



Predicting financial crisis happening by using data envelopment technique (a comparative study using Springate, Altman, Ohleson, Zimmesky, Shirata) in Tehran Stock Exchange

Zahra KOHANDEL^{1,*}, Khadije FARDİ², Hadi KORD JAVADI³

¹*Al-Zahra University Branch, Tehran*

²*Young Researchers and Elite Club behbahan Branch, Islamic Azad University, behbahan, Iran*

³*Young Researchers and Elite Club Torbat-e-Heydarieh Branch, Islamic Azad University, Torbat-e-Heydarieh, Iran*

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Abstract. Regarding the effects of financial vulnerability of companies for different beneficiary groups, the presentation of financial vulnerability prediction patterns has always been one of the most attractive issues in financial researches. In current prediction patterns mainly financial ratios are utilized as prediction variables. In this research the efficiency of firms has been calculated by using data envelopment analysis technique. To do so, first we designed a pattern by using this variable and to investigate the results better we tried to consider model posed by Springate, Altman, Ohleson, Zimmesky, and Shirata. Then models mentioned were ranked according to their efficiency and the results were compared with the primary ones. Thus, 21 hypotheses were devised. The statistical population for this research entailed all companies enlisted in Tehran Stock Exchange. Our statistical sample included 52 financially vulnerable companies and 52 safe ones during the time period between 2005 and 2011 and in order to categorize them into two groups we used article 141 of business rule. Results showed that the designed pattern was based on efficiency mark of financial crisis prediction capability in companies enlisted in Stock Exchange up to two years before it happens. Also results approved the improvement of prediction of vulnerable companies by applying efficiency mark to models but this improvement was not very considerable.

Keywords: Financial vulnerability, models of: Springate, Altman, Ohleson, Zimmesky, and Shirata

1. INTRODUCTION

Due to increasing companies and business institutions and creating complexities in economic and business relationships the duties of finance section have changed dramatically. The emphasis of governments on economic growth has resulted in increasing and extra expansion of companies and aid institutions and these tasks have become more complex. On the other hand, technological developments and broad environmental changes have resulted in excessive speed of economy and due to increasing competitions of entities, the achievement of earnings has become limited and tendency for bankruptcy has increased. The amount of occurrence of financial crises worldwide during recent years has been more than any other time. During two last decades economic figures and numbers have shown a tremendous amount of bankruptcies. The existence of financial crises in a country is an important economic index which deserves the attention of public. Also economic costs of bankruptcy are too much. Thus, financial crisis prediction capability and avoiding it to happen is fundamentally important and it prevents unsuitable appropriation of rare economic resources. The presentation of an exact definition of groups involved in bankruptcy is very difficult. But it can be claimed that management, investors, creditors and legal institutions are exposed to bankruptcy phenomenon more than others. When total liabilities of a company is more than its total assets' fair value it is bankrupted. In this case the firm can announce bankruptcy through legal referents.

*Corresponding author. *Email adress: zahrakohandel@yahoo.com*

1.1. Financial vulnerability stages

Newton (1998) divided the stages which lead to an undesirable status regarding financial position of a company as follows: hidden periods, cash shortage, and inability to repay financial or business debts, inability to repay debts completely, and finally bankruptcy. Although most bankruptcies follow these stages, some companies may reach complete bankruptcy without going through all stages above. The status of a business entity will not lead to a sudden and unexpected bankruptcy. In hidden stage there may exist one or several undesirable states in a hidden form for the business unit without being recognizable immediately. For example changes in production demand, continuous increases in overload costs, abandoning production methods, and ... are among these factors.

Hidden periods, cash shortage, and inability to repay financial or business debts, inability to repay debts completely, finally bankruptcy according to the definition posed by Altman (1986) bankruptcy happens when a company is not able to repay its liabilities and thus it can not continue its activities.

Identifying the reasons of bankruptcy is not an easy task but we can mention the following items on the whole:

1. Characteristics of economic system
2. Changes in business
3. Financing
4. Mismanagement
5. Interest rate changes
6. Inflation
7. Competition
8. Business fluctuations
9. Accidents
10. Government decisions
11. High production costs
12. Raw materials' price fluctuations

Table (1-1): Researches related with designing financial vulnerability and bankruptcy patterns.

