Prioritization of factors affecting the exit from the bankruptcy of companies listed in the Tehran Stock Exchange

Fateme Sahraei[a], Jafar Jamali[a,*], Hamidreza Vakilifard[b], Ali Zare[c], Seyed Yaghoub Zeraatkish[d]

[a]Department of Financial Management, Faculty of Management and Economics, Science and Research Branch, Islamic Azad University, Tehran, Iran

[b]Department of Accounting, Faculty of Management and Economics, Science and Research Branch, Islamic Azad University, Tehran, Iran

[c]Department of Law, Faculty of Theology and Political Sciences, Sciences and Research Branch, Islamic Azad University, Tehran, Iran

[d]Department of Agricultural Economic, Faculty of Agricultural Sciences and Food Engineering, Sciences and Research Branch, Islamic Azad University, Tehran, Iran

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Abstract

Companies should evaluate the nature of the crisis after a detailed pathology of the factors causing the problem and look for appropriate solutions to get out of this crisis. This study was conducted on 144 companies from 2010-2021 to prioritize the factors affecting the exit from bankruptcy and financial revival of the companies using the analysis of multiplayer artificial neural networks. First, financial ratios obtained from the literature review and expert evaluation were independentist of each other through principal component analysis. Then, the main components affecting exit from bankruptcy under logistic regression models were identified, and finally, the final logistic model for exit from bankruptcy was presented. Based on the results, the essential financial variable in exiting bankruptcy is the change in capital increase policies from the place of stock issuance. The least critical variable is the change in dividend policies.

Keywords: Bankruptcy, Exit from bankruptcy, Financial revival, Artificial neural network
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1 Introduction

The exit of weak and sick companies and the entry of solid and healthy companies is necessary for reforms and economic dynamism. This action provides the basis for reallocating production resources from inefficient companies without the ability to sustain and survive to efficient companies with the ability to survive and maintain in turbulent environments. However, corporate bankruptcy's costs on the country's economy are massive and sometimes irreparable. Therefore, a better understanding of company revival and its influential factors helps to limit the risk of bankruptcy and its imposed costs to a large extent by increasing the ability and capability of reviving companies in crisis.

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*Corresponding author

Email addresses: parasahraei@yahoo.com (Fateme Sahraei), jafar.jamali@gmail.com (Jafar Jamali), vakilifard.phd@gmail.com (Hamidreza Vakilifard), alizare@srbiau.ac.ir (Ali Zare), drzeraatkish@gmail.com (Seyed Yaghoub Zeraatkish)

1- The concept of financial revival (exit from bankruptcy)

Some organizations experience financial helplessness and face challenging and deteriorating operating margins. Financial revival significantly improves the organization's operating profit margin and financial health [1]. The financial revival of a business unit changes the weak performance status of the company and improves the performance of indicators.

2- Reviewing the literature on financial revival

Many studies have been conducted regarding the revitalization process. [1] stated that the revitalization process is strongly company-oriented and focuses on managerial recognition, efficiency, and performance. The company should identify the causes of financial distress by the senior management and have stable strategic management to coordinate the rehabilitation process and, finally, get the support of the stakeholders to support the rehabilitation process. A study found that in the Early restructuring period, most companies use the Dividend policy, Cost efficiency, Asset restructuring, and the Late restructuring period to pay debts. Based on this study, top-level management should reduce the payment of dividends to minimize the cost and reduce the company's assets in the early period. Then, they can start reducing their debt at the end of the restructuring period. A study described a successful financial revival and believed that such a recovery indicates a situation where the company has had financial distress for two consecutive years (negative Z-score) followed by a relatively successful situation (Z-score). The financial revival will fail if the company never revives from the distress. This study found that revitalizing companies is what they expect when they experience bankruptcy. [4] found that restructuring measures play a crucial role in the revitalization process of any company. Despite the strategies' effectiveness, American company managers emphasize financial restructuring measures more during the period. [2] examined three separate issues related to corporate asset restructurings, including mergers, acquisitions, or divestitures. Contrary to the previous findings, they showed that bank divestitures are not done due to the need for capital but rather due to mergers and specific bank characteristics, such as operating inefficiency, size, performance, and financial limitations. The most critical aspect of strategic management should be the ability to respond to a rapidly changing world with increasing trends. Companies do not have to reach the edge of a cliff to implement recovery strategies but can do so before a crisis erupts.

