excellent performance.

1 Introduction

One of the most important factors which influences the investment decisions is the return on investment. Rostami and Haghighi [10] showed that it is crucial to identify the effect of the risk factors for determining the capital cost and evaluating the investments. Chen et al. [9] pointed out that one of the most important needs of the investors is examining the complete set that covers all aspects of the financial condition of a business unit which leads to a boom in the capital market. The investment can be interpreted in the different dimensions and in the different concepts, but the most comprehensive interpretation can be expressed as the commitment of money or the capital to financially purchase other assets or assets, in order to benefit from the profitable returns or the interest in the form of interest, the interest or the profit. It is the value of the means (capital gains). among the various types of investment, we can

* Corresponding author. Tel.:*09122509183*.
E-mail address: Zbmosi@gmail.com

mention the stock market investment which has its own components and it is one of the least risky investments and the most profitable types of investment. It should be noted that the investing in the stock market can be relatively risky if it is not thoroughly analyzed. Hence, the most important principle in the various investments, especially the investing in the stock market, is the risk management and increasing the return on investment, see Abad & Benito [1], Bakhtiyariasl [4], Izadikhah [17, 18] and Tavakolia et al. [29] for more details. On the other hand, risk-taking in financial sciences is called extra interest and the price paid by investors for risk, taking into account the amount of the securities risk and the degree of risk-taking of the investor which is called risk-taking. In other words, it is the amount which is added by the investor to the interest rate on the expected capital in terms of risk. The difference between the return on assets and the return on risk-free is called risk-only. Value at risk is a type of risk, which is imposed on the shareholders due to the increase in debt. The additional risk, which is discussed under the heading of financial leverage, is raised by the operation and utilization of debt in the bank. If the bank borrows more loans (the more bonds are issued), then the bank's net profit margin decreases and its normal financial risk increases The most important principle before dealing with the two components of risk and return is the concept of the role of the stock market in terms of macroeconomics, which is considered in four dimensions.

First, the equipping financial resources through the sale of bonds and stocks is one of the surest ways to raise funds needed for investment. Second, the division of the large holdings through the sale of their shares on the stock exchange from a macroeconomic point of view became more equitable distribution goals. Third, one of the important principles is that the stock market is a complete market. In addition to allocating the monetary capital, the financial markets also distribute the financial risks. In fact, the risk of engaging in financial activities and investing is separated and distributed through the creation and distribution of securities. In other words, the large-scale financial markets (money and capital markets) transfer and distribute the risk-taking people who are engaged in large and high-risk financial activities to savers who are willing to accept the risk of an uncertain return. In addition to separating employment and investment risk, the financial markets enable individuals to diversify their investments. The creating diversity in the portfolio leads to the risk reduction. The total risk is reduced because the loss in some investments is offset by the benefits of the other investments.

In fact, the problems considered in this paper are as the complex, vague and uncertain problems of the decision making in stock exchange bank due to the combination of the different methods for providing the bank's intelligent credit risk management system under macroeconomic indicators, based on the variables such as: bank deposit rate factor, exchange rate factor, inflation rate factor, GDP growth rate factor, unemployment rate factor and Stated. On the other hand, the need for an intelligent system to increase the trust and confidence in the decision making, as well as the need for the multiple expertise through the simultaneous application of knowledge of experts in various fields to solve research problems, led to the present research to provide the intelligent credit risk management system. The bank's credit risk in the presence of the macroeconomic indicators and under the title BANK-CRS.MES, is presented for the first time in the field of research related to the subject. The rest of this paper is as follow: Section 2 reviews some basic theoretical concepts. Section 3 presents the method. Section 4 analyzes the data and results. Section 5 concludes the paper.

2 Theoretical Review of the Research

Moayer and Bahri [23] showed that it is important to understand the risk of investing and recognize the

potential rewards that come from investing for adopting the investment strategies. Knowing the potential risks facing a particular asset class or investment will allow one to have the better control on the emotional reactions that the investment brings. Awareness of the risk of some investments will also help the individual for allocating his assets and choosing assets with appropriate risk to his position so that he can better manage his tax risk. The first step is to accept the fact that there is risk in every investment and every investment is exposed to risk. Knowing this can help the investor to make better decisions and adopt a conscious strategy of risk by using the technique of asset allocation and diversification. Most importantly, it gives a better understanding about the risk of self-confidence to plan your savings and investments more seriously and to follow a legitimate investment strategy, regardless of market performance. The next step is to evaluate the potential investment options by the main sources of risk. For example, if one is interested in investing in equity mutual funds, one should consider the risk of market transactions. Have to exploit to reduce the overall risk of their portfolio. In fact, He et al. [15] showed that the venture capital, also known as bold investment or entrepreneurial investment, is the necessary financing for businesses and start-up banks (start-ups and entrepreneurs). Although growth is valuable, but there is a lot of risk. In the first stage of the national growth and development, the banks focus on the investors who compensate for the capital gap and lack of liquidity of entrepreneurial banks through their meticulous evaluation and are included in their group of shareholders. The risky investor with active management and planning for developing the strategic models in the target bank and the value added and increasing the stock price of these banks play important roles. Prosperity and development of risky investment activities is the driving force and the main axis of growth of new products and innovation in the field of technology.

Banks and financial institutions provide facilities to their credit customers, which are always exposed to the credit risk, which means that the credit customers may not meet their obligations. For example, the customer may not pay part or all of the installments of his facility within a certain period of time, in which the customer is said to have defaulted. Therefore, the bank or financial institution suffers a loss due to the customer default. Of course, it is worth noting that this credit loss can also occur due to the changes in the credit quality, which for simplicity only defective events are considered here. In this regard, for each credit customer, three components are considered: Delayed exposure value (EAD), Conditional Loss (LGD), Probability of default (PD). In fact, in the above relation, EAD and LGD are not random and they are considered as the fixed values, which of course may not be the case PD. If the losses of each borrowers' facilities are independent, then the description of the loss function is reduced to the problem of describing the marginal distribution of each borrowers' facilities' losses. But in practice, determining the correlation between losses in the credit portfolio and these correlations are the main challenges in the field of the credit portfolio risk modeling. Identifying the operational risk incentives affecting the housing bank's credit portfolio to Provide the strategies for reducing them confront with a variety of risks, which the most important of them is operational risk.

The wing committee defines the operational risk as the risk of loss resulting from the inadequacy or inefficiency of the internal processes, personnel, systems or external events. One of the losses that can be caused by the operational risk is the credit default by the customers. So far, the experts have introduced various metrics for measuring the risk, each of which refers to an aspect of the uncertainty and sometimes complements each other. The risk measurement criteria were first determined by studying the statistical dispersion indices, and then some measures such as durability, beta coefficient and value at risk were developed. On the other hand, in the financial literature, risk can be defined as the unexpected events, which are usually a change in the value of assets or liabilities (Nofsinger, et al. [24]). There are the different methods for classifying the financial risks. The definition of each can be different

based on the classification method and its subject. In the general definition, risk is the likelihood which a particular action or action (or inaction) will result in unpleasant or unintended consequences or outcomes. Almost all human endeavors involve some degree of risk, however, some of them carry more Nofsinger, et al. [24] and Chen & Du [8] presented the types of the financial risks in the investment portfolio as reviewed in Table 1.