Year	Researcher/researchers	Variables studied	Research findings
1983	Toffler	investment return rate, flowing capital, (financial risk, liability to owners' equity ratio), liquidity	The share for each of these variables in predicting bankruptcy was assessed to be 0.53, 0.13, 0.18, and 0.16, respectively.
1984	Zimesky	ratios of net earnings to total assets, total liabilities to total assets, current assets to current liabilities	If the ratio calculated based on research variables or a company is less than zero it will be categorized as bankrupted and if not it is not bankrupted.
1984	Fulmer	ratios of accumulated earnings to total assets, sales to total assets, earnings before tax to owners' equity, cash flow to total liabilities, liabilities to total assets, current liabilities to total assets, logarithm of all tangible assets, flowing capital to total liabilities, logarithm of earnings before interest and interest tax	If the ratio calculated based on research variables or a company is less than zero it will be categorized as bankrupted and if not it is not bankrupted.

1.2. Research hypotheses

1. We can predict the occurrence of financial crisis in manufacturing companies accepted in Tehran Stock Exchange using a pattern based on data envelopment analysis.
2. We can predict the occurrence of financial crisis in manufacturing companies accepted in Tehran Stock Exchange using a pattern based on Springate's model.
3. We can predict the occurrence of financial crisis in manufacturing companies accepted in Tehran Stock Exchange using a pattern based on Altman's model.
4. We can predict the occurrence of financial crisis in manufacturing companies accepted in Tehran Stock Exchange using a pattern based on Ohleson's model.
5. We can predict the occurrence of financial crisis in manufacturing companies accepted in Tehran Stock Exchange using a pattern based on Zimesky's model.
6. We can predict the occurrence of financial crisis in manufacturing companies accepted in Tehran Stock Exchange using a pattern based on Shirata's model.
7. We can predict the occurrence of financial crisis in manufacturing companies accepted in Tehran Stock Exchange using a pattern based on Springate's model by using efficiency mark.
8. We can predict the occurrence of financial crisis in manufacturing companies accepted in Tehran Stock Exchange using a pattern based on Altman's model by using efficiency mark.
9. We can predict the occurrence of financial crisis in manufacturing companies accepted in Tehran Stock Exchange using a pattern based on Ohleson's model by using efficiency mark.
10. We can predict the occurrence of financial crisis in manufacturing companies accepted in Tehran Stock Exchange using a pattern based on Zimesky's model by using efficiency mark.
11. We can predict the occurrence of financial crisis in manufacturing companies accepted in Tehran Stock Exchange using a pattern based on Shirata's model by using efficiency mark.
12. There is a meaningful difference between overall precision of prediction pattern based on data envelopment analysis and overall precision of prediction pattern based on Springate's model.
13. There is a meaningful difference between overall precision of prediction pattern based on data envelopment analysis and overall precision of prediction pattern based on Altman's model.
14. There is a meaningful difference between overall precision of prediction pattern based on data envelopment analysis and overall precision of prediction pattern based on Ohleson's model.

15. There is a meaningful difference between overall precision of prediction pattern based on data envelopment analysis and overall precision of prediction pattern based on Zimesky's model.
16. There is a meaningful difference between overall precision of prediction pattern based on data envelopment analysis and overall precision of prediction pattern based on Shirata's model.
17. There is a meaningful difference between overall precision of prediction pattern based on Springate's model and overall precision of prediction pattern based on Springate's model with efficiency mark.
18. There is a meaningful difference between overall precision of prediction pattern based on Altman's model and overall precision of prediction pattern based on Altman's model with efficiency mark.
19. There is a meaningful difference between overall precision of prediction pattern based on Ohleson's model and overall precision of prediction pattern based on Ohleson's model with efficiency mark.
20. There is a meaningful difference between overall precision of prediction pattern based on Zimesky's model and overall precision of prediction pattern based on Zimesky's model with efficiency mark.
21. There is a meaningful difference between overall precision of prediction pattern based on Shirata's model and overall precision of prediction pattern based on Shirata's model with efficiency mark.

