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Evaluating the Model and Formula of Continuity of Activities and Use of the Health Diagnosis Division in Iranian Firms

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ABSTRACT

The present research concerns the bankrupt manufacturing companies from the perspectives of the independent and court-assigned auditors, as well as creditors and banks, as the rising number of bankruptcies in the country has left negative impacts on unemployment and undesirable social harms, in addition to incurring heavy financial burdens for the three powers of the government, the parliament, the judiciary and the police. In the previous article, the intended formula and model were first elicited from the classic Grounded Theory (Emergent - estimated, graded). The present study, however, compares the logistic regression with Sugeno's adaptive neuro-fuzzy inference system (ANFIS) to describe the Kolmogorov-Smirnov, *Mann–Whitney* U, and *Hosmer*-Lemeshow tests, etc. Here, the study forms five ANFIS methods and three sets of training, testing and checking (validation) to investigate and confirm the formula of the health diagnosis division and its continuity of use. Evaluation of the best and worst manufacturing companies, which was studied from the fiscal year of 2012 to 2014., using the devised model reveals a range of numbers, including + 2.113 to - 0.189, which indicate the normal and abnormal situations of the companies. As for the continuity of the activities (standard 570 of the auditing) and the clause on specific content, the numerical indicator of 0.595 and the contingent clause with the numerical indicator of 0.595 before 0.189, and the rejected clause with the numerical indicator of -0.189 can be used for the statement of the independent auditors. This model can evaluate manufacturing companies with a number of financial rations and identify their bankruptcy and non-bankruptcy status. Also, for the court auditors, the time of the beginning of the bankruptcy with the numerical indicator of 0595 and the numerical indicator of -0.189 for the declaration of full bankruptcy can be used for the auditors of the courts.

Keywords: health and continuity diagnosis division, unique balance sheet betas, profit and loss, consolidated (balance sheet, profit and loss, cash flow), bankruptcy, insolvency.

1. Introduction

There is no official statistic of the number of bankrupt legal and natural people in Iran; however, consistent with the World Bank's Ease of Doing Business Section, and considering Iran's ranking and score, one would understand the importance of this subject. In 2015, Iran held a score of 21 out of 100 and 107 out of 190, while in 2018, it scored 23 out of 100 and 160 out of 190 (2020 Ordibehesht Online Economy News outlet). Also, as broadcast by the national broadcasting services, officials talked about an increase of 700% in applications for bankruptcies (2016 Mehr news agency). On the other hand, the development of a bankruptcy office affiliate with the judiciary in all provinces is a strong indication of widespread bankruptcy nationwide. The rising number of bankruptcies in the country has left negative impacts on unemployment and undesirable social harms, in addition to incurring heavy financial burdens for the three powers of the government, the parliament, the judiciary and the police. If no true estimate of bankrupt firms is achieved, especially of manufacturing companies and those active in society, the destructive impacts on the GDP rate and unemployment rate as well as destruction of the productive capital market will, over time, weaken the main pillars of the economy. Here, there is a preventive factor that plays a key role in the business environment. Currently, auditors have not provided a stable and uniform model for the auditing professions. Of almost 13 major models of the world, none can be said to be the best and is a reliable model for Iran. On the other hand, court auditors are now facing problems with determining the dates of bankruptcies and gradual or immediate liquidations. Thus, there is no unique and effective procedural model. This study deals with these drawbacks and promises new perspectives. And can present bankruptcy in its concept (legal and financial) for its users. It is noteworthy that this model, based on its Iranian kind, fully complies with accounting and auditing standards of Iran, and results in the expansion of research environment and more research in other activities and accounting categories, especially the continuation of activities and determination of an appropriate alternative to independent and court accounting statements. On the other hand, it provides a context for research in other countries for manufacturing companies and investment sector, as well as for expanding legal, financial and commercial fields and other relevant sectors.

2. Theoretical basics and development of research hypotheses and variables

The financial health of economic systems is highly critical for countries. By financial health, it refers to the creation of conditions that prevent financial crises and consequently the occurrence of such events as changing interest rates, the value of assets, bankruptcies and closure of economic firms (Mirbagher et al. 2016). In other words, the financial health of firms concerns the continuity of the activities, bankruptcies, financial insolvency and qualitative characteristics of accounting information (relevance and reliability). Many researchers, such as Beaver, Altman, Shirata, Uhleson, etc., have provided models to predict financial bankruptcies of companies by considering the financial ratios of those companies and other variables set out in financial statements. These models help prevent companies from financial bankruptcies and wastage of existing sauces, as they help the companies to renew their management structures and to be able to compete with other companies and continue their studies (Barket et al.; 2018). Consistent with the prediction of bankrupt companies from 2001 to 2010, as suggested by the list of companies removed from the Tehran Stocks Exchange, and pursuant to article 141 of the Commerce Law, the best evaluation method using Sugeno's adaptive neuro-fuzzy inference system yielded a rate of 83.57% (Vakilfard et al., 2013). In another article, the model and formula of continuity of activities have been provided, while the present article examines the said model and compares the logistic regression method and Sugeno's neuro-fuzzy inference system (ANFIS).

2.1. Research questions

1) Which logistic regression method or Sugeno's Adaptive Neuro-Fuzzy Inference (ANFIS) method is the best and most appropriate tool to confirm the application of the model?
2) Do these classified ratios as health diagnosis division of the manufacturing companies have the ability to provide a normal and abnormal status of the manufacturing companies?

To answer the above hypothesis, the dependent variable is y, and its range of variations varies from a_3, a_2 to a_1. The independent variable also includes three groups of balance, profits and losses and consolidated groups (balance, profit and loss, cash flow), with the coefficient of effects of these groups (beta) derived from these ratios and tested by logistic regression methods.

To compare and use Sugeno's Adaptive Neuro-Fuzzy Inference System method, the formula for developing a model for five separate ANFISs is taken into account, which includes: the product of the balance sheet ratio - the product of the profit and loss ratio - the product of the consolidated ratio constitutes the total product, as the last ANFIS component is regarded to examine the bankruptcy status of the company, while the output of the above four ANFISs was regarded as its input. Later, the data are divided into three sets: the training set (including 25 bankrupt and 25 non-bankrupt companies), the testing set (including 9 bankrupt and 8 non-bankrupt companies) and the checking or validation set (including 9 bankrupt and 8 non-bankrupt companies) with the outputs being analyzed and provided.