Table 1: Types of the Financial Risks in the Investment Portfolio

Types of the financial risk	Explanations of the financial risk
Exchange rate risk	Exchange rate risk is a type of the financial risk that arises from the purchase of the securities issues at the different exchange rates. This risk is more likely when the investor buys assets in the different countries. The more volatile the exchange rate between the two countries, the greater the exchange rate risk.
Market risk	Market risk examines the volatility of asset prices in the market. Market risk management begins with this question "how much the stock will move if the stock price moves in the opposite direction to the investor?". The next step is to develop a strategy for the investor to respond to the market move. Investors are usually faced with the direct and indirect market risks.
Cash risk	At liquidity risk, the investors and the traders cannot buy or sell their own assets without drastically changing their price.
Credit risk	Credit risk is the risk that a lender will lose money due to the borrower's shortfall. If the credit risk grows irrationally in a country, then that country will face an economic crisis. The worst financial crises in the last 90 years have occurred due to the global expansion of the credit risk.
Operational risk	Operational risk is the risk of financial losses due to the defects in the internal processes, systems or methods. These defects are often the result of human error occurring by accident or fraudulent activity that is intentional. In order to reduce the operational risk, each company must conduct periodic security inspections and adopt robust procedures to have a strong internal management.
Compliance Risk	When a company violates the rules and regulations of its jurisdiction, it may incur losses known as legal risk. To prevent such losses, many companies use special procedures such as money laundering (AML) and the customer authentication system (KYC).
Systemic risk	Systemic risk is the probability of a specific event occurring that has a negative impact on a particular industry or market. Systemic risks are often found in companies that are part of an industry and are highly interdependent.

On the other hand, the study of fluctuations in the case of the macroeconomic variables is important for recognizing the effect of these variables on the entire economic system. Lei, et al. [20] pointed out that the prevailing economic conditions and cycles of recession and their prosperity affect the entire economic system, especially the banking system, and the recession creates the critical conditions for the banking sector. It should be noted that the macroeconomic variables include the economic growth rate, the inflation rate, the exchange rate, the unemployment rate, per capita income and the interest rate of the banking facilities. He, et al. [15] proved that the interest rate is the price paid to receive the credit or money from the perspective of the macro and the economic enterprises, which some acall it as the cost of the renting money. According to the economic experts, some of the causes of shocks and the financial crises are the government intervention, the government relations with the private sector and the central bank, the inflation, the incentives or the barriers for investors in the materials and the export sectors, and the liberalization or monopoly of banks in allocating the credit to high-yield activities. These causes can encourage or punish the effect of decreasing or increasing the bank interest rates on

the economy, see Psychalis [26] and Pattnaik, et al. [25] for more details. From the point of view of investors and manufacturing companies, the interest rate is the price of the capital production input and it is directly one of the production costs in the cost price of the product (Corzo, et al. [10]).

Macroeconomy examines the economic issues at the national macro level of a country. The field of the study of the world economy is the responsibility of the international economic. The issues such as the economic stability, the foreign trade balance, the economic growth, the employment, the inflation, the government expenditures and the revenues, the economic recession, the economic crisis, the unemployment, and the development economics are examined in this section. The macroeconomics, in contrast to the microeconomics, refers to the macroeconomic categories in the economics and examines and evaluates the business concepts in the large scale. In microeconomics, we are faced with production inputs, supply, sale and purchase, and also with the diagrams and patterns of the consumer, the producer behavior, the luxury goods, the gifs, the surplus supply, the production, the changes in quantity and price and supply and the demand in the markets. While the macroeconomics has gone further and refers to the investment, the economic growth, the gross national growth, the unemployment, the recession, the inflation, the total stock index and savings. Regarding the study at the household level, the poverty and discrimination is one of the topics of microeconomics.

One of the most important benefits of reviewing the research background is providing the better understanding, the key concepts of the research problem and, consequently, it can help us to express the problem more clearly and accurately and its difference with other problems can be seen as well as its relationship with similar research problems, linking research findings to similar research, recognizing research deficiencies and avoiding duplication of work, finding more accurate methods and tools and sometimes solving the current problem with the innovative ways and avoiding inappropriate and ineffective methods, providing a solid basis for valid reasoning in researchable cognitive reasoning in research. In the following, the most relevant researches in the internal research background up to 1399 and the external research background up to 2020 are presented:

Farid et al. [13] showed that the importance of the momentum movement strategy was investigated due to the uncertainty in the stock market and its effect on the investment. According to the statistical population, the considered limitations of 48 companies listed in Tehran Stock Exchange for a period of 6 years from 1387 to 1392 were examined. The results of data analysis show that the most securities trading strategies are portfolios. The winner shows a higher systematic financial risk than the losing portfolio. Zomordian et al. [31] showed that in a research design, a high-sequence risk measurement scale, i.e. calculate the daily value of liquidity at risk at risk (LIVaR). Therefore, their purpose is to explicitly examine the aspect of internal liquidity related to the size of banks. By reconstructing the categorized information, significant changes in actual and friction-free (programmed) returns occurred, and two variables were jointly modeled. The risk related to the planned liquidity cost was graded in the next step. The model used in this study was used to identify the effect of planned liquidity risk on total risk and VaR evaluation of returns located at a point in time. Rostamian et al. [27] calculated the operational risk in the Iranian banking system (due to the importance of the operational risk management in banks) by calculating the value-at-risk index in the form of generalized value-creating theory (GEV). In order to calculate the operational risk, the operating loss data of 12 banks listed on the stock exchange during the years 2016-2017 have been exploited. In order to homogenize the banks' operating losses, the ratio of losses to assets of each bank in the mentioned years was calculated and in blocks 2, 3 and 4, the value at risk ratio of losses to assets was calculated at 99% and 95% confidence levels. The results show that the higher level of confidence increases the value-at-risk index so that at 99% confidence level, it can be said that the ratio of loss to assets in the Iranian banking system does not exceed 0.44.

Dastgir et al. [11] investigated the effect of the financing restrictions on the risk of stock price falls by considering the effect of an obligation statement for the period 1389 to 1395. The method of data collection is the method of mining documents and referring to the databases and the method of data analysis is inferential. The software used to prepare data and estimate models is Stata and ivory. Combined data model was used to test the research hypotheses. The test results show that the financing constraints increase the likelihood of stock prices falling. Fallahzadeh et al. [12] conducted a study to investigate two-way relationship between information disclosure and concurrency and the risk of stock price falls in the period 2008 to 2015. The method of data collection is the method of document mining and referring to databases and the method of data analysis is inferential. To test the research hypotheses, the system of equations was estimated simultaneously with the use of two-stage regression method. According to the agency theory, increasing the level of disclosure reduces information asymmetry, increases control and supervision of performance, increases investor confidence and reduces the risk of falling stock prices. Also, according to the signaling theory, with the increase in the risk of stock price falls, managers publish good news and delay the release of bad news. Adeli et al. [3] applied the econometric methods and used the statistics related to Iranian banks (available in the Central Bank and Statistics Center of Iran), they sought to investigate the effect of the uncertain macroeconomic variables on the credit risk of Iranian banks.