1.3. Study population and statistical sample

The statistical society for this research entails all firms accepted in Tehran Stock Exchange. In this research we needed information of two groups of firms having financial crises and those that did not have financial crises to adjust bankruptcy prediction patterns. To select our sample we applied the following criteria:

1. Firms should be manufacturing companies.
2. They should have been accepted in Tehran Stock Exchange before 2005.
3. Their fiscal year should end on 29th of Esfand (20th March).
4. Regarding vulnerable companies: they should have at least enlisted once under those which were based on article 141 of rules.
5. Their information should be accessible.
6. They should not be among investing (holding) companies.

Regarding the observation of conditions above, sampling was systematically and purposefully done on a list including 52 companies having financial crisis and 52 safe companies (104 total numbers of companies).

Those companies were included in the sample that were present in the Stock Exchange and were not excluded. Thus, we utilized a deletion sampling method. On the whole 189 persons had the conditions mentioned above.

1.4. Research method

In order to categorize companies into two groups of financially vulnerable and safe companies we used presupposition in article 141 of business rule as categorization criteria.

Although in previous related researches in Iran considering article 141 as bankruptcy criterion, considering the fact that firms being exposed to this article do not necessarily announce bankruptcy and being dissolved, in this research we have called such companies as financially vulnerable companies. To choose vulnerable companies from among manufacturing companies all firms which were accepted during the time period between 2005 and 2011 and were at least once categorized under article 141 of business rule (our criterion is the existence of financial vulnerability in this research) were selected and the number was 52. The year through which vulnerability occurred was considered as the base year (t).

1.5. A pattern based on data envelopment analysis

The efficiency of a unit requires comparing its inputs and outputs. If a unit has different data and outputs and the value (coefficient) of each is known we can calculate their efficiency:

Equation (1-1): efficiency = total weight given to outputs / total weight given to inputs

In most cases the coefficient of inputs and outputs is not known. Here we can use data envelopment analysis (DEA). DEA is a non-parametric method based on mathematical linear programming in order to determine the efficiency of decision maker units or economic entities based on data and outputs.

One of the characteristics of DEA models is their return to index structure which represents the relationship between the ratio of changes of data and outputs of a decision making unit. Return to index can be fixed or changeable. BCC patterns are among changeable patterns regarding return to index and their mathematical representation is as follows:

$$MaxZ = \frac{\sum_{r=1}^s u_r y_{r_o} + w}{\sum_{i=1}^m v_i}$$

M= number of inputs

U= weight of output

X= input (data)

W= free in sign variable

S= number of outputs

N= number of DMUs

V= weight of input

Y= output

If we solve this pattern for each of the units, a number between 0 and 1 will be gained which is the efficiency of that unit and shows whether it is efficient or inefficient.

Regarding research background and the operational outlook presented, sum of total assets and operational costs were selected as input and operational earning and accumulated earning of start of the period were chosen as outputs of the model.

Springate's pattern:

Equation (1-3): $Z = 1.3x_1 + 3.07x_2 + 0.66x_3 + 0.4x_4$

Based on this pattern if $Z < 0.862$, the company is considered to be bankrupted and if not it would be safe.

Altman's pattern:

Equation (1-4): $Z = 0.71x_1 + 0.847x_6 + 3.107x_2 + 0.42x_7 + 0.998x_4$

Based on this pattern if $Z < 1.33$, the bankruptcy probability will be high. If $1.33 < Z < 2.9$, the company is in bankruptcy danger and it is probable to encounter financial crisis. And finally if $Z > 2.9$, there is a very low probability of bankruptcy for the company.

Ohleson's pattern:

Equation (1-5): $Z = 1.3x_1 + 3.07x_2 + 0.66x_3 + 0.4x_4$

Based on this pattern if $Y < 0$, the company is considered to be bankrupted and if not, it would be safe.

Zimesky's pattern:

Equation (1-6): $Y = 4.3 - 4.5x_{13} + 5.7x_9 - 0.004x_{16}$

Based on this pattern if $Y < 0$, the company is considered to be financially vulnerable and if not, it would be safe.