Most Iranian studies on the revival of companies in the economic recession have been conducted using qualitative methods and case studies and less quantitative ones. Survey methods were used with inadequate samples to generalize the results. Many factors affect reviving crisis-stricken companies and improving their performance indicators, which have not yet been fully identified and carefully examined. Researchers researching revitalizing companies during an economic decline and recession have not established a proper connection between the research model and the existing strategic management theories. In other words, fewer theoretical foundations and existing strategic management theories have been used in forming theoretical and conceptual research models. Most of the obtained results are contradictory, and there are many discussions about their accuracy, validity, and generalizability. Most of the studies were in developed countries, and this issue has been addressed less. For example, no comprehensive research has been performed in Iran regarding the strategies for reviving companies in crisis and their relationship with financial performance indicators. [3] stated that rehabilitation is not isolated and formed by a series of events to tell the story of the crisis, deal with it, and the result of rehabilitation measures. Revitalization involves change, is a dynamic phenomenon, and includes a series of interrelated actions with a specific time sequence. A model of the revival of crisis-stricken companies was designed. These models could not provide a complete picture of the way and factors of crisis formation until the end and end of the decline and crisis in crisis-stricken companies.

Therefore, companies that plan to get out of the problem faster and continue to grow should obtain a precise diagnosis of the factors that cause the crisis. After assessing the nature of the situation, they should first implement efficiency-oriented strategies such as debt reorganization, cost reduction, and operational asset reduction. Then, key effectiveness strategies should be followed, such as transfer of assets, investment in assets, product change, and market change. Good interaction with the government, shareholders, banks, and suppliers and strengthening management systems and procedures can enhance the probability of success in reviving companies in crisis. There was a significant relationship between financial variables and getting out of poverty. Financial ratios of current liabilities to total assets, net profit to sales, and sales to current assets had the most significant explanatory power for the financial revival of helpless companies.

2 Research procedure

Based on the screening process, 144 companies out of all the companies listed in the Tehran Stock Exchange were studied as a statistical sample of the research. Then, the factors affecting the exit from bankruptcy were tested using the data collected from the statistical sample. The inferential statistics section first discussed the independence of financial ratios from each other through Principal Component Analysis (PCA). Then, the main components affecting exiting from bankruptcy were identified under logistic regression models, and finally, the final logistic model for exiting from bankruptcy was presented. In addition, the analysis of multilayer artificial neural networks was used to evaluate the reliability of the results in identifying the factors affecting the exit from bankruptcy, and the importance of these factors was prioritized through this analysis.

2.1 Research variables

The Black-Scholes model was used to detect the bankruptcy of companies. Based on [5] and the pricing model of Black and Scholes (1973), a company is in bankruptcy when the value of its assets is less than the number of its liabilities and the value of the company's assets does not correspond to the number of its liabilities. Therefore, the equity value becomes zero. Thus, the probability of bankruptcy can be measured based on the intrinsic value of its equity and the following relationship. The intrinsic value of equity under the Black-Scholes model is defined through the following relationship:

$$E_{i,t} = A_{i,t}\Phi(d_1) - L_{i,t}e^{-r(T-t)}\Phi(d_2) \tag{1}$$

So that

$$E_{i,t} = A_{i,t}\Phi(d_1) - L_{i,t}e^{-r(T-t)}\Phi(d_2) \tag{2}$$

Finally, the probability of bankruptcy of the company is equal to:

$$P(y_{i,t} = 1) = \Phi\left(\frac{Ln(L_{i,t}) - Ln(A_{i,t}) - (\mu + \frac{\sigma^2}{2})(T-t)}{\sigma\sqrt{T-t}}\right) \tag{3}$$