The macroeconomic variables including the economic growth rate, inflation rate, exchange rate and interest rate of bank facilities are as independent variables and the ratio of non-current receivables to total bank facilities has been used to measure credit risk as a dependent variable. The statistical sample of the research is for 10 years from 1387 to 1396 and includes 5 state-owned banks (national, housing, industry and mining, Sepah and agriculture) and 5 private banks (Mellat, Parsian, Saman, Karafarin and Eghtesad-e-Novin). The results show that the uncertainty of the variables of production growth rate, the inflation rate and the exchange rate has a positive and significant effect on the banks' credit risk. However, the effect of the uncertain interest rate of bank facilities on the credit risk of banks in the time and place of the research is negative. Kohzadi [17] research was conducted to investigate the credit risk and profitability of Iranian commercial banks. The statistical population of the present study was all commercial banks in the country in 1398, which included 23 banks. Among the population of all banks, i.e. all 23 banks, the sample was selected by numerical sampling method. The method of this study was descriptive-correlational. Reliable sources were used to collect information on quantitative indicators related to credit risk and profitability indicators. In order to analyze the research data, SPSS and AMOS statistical software were used. The results showed that there is a significant relationship between credit risk and profitability of banks

Gholamzadeh [14] studied the factors affecting the interest rates after the financial crisis of 2008 in selected developed countries. To do this article, a sample of 15 selected developing and developed countries for the period 2000-2017 has been used. According to the results of Petronian panel co-integration for selected developed and developing countries and due to the low level of significance from 0.05, the null hypothesis that there is no co-integration relationship between the variables can be rejected and the test proves the convergence of variables. And the variables are accumulated in the long run and there is a long-term relationship between them. According to the results of model estimation in two groups of developing and developed countries, it can be stated that the variable of inflation rate has a positive and significant effect on interest rates, which shows the confirmation of Taylor's theory and the alignment of interest rates and inflation rates. A worthy study (1399) found that the global financial crisis that began in September 2008 severely damaged investor confidence, affected bank profitability

and the performance of capital markets in many countries, and destroyed many companies around the world. According to research, this crisis has also affected the Iranian capital market with a delay. In times of crisis, corporate executives are aware of the increasing impact of financial reporting on operators' decisions. In the research of Abdolshah and Moshiri [2], the stress test of default probabilities in Iranian stock exchange banks is performed using the credit portfolio approach. The study method is based on a system of equations and simulations. In the first stage, the effect of macroeconomic variables on default rates is estimated. Then the dynamic relationships of macroeconomic variables are estimated using the VAR model. Using the system of two-step equations and the structure of the variance-covariance matrix of the residuals, the Monte Carlo probability probability simulation is performed on a one-year time horizon under the baseline and stress scenarios. Finally, the magnitude of the effect of different shocks is calculated by comparing the probabilities of failure under different stress scenarios with the baseline scenario (shock-free scenario). First, in order to compare the effect of different shocks as much as a standard deviation on each of the macroeconomic variables, a shock is applied, which these scenarios do not necessarily indicate the worst situation that is the goal of the stress test. Therefore, based on the data of Iran's economy, four limit scenarios have been defined and their effects have been studied. The simulation results show that the unemployment rate shock was the most destructive factor for default rates. The second strong shock affecting the default rate is the exchange rate shock. The GDP growth rate shock has also had a significant effect. Inflation rate shock is the least effective shock. These results are also consistent with the coefficients obtained from estimating the negation equation and their significance. Comparing the effects in different distribution multiples, it is observed that all shocks in the lower sequence have more effect than the upper sequence. The results also show that the effects of shock increase in the second period, but have decreased in subsequent periods.

Based on the Wilson credit risk model, Bass [5] provides a framework for credit risk stress testing of Austrian banks, which has been used in credit risk stress tests in many countries. In this model, the probability of total default is modeled as a function of macroeconomic variables. Then, by simulating, a path of future default probabilities is presented until the distribution of losses is determined. In the study of Nofssinger et al. [24] the relationship between decision making, financial risk and behavioral bias was modeled with emphasis on the role of testosterone and investor stress. We are talking about criteria on which to make decisions, and sometimes these decisions may be biased. In fact, when we evaluate the situation around us on the basis of individual biases, we will in fact examine all the problems of the world within the framework of certain criteria that we have learned from personal experience. Chen et al. [9] in a study aimed at marketing for value at risk in the financial market, examined that financial risk assessment by utilizing applications and research on value at risk (VaR) in daily practice, mainly because of its simple form and easy interpretation. Has been affected. In the analysis of real data, we see that the risks calculated using MMVaR are about 20% more valid than the risks calculated using classical VaR, which is evidence for proving the requirements of the capital adequacy ratio of the new capital. It can become a standard of daily risk management.

Lei et al. [20] presented a model to analyze the position of the financial crisis in understanding the economic risk of crude oil traders based on the MIDAS quantitative regression approach. In fact, they stated the importance of understanding economic risk increases when a significant portion of a crude oil traders' portfolio consists of a currency based on market conditions. Hu et al. [16] Presented a model for analyzing the spread of re-debt risk and credit risk in the 2008 financial crisis. In fact, they stated that the risk of recurring debt is one of the risks associated with the risk of market transactions that occur due to changes in bank deposit rates. On the other hand, accounting profit information has an increasingly informative content in predicting systematic financial risk in relation to the financial crisis.

Pattnaik et al. [25] evaluated the trade credit research before and after the 2008 global financial crisis based on a bibliographic overview. In fact, they argued that successive global financial crises necessitated integrated trade credit management. The results showed that there is a significant relationship between accounting profit and economic crisis with systematic financial risk. Chen and Du [8] investigated the role of information disclosure in the financial intermediation with the financial risk. In fact, everyone has behavioral biases and prejudices about themselves. We judge the people, the opportunities, the policies of the government as well as the economic situation. In order to summarize this section, we should say that the theoretical framework of the financial risk management identifies the important variables in the situation that is related to the research issue and the relationship between these variables. After examining the theoretical foundations, it was found that due to the research gap between the financial risk management based on GDP growth rate, inflation rate, bank deposit rate, unemployment rate, and exchange rate and the lack of a model to help bank financial experts and financial analysts, the stock exchange can be found as the innovation of this study for providing an intelligent credit risk management system of the bank under the macroeconomic indicators and also in order to eliminate the mentioned research gaps. In this study, according to the studies conducted in Scopus, ScienceDirect, Springer, IranDock, Islamic World Citation Databases, as well as researches in Tehran universities, we intend to test the credit risk crisis model of listed banks under macroeconomic indicators. MATLAB is used to design and explain in the artificial intelligence environment.

Table 2: Research Model Variables

Variable title	Type of variable			quantitative		Qualitative		Variable measurement method	Scale
	background	independent	dependent	continuous	discrete	nominal	Rating		
Bank deposit rate factor		*		*				Economics and artificial intelligence	Relative
Exchange rate factor		*		*				Economics and artificial intelligence	Relative
Inflation rate factor		*		*				Economics and artificial intelligence	Relative
GDP growth rate factor		*		*				Economics and artificial intelligence	Relative
Unemployment rate factor		*		*				Economics and artificial intelligence	Relative
Credit risk management of the bank to reduce the probability of default			*	*				Economics and artificial intelligence	Relative

3 Research Method

The working method has been used to provide an intelligent credit risk management system for the bank the macroeconomic indicators, is based on the exploitation of scientific documents and reports, and analysis of panel data related to annual reports and datasets of stock exchange banks, using MATLAB programming environment. In this study, MATLAB R2017b programming environment is used to design the intelligent system (BANK-CRS.MES). Library studies, Internet browsing, research studies, books, articles in domestic and international journals, statistics and documents published by the

university are used. Also, in order to collect information related to the research background, the library documents and information received from Internet sites, the reputable domestic and international journals, and the research-related to topics are used. The most important tools for collecting data in the present study is a questionnaire and data. The statistical population studied in this research are the experts and documents of listed banks, the professors and students in the fields of economics, banking, financial management, accounting and industrial-financial engineering. In fact, the variables of the proposed model are as Table 2.