3. Literature Review

Because the model is an Iranian-specific model, and the model-design article has referred to the latest achievements outside of the country, the present article involves a literature review of Iranian researchers.

Fakhr Hosseini and Aghaei Meibodi (2019) investigated in a study entitled "Prediction and Identification of High-Bankruptcy Companies In the Tehran Stocks Exchange (a different analysis of the models." This study used Altman, Spring, Zimski, Fulmer and MacKay's genetics models to differently investigate the probability of predicting the bankruptcy of companies on the Tehran Stocks Exchange, as compared to previous research, aiming to introduce companies with a greater probability of bankruptcy based on a comparative approach arising from different models. They used 75 companies that were not subjected to article 141 of the Commerce Law to meet this goal. Data required were gathered for a ten-year period (2007-2017). Consistent with the results, using the above models, companies with greater rates of bankruptcy were determined, and also probably bankrupt companies were separated. As well, results indicated that excluding MacKay's model, three companies with a greater probability of bankruptcy were included in the remaining models, as Zimski's model held a higher coefficient of determination compared to others; for this, it is suggested that it has more accuracy for predicting bankruptcy; in the meantime, debt ratios, asset flow and return on assets were more critical in determining the bankruptcy of the companies.

Pourtabarestani et al. (2010) investigated in a study entitled "Quantification of Independent Auditors' Report Using Fuzzy Approach and Examining the Capacity of Predicting Bankruptcy based on Quantified Reports in comparison with the Type of Auditing Reports." The results suggest many suspicions and basic ambiguities about the ability of the current auditing reports in transferring the messages intended by the auditors, such as reflecting the results of evaluating the ability to continue future activities of the units under investigation to the users of financial statements. For the first time, this research has quantitively evaluated the qualitative auditing reports using the FAHP method and has discussed the numerous effects of this variable. The goals of this research were to study the power of prediction of bankruptcy as suggested by the quantitative reports, as compared to types of auditing reports, and to quantify the independent auditors' reports using the fuzzy approach. For this, following an analysis of 1140 auditing reports in the 2000s, the qualitative comments of the auditors were quantified, and the least squares regression and mixed logit, qualitative comments and effects of quantitative scores were used to evaluate the bankruptcy. Results indicated that the score of the previous year's auditing reports could leave a negative and significant effect on the bankruptcy indicator, though the type of the past year's auditing report and clauses related to the existing legal claims as well as the problem of continuity of activity in it will not have a significant effect on the fiscal year's bankruptcy indicator. This issue indicates that the type of auditing report of the past year and the clauses of continuity of activity in it to predict bankruptcy lacks information content as compared to the sore of the auditing report.

Botshekan et al. (2018) provided a mixed method in a study entitled "Prediction of Financial Insolvency of Companies Listed on the Tehran Stocks Exchange." For this, using article 141 of Commerce Law, 29 financial ratios were randomly gathered for the manufacturing companies with financial insolvency

and to the same extent for the healthy companies listed on the Tehran Stocks Exchange from 2006 to 2016. This list of ratios was achieved by using audited financial statements for one, two or three-year periods prior to insolvency. Then, the best financial ratios, together with the coefficient of the importance of each, were selected via statistical tests and decision-making algorithms of DEMATEL and Fuzzy TODIM approaches. Also, financial insolvency was predicted using the support vector machine. Pairwise test results suggested a difference in the accuracy of the proposed model to predict financial insolvency for all three years of t-1, t-2 and t-3, compared to the accuracy of Altman's models and logistic regression at the error level of 1%.

Hamid Reza Vakili Fard et al. (2014) did a study to provide a model to predict bankruptcy using the ANFIS method. The statistical population of this study included all companies listed on the Tehran Stocks Exchange from 2001 to 2010, which, according to article 141 of the Commerce Law, includes 40 bankrupt and 40 non-bankrupt companies. These companies were randomly divided into three sets; a training set for designing the model, a testing set and a checking set for the validation of the model. The financial ratios of these companies were also taken into account. Thus, the article concluded that the ANFIS method enjoyed a higher accuracy rate and the findings were consistent with the research by Hu Tsing (2005), Porubenis et al. (2008) and Pachum and Kasmas (2011). Thus, consistent with the model provided, the financial crisis in companies can be predicted from one year earlier, and measures can be taken to void bankruptcy.

4. Review of the Model Design

A number of questions were raised, which are: what is the goal of the research? The goal is to demonstrate, "is there a criterion to diagnose continuity of activity and health for Iranian manufacturing companies?" Based on this main question, a number of secondary questions are provided.

First question: What is the status and significance of financial reports by considering all financial and trade laws as well as accounting and auditing standards?

Second question: What is the status and significance of financial ratios and the most applicable ratios?

Third question: How are the classification and accumulation of coefficients of effects of each of the applied financial ratios?

Fourth question: Are constraints observed in the model considering that mathematical signs have their own specific concepts in financial statements?

Results from the grounded theory using an emergency, estimate and graded methods for question 13 led to the design of the following model:

$$y_1 \geq a_1 = \pm\beta_1 \sum A_1 \pm \beta_2 \sum A_2 \pm \beta_3 \sum A_3$$

$$\beta_n A_n = \beta_n \times \sum A_n$$

$$a_2 = y_2 \leq a_3 = \pm\beta_1 \sum B_1 \pm \beta_2 \sum B_2 \pm \beta_3 \sum B_3$$

$$\beta_n B_n = \beta_n \times \sum B_n$$

a_1: The mean of the highest number taken from the best Iranian manufacturing companies (normal limit of continuity of activity and health division)

a_2 : The mean of the lowest number taken from the best Iranian manufacturing companies (the beginning of insolvency and the abnormal limit of the continuity of activity and health division)

a_3: The mean of the highest number was taken from the worst Iranian manufacturing companies (abnormal limit of continuity of activity and health division)

Y_1 : Algebraic sum derived from testing Iranian manufacturing companies in the division (dependent variable)

Y_2 : Algebraic sum derived from testing Iranian manufacturing companies in the division (dependent variable)

β : A coefficient of a group of financial ratios that can select any positive or negative integer, which includes:

$\beta_1 \pm$: Capital and savings at the end of the period divided by the sum of the balance of the yearly balance sheet under consideration along with the audited report

$\beta_2 \pm$: Accumulated profit (loss) of the end of the period divided by the sum of the balance of the yearly balance sheet under consideration along with the audited report (Computation condition: if the coefficient of the group is negative and the answer to the extracted ratios is negative, the answer will be multiplied by -1).