Shirata's pattern:

Equation (1-7): $A = 0.014x_6 - 0.058x_{17} - 0.062x_{18} - 0.003x_{19} + 0.7416$

Based on this pattern if $Z < 0.38$, the company is considered to be bankrupted and if not, it would be safe.

Springate's pattern by using efficiency mark:

$Z = 1.3X1 + 3.07 X2 + 0.66 X3 + 0.4 X4 + aX5$

Altman's pattern by using efficiency mark:

$Z = 0.717X1 + 0.847X6 + 3.107X2 + 0.42X7 + 0.998X4 + aX5$

Ohleson's pattern by using efficiency mark:

$Y = -1.3 - 0.4X8 + 6X9 - 1.4X1 - X10 + 0.1X11 - 1.8X12 + 0.3X13 - 1.7X14 - 0.8X15 + aX5$

Zimesky's pattern by using efficiency mark:

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$$Y = -4.3 - 4.5X_{13} + 5.7X_9 - 0.004X_{16} + aX_5:$$

Shirata's pattern by using efficiency mark:

$$\hat{Z} = 0.014X_6 - 0.058X_{17} - 0.062X_{18} - 0.003X_{19} + 0.7416 + aX_5$$

2. RESEARCH FINDINGS

Table 1. A summary of results of comparative study of Nikoee statistics' adjustment in models under investigations

Results	Rated performance			No performance rating			The period studied	Model
	Percentage of compliance	-2 Log likelihood	- R2	Percentage of compliance	-2 Log likelihood	- R2		
With the introduction of variable performance indicators Nekoyee model of relative improvement, but does not contribute significantly to the improved results	70.2	158.678	.464	72.1	160.891	.458	During the two years of the study	Sprain gate
	87.0	115.658	.564	88.9	116.472	.562	During the two years of the study	Altman model
	87.5	147.525	.492	86.5	148.392	.490	During the two years of the study	Model Ahlsvn
	85.6	142.438	.504	86.1	142.772	.503	During the two years of the study	Model Zymsky
	83.0	153.275	.474	83.5	156.932	.464	During the two years of the study	Model Shyrata

Table 2. Summary of results of average observed ranks in data envelopment model and models being studied

	Sum of Ranks	Mean Rank	N	
There is no significant difference between the two models(Confirming the hypothesis H0)	44096.00	212.00	208	Sprain gate
	42640.00	205.00	208	Efficiency Index
Altman model is significantly better (Rejection of the hypothesis H0)	47736.00	229.50	208	Altman
	39000.00	187.50	208	Efficiency Index
Ahlsvn model is significantly better (Rejection of the hypothesis H0)	47320.00	227.50	208	Ahlsvn
	39416.00	189.50	208	Efficiency Index
Zymsky model is significantly better (Rejection of the hypothesis H0)	47112.00	226.50	208	Zymsky
	39624.00	190.50	208	Efficiency Index
Shyrata model is significantly better (Rejection of the hypothesis H0)	46176.00	222.00	208	Shyrata

3. CONCLUSION AND SUGGESTIONS

First we will refer to results of each hypothesis in isolation and then will present the overall conclusion regarding the findings in this research:

First hypothesis:

We can predict the occurrence of financial crisis in manufacturing companies accepted in Tehran Stock Exchange using a pattern based on data envelopment analysis.

Data envelopment analysis technique which is often used to assess efficiency of economic entities and is a criterion for credit ranking of companies will represent a number between 0 and 1 for each company in which 0 shows complete inefficiency and 1 show a complete efficiency of the intended company. In this research we were trying to find a method to use this technique as a method to predict financial crisis of manufacturing companies. Finally in order to identify the departure point of the model we compared the average efficiency of bankrupted and non-bankrupted companies (the point 0.25 was chosen as the pattern cut point with %95 assurance). This model has succeeded to predict financial crisis correctly 2 years before the incident with %60 precision. Also during one year before financial crisis it has predicted %73 of companies in their real groups which is an outstanding amount. Thus, data envelopment analysis technique can divide companies into two groups of those that are safe and those which are exposed to financial crisis. Therefore, the first research hypothesis is approved. This result accords with the theoretical framework of this research.