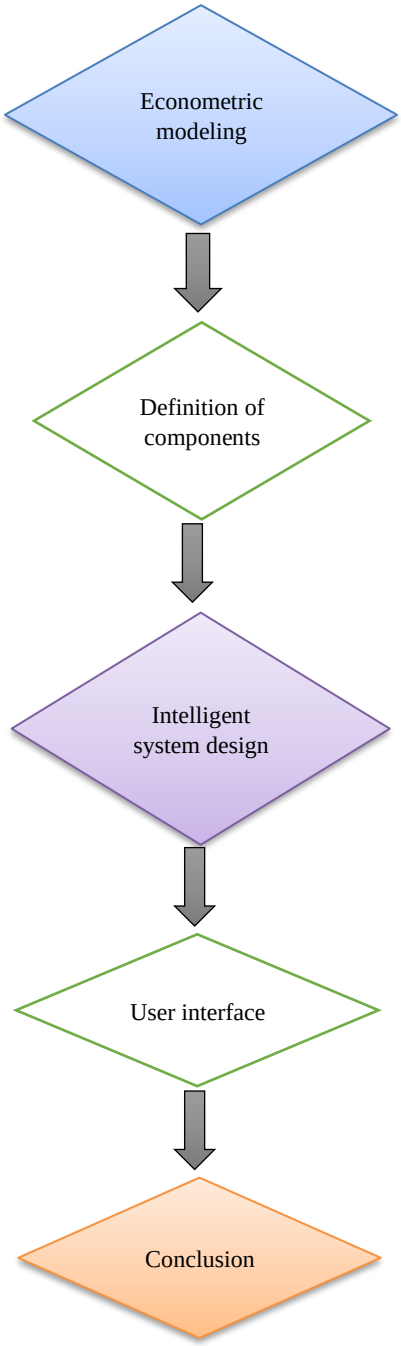

Fig. 1: Flowchart of Research Steps

On the other hand, one of the most important reasons for using MATLAB programming environment in this study is that the real-world problems typically have a complex structure that indicates ambiguity and uncertainty in their definition and understanding. Ever since one can think, he/she has always faced ambiguity in the various social, technical and economic issues. Even the invention of the computer and its practical development in the analysis of the real-world problems cannot solve the problem of the ambiguity and uncertainty. Despite inaccurate and inadequate information in the face of complex real-world problems, human beings almost understand and analyze the behavior and nature of the system. The human brain defines and evaluates the sentences based on a variety of factors based on the inferential thinking, and modeling them into language and mathematical formulas would be very complicated if not impossible. variables are expressed based on the linguistic (spoken) values, which are in the set of phrases (words /idioms), and linguistic expressions are attributes for linguistic variables. Here, language variables are called variables for which acceptable values are human and machine languages instead of numbers, words and sentences. The flowchart of the research steps is as follows:

Economic modeling of concepts in this study is to identify the input and output components and draw relationships between them, the definition of the qualitative components by using linguistic constraints and assigning fuzzy numbers and sets, ANN training data and membership functions. Designing of the intelligent system based on the definitions and then optimizations made using MATLAB software. Inference has access to fuzzy rules. Designing and then optimizing the user interface and how to display the options and how to use the intelligent system design and then optimization are as the most problems.

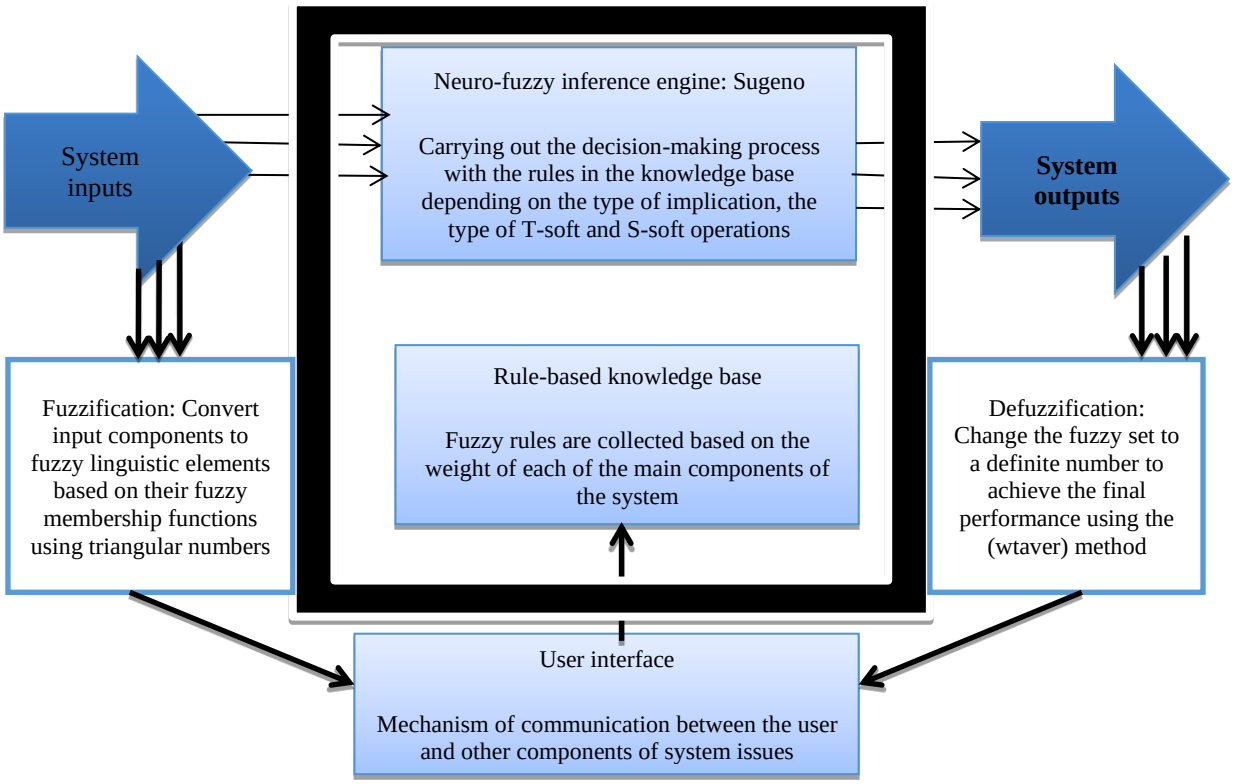

Fig. 2: Structure of the intelligent research system (BANK-CRS.MES)

Economic modeling is the concepts of the study area to identify the input and output components and investigate the relationships between them.

Definition of qualitative components is using the linguistic constraints and assigning the fuzzy numbers and sets; ANN training data and membership functions

Intelligent system design is based on the definitions and design and then optimizations made using MATLAb software. This step inclu

des extracting expert rules and evaluating them by experts and creating a fuzzy rules database as well as designing and then optimizing the inference engine.

User interface is designing and then optimizing the display options and the use of the intelligent system.

Conclusion is analysis of the intelligent research system outputs.

In this study, after examining the structure of the research systems (Tabandeh, et al. [28], Koskivaara [20], Koskivaara [19], Cerullo & Cerullo [6], and Lin & Lee [22], Moayer & Bahri [24]), at the end of which five steps were taken to design an intelligent system for modeling the research using the MATLAB programming environment, are as follows:

In the research decision-making model, the bank credit risk management to reduce the probability of default determines the relationship between variables. In fact, the input components of the intelligent research system of this present study are the unemployment rate factor component, the inflation rate factor component, the GDP growth rate component, the component bank deposit rate factor, and the exchange rate factor component, and the output component of the intelligent research system, is the status of the bank credit risk management to reduce the probability of default.