$\beta_{3\pm}$: The cash balance of the end of the period divided by the sum of the balance of the yearly balance sheet under consideration along with the audited report, with A_1 and B_1 are balance sheet ratios groups as follows:

{1- Current liabilities divided by current assets [computation condition: if the answer to the ratio is

greater than one, it has a negative sign, while the reverse case has a positive sign] of the year under consideration along with the audited report}
{2- Total long-term liabilities divided by total long-term assets [computation condition: if the answer to the ratio is greater than one, it has a negative sign, while the reverse case has a positive sign] of the year under consideration along with the audited report}
{3- The book value of the shares divided by the total liabilities [no limit] of the year under consideration along with the audited report}
A_2 and B_2 are profit and loss, ratio groups:
{1- Operating profit (loss) divided by net sales [computation condition: if it is profit, it has a + sign, and if it is a loss, it has a – sign [the year under consideration along with the audited report}
{2- Profit and (no-special loss) divided by net sales [computation condition: if it is a profit, it has a + sign, and if it is a loss, it has a – sign [the year under consideration along with the audited report}
A3 and B3 are consolidated ratio groups [(balance, profit and loss, cash flow)]:
{1- Pre-tax profits divided by total assets [computation condition: if it is a profit, it has a + sign, and if it is a loss, it has a – sign] of the year under consideration along with audited report}
{2- Net sales divided by total assets [no limit] of the year under consideration along with the audited report}
{3- Pre-tax profits divided by the price of shares book [computation condition: if it is a profit, it has a + sign, and if it is a loss, it has a – sign] of the year under consideration along with the audited report}
{4- Cash flows from operating activities divided by [computation condition: the absolute value of net working capital (+input and -output (of the year under consideration along with the audited report)
{5- Cash activities from an investment divided by non-current assets [computation condition: (+input and -output) [(of the year under consideration along with the audited report)
{6- Cash activities from financing activities divided by total liabilities] computation condition: (+input and -output) [of the year under consideration along with the audited report} (Tahirnia et al.-2020)

5. Research Methodology

This study falls under mixed researches (qualitative and quantitative methods) and is an applied one. It provides a theory in the form of a grounded template and uses statistical methods (descriptive and inferential) as well as neuro-fuzzy inferences to analyze and compare the data. MATLAB, SPSS, and Microsoft Office were also the software used to do this.

5.1. Inferential statistics (regression)

Consistent with many types of research, the dependent variable has only two possible results and can only accept one of two zero or one method, with the value of the latter meaning the occurrence of an intended event and the value of the former meaning non-occurrence of it (or vice versa). For example, the bankruptcy or non-bankruptcy of companies can be predicted and estimated by means of several independent variables, or the level of intelligence, success or failure of an individual in an entrance exam can be predicted by means of his efforts. Under these circumstances, there are two statistical techniques which are: discriminant analysis and logistic regression, with the latter being a more powerful tool than the former analysis.

Logistic regression is similar to normal regression, with the difference being that the estimation of the coefficient method is not the same. In logistic regression, instead of minimizing squared errors (which is performed in ordinary regression), the probability that an event occurs is maximized. Also, in ordinary regression analysis, standard F and T statistics are used to examine the significance of the relationship, while in logistic regression, "chi-square" and "Wald" statistics are used (Mansour Mo'meni, 159-158; 2008).

In logistic regression, a concept called odd rate (the $\frac{p_i}{1-p_i}$ratio which is the probability of the occurrence of the event to the probability of the non-occurrence of the event ratio) is used, and the odd ratio logarithm is calculated from the following relation. This model is known as the logit model.
Relation:

$$ln\left(\frac{p_i}{1-p_i}\right) = b_0 + b_i x_i$$

For example, if the level of effort and of intelligence affect the probability of success in the entrance exam, we will then have the following:

level of intelligence(B2 + level of effort) =B0+B1
probability of success in the entrance exam / probability of failure in the entrance exam (Ln)

5.2. Logistic model using ENTER method

In this method, all independent variables are simultaneously entered into the SPSS program to show the effect of all variables (important and non-important) on the dependent variable.

5.3. Logistic Model by Using ENTER Method

According to this method, all independent variables are simultaneously entered into the SPSS program to demonstrate the effect of all variables (important and non-important) on the dependent variable.

5.4. Fuzzy sets

There are many inaccurate concepts around us that are used in different daily expressions. Note this sentence: "The weather is good." There is no quantity for the goodness of the weather to get it measured; rather, it is a qualitative sense. In fact, the human brain considers various factors and defines and values sentences by means of inferential thinking. If modeling these expressions is not made possible through mathematical formulas, it will be highly complicated. Fuzzy logic is a new technology that replaces ways required for designing and modeling a complicated system of mathematics with language values and the proficient individual's knowledge. Professor Lotfizadeh reasons that man does not need accurate information inputs; rather, he is able to carry out a higher-order comparative control. Thus, if we design feedback controllers in systems in a way that they receive ambiguous data, these data can be easily and more effectively used. Consistent with these definitions, the fuzzy logic can be used in simple and small microcontrollers and embedded ones as well as in large networked multi-channel PCs or control systems. This logic provides executive power in hardware, software or a combination of both. In fact, fuzzy logic provides a simple way to arrive at a conclusive and certain way based on incomplete, erroneous, ambiguous and vague information data. The fuzzy logic expresses a simple law based on "If x and y, then z."