Second hypothesis:

We can predict the occurrence of financial crisis in manufacturing companies accepted in Tehran Stock Exchange using a pattern based on Springate's model.

To study the possibility of predicting financial crisis by using Springate's model, first we used Chi2 test to investigate about the meaningfulness of this model regarding two years in isolation. Then regarding Nikoee statistics' results, the adjustment of Springate's pattern showed the capability of the model in identifying dependent variable. This pattern performed successfully in predicting companies in year t-1 (one year before financial crisis occurrence) and in year t-2 %81.7 and %62.5, respectively. Also Springate's pattern achieved a success of %72.1 regarding the sum of two years. Regarding what was pointed out, the second hypothesis claiming: "We can predict the occurrence of financial crisis in manufacturing companies accepted in Tehran Stock Exchange using a pattern based on Springate's model" was approved in 0.05 error levels (%95 assurance levels).

Third hypothesis:

We can predict the occurrence of financial crisis in manufacturing companies accepted in Tehran Stock Exchange using a pattern based on Altman's model.

To study the possibility of predicting financial crisis by using Altman's model, first we used Chi2 test to investigate about the meaningfulness of this model regarding two years in isolation. Then regarding Nikoee statistics' results, the adjustment of Altman's pattern showed the capability of the model in identifying dependent variable. This pattern performed successfully in predicting companies in year t-1 (one year before financial crisis occurrence) and in year t-2 %91.4 and %79.8, respectively. Regarding what was pointed out, the third hypothesis claiming: "We can predict the occurrence of financial crisis in manufacturing companies accepted in Tehran Stock Exchange using a pattern based on Altman's model" was approved in 0.05 error levels (%95 assurance levels).

Fourth hypothesis:

We can predict the occurrence of financial crisis in manufacturing companies accepted in Tehran Stock Exchange using a pattern based on Ohleson's model.

To study the possibility of predicting financial crisis by using Ohleson's model, first we used Chi2 test to investigate about the meaningfulness of this model regarding two years in isolation. Then regarding Nikoee statistics' results, the adjustment of Ohleson's pattern showed the capability of the model in identifying dependent variable. This pattern performed successfully in

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predicting companies in year t-1 (one year before financial crisis occurrence) and in year t-2 %90.4 and %85.6, respectively. Regarding what was pointed out, the fourth hypothesis claiming: "We can predict the occurrence of financial crisis in manufacturing companies accepted in Tehran Stock Exchange using a pattern based on Ohleson's model" was approved in 0.05 error levels (%95 assurance levels).

Fifth hypothesis:

We can predict the occurrence of financial crisis in manufacturing companies accepted in Tehran Stock Exchange using a pattern based on Zimesky's model.

To study the possibility of predicting financial crisis by using Zimesky's model, first we used Chi2 test to investigate about the meaningfulness of this model regarding two years in isolation. Then regarding Nikoee statistics' results, the adjustment of Zimesky's pattern showed the capability of the model in identifying dependent variable. This pattern performed successfully in predicting companies in year t-1 (one year before financial crisis occurrence) and in year t-2 %89.4 and %82.7, respectively. Also Zimesky's pattern achieved a success of %86.1 regarding the sum of two years. Regarding what was pointed out, the fifth hypothesis claiming: "We can predict the occurrence of financial crisis in manufacturing companies accepted in Tehran Stock Exchange using a pattern based on Zimesky's model" was approved in 0.05 error levels (%95 assurance levels).

Sixth hypothesis:

We can predict the occurrence of financial crisis in manufacturing companies accepted in Tehran Stock Exchange using a pattern based on Shirata's model.

To study the possibility of predicting financial crisis by using Shirata's model, first we used Chi2 test to investigate about the meaningfulness of this model regarding two years in isolation. Then regarding Nikoee statistics' results, the adjustment of Shirata's pattern showed the capability of the model in identifying dependent variable. This pattern performed successfully in predicting companies in year t-1 (one year before financial crisis occurrence) and in year t-2 %91.2 and %77.9, respectively. Regarding what was pointed out, the sixth hypothesis claiming: "We can predict the occurrence of financial crisis in manufacturing companies accepted in Tehran Stock Exchange using a pattern based on Shirata's model" was approved in 0.05 error levels (%95 assurance levels).