4 Data Analysis

In this paper, the intelligent research system using MATLAB software, called BANK-CRS.MES, is presented for the first time in the field of research related to the subject. In fact, an intelligent system is a system who's the input information can be inaccurate, i.e. the input information of an intelligent system is in the form of intelligent sets or fuzzy numbers. On the other hand, the processing of an intelligent system can be inaccurate. One of the most famous and practical inaccurate processes in the intelligent systems is the use of intelligent rules database. In the smart rules database, each rule is defined with an "if-then" structure. According to the application of intelligent system designed in this research, at the end of the five steps for designing and implementing intelligent research system were considered, which are:

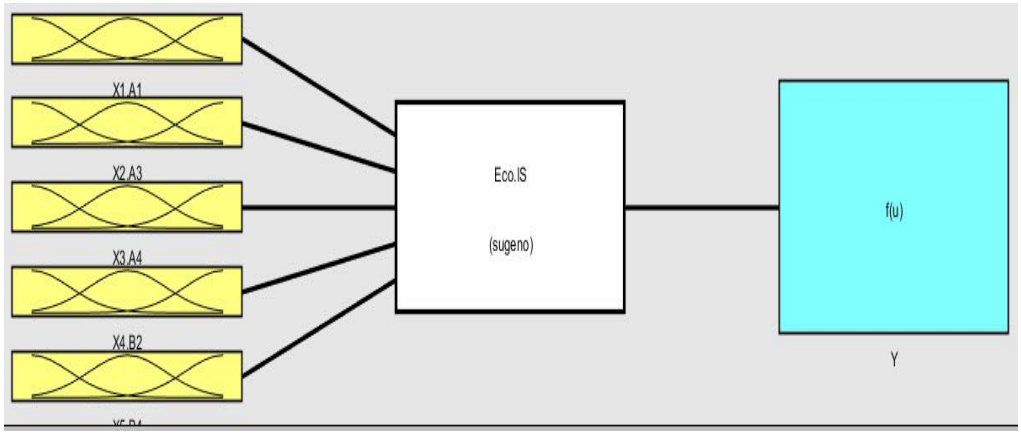

Fig. 3: Model of Input Components of the Mentioned System Module

Step 1: Identifying the input and output components of the system: After finalizing the economics model of the intelligent research system, the input and output components of the intelligent system were defined. The input components of the intelligent research system utilizing MATLAB R2017b software, called BANK-CRS.MES, are: component "Inflation Rate Factor (A4), component" Bank Deposit Rate Factor (B4)"; component "Unemployment Rate Factor (A3)", component "Exchange Rate Factor (B2)", component of GDP growth rate (A1). The output component of the system is the component "Credit risk management of the bank to reduce the probability of default." The output of the smart system is shown as Fig. 3.

Step 2: Defining the qualitative components by using linguistic constraints and assigning intelligent numbers and sets and membership functions to them. Table and shape of language components, fuzzy values as well as membership functions of triangular numbers and trapezoids associated with internal input and output components. The triple and fifty spectra show:

Table 3: Linguistic Components Related to the Intelligent System Input Components

Membership functions of triangular numbers	**English equivalent**	**Linguistic component**
(0.3 0.15 0)	Low	Low
(0.7 0.5 0.3)	Medium	Medium
(1 0.85 0.7)	High	High
ANFIS system training data		
0,0,0,0,0,0		
0-0.025,0-0.025,0-0.025,0-0.025,0-0.025,0.05		
0.05-0.075,0.05-0.075,0.05-0.075,0.05-0.075,0.05-0.075,0.15		
0.25-0.30,0.25-0.30,0.25-0.30,0.25-0.30,0.25-0.30,0.35		
0.35-0.4,0.35-0.4,0.35-0.4,0.35-0.4,0.35-0.4,0.45		
0.45-0.5,0.45-0.5,0.45-0.5,0.45-0.5,0.45-0.5,0.55		
0.55-0.6,0.55-0.6,0.55-0.6,0.55-0.6,0.55-0.6,0.65		
0.65-0.7,0.65-0.7,0.65-0.7,0.65-0.7,0.65-0.7,0.75		
0.75-0.80,0.75-0.80,0.75-0.80,0.75-0.80,0.75-0.80,0.85		
0.85-0.9,0.85-0.9,0.85-0.9,0.85-0.9,0.85-0.9,0.925		
0.95-1,0.95-1,0.95-1,0.95-1,0.95-1,0.975		
1,1,1,1,1,1		

Step 3: Designing an intelligent system knowledge database: This step involves the extracting the rules of expertise and evaluating them by experts and creating a database of neural-fuzzy rules. The neural-fuzzy rule database is a set of "if-then" rules that are at the heart of the intelligent system, because the other components of the intelligent system are used to implement these rules effectively and efficiently. Here, the probability of occurrence of different states between the main components of the same expert system is considered. The starting point for building a rule-based knowledge base in an intelligent system is to obtain a set of rules. If then the neuro-fuzzy is the knowledge of experts or the knowledge of the field under study, the next step is to combine these rules into a single system. Other rules of the knowledge base of this expert system were also produced in this way. Finally, the number of neural-fuzzy rules of the mentioned system module of the intelligent system is equal to 243 dues to the existence of 5 main components, each of which has 3 modes. The figure related to the neural-fuzzy rules databases of the intelligent system module is as follows:

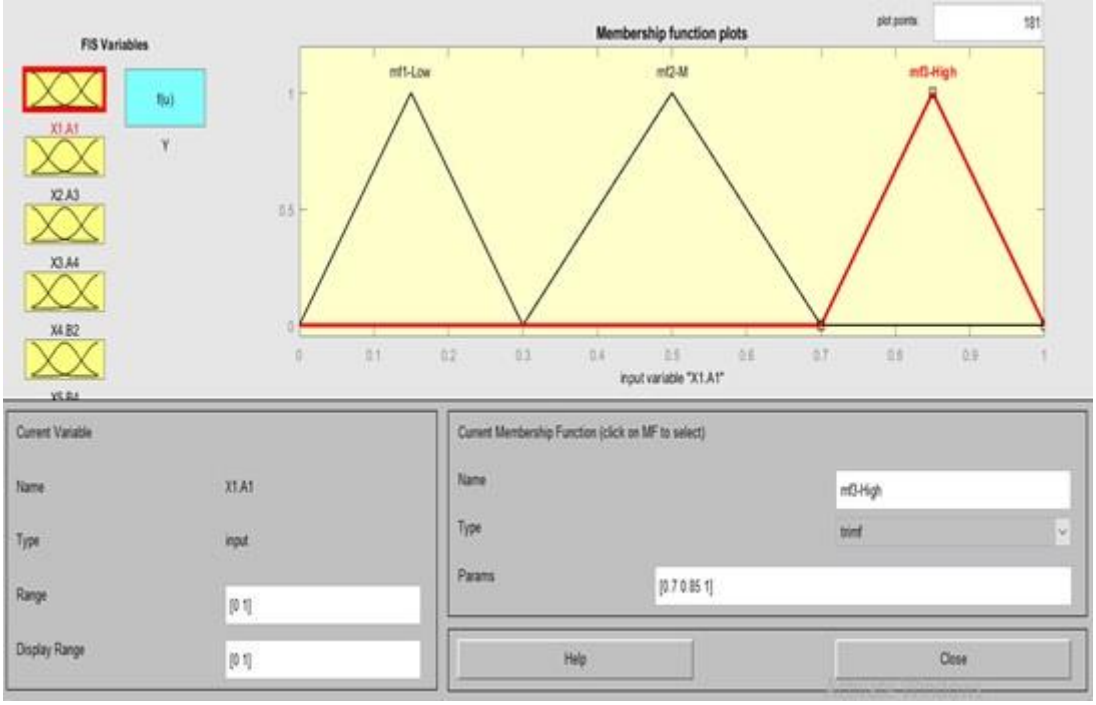

Fig. 4: Component Separation Intelligent System Input-Fuzzy Values Related to Language Components (Triangle Number Membership Functions)