5.5. Fuzzy Model

Fuzzy logic is a novel technology that replaces ways required for designing and modeling a complicated system of mathematics with language values and the proficient individual's knowledge, aiming to simplify and make effective the system design. The fuzzy logic is characterized by getting incomplete and illogical inputs to conclusive responses by using some laws as (if, …then, …). ANFIS uses a set of input/output data to create a Fuzzy Inference System (FIS). One example of Sugeno's fuzzy inference system is given in Figure 1. It is supposed that studied FIS is made of two x and y inputs and a z output, as the laws existing in this system are as follows:

Rule 1: if x is A1 and y is B1, then f1=p1x+q1y+r1
Rule 2: if x is A2 and y is B2, then f2=p2x+q2y+r2

If average center defuzzification is used for defuzzification, the output will be as follows:

$$f = \frac{w_1 f_1 + w_2 f_2}{w_1 + w_2} = \bar{w}_1 f_1 + \bar{w}_2 f_2 \quad st \quad \bar{w}_1 = \frac{w_1}{w_1 + w_2} \;,\; \bar{w}_2 = \frac{w_2}{w_1 + w_2}$$

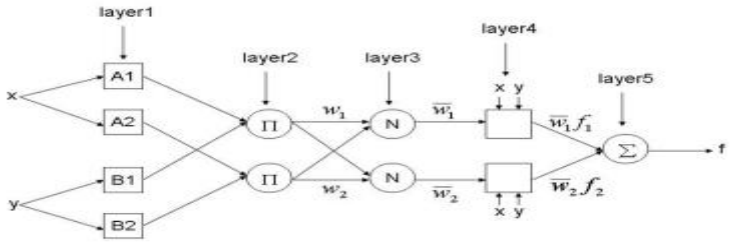

Figure 1: ANFIS structure

Layer 1: In this layer, the degree of membership of the input groups is marked by various fuzzy intervals using the membership function.

$$O_{1,i} = \mu_{A_i}(x)\ ,\ i = 1,2$$
$$O_{1,i} = \mu_{B_{i-2}}(y)\ ,\ i = 3,4$$

Layer 2: Each node of this layer computes the degree of activity of a law.

$$O_{2,i} = w_i = \mu_{A_i}(x) \times \mu_{B_i}(y)\ ,\ i = 1,2$$

Layer 3: In this layer, the degree of the activity of the *i*th law is normalized as follows:

$$O_{3,i} = \bar{w}_i = \frac{w_i}{\sum_{i=1}^{2} w_i}\ ,\ i = 1,2$$

Layer 4: In this layer, the output of each node is equal to:

$$O_{4,i} = \bar{w}_i f_i = \bar{w}_i (p_i x + q_i y + r_i)\ ,\ i = 1,2$$

Layer 5: In this layer, the final output, which is the sum of the outputs of the previous layer nodes, is computed as follows:

Meantime, the MATLAB software has been explained for this.

$$O_{5,i} = \sum_{i=1}^{2} \bar{w}_i f_i$$

5.5. Statistical Population

The statistical population in this study includes two parts: the best and worst manufacturing companies from a list of the top 100 companies introduced by the Industrial Management Organization, which are listed on the Iranian capital market, as well as bankrupt manufacturing companies selected from among the companies listed by the Bankruptcy Division of the Judiciary. This statistical population was used to validate and confirm the usability of the model. On the other hand, considering the limitations and diversity of economic activities, 100 top companies listed by the Industrial Management Organization were selected as the best companies in various manufacturing fields (merely goods and products manufacturers), which held membership conditions in the capital market (including 28 manufacturing companies). In the meantime, the companies removed from the capital market because of non-compliance with financial conditions and sustaining of losses in various production fields and those which did not meet the membership conditions in the capital market (including 28 manufacturing companies) were selected as the worst companies.

5.6. Data gathering and analysis

Mathematical equations and models designed from the Grounded Theory were developed for the winning companies (the best companies), selected from among the 100 top companies by the Industrial Management Organization, as the results are extracted. Compared to these companies, there is the second group of companies that have been delisted from the Stocks Exchange due to financial constraints and are having bankruptcy cases in the national judiciary systems. Also, an exploratory model has been implemented for these companies, and the results are extracted. In the end, this model provides a range of numbers for the successful and insolvent as well as bankrupt companies, which have been ranked as the best (the highest normal limit) and the worst (the lowest normal limit) in the health diagnosis division, as the status of these companies is examined by these two criteria (the minimum and maximum of the ratios). These three financial ratios can be simulated like human medical tests.

6. Research findings

6.1. Normalcy of the research variables from logistic regression methods, including

H_0: Distribution of the studied independent variables is normal

H_1: The distribution of the studied independent variables is not normal

The table gives Kolmogorov-Smirnov test results on the normality of studied ratios. As noted, in all ratios (independent variable), except for the consolidated (ratio 1) and the total product of the ratios, the significance level of the said test is less than 0.05, and the null hypothesis (distribution of studied variables is normal) is rejected, and the opposite hypothesis is confirmed. In other words, the distribution of all said variables, except for the consolidated (ratio 1) and the total product of the ratios, is not normal. Normality of the dependent variable of the total product of the ratios will satisfy the conditions to use the linear regression in other findings. Thus, because most studied ratios of this research are not normal, non-parametric tests were

used to investigate and test the research hypotheses. As a result, *Mann–Whitney* U, which is the non-parametric equivalence to the T-test, was used.

Table 1. Kolmogorov-Smirnov Test.

Variable	Mean	SD	Kolmogorov-Smirnov Z	Sig.
Balance sheet (ratio 1)	-0.429	1.400	2.755	.000
Balance sheet (ratio 2)	-.217	3.851	6.000	.000
Balance sheet (ratio 3)	.452	.720	3.495	.000
Profit and loss (ratio 1)	.114	.421	2.828	.000
Profit and loss (ratio 2)	.207	.296	1.761	.000
Consolidated (ratio 1)	.060	.201	.957	.000
Consolidated (ratio 2)	.912	.995	3.052	.000
Consolidated (ratio 3)	.523	1.911	2.042	.000
Consolidated (ratio 4)	-.431	7.691	4.260	.000
Consolidated (ratio 5)	-.108	.286	2.548	.000
Consolidated (ratio 6)	3.615	19.05	5.228	.000
Product of balance sheet ratio	-.193	4.149	3.476	.000
Product of consolidated balance sheet	4.570	20.663	4.051	.000
Product of profit and loss ratio	2.463	15.594	5.742	.000
Product of all ratios (Dependent variable)	1.884	6.095	1.264	.082