In which, $A_{i,t}$ is equal to the market value of the assets, $L_{i,t}$ donates the total book value of the company's liabilities, and $T-t$ presents the length of the period in which the intrinsic value of equity at the beginning (at the moment t). In addition, $\Phi(.)$ represents the standard normal cumulative distribution, μ is the expected value of the logarithmic return on assets $Ln\frac{A_{i,t}}{A_{i,0}}$ during one year and the volatility of the logarithmic return on the company's assets during one year. The mean and standard deviation of the natural logarithm of the monthly market value of the company's assets divided by the market value of the assets at the beginning of the financial period is used to estimate μ and σ, respectively. After calculating the probability values $P(y_{i,t} = 1)$, if this probability is more significant than 0.5, the company is declared bankrupt, and otherwise, it is identified as non-bankrupt. First, bankrupt companies are determined according to the Black-Scholes criterion ($P(y_{i,t} = 1)$). The probability is calculated for their subsequent periods to detect the exit of companies from the state of financial helplessness or bankruptcy. The value of this probability for a previously bankrupt company to be less than 0.5 indicates the year in which that company exited bankruptcy. y, detecting companies' exit from bankruptcy is based on a two-member sequence of probabilities $\{P[y_{i,t} = 1 =], P[y_{i,t+k} = 1]\}$. In this sequence, k is a natural number representing the years the company has been bankrupted.

According to experts' opinions and theoretical bases, 16 financial ratios have created conditions for companies to exit from bankruptcy, and their effectiveness is evaluated in the final research model. The ratios are studied based on their decrease or increase compared to the year of bankruptcy diagnosis. In other words, after identifying the companies out of bankruptcy, the reduction or increase of each mentioned ratio in the year of exit from bankruptcy was calculated compared to the year of bankruptcy detection. Therefore, the exit model from companies' bankruptcy can be defined as Equation (4). This model is fitted only for companies identified as bankrupt under the Black-Scholes model. The information related to the year of bankruptcy detection is used to fit this model until the end of the companies' research period.

$$
\begin{aligned}
LN\left(\frac{P[y_{i,t}=1]}{1-P[y_{i,t}=1]}\right) =& \beta_0 + \beta_1 DIV_{i,t-k:t} + \beta_2 FIN_{i,t-k:t} + \beta_3 EQ_{i,t-k:t} + \beta_4 EXPENSE_{i,t-k:t} + \beta_5 FIXSALE_{i,t-k:t} \\
&+ \beta_6 COST_{i,t-k:t} + \beta_7 MV_{i,t-k:t} + \beta_8 RETAIN_{i,t-k:t} + \beta_9 SALE_{i,t-k:t} + \beta_{10} COMP_{i,t-k:t} + \\
&\beta_{11} REC_{i,t-k:t} + \beta_{12} PAY_{i,t-k:t} + \beta_{13} BOARD_{i,t-k:t} + \beta_{14} INST_{i,t-k:t} + \beta_{15} INV_{i,t-k:t} + \\
&\beta_{16} RISK_{i,t-k:t} + \epsilon_{i,t}
\end{aligned} \tag{4}
$$