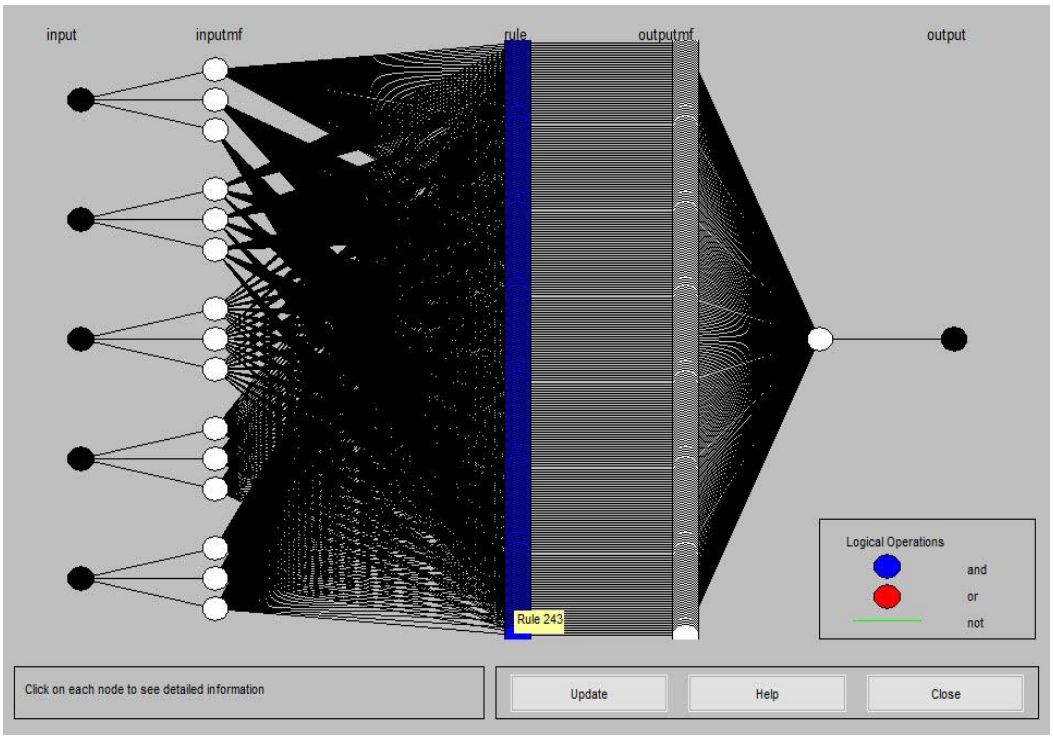

Fig. 5: How to Generate Neural-Fuzzy Rules Automatically within the Intelligent System Knowledge Base

Step 4: Designing the intelligent system inference engine: In this step, the waver method has been

selected for de-intelligence to convert intelligent numbers and sets to a definite value to actually evaluate the system performance. The following figure shows the inference engine of an intelligent system:

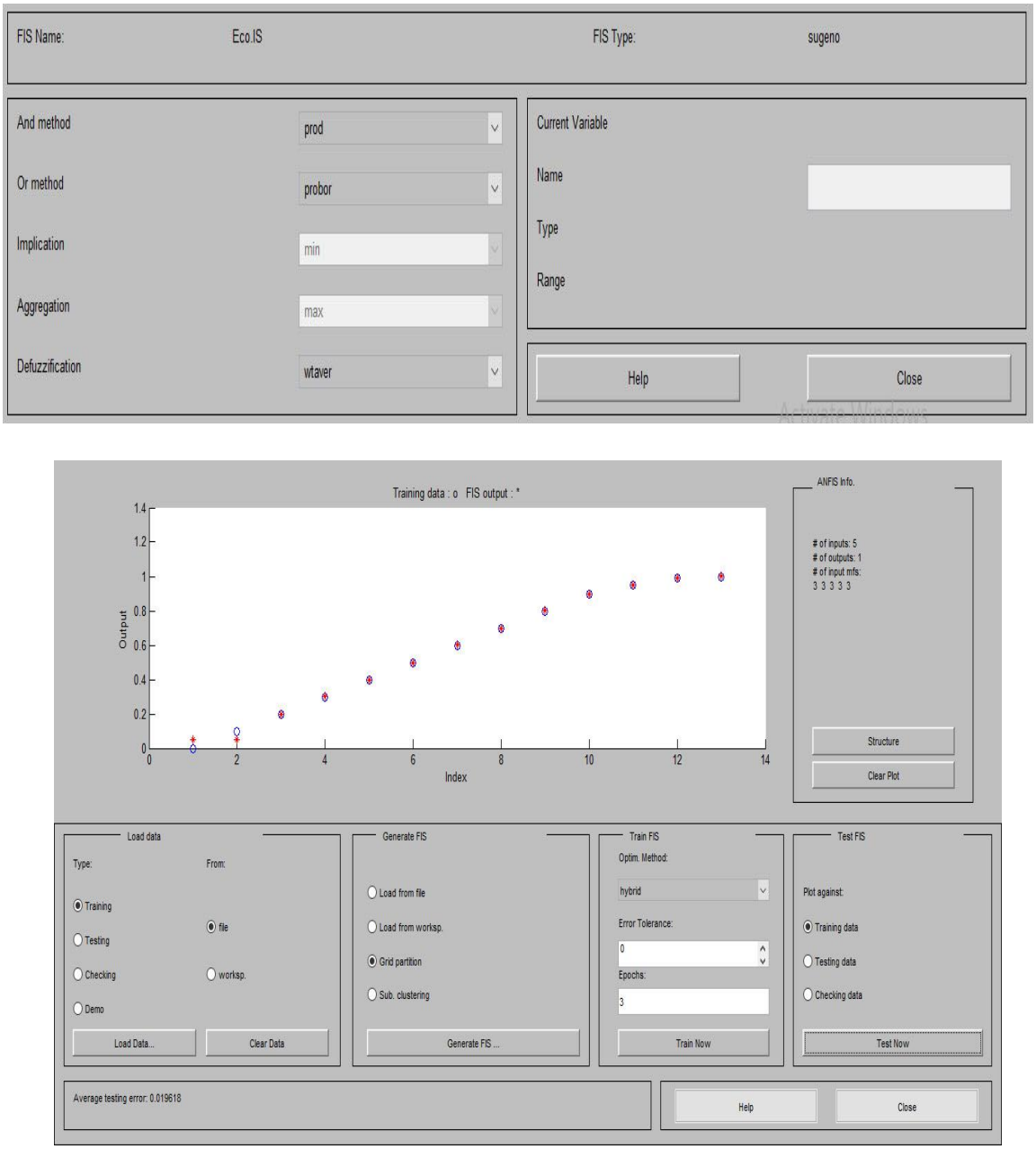

Fig. 6: Intelligent System Inference Engine

Using MATLAB software, inference can be made based on the rules in the intelligent system knowledge database. The average error of test data in the inference engine of the intelligent system for "bank credit risk management to reduce the probability of default" is equal to 0.0196 (less than 2%), which shows very high accuracy of the artificial neural network calculations and fuzzy research logic. In fact, the most important reason for using the Sugeno inference engine (instead of Mamdani) is that in Mamdani inference engine, the choice of type of implication and style of aggregation of intelligent rules (to collect intelligent rules for inference and conclusion) is not fixed. Min is used to select the type

of request in MATLAB software because the Prod operator of the fuzzy set shortens and in curses the output. Intelligent output analysis in an intelligent system converts intelligent output to a definite number.

In MATLAB software intelligent output analysis section, the waver method is used because this intelligent output analysis helps to reduce the complexity of the problem and also shorter time for calculations. Here, due to the connection of the intelligent rules of the system by using the "And" operator, in MATLAB software, we select the "Max" style of aggregation of intelligent rules. In this case, the more precise sum of each output set of rules is considered, not part of them.