Table 2. **Mann–Whitney *U test results.***

Variable	Group	Mean ranking	Mann-Whitney U	Z	Sig.
Balance sheet (ratio 1)	Best Companies	95.29	2622	-2.874	.004
	Worst companies	73.71			
Balance sheet (ratio 2)	Best Companies	98.96	2313	-3.854	.000
	Worst companies	70.04			
Balance sheet (ratio 3)	Best Companies	101.18	2127	-4.444	.000
	Worst companies	67.82			
Profit and loss (ratio 1)	Best Companies	110.26	1364	-6.865	.000
	Worst companies	58.74			
Profit and loss (ratio 2)	Best Companies	102.79	1992	-4.873	.000
	Worst companies	66.21			
Consolidated (ratio 1)	Best Companies	112.83	1148	-7.550	.000
	Worst companies	56.17			
Consolidated (ratio 2)	Best Companies	85.76	3422	-.336	.737
	Worst companies	83.24			
Consolidated (ratio 3)	Best Companies	110.24	1368	-6.852	.000
	Worst companies	58.79			
Consolidated (ratio 4)	Best Companies	88.49	3193	-1.063	.288
	Worst companies	80.51			
Consolidated (ratio 5)	Best Companies	95.57	2598	-2.950	.003
	Worst companies	73.43			
Consolidated (ratio 6)	Best Companies	86.74	3340	-.597	.551
	Worst companies	82.26			

Because in the *Mann–Whitney* U test, the significance level of eleven variables is less than 0.05, it can be said that the eleven ratios for the two best and worst groups have a significant difference from each other. Thus, they can be used as independent variables to estimate the best and worst companies. In other words, the eleven independent variables under study were determined to be

appropriate for distinguishing the best and worst companies from each other. Thus, the relationship between studied ratios and the best and worst companies can be investigated.

Table 3. Correlation of studied ratios.

Description	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11
Balance sheet (ratio 1) (x1)	1.000	.035	-.131	-.124	.070	-.342	-.027	.058	-.259	.138	.097
Balance sheet (ratio 2) (x2)	.035	1.000	.040	.092	-.085	.003	.077	-.026	.025	.043	.016
Balance sheet (ratio 3) (x3)	-.131	.040	1.000	-.016	-.082	-.128	.055	.330	.041	-.020	-.495
Profit and loss (ratio 1) (x4)	-.124	.092	-.016	1.000	-.526	.125	.241	-.195	.142	.023	-.023
Profit and loss (ratio 2) (x5)	.070	-.085	-082	-.526	1.000	-.308	.013	.009	-.132	-.013	-.173
Consolidated (ratio 1) (x6)	-.342	.003	-.128	.104	-.308	1.000	.009	-.514	.116	-.045	.034
Consolidated (ratio 2) (x7)	-0.27	.077	.055	.241	.013	.009	1.000	-.323	.214	.181	-.031
Consolidated (ratio 3) (x8)	.058	-.026	.330	-.195	.009	-.514	-.323	1.000	-.015	-.071	-.061
Consolidated (ratio 4) (x9)	-.259	.025	.081	.142	-.132	.116	.214	-.015	1.000	-.076	-.055
Consolidated (ratio 5)(x10)	.138	.043	-.020	.028	-.013	-.045	.181	-.071	-.076	1.000	.217
Consolidated (ratio 6) (x11)	.097	.016	-.495	-.023	-.173	.034	-.031	-.061	-.055	.217	1.000

The above table gives a correlation of all studied ratios. In this stage, correlation coefficient values were used to evaluate the linearity of the measurement model criteria. Multiple linearities occur when two or more explanatory variables (independent variables) in a multivariate regression have a higher correlation (greater than 0.7) against each other. The correlation here it is meant the presence of a linear relationship between independent variables. The level and type of linearity will differ depending on the intensity of the correlations between independent variables. Linearity is more or less existing in all regression models. What is important is the intensity of linearity between independent variables. The presence of "full linearity" violates the classic assumptions of the regression models. As noted, the correlation value between all studied ratios was less than 0.7; as a result, there are no multiple linearities which causes the violation of classic assumptions of the regression model. Later, the relationship between studied rations and the best and worst companies is studied through logit regression.

Logit regression analysis to examine the effects of all balance sheet, consolidated and profit ratios on the dependent and nominal variables of the best and worst companies:

As noted from the above table, the generalized logit regression pattern to measure the probability of the predicted risk degree for the occurrence of the binary dependent variable of the best and worst companies holds the rate of 83.3%, which indicate higher efficiency. According to this table, the predicted results are compared with the observed results. As suggested by this table, the ability of the model to predict the predicted risk for the occurrence of the binary dependent variable of the best companies is 81%, the ability of the model to predict the risk for the worst companies is 85.7%, while the overall ability of the model is a sum of 83%, and since the percentage of the model's correctness is greater than the cut-off value (determined to be 50%), this pattern involves a constant value, as variables of the product of balance sheet, the product of profit and loss ratios and product of consolidated rations enjoy very good fit. According to table (4-4), the value of the logarithm of the model probability is 127.81, which still indicates a significant relationship between the independent and dependent variables of the model. On the one hand, consistent with the squared statistics, the Cox and Snell correlation coefficient was 46.5% of the changes in the dependent variable as explained by the three independent variables. The product of balance sheet ratios, profit and loss ratios and consolidated ratios were thus explained. In this connection, based on the squared statistic, the correlation coefficient of the Nagel Grek test was 62% of the changes in the dependent variable as explained by the three explanatory variables. Thus, the coefficients of the determination of the estimated model based on the last two statistics suggested the appropriateness of the explanatory power of the model.

Table 4. Classification table (examining the efficacy of the logit regression model).

Observed for the occurrence of the dependent binary variable	Predicted for the occurrence of the dependent binary variable of best and worst companies		
	Group		The percentage of correct observations of the occurrence of the dependent variable
	Best Companies	Worst companies	
Best Companies	68	16	81.0
Worst companies	12	72	85.7
Mean percentage of correct observations			83.3

Table 5. Evaluation of the power to explain the fit model.