Table 1: Factors assessed by experts affecting companies' exit from bankruptcy

No.	Factors affecting bankruptcy exit	CVI	CVR
1	A reduction in cash dividends	93.0	1
2	The capital increase from bank financing	93.0	6.0
3	The capital increase from the issue of shares	87.0	1
4	Reduce administrative, general, and selling expenses	93.0	1
5	Depreciation of fixed assets	87.0	1
6	Reducing the cost of the product	93.0	87.0
7	Increase in stock market value	8.0	1
8	Increase in a cash balance	93.0	1
9	Positive sales growth	1	1
10	Reduction of management compensation	1	87.0
11	Reducing the turnover period of accounts receivable	8.0	1
12	Increasing the turnover period of accounts payable	1	73.0
13	Change in the composition of the board of directors	93.0	6.0
14	Change in institutional ownership ratios	87.0	6.0
15	Reducing the inventory of materials and goods (reducing storage costs)	87.0	87.0
16	Risk management activities in the company	8.0	73.0

where, $P[y_{i,t} = 1]$ equals the probability of bankruptcy of company i in year t, which is greater than 0.5 in bankrupt companies according to the Black-Scholes model. This value is smaller than 0.5 when the companies have exited from bankruptcy. $DIV_{i,t-k:t}$ presents the percentage of decrease in the dividends of the company i in period t compared to the first period in which they were identified as a bankrupt company under the Black-Scholes model (period $t - k$). $FIN_{i,t-k:t}$ donates the capital increase percentage of the company i in period t from bank financing compared to the first period when they were identified as bankrupt under the Black-Scholes model (period $t - k$). $EQ_{i,t-k:t}$ represents the percentage increase of the company i's capital in period t from the place of issuing shares compared to the first period identified as a bankrupt company under the Black-Scholes model (period $t - k$). $EXPENSE_{i,t-k:t}$ shows the percentage reduction in administrative, general, and sales expenses of the company i in period t compared to the first period identified as a bankrupt company under the Black-Scholes model (period $t - k$). $FIXSALE_{i,t-k:t}$ is equal to the percentage of reduction in fixed and tangible assets of the company i in period t compared to the first period identified as a bankrupt company under the Black-Scholes model (period $t - k$). $COST_{i,t-k:t}$ indicates the percentage reduction in the cost price of the product/service of the company i in period t compared to the first period identified as a bankrupt company under the Black-Scholes model (period $t - k$). $MV_{i,t-k:t}$ presents the percentage increase in the market value of company i in period t compared to the first period in which they were identified as a bankrupt company under the Black-Scholes model (period $t - k$). $RETAIN_{i,t-k:t}$ shows the percentage increase in the cash balance of company i in period t compared to the first period identified as a bankrupt company under the Black-Scholes model (period $t - k$). $SALE_{i,t-k:t}$ presents the percentage increase in sales of the company i in period t compared to the first period identified as a bankrupt company under the Black-Scholes model (period $t - k$). $COMP_{i,t-k:t}$ represents the percentage of reduction in the compensation of managers of the company i in period t compared to the first period in which they were identified as a bankrupt company under the Black-Scholes model (period $t - k$). $REC_{i,t-k:t}$ is equal to the percentage reduction in the period of receiving accounts receivable of the company i in period t compared to the first period that was identified as a bankrupt company under the Black-Scholes model (period $t - k$). $PAY_{i,t-k:t}$ shows the percentage increase in the payment period of the company i's accounts payable in period t compared to the first period identified as a bankrupt company under the Black-Scholes model (period $t - k$). $BOARD_{i,t-k:t}$ is the measure of the change in the structure of the board of directors of the company i in period t compared to the first period identified as a bankrupt company under the Black-Scholes model (period $t - k$). If there has been a change in the position of the CEO or executive director of the company, the value of this variable will be equal to 1; otherwise, it will be equal to zero. $INST_{i,t-k:t}$ indicates the change in the composition of institutional owners of the company i in period t compared to the first period under the Black-Scholes model as a bankrupt company (period $t - k$). If there is a change in the ownership ratios of the company's institutional owners, the value of this variable will be equal to 1; otherwise, it will be equal to zero. $INV_{i,t-k:t}$ presents the percentage of reduction in the stock of materials and goods of the company i in period t compared to the first was identified as a bankrupt company under the Black-Scholes model (period $t - k$). $RISK_{i,t-k:t}$ is the risk management measure of the company i in period t. If information about the management of market and economic risks in the company is disclosed in the report of the board of directors to the assembly, the value of this variable is equal to 1. Otherwise, it is equal to zero.