Step 5: Description of how to operate the intelligent system is designed and its output analysis: To analyze the behavior of the output component of the system "Credit risk management of the bank to reduce the probability of default" can be done to analyze the intelligent system output numerically (accurately) and linguistically. To analyze the behavior of the output component of the system, it is necessary to calculate the fuzzy values of the input components. Based on the available analysis, the behavior of the output component in the module of the mentioned system is numerically and linguistically based on the 5 input components of the system, namely, the component "Inflation rate factor (A4); the component" Bank deposit rate factor (B4) "; (A3); Component "Exchange Rate Factor (B2)"; And the component "GDP growth rate factor (A1)" was performed. The following figure analyzes the behavior of the input and output components of the intelligent system module:

Fig. 5: Analysis of Component Behavior Output in The Mentioned System Module Numerically and Linguistically Based on 5 Input Components

Based on the calculations performed with the GARCH economics model in the figure above, it is found that the position of "bank credit risk management to reduce the probability of default" of 5.46 is within a 7-value range, i.e. the target variable is exactly in the position of 91 percent (fifth level). The output of the system is excellent. After designing the intelligent research system, the outputs and answers of the intelligent system of this research were compared with the opinions of the mentioned experts in a separate measurement tool, the result of which can be seen based on the rules of the intelligent system and the average answers of experts. According to the available descriptive information, it is possible to compare the outputs of the intelligent system of this research with the average opinions of experts. Since the opinions of experts are expressed based on the membership functions of the output

component (with 5 MF), so to test the system's hypothesis, the percentage difference between the outputs of the intelligent system of this research can be exploited with the average opinions of experts. The final difference between the intelligent system outputs of this research and the average opinions of experts is not significant and is equal to 6 percent. Since there is not enough reason to accept the null hypothesis, the opposite hypothesis is accepted, i.e. there is no significant difference between the average opinions of experts and the outputs of the "smart system".

5 Conclusion

One of the most important results of the research "Designing an intelligent research system using MATLAB programming software" is that, regarding the calculations made with the GARCH economics model, the input values of the component "Inflation factor (A4) with weight equal to 0.9437 members" High H "); Component" Bank Deposit Rate Factor (B4) "weighing 0.959346 (equivalent to membership function" High H "); Component Unemployment Rate (A3) weighing 0.990343 (equivalent to membership function" High H "); Component "Exchange Rate Factor (B2)" weighing 0.990413 (equivalent to the membership function "High H"); And the component "GDP growth rate factor (A1) with a weight of 0.959256 (equivalent to the membership function of" high H "); 0.9593] means 5.46 is in a range of 6, i.e. the target variable is exactly in the 91st position (the fifth level of the system output is excellent), because observing the country's economic trend indicates the occurrence of many inflationary recessions in the Iranian economy. The most severe inflationary recession in the country's economy is after the war years, so that from the summer of 1390 to the spring of 1392, production decreased by 14%, consumption by 13% and investment by 36%, while prices increased by 70% from year 1392 to 1394. Inflation has decreased and the output gap is decreasing at the same time. According to some experts, one of the main reasons for the decrease in the output gap is the existence of disruption in the banking system. Also, the decrease in oil prices in year 1394 is another reason Demand was in the economy.

Here, by using the outputs of the intelligent system, the status of "bank credit risk management to reduce the probability of default" can be based on the components such as "inflation rate factor (A4);" bank deposit rate factor (B4) "; unemployment rate component (A3); Component "Exchange Rate Factor (B2)"; Finally, the scientific exploits of this research, as well as suggestions for other researchers to continue working, because of the financial crises and scandals caused by the bankruptcy of some large companies in countries, are analyzed. In fact, the most important and key proposal of the present study to provide an intelligent credit risk management system of the bank under the macroeconomic indicators is that due to the vital importance of the relationship is very important. Between "bank credit risk management to reduce the probability of default" and GDP growth rate factor (A1), interest rate factor (A2), unemployment rate factor (A3), inflation rate factor (A4), per capita income growth rate factor (A5).

Also, the study of the relationship between the target variable and the independent variables of the research; the bank's credit risk management can be implemented comprehensively to reduce the probability of default because the study of the financial statements of listed banks shows that there are three specific income levels in banks: The biggest banks in the country are the best They are dedicated to D and as a result are in the top ranks in most income indicators. The second group are the middle-income groups that have achieved acceptable performance according to the amount of their capital. But the third group are banks that are not in a good position in terms of income indicators and their one-year income is recorded negatively. The situation of stock exchange banks in terms of income indicators shows that privatized state-owned banks such as Mellat and Saderat, which are among the largest banks in the country, have the best position in three of the six income indicators studied.

The following table compares the most important results and findings of the present study with the

results and findings of the most relevant research in the theoretical literature:

Table 4: Comparison of Findings of the Most Relevant Researches in the Theoretical Literature with the Findings of the Present Study

	Comparison of research innovations																			
Source	Financial crisis	Credit risk	Macroeconomics	Credit rating	Economic growth	Economic crisis	The inflation rate	Exchange rate	GDP growth rate	Unemployment rate	Oil revenue growth rate	Credit risk management of the bank to reduce the probability of default	Case study: stock exchange banks	Artificial Neural Networks	Expert system	Intelligent computing	Matlab Artificial Intelligence Environment	The average error of artificial intelligence calculations	Annual data	Validation
Hu 2020	❋	❋	–	–	–	–	–	–	–	❋	–	–	–	–	–	–	–	–	–	❋
Psy-chalis, 2020	–	–	❋	–	–	❋	❋	–	❋	–	–	–	–	–	–	–	–	–	–	–
Pattnaik, et al. 2020	❋	–	–	–	–	❋	–	–	❋	–	–	–	–	–	–	–	–	–	–	❋
Corzo, et al. 2020	❋	❋	–	–	–	–	❋	❋	–	–	–	–	–	–	–	–	–	–	–	–
Lei, et al. 2019	❋	❋	❋	–	–	–	–	❋	–	–	❋	–	–	–	–	–	–	–	–	❋
Aste-riou & Spanos. 2019	–	–	❋	–	❋	❋	❋	–	❋	–	–	–	–	–	–	–	–	–	–	❋
current study	❋	❋	❋	❋	❋	❋	❋	❋	❋	❋	❋	❋	❋	❋	❋	❋	❋	❋	❋	❋

One of the methods used by banks and financial and credit institutions to assess the risk of default of a real or legal customer is to determine the customer's credit, which is now possible in the Iranian banking system through this system. Good turnover, no returned checks, good calculations, etc., are the criteria that determine the default rate of each customer. Finally, the research recommendations are based on the role of factors affecting default risk in the credit risk crisis test of listed banks under macroeconomic

indicators; is presented. Credit or default risk measurement variables are:

Probability of default: It is probable that the party to the contract will not fulfill all or part of its obligations, willingly or unwillingly, within the period specified in the contract.

Credit commitment rate: Indicates how much of the liabilities are affected by the default at the time of default.

Recovery rate: In case of default, what percentage of liabilities can be repaid by other means such as collateral and.

In fact, the bonds that governments have guaranteed repayment of principal and interest over a period of time, such as bonds issued by ministries to compensate for the liquidity of their projects and are tax-exempt, usually have a very low risk of default. Given that they introduce the guarantee of the central bank on behalf of the government as their support. Perhaps for this reason, the risk of default is very low for participation bonds and Islamic treasury bonds, for which the demand is very high. In view of the above, the most important recommendations and suggestions for further research can be expressed as follows:

Utilization of the intelligent multi-criteria decision making (MCDM) techniques to rank inter-model relationship networks to model intelligent ontology research (modeling) for comprehensive modeling of knowledge areas related to the presentation of intelligent credit risk management system of Saman Bank) For dynamic modeling of bank credit risk management to reduce the probability of default.