Stage	-2Log Probability	Cox and Snell's squared correlation coefficient	Nigel Grec's squared correlation coefficient
One	127.819	.465	.620

Table 6. Comparison of estimated values with real observations using the Hosmer and Lemeshow tests.

Stages	Best Companies		Worst companies		Total
	Observed	Expected	Observed	Expected	
1	17	16.945	0	.055	17
2	16	16.455	1	.545	17
3	15	14.820	2	2.180	17
4	12	11.371	5	5.629	17
5	10	8.874	7	8.126	17
6	7	7.143	10	9.857	17
7	6	4.861	11	12.139	17
8	0	2.612	17	14.388	17
9	0	.861	17	16.139	17
10	1	.059	14	14.941	15

In the above ten relations (ten steps), the more the observed or experimental and predicted frequency difference tends to zero, the more accurate the model is in predicting the occurrence of the dependent variable, and the probability value of the Hosmer-Lemeshow test statistic will be greater than Alpha rate of 5%.

Table 7. Probability value test of the Hosmer-Lemeshow test to match the observed and expected cases.

Stage	Che-square	Freedom degree	Sig.
One	9.178	8	.328

The stated process has compared the observed values with the expected values using the Hosmer-Lemeshow test statistic. The higher significance value of the chi-square test above 0.05 is an indication of a good match. Accordingly, the significance value is greater than 0.05, so it is thus concluded that there is a match between the number of observed and expected cases, which suggests the insignificance of the deviation (error) level.

Table 8 presents results from SPSS software for the comprehensive model. The values in this table from the second column on the right respectively indicate the constant values of the said independent variables, standard errors, or standard deviation of the error of each and every regression relation coefficient (S.E), independent variable coefficients, Wald test, freedom degree, significance, or the value of probability of point estimation of the odd ration.

In other words, given the value of probability value which is less than 0.05 in the independent variables of balance sheet ratio 3, profit and loss ratios of 1 and 2 and consolidated rations (mixed) of 1, 2, and 6, it is concluded that the binary dependent variable is explained by the said independent variables and the independent variables of the balance sheet ratios of 1 and 2, and consolidated ratios of 3, 4, and 5 have no effects on the dependent variable. Thus, the logit model is as follows:

The regression analysis of investigating the effects of ratio products under study (balance sheets, consolidated, and profit and loss) on the product of all rations using simultaneous method of variables by the best and worst companies.

The above table gives the results of the effects of the product of studied ratios (balance sheets, consolidated, and profits and loss) on the product of total ratios. As clear from the table, the significance of the F test in the best and worst companies is less than 0.05; thus, it is concluded that the regression equation coefficient pertaining to at least one of the independent variables of the product of total ratios in both groups opposes zero. On the other hand, the significance of the t statistics of all independent variables is less than 0.05. As a result, all products of the studied rations (balance sheet, consolidated and profit and loss) affect the product of all ratios. It is noteworthy that based on the partial correlation of Beta, the resulting variable coefficient of the profit and loss ratio in the worst companies is negative, suggesting that the product of the profit nd loss ratio

negatively affects the product of total ratios. However, all relations in the best companies are positive and significant. Thus, the regression model pertaining to the best companies (y1) and worst companies (y2) is as follows:

$y_1 = -0.489 + 0.643X_1 + 0.009X_2 + 1.010X_3$

As inferred from analyses, the resulting model is effective enough; however, to remove ambiguities, the U-Mann Whitney Test is used to evaluate the ratios. On the other hand, the beta coefficient of all three categories is used to raise the coefficients.

Table 8. Confidence interval for the coefficients of the comprehensive generalized logit regression model.

Indeoednet variabels	Variable coefficients	Standard error	Wald Statistic	Freedom degree	Peobability value	Odd	٪۹۵ Confidence interval for the logarithm of the coefficients of the generalized logit regression equation	
							The lower limit of the model coefficient logarithm The minimum odds ratio or variable chance	The upper limit of the model coefficient logarithm Maximum odd ratio or variable chance
balance sheet ratio 1(x1)	.337	.206	2.671	1	.102	1.401	.935	2.100
balance sheet ratio 2(x2)	-.125	.159	.619	1	.431	.882	.646	1.205
balance sheet ratio 3(x3)	-1.872	.957	3.825	1	.051	.154	.024	1.004
profit and loss ratio 1(x4)	-8.632	2.737	9.950	1	.002	.000	.000	.038
profit and loss ratio 2(x5)	6.654	3.140	4.490	1	.034	775-783	1.648	365218.668
Consolidated ratio 1(x6)	-10.402	3.260	10.184	1	.001	.000	.000	.018
Consolidated ratio 2(x7)	-.886	..446	3.942	1	.047	.412	.172	.989
Consolidated ratio 3(x8)	.306	.240	1.631	1	.202	1.358	.849	2.174
Consolidated ratio 4(x9)	-.038	.035	1.170	1	.279	.963	.899	1.031
Consolidated ratio 5(x10)	..212	.676	.098	1	.754	1.236	.328	4.655
Consolidated ratio 6(x11)	.045	.021	4.511	1	.034	1.046	1.003	1.090
Constant value	1.681	.625	7.248	1	.007	5.373		

Table 9. Results of the effect of the studied ratios (balance sheet, consolidated and profit and loss) on the total product of the ratios.

	independent variable	dependent variable	multiple correlation coefficient (r)	multiple determination coefficient (r2)	f	sig.	coefficient (b)	partial correlation coefficient (beta)	t statistic	sig.
Best companies	Constant coefficient	Totl roduct of all ratios	.996	.992	3644.526	.000	-.489		-4.686	.000
	Product of balance sheet ratio (x1)						.643	.101	9.284	.000
	Product of the consolidated ratio (x2)						.009	.023	2.004	.048
	Product of profit and loss ratio (x3)						1.010	.957	90.168	.000
Worst companies	Constant coefficient		.770	.593	38.827	.000	-.886		-1.395	.167
	Product of balance sheet ratio (x1)						.997	.643	8.962	.000
	Product of the consolidated ratio (x2)						.246	.443	5.236	.000
	Product of profit and loss ratio (x3)						-.200	-.192	-2.269	.026

6.2. Validation of the model of the best and worst manufacturing companies in Iran through Neuro-Fuzzy Tests (Adaptive Neuro-Fuzzy Inference (ANFIS))

The ratios obtained from the best and worst companies that yielded the final variables of the model were introduced as the inputs to the ANFIS.