2.2 Durability of the research variables

The generalized Dickey-Fuller test was used to test the significance of the variables affecting exit from bankruptcy due to the decrease in the number of time series observations at each stage to analyze exit from bankruptcy. This test tests the hypothesis of a unit root in series values (Table 2).

Table 2: Durability test of research variables

Variable	statistics LLC/ADF	Significance
Change in the structure of the board of directors	-9.332045	0.0000
Change in executive compensation	-9.965259	0.0000
Change in the cost of the product	-9.479792	0.0000
Change in dividends	-9.939658	0.0000
Change in a capital increase from the share issue	-14.61612	0.0000
Exit from bankruptcy	-8.574477	0.0000
Changes in administrative, general, and selling expenses	-7.476476	0.0000
Change in a capital increase from loan location	-10.18641	0.0000
Changes in fixed and tangible assets	-8.463967	0.0000
Change in the composition of institutional owners	-9.103778	0.0000
Change in the inventory of materials and goods	-9.214850	0.0000
Change in market value	-8.954110	0.0000
Change in the payment period of accounts payable	-7.427456	0.0000
Change in the period of receipt of accounts receivable	-7.561385	0.0000
Change in a cash balance	-8.128470	0.0000
Risk management disclosure	-7.620472	0.0000
Change in sales	-9.467440	0.0000
-		

Table 2 presents the significance levels of all the mentioned tests smaller than the first type error of 0.05. As a result, the null hypothesis of the test statistic based on the existence of a unit root is rejected, and it can be accepted that the studied series are at this error level. Therefore, the behavior of variable values does not undergo trend changes over time.

2.3 The model of exiting from bankruptcy (financial revival)

The results of the financial revival model of companies are presented using the principal components identified from the number 16 research variables.

2.3.1 Logistic regression analysis

The results of the financial revival model of companies were presented using the principal components identified from 16 variables. The logistic model was first fitted using all the main components, and then the principal components not affecting financial revival were removed to achieve the optimal model. The final model of financial revival was fitted based on significant main components (Table 3).

2.3.2 Analysis of goodness of fit of the model

The predictor variables in the final model of the financial revival of companies improved the likelihood function by 71.25% in examining the goodness of fit indices of the model based on McFadden's coefficient of determination index. The main forecasting components in the final model could be practical, up to 71.25%, in the accuracy of diagnosing the financial revival of companies. Therefore, the general relationship between predictor variables and the financial revival of companies was significant. The significance of the Hosmer-Lemshow statistic (p-value = 0.2292) was more significant than the first type error of 0.05 to test the appropriateness of the regression model of the research, indicating the appropriateness of the logistic regression model of the study. The significance level of the likelihood ratio test (p-value = 0.000) is less than 0.05, showing the goodness of fit of the research's logistic regression model to predict companies' financial revival.

2.4 Factors affecting exit from bankruptcy (financial revival)

According to the results of the companies' financial revival diagnosis models, eight main components out of the 16 main components studied significantly impacted the companies' financial revival. Since each principal component is a linear combination of all the 16 research variables in detecting companies' exit from bankruptcy and financial revival,

Table 3: Estimation results of the logistic regression model of financial revival