Seventh hypothesis:

We can predict the occurrence of financial crisis in manufacturing companies accepted in Tehran Stock Exchange using a pattern based on Springate's model by using efficiency mark.

To design Springate's model by using efficiency mark, first the variable for efficiency (X5) was added to the model and then to study the meaningfulness of model regarding two years in isolation we used Chi2 test. Then regarding Nikoee statistics' results, the adjustment of Springate's pattern by using efficiency mark showed the capability of the model in identifying dependent variable. This pattern performed successfully in predicting companies in year t-1 (one year before financial crisis occurrence) and in year t-2 %82.7 and %65.4, respectively. Also Springate's pattern achieved a success of %70.4 regarding the sum of two years. Regarding what was pointed out, the seventh hypothesis claiming: "We can predict the occurrence of financial crisis in manufacturing companies accepted in Tehran Stock Exchange using a pattern based on Springate's model by using efficiency mark" was approved in 0.05 error levels (%95 assurance levels).

Eighth hypothesis:

We can predict the occurrence of financial crisis in manufacturing companies accepted in Tehran Stock Exchange using a pattern based on Altman's model by using efficiency mark.

To design Altman's model by using efficiency mark, first the variable for efficiency (X5) was added to the model and then to study the meaningfulness of model regarding two years in isolation we used Chi2 test. Then regarding Nikoee statistics' results, the adjustment of Altman's pattern by using efficiency mark showed the capability of the model in identifying dependent variable. This pattern performed successfully in predicting companies in year t-1 (one year before financial crisis occurrence) and in year t-2 %93.4 and %83.7, respectively. Regarding what was pointed out, the eighth hypothesis claiming: "We can predict the occurrence of financial crisis in manufacturing companies accepted in Tehran Stock Exchange using a pattern based on Altman's model by using efficiency mark" was approved in 0.05 error levels (%95 assurance levels).

Ninth hypothesis:

We can predict the occurrence of financial crisis in manufacturing companies accepted in Tehran Stock Exchange using a pattern based on Ohleson's model by using efficiency mark.

To design Ohleson's model by using efficiency mark, first the variable for efficiency (X5) was added to the model and then to study the meaningfulness of model regarding two years in isolation we used Chi2 test. Then regarding Nikoee statistics' results, the adjustment of Ohleson's pattern by using efficiency mark showed the capability of the model in identifying dependent variable. This pattern performed successfully in predicting companies in year t-1 (one year before financial crisis occurrence) and in year t-2 %90.4 and %85.6, respectively. Regarding what was pointed out, the ninth hypothesis claiming: "We can predict the occurrence of financial crisis in manufacturing companies accepted in Tehran Stock Exchange using a pattern based on Ohleson's model by using efficiency mark" was approved in 0.05 error levels (%95 assurance levels).

Tenth hypothesis:

We can predict the occurrence of financial crisis in manufacturing companies accepted in Tehran Stock Exchange using a pattern based on Zimesky's model by using efficiency mark.

To design Zimesky's model by using efficiency mark, first the variable for efficiency (X5) was added to the model and then to study the meaningfulness of model regarding two years in isolation we used Chi2 test. Then regarding Nikoee statistics' results, the adjustment of Zimesky's pattern by using efficiency mark showed the capability of the model in identifying dependent variable. This pattern performed successfully in predicting companies in year t-1 (one year before financial crisis occurrence) and in year t-2 %89.4 and %82.8, respectively.

Also Zimesky's pattern achieved a success of %85.6 regarding the sum of two years. Regarding what was pointed out, the tenth hypothesis claiming: "We can predict the occurrence of financial crisis in manufacturing companies accepted in Tehran Stock Exchange using a pattern based on Zimesky's model by using efficiency mark" was approved in 0.05 error levels (%95 assurance levels).

Eleventh hypothesis:

We can predict the occurrence of financial crisis in manufacturing companies accepted in Tehran Stock Exchange using a pattern based on Shirata's model by using efficiency mark.