Table 10. ANFIS input variables.

Indicators	Sub-indicators
Product of balance sheet ratio	Balance sheet (ratio 1)
	Balance sheet (ratio 2)
	Balance sheet (ratio 3)
	A beta ratio of the balance sheet
Product of loss and profit ratio	Loss and profit ratio (1)
	Loss and profit ratio (2)
	A beta ratio of loss and profit
Product of consolidated ratio (balance sheet, loss, profit, cash flow)	Consolidated ratio (1)
	Consolidated ratio (2)
	Consolidated ratio (3)
	Consolidated ratio (4)
	Consolidated ratio (5)
	Consolidated ratio (6)
	Consolidated beta ratio

To develop a prediction and diagnosis prediction model, five separate ANFISs were used. Four of which indicated the product of the balance sheet ratio, product of profit and loss ratio, the product of consolidated ratio, and total product. The last ANFIS investigates the bankruptcy status of the companies, and the output of the four ANFISs was taken as its inputs. Data were divided into three sets: training sets (including 25 bankrupt and 25 non-bankrupt companies), testing set (including 9 companies and 8 non-bankrupt companies) and checking or validation set (including 9 bankrupt and 8 non-bankrupt companies). Thus, the derived inputs are the product of the balance sheet, the product of profit and loss, and the product of consolidated ratios, as the outputs are the total product of the ratios. The outputs of all three states are given in Figures 1-3.

6.2.2. Output in the training state

The deductive clustering method was used with a coefficient of the effect of 0.08, as the hybrid method was used as an optimal method for the manufacturing of the FIS training. This system is one of Sugeno's types, as variables have been converted into fuzzy variables using Gaussian functions.

6.2.3. Outputs under testing state:

The sign (*) indicates the output of a system, and the sign (blue circle) indicates bankruptcy status, as validation in the ANFIS model has an almost logical overlap. This suggests a lack of over-fit phenomenon. Under this state, the mean errors computed is 0.0001171.

6.2.4. Output under checking state:

In Figure 3, the sign * indicates the output of the system and an indicator of bankruptcy status, while the mean error estimated is 0.3741, which is less than 1.

Code output: The above issues can be written in the form of code that the best model and the worst model were obtained with an accuracy of 99.91%, which indicates the good performance of this method.

7. Discussion

Consistent with research findings from the best and worst companies, we have the following:

Table 11. Consecutive three years of the best and worst companies as for the division results.

Row	Description of ratios	Sum of the best	Mean of the best	Sum of the worst	Mean of the worst
1	Balance sheet (ratio 1)	-5.810	-0.068	-66.248	-0.779
2	Balance sheet (ratio 2)	12.791	0.150	-49.245	-0.579
3	Balance sheet (ratio 3)	56.767	0.668	19.166	0.225
4	A beta ratio of the balance sheet	21.060	0.248	18.789	0.221
5	Profit and loss (ratio 1)	25.395	0.299	-6.612	-0.073
6	Profit and loss (ratio 2)	27.367	0.322	7.331	0.086
7	A beta ratio of profit and loss	14.978	0.176	-22.788	-0.268
8	Consolidated ratio (1)	14.523	0.171	-4.525	-0.053
9	Consolidated ratio (2)	95.732	1.126	57.537	0.677
10	Consolidated ratio (3)	107.590	1.266	-19.810	-0.233
11	Consolidated ratio (4)	-25.967	-0.305	-46.503	-0.547
12	Consolidated	-11.503	-0.135	-6.550	-0.077

Row	Description of ratios	Sum of the best	Mean of the best	Sum of the worst	Mean of the worst
	ratio (5)				
13	Consolidated ratio (6)	351.159	4.131	256.129	3.013
14	Beta consolidated ratio	4.747	0.056	1.981	0.023
15	Product of balance sheet ratio	27.798	0.327	-36.268	-0.427
16	Product of profit and loss ratio	25.620	0.301	3.432	0.040
17	Product of consolidated ratio	126.210	1.485	16.789	0.198
18	Product of total Y ratios	179.627	2.113	-16.047	-0.189

The above table was made by assuming the removal of time lags as it shows the computation of three consecutive years using a mathematical model, with the mean best manufacturing company being +2.113 and that of the worst manufacturing company being -0.189.

However, the output of the model design, if it is to be presented in numerical forms, will be as follows:

$$y_1 \geq a_1 = \pm\beta_1\sum A_1 \pm \beta_2\sum A_2 \pm \beta_3\sum A_3$$

$$\beta_n A_n = \beta_n \times \sum A_n$$

[Y_1> or = 2.113]=0.327+0.301+1.485

$$a_2 = y_2 \leq a_3 = \pm\beta_1\sum B_1 \pm \beta_2\sum B_2 \pm \beta_3\sum B_3$$

$$\beta_n B_n = \beta_n \times \sum B_n$$

[0.595 = y_2<or= -0.189]= 0.338+0.156+0.101 and /or -0.427 +0.040+0.198

As inferred from the formula, the companies studied in the next table, where answers to their ratios will be extracted from the model, will be ideal if they are higher than 2.113 and will be under a warning situation if the ratios are equal to 0.595, and if they tend to negative from -0.189, they will be under bankruptcy. Also, one can refer to the entry of smaller data and each and every balance sheet, profit and loss and consolidated ratios, and compare the best and worst companies.

8. Conclusion

- Which logistic regression method or Sugeno's ANFIS method is the most appropriate tool for the applicability of the model?

Given research findings, one would say that the 5the logistic regression method (with a high probability of 80%) and the ANFIS method (with a high probability of 99%) are the best tools to evaluate the model. However, the 99% coefficient of the ANFIS method has an advantage over the logistic regression method. Thus, using mathematical logic, it is better to take priority to the ANFIS method.

- Could these classified ratios as the diagnosis of the health division of Iranian manufacturing companies provide a normal or abnormal statement of the manufacturing companies?

To answer this question, a number of stocks-listed and non-stocks companies were randomly selected and given in the table below:

Table 12. Testing 13 random companies to evaluate the bankruptcy model.