Variable	Initial model			Significant component model		
	Coefficient	Z-value	Significant	Coefficient	Z-value	Significant
PC1	0.091653	1.547242	0.1218	-	-	-
PC2	-3.956153	-3.050539	0.0023	-2.821713	-3.565380	0.0004
PC3	-1.289887	-2.416911	0.0157	-1.004476	-2.308584	0.0210
PC4	-1.330843	-2.697656	0.0070	-0.914746	-2.765330	0.0057
PC5	2.847729	2.773892	0.0055	2.229933	3.008887	0.0026
PC6	-1.931368	-2.978230	0.0029	-1.588076	-2.965385	0.0030
PC7	-2.717786	-2.707437	0.0068	-1.934484	-3.067902	0.0022
PC8	-2.629481	-2.483457	0.0130	-2.020325	-2.809467	0.0050
PC9	0.612754	1.054388	0.2917	-	-	-
PC10	-8.403752	-2.752968	0.0059	-6.491438	-3.201246	0.0014
PC11	0.424502	0.294382	0.7685	-	-	-
PC12	-0.231440	-0.248592	0.8037	-	-	-
PC13	-1.690377	-0.623601	0.5329	-	-	-
PC14	-1.314961	-0.893220	0.3717	-	-	-
PC15	7.861768	1.339721	0.1803	-	-	-
PC16	-16.36171	-0.884407	0.3765	-	-	-
Goodness of fit						
Likelihood ratio statistic	77.46103			83.36538		
Significance of the model	0.0000			0.0000		
McFadden coefficient of determination	0.712500			0.712500		
The significance of Hosmer Lemshu	0.1063			0.2292		

the 16 variables identified from the expert analysis of the research had a significant impact on the companies' financial revival. Therefore, the influential factors in the financial revival of companies are the number of 16 variables and the financial ratio.

2.4.1 Evaluation of the predictive power of the model

Table 4 shows the percentage of correct predictions of the model to predict the model's ability to detect the financial revival of companies.

Table 4: The percentage of correct predictions of the financial revival model

Prediction Group	Correct prediction (percentage)	Incorrect prediction (percentage)
Failure to exit bankruptcy	48.09	51.91
Exit from bankruptcy	72.72	27.28
All companies	65.64	34.36

Table 4 indicates that the financial revival model of companies using the principal components consisting of 16 financial ratios can correctly predict 64.65% of the situations of financial revival or lack of financial revival of companies. The power of this model in correctly identifying companies that have come out of bankruptcy (72.72%) was more than its power in correctly identifying companies that have not come out of bankruptcy and financial revival (48.09%).

2.5 Artificial neural network analysis

Multilayer artificial neural networks were used to evaluate the results' reliability and predict companies' financial revival. This analysis identified a hidden layer with four neurons based on the lowest prediction error. The research observations were divided into two groups learning observations (70%) and tests (30%), and the artificial neural network learning process was performed on the learning group. The results of the method's accuracy in predicting the financial revival of companies were done using test data that did not play a role in the learning process of the algorithm. Figure 1 shows the formation of a neural network with an input layer, a hidden layer, and an output layer in predicting the financial revival of companies.

According to Figure (1), eight main components and one bias parameter were entered into the neural network's input layer as predictive factors. A hidden layer consisting of a skew parameter and the number of four neurons was formed using the hyperbolic tangent transfer function, which led to the prediction of the values of the dependent variable (financial revival/absence) in the output layer. The artificial neural network composed of the main components could correctly predict 69.2% of the companies' financial revival situations, which shows the acceptable power of this
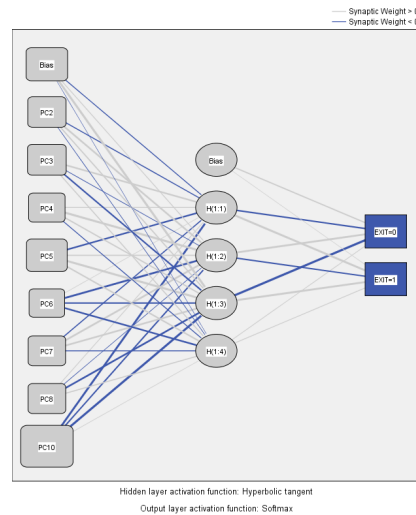
Figure 1: One-layer artificial neural network in predicting the financial revival of companies
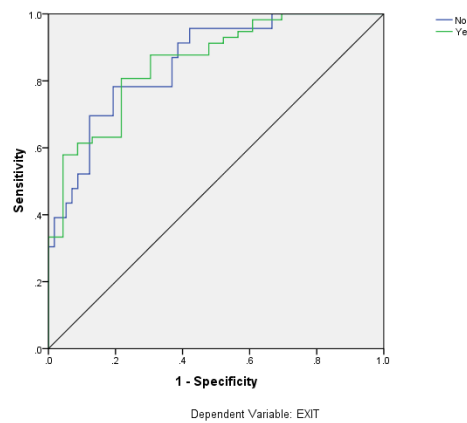