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To design Shirata's model by using efficiency mark, first the variable for efficiency (X5) was added to the model and then to study the meaningfulness of model regarding two years in isolation we used Chi2 test. Then regarding Nikoee statistics' results, the adjustment of Shirata's pattern by using efficiency mark showed the capability of the model in identifying dependent variable. This pattern performed successfully in predicting companies in year t-1 (one year before financial crisis occurrence) and in year t-2 %91.2 and %77.9, respectively. Regarding what was pointed out, the eleventh hypothesis claiming: "We can predict the occurrence of financial crisis in manufacturing companies accepted in Tehran Stock Exchange using a pattern based on Shirata's model by using efficiency mark" was approved in 0.05 error levels (%95 assurance levels).

Twelfth hypothesis:

There is a meaningful difference between overall precision of prediction pattern based on data envelopment analysis and overall precision of prediction pattern based on Springate's model.

To study about this hypothesis we used Man-Whitney's test. Results of this test showed that there is not a meaningful difference between average ranks of observations related to the variable "the success amount of prediction by the two models under investigations". In fact the acceptance of H_0 in a meaningfulness level of %5 shows that twelfth hypothesis was rejected. It should be noted that the rejection of this hypothesis shows a high capability of data envelopment analysis technique in predicting financial status of companies because Springate's model is one of the successful and common models in prediction financial vulnerability. And since there is not a meaningful difference between results of this model and results of DEA technique, we can conclude that financial vulnerability prediction capability using DEA technique would be one of the best and most common models of financial crisis prediction.

Thirteenth hypothesis:

There is a meaningful difference between overall precision of prediction pattern based on data envelopment analysis and overall precision of prediction pattern based on Altman's model.

To study about this hypothesis we used Man-Whitney's test. Results of this test showed that there is a meaningful difference between success amounts of prediction by the two models under investigations.

To put it out simply it can be said that Altman's model performs meaningfully more successful than DEA technique in financial status prediction for companies. Thus, thirteenth hypothesis is approved in an assurance level of %95.

Fourteenth hypothesis:

There is a meaningful difference between overall precision of prediction pattern based on data envelopment analysis and overall precision of prediction pattern based on Ohleson's model.

To study about this hypothesis we used Man-Whitney's test. Results of this test showed that there is a meaningful difference between success amounts of prediction by the two models under investigations.

To put it out simply it can be said that Ohleson's model performs meaningfully more successful than DEA technique in financial status prediction for companies. Thus, fourteenth hypothesis is approved in an assurance level of %95.

Fifteenth hypothesis:

There is a meaningful difference between overall precision of prediction pattern based on data envelopment analysis and overall precision of prediction pattern based on Zimesky's model.

To study about this hypothesis we used Man-Whitney's test. Results of this test showed that there is a meaningful difference between success amounts of prediction by the two models under investigations.

To put it out simply it can be said that Zimesky's model performs meaningfully more successful than DEA technique in financial status prediction for companies. Thus, fifteenth hypothesis is approved in an assurance level of %95.

Sixteenth hypothesis:

There is a meaningful difference between overall precision of prediction pattern based on data envelopment analysis and overall precision of prediction pattern based on Shirata's model.

To study about this hypothesis we used Man-Whitney's test. Results of this test showed that there is a meaningful difference between success amounts of prediction by the two models under investigations.

To put it out simply it can be said that Shirata's model performs meaningfully more successful than DEA technique in financial status prediction for companies. Thus, sixteenth hypothesis is approved in an assurance level of %95.

Seventeenth hypothesis:

There is a meaningful difference between overall precision of prediction pattern based on Springate's model and overall precision of prediction pattern based on Springate's model with efficiency mark.

In financial vulnerability prediction models, a model acts better that has a smaller likelihood ratio logarithm and a higher proper prediction adjustment among Nikoe adjustment statistics.

Regarding Nikoe adjustment statistics' results of the regression model, the two models mentioned were compared to each other for each of the two years in isolation first and then for the period of two years. These results showed that in the two variables above Nikoe adjustment indexes' model has caused a relative improvement. In fact a higher identification coefficient has resulted in a smaller likelihood logarithm and a higher adjustment percentage. But the amount of resulted improvement was not considerable. Thus, results of Man-Whitney test showed that there is not a meaningful difference between prediction success amounts of the two models under investigations and finally in an assurance level of %95 we could accept H_0 and reject the researcher's hypothesis.