Row	Company name	Product of balance sheet ratio	Profit ratio product	Consolidated ratio product	Yn	Evaluation result
1	Iran Aluminium Manufacturing Co. (2019) (Billion Rials)	0.224	0.100	0.121	0.445	Warning
2	Arak Aluminium Manufacturing Co. (2016) (Million Rials)	-0.425	-0.009	0.006	-0.428	Bankrupt
3	Iralko (2014) (Million Rials)	-0.106	-0.001	-0.001	-0.108	Bankrupt
4	Tehran Darou (2019) (Million Rials)	-0.021	0.037	0.252	0.268	Warning
5	Welding and Oxygen (2019) (Million Rials)	-4.047	-4.493	-0.281	-8.821	Bankrupt
6	Packaging industries (2019) (Million Rials)	2.215	-0.155	0.016	2.075	Non-bankrupt
7	Pars Pamchal (2018) (Million Rials)	-0.751	-0.001	0.000	-0.752	Bankrupt
8	Pakvash (2017) (Million Rials)	0.075	0.191	0.005	0.272	Warning
9	Keivan (2013)) (Million Rials)	-0.085	-0.054	0.004	-0.134	Serious warning

Row	Company name	Product of balance sheet ratio	Profit ratio product	Consolidated ratio product	Yn	Evaluation result
10	Neopan (2019) (Million Rials)	0.315	0.005	0.205	0.526	Warning
11	Tractor manufacturing industrial machinery (2011) (Million Rials)	-0.621	-1.067	-0.016	-1.704	Bankrupt
12	Teran Shimi Drug Maker (2019) (Million Rials)	0.051	0.061	0.167	0.280	Warning
13	Kaf (2019) (Million Rials)	-0.288	-4.099	-0.009	-4.396	Bankrupt
١٤	Iralko (2020) (Million Rials)	0.202	0.182	0.148	0.532	Warning
١٥	Mehrkam Pars (2020) (Billion Rials)	-0.139	-0.009	0.051	-0.097	Serious warning
١٦	Natioanl Copper and Zinc (2020) (Billion Rials)	-0.206	0.381	0.103	0.277	Warning
١٧	Naft Tabriz (2020) (Billion Rials)	0.122	0.181	0.481	0.784	Non-bankrupt
١٨	Simorgh Manufacturing and Agriculture (2020) (Billion Rials)	0.279	0.228	0.349	0.856	Non-bankrupt
١٩	Zinc Mine Development (2020) (Billion Rials)	0.289	1.385	-1.133	0.542	Warning
٢٠	Lorestan Koloucheh (2020) (Billion Rials)	2.082	0.000	-0.169	1.913	Non-bankrupt
٢١	Non-listed manufacturing company (2020) (Billion Rials)	-0.314	-0.333	-0.010	-0.478	Bankrupt
٢٢	Namasaan Co. (2020) (Billion Rials)	-0.394	-0.544	0.002	-0.946	Bankrupt
٢٣	Almahdi Aluminium Co.	-0.740	-0.089	0.517	-0.312	Bankrupt

As noted, the corporate situation can be predicted using a range of numbers derived from the relevant ratios can be obtained; also, as for the applicability of the components of each category of ratios, each of the ratios can be taken into account consistent with a range of normal ratios (from the best companies) and abnormal ratios (from the worst companies) through simulations.

For more explanations, please refer to the following table, which is taken for two randomly selected companies:

Table 14. Diagnosis and continuity of activity and health division.

Test	Best results	Worst results	Normal range of the best	Normal range of the worst
Balance sheet	Packaging industries Company	Kaf Company (2019)		
Ratio 1	0.554	-4.618	-0.068	-0.779
Ratio 2	0.388	0.19	0.150	-0.579
Ratio 3	1.812	0.015	0.668	0.225
Sum of ratios	2.754	-4.413	0.750	-1.133
The beta of the balance sheet	0.804	0.065	0.248	0.221
Product of balance sheet	2.215	-0.288	0.327	-0.427
Profit and loss				
Ratio 1	0.267	-1.862	0.299	-0.073
Ratio 2	0.362	-0.063	0.322	0.086
Sum of ratios	0.629	-1.925	0.621	0.013
The beta of profit and loss	-0.247	-2.129	0.176	-0.268
Product of profit and loss	-0.155	-4.099	0.301	0.040
Consolidated				
Ratio 1	0.145	-0.158	0.171	-0.053

Ratio 2	0.375	0.022	1.126	0.677
Ratio 3	0.18	-2.845	1.266	-0.233
Ratio 4	0.321	0	-0.305	-0.547
Ratio 5	-0.002	0	-0.135	-0.077
Ratio 6	-0.198	0	4.131	3.013
Sum of ratios	0.821	-2.981	6.253	2.780
Consolidated beta	0.019	0.003	0.056	0.023
The total product of all three ratios	2.075	-4.396	2.113	-0.189
Scope of changes	Y=2.075	Y=4.396	y≥ or 2.113	0.595≤y Packaging industries Company-0.189

As noted from the above table, the selected companies have relevant ratios, and the corresponding coefficients and each ratio group can be investigated.

The researchers of the article maintain that this model, like human medical laboratories, is capable of predicting the health of manufacturing companies, and it is hoped that one day this division could provide 21 key tests for corporate development.

In the end, the relevant model is summarized and illustrated in the form of a diagram and figure on the next page (Figure 4).

Because the mentioned model is designed only for manufacturing companies in Iran, a separate study should be carried out by other researchers for analyzing and comparing the results; however, the present study has three unique features relative to other studies on the subject of bankruptcy, 1- Measures taken by researchers using the scientific method of grounded theory from among the 36 ratios used in the proposed models by selecting 11 practical ratios and imposing computational limits for some of those ratios 2- Classifying ratios into three categories of balance sheet, profit and loss, cash flow (consolidated or mixed) using statistical tests, and applying the results in many manufacturing companies, and 3 - Defining the coefficients for each of the three classes.

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Figure captions

Figure 1. Training with 20 times of iterations.

Figure 2. Output of the testing model after 10 times of iterations.

Figure 3. Output of checking model after 30 times of iteration.

Figure 4. Mathematical model for bankruptcy of manufacturing companies in schematic form.