Figure 2: ROC curve of artificial neural network in predicting a financial revival

model. Figure 2 shows the ROC curve of this analysis, which reflects the accuracy and precision of the method's prediction.

According to Figure 2 and Table 5, the area under the curve for comparing the accuracy of forecasting in both groups of companies out of bankruptcy (green curve) and not out of bankruptcy (blue curve) was more significant than 0.8 and equal to 0.855. These results showed the high power of this analysis in predicting the financial revival of companies and, as a result, its validity.

Table 5: Accuracy of predicting financial revival in artificial neural network

Criteria	Results
The area under the ROC curve	0.855
Correct prediction accuracy	69.2

The normalized coefficients of their importance were used in artificial neural network analysis to measure the importance of each of the main components in predicting the financial revival of companies (Table 6).

The summary of the findings is presented in Figure 3.

Therefore, the tenth main component was the most critical factor in the financial revival of companies. The importance order of financial variables in exiting from bankruptcy and financial revival of companies can be summarized as follows based on the magnitude (absolute value) of the coefficients of each variable in forming this component. Change in capital increase policies from the place of issuing shares, 2) Change in fixed and tangible assets, 3) Change in the payment period of accounts payable, 4) Change in administrative, general, and sales expenses, 5) Change in

Table 6: Importance coefficients and normalized importance of components in predicting a financial revival

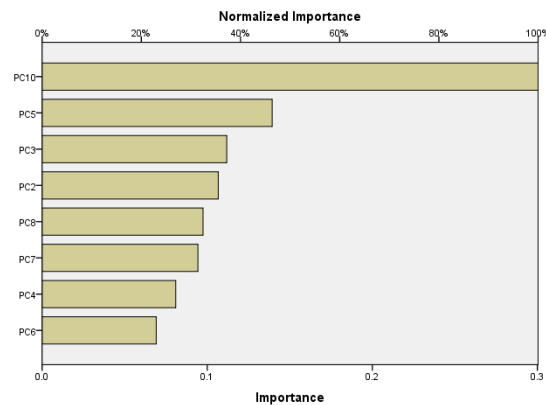|	Importance factor	Normalized significance coefficient	Order of importance
PC2	0.107	0.355	4
PC3	0.112	0.372	3
PC4	0.081	0.269	7
PC5	0.139	0.464	2
PC6	0.069	0.230	8
PC7	0.094	0.314	6
PC8	0.097	0.324	5
PC10	0.300	1.000	1

Figure 3: Order of importance of components in predicting a financial revival

market value, 6) risk management, 7) change in the period of receiving accounts receivable, 8) change in institutional ownership, 9) change in the inventory of materials and goods, 10) change in the cost of the product, 11) change in the number of sales, 12) Change in managers' bonus, 13) Change in the structure of the board of directors, 14) Change in the cash balance, 15) Change in a capital increase from the loan, 16) Change in profit sharing policies.

3 Conclusion

The artificial neural network composed of the main components can correctly predict 69.2% of the situations of financial revival or non-revival of companies. This result shows the good power of this model in detecting the exit or non-exit of companies from bankruptcy using the principal components of financial ratios. According to the findings, the most crucial financial variable is the exit from bankruptcy and financial revival of companies and the change in capital increase policies from the place of stock issuance. The least important is the change in profit-sharing policies. Therefore, policymaking in line with the above cases can significantly impact the companies' financial revival and bankruptcy.

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