Eighteenth hypothesis:

There is a meaningful difference between overall precision of prediction pattern based on Altman's model and overall precision of prediction pattern based on Altman's model with efficiency mark.

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Nineteenth hypothesis:

There is a meaningful difference between overall precision of prediction pattern based on Ohleson's model and overall precision of prediction pattern based on Ohleson's model with efficiency mark.

In financial vulnerability prediction models, a model acts better that has a smaller likelihood ratio logarithm and a higher proper prediction adjustment among Nikoee adjustment statistics.

Regarding Nikoee adjustment statistics' results of the regression model, the two models mentioned were compared to each other for each of the two years in isolation first and then for the period of two years. These results showed that in the two variables above Nikoee adjustment indexes' model has caused a relative improvement. In fact a higher identification coefficient has resulted in a smaller likelihood logarithm and a higher adjustment percentage. But the amount of resulted improvement was not considerable. Thus, results of Man-Whitney test showed that there is not a meaningful difference between prediction success amounts of the two models under investigations and finally in an assurance level of %95 we could accept H_0 and reject the researcher's hypothesis.

Twentieth hypothesis:

There is a meaningful difference between overall precision of prediction pattern based on Zimesky's model and overall precision of prediction pattern based on Zimesky's model with efficiency mark.

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Regarding Nikoee adjustment statistics' results of the regression model, the two models mentioned were compared to each other for each of the two years in isolation first and then for the period of two years. These results showed that in the two variables above Nikoee adjustment indexes' model has caused a relative improvement. In fact a higher identification coefficient has resulted in a smaller likelihood logarithm and a higher adjustment percentage. But the amount of resulted improvement was not considerable. Thus, results of Man-Whitney test showed that there is not a meaningful difference between prediction success amounts of the two models under investigations and finally in an assurance level of %95 we could accept H_0 and reject the researcher's hypothesis.

Twenty first hypothesis:

There is a meaningful difference between overall precision of prediction pattern based on Shirata's model and overall precision of prediction pattern based on Shirata's model with efficiency mark.

In financial vulnerability prediction models, a model acts better that has a smaller likelihood ratio logarithm and a higher proper prediction adjustment among Nikoee adjustment statistics.

Regarding Nikoee adjustment statistics' results of the regression model, the two models mentioned were compared to each other for each of the two years in isolation first and then for the period of two years. These results showed that in the two variables above Nikoee adjustment indexes' model has caused a relative improvement. In fact a higher identification coefficient has resulted in a smaller likelihood logarithm and a higher adjustment percentage. But the amount of resulted improvement was not considerable. Thus, results of Man-Whitney test showed that there is not a meaningful difference between prediction success amounts of the two models under investigations and finally in an assurance level of %95 we could accept H_0 and reject the researcher's hypothesis.

3.1. Overall research conclusion:

In this research we tried to measure the possibility of financial vulnerability occurrence in capital market in Iran by using data envelopment analysis technique. According to hypothesis one, we can claim that DEA technique can be used to predict financial crisis and it was approved. Then we studied about 5 models posed by Springate, Altman, Ohleson, Zimmesky, and Shirata and found that all of them have had a considerable amount of proper prediction capability of the companies regarding how to categorize companies into two groups of vulnerable and safe firms. Then the application of efficiency variable in models mentioned was investigated. Although it didn't have significant effects but we can not ignore a relative improvement of efficiency indexes because when a researcher wants to choose one from among the two models, surely he will select the one which has a more desirable Nikoee adjustment statistics. Finally in comparing DEA technique with financial crisis prediction models, all models except Springate were recognized to be superior compared to DEA.

3.2. Suggestions for future researches

1. Studying the relationship between efficiency mark calculated by using data envelopment analysis method with other financial variables
2. Studying the effect of entering efficiency mark calculated by using data envelopment analysis method on precision of prediction by patterns posed by using other techniques such as Logit analysis and artificial neural network
3. Comparing the capability of different models regarding industry isolation and also by using statistical tests other than Logistic regression

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