References

[1] Abad, P., Benito, S., *A Detailed Comparison of Value at Risk in International Stock Exchanges,* Fundación De Las Cajas De Ahorros, Documento De Trabajo (452/2009), 2009, P.1-45.

[2] Abdul Shah, F., Moshiri, S., *Stress test of default probabilities of Iranian stock exchange banks with credit portfolio approach,* Economic Research Review, 2017 , **17**(66) , P. 23-54. (in Persian)

[3] Asteriou, D., Spanos, K., *The relationship between financial development and economic growth during the recent crisis: Evidence from the EU,* Finance Research Letters, 2019, **1**(28), P. 238-45. Doi:10.1016/j.frl.2018.05.011.

[4] Bakhtiyariasl Asl, C., Davoodi, SM., Abdolbaghi Ataabadi A., *Designing and evaluating the profitability of linear trading system based on the technical analysis and correctional property*, Advances in Mathematical Finance and Applications, 2021, **3**. Doi:10.22034/AMFA.2021.1906285.1474

[5] Boss, M., *A macroeconomic credit risk model for stress testing the Austrian credit portfolio*, Financial stability report, 2002,**4**, P. 64-82.

[6] Cerullo, M.J., Cerullo, V., *Using neural networks to predict financial reporting fraud: Part 1*, Computer Fraud & Security, 1999, **1**(5), P.14-7. Doi:10.1016/S1361-3723(99)80015-3

[7] Chan, W.H., Le, M., Wu, Y.W., *Holding Bitcoin longer: The dynamic hedging abilities of Bitcoin,* The Quarterly Review of Economics and Finance, 2019, **1**(71), P. 107-13. Doi:10.1016/j.qref.2018.07.004

[8] Chen, Y., Du, K., *The role of information disclosure in financial intermediation with investment risk*, Journal of Financial Stability, 2020, **1**(46), P. 100-120. Doi: 10.1016/j.jfs.2019.100720

[9] Chen, Y., Wang, Z., Zhang, Z., *Mark to market value at risk*, Journal of Econometrics, 2019, **208**(1), P. 299-321. Doi:10.1016/j.jeconom.2018.09.017

[10] Corzo, T., Lazcano, L., Márquez, J., Gismera, L., Lumbreras, S., *A common risk factor in global credit and equity markets: An exploratory analysis of the subprime and the sovereign-debt crises*, Heliyon. 2020, **6**(6), P. 39-80. Doi:10.1016/j.heliyon.2020.e03980

[11] Dstgir, M., Sakiani, A., Salehi, N., *The effect of financial constraints on the risk of stock price falls considering the effect of accruals*, Accounting Knowledge Quarterly, 2009, **10**(1) (in Persian).

[12] Falahzadeh Abarqoui, A., Taftian, A., and Heerani, F., *Investigating the Relationship between Information Disclosure and Stock Price Simultaneity and Its Risk of Falling Using the Simultaneous Equation System*, Accounting Knowledge Quarterly, **10**, 2009 (in Persian).

[13] Farid, D., Mahmoudi, M., and Taghiban Dinani, Z., *Systematic Financial Risk Survey in Momentum Trading Strategy in Tehran Stock Exchange*, International Conference on Management and Humanities, UAE-Dubai, Vira Capital Institute of Managers, 2015 (in Persian).

[14] Gholamzadeh, M., *A Study of Factors Affecting Interest Rates after the 2008 Financial Crisis in Selected Developed and Developing Countries*, The First Accounting and Management Conference, 2019 (in Persian).

[15] He, Q, Liu, J, Gan, J, Qian, Z., *Systemic financial risk and macroeconomic activity in China*, Journal of Economics and Business, 2019, **102**, P. 57-63. Doi:10.1016/j.jeconbus.2018.10.002

[16] Hu, GX., *Rollover risk and credit spreads in the financial crisis of 2008*, The Journal of Finance and Data Science, 2020, **1**(6), P.1-5. Doi:10.1016/j.jfds.2020.06.001

[17] Izadikhah, M., *DEA Approaches for Financial Evaluation-A Literature Review*, Advances in Mathematical Finance and Applications, 2022, **7**(1), P. 1-37. Doi:10.22034/AMFA.2021.1942092.1639

[18] Izadikhah, M. *Financial Assessment of Banks and Financial Institutes in Stock Exchange by Means of an Enhanced Two stage DEA Model*. *Advances in Mathematical Finance and Applications*, 2021, **6**(2), P. 207-232. Doi: 10.22034/amfa.2020.1910507.1491

[19] Kohzadi Tahneh, A., *A Study of the Relationship between Credit Risk and Profitability of Iranian Commercial Banks*, Sixth International Conference on Management and Accounting, Tehran, 2019 (in Persian)

[20] Koskivaara, E., *Different pre-processing models for financial accounts when using neural networks for auditing*, ECIS 2000 Proceedings, 2000, 1, P. 3-20.

[21] Lei, L., Shang, Y., Chen, Y., Wei, Y., *Does the financial crisis change the economic risk perception of crude oil traders? A MIDAS quantile regression approach*, Finance Research Letters, 2019, **30**, P.341-51. Doi:10.1016/j.frl.2018.10.016

[22] Lin, C.T., Lee, C.G., *Neural fuzzy systems: a neuro-fuzzy synergism to intelligent systems*, Prentice hall, 1996.

[23] Mishra, R.N., Mohanty, K.B., *Real time implementation of an ANFIS-based induction motor drive via feedback linearization for performance enhancement*, Engineering Science and Technology, an International Journal, 2016, **19**(4), P. 1714-30. Doi:10.1016/j.jestch.2016.09.014

[24] Moayer S, Bahri PA., *Hybrid intelligent scenario generator for business strategic planning by using ANFIS*, Expert Systems with Applications, 2009, **36**(4), P. 7729-37. Doi:10.1016/j.eswa.2008.09.046

[25] Nofsinger, J.R., Patterson, F.M., Shank, C.A., *Decision-making, financial risk aversion, and behavioral biases: The role of testosterone and stress*, Economics & Human Biology, 2018, **29**, P. 1-6. Doi:10.1016/j.ehb.2018.01.003

[26] Pattnaik, D., Hassan, M.K., Kumar, S., Paul, J., *Trade credit research before and after the global financial crisis of 2008–A bibliometric overview*, Research in International Business and Finance, 2020, **30**, P. 101-287. Doi:10.1016/j.ribaf.2020.101287

[27] Rostamian, N., Hosseini Yakani, A., Kashiri Kolaei, F., *Measuring Operational Risk in the Iranian Banking System Using Risk-Value Index*, 7th National Conference on Accounting and Management Applications, Tehran, Asia Gold Communication Group, 2017 (in Persian).

[28] Tabandeh, R., Jusoh, M., Nor, N.G., Zaidi, M.A., *Estimating factors affecting tax evasion in Malaysia: A neural network method analysis*, Prosiding Persidangan Kebangsaan Ekonomi Malaysia Ke VII. 2012, P. 15-25.

[29] Tavakolia, M., Doostib, H., Chesneauc, C., *Capsule Network Regression Using Information Measures*: An Application in Bitcoin Market. Doi:10.22034/AMFA.2021.1932547.1603

[30] Zadeh, LA., *Fuzzy collection*, Inf. Control. 1965, **8**(33), P. 8-56.

[31] Zomordian, G., Hemmati Asyabraki, M., Radkoftroudi, H., *Periodic Value Exposure Value Test (LiVaR) and risk management using self-regression vector (VAR) model*, Financial Knowledge of Securities Analysis (Financial Studies), 2017, **10**, P. 59-69 (in Persian).