



ORIGINAL ARTICLE

Application of Intellectual Capital on the Financial Distress Model Using Neural Network

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ABSTRACT

Due to the tremendous impact of intellectual capital on better performance and emphasis on creating value-added as necessity for survival in the present era and direct relationship between value-added & The concept of financial distress, studying the relationship intellectual capitals and effective financial variables is important. The objective of this research is highlighting the role of intellectual capital in preventing financial distress of Tehran Stock Exchange companies. In this research, Polik intellectual value added coefficient model has been used for measuring intellectual capital and interest panel model, then by using generalized squares least estimator, we have studied the relationship between Intellectual Capital Structures & research variables (human capital efficiency, structural capital efficiency, and applied capital efficiency). To apply conceptual model of research, the statistical community of all companies who are activating in Tehran Stock Exchange, Sampling was carried out based on screening in them and 55 companies which were eligible, were selected; the data was considered within 2005-2011. The results of research show that intellectual capital is related to return on equity, return on assets, employee productivity, the ratio of market value to office value of per share and interest of per share.

Key words: intellectual capital, Bankruptcy (financial distress), neural networks

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INTRODUCTION

Nowadays, knowledge has been tabernacle financial capitals especially in competitive & technology environment as the most important capital. So the concept of intellectual capital has important & extensive application. How to manage the massive volume of information and the effective use of them in improving making decision is controversial issue in the current era, one of the research important issues in the field of computer science is implementing a model similar to the internal system of the human brain to analyze various systems based on experience, in this regard, neural networks are among the most dynamic areas of research in contemporary era which has attracted various people of interdisciplinary; Using neural networks and genetic algorithms is more common these days more than before for solving applied complex problems [1]. Increasing gap between the companies actual & office value has attracted researcher's attention to explain the unseen value which have been removed of the financial statements. The value which we call intellectual capital and it is present in all organization dimensions like a knowledge statue, the importance of the current research is resulted from an increasingly importance that this less-known capital (intellectual capital) has in real value of companies and their financial performance & their success & failure in today's competitive & complex environment. Given the things that different researchers have done, it seems that intellectual capital of hidden values is distorting financial statements & it's the thing that pushes organizations to achieve competitive advantages. In addition, it's believed that limitations of financial statements face the exact explanation of company value with problem & reveals this reality that these days, economic value resources are the result of intellectual capital not material goods products [2]. One of the most important characteristics of this research is using neural network (for price prediction), applications of this network are unknown correlations between optimal features & the value of decision making issues variables (where the solution is unknown), Issues that have no algorithmic solution, and where there is incomplete data; the main advantage of this network is their wonderful ability in learning and their stability In front of input small perturbation [3]; By using neural networks in this research, one can make decision with more confidence regarding the future of a company's stock. The main issue of this research is studying the role

& importance of intellectual capital in real value of companies & their financial function; it's an issue which has determinant importance and place in companies' success or failure. This research studies the amount of intellectual capital effect on the function of Bankrupt companies listed on the Stock Exchange & it has provided the possibility to handle large volume of information and the effective use of them in improving decision making as an Intelligent System by using neural network. So, at first, 5 key indices of companies' performance & efficiency of intellectual capital index by using "polik" model in statistical community of companies accepted in Stock Exchange within 2005-2009 and then panel model was used & using generalized squares least estimator, we have studied the relationship between Intellectual Capital Structures & research variables (human capital efficiency, structural capital efficiency, and applied capital efficiency).

RESEARCH METHODOLOGY

Given that the subject of research is to solve one of the problems of investing society it is applicable type and on the other side, the type of research method is descriptive one in terms of purpose which has used survey method & help discovering the relationship between phenomena and variables and designed models test by applying regression method which is proposed in correlation research.

In this research, literature and theory parts related to research subject are studied by referring to library sources such as: books, Weekly magazines, monthly, quarterly, academic dissertations and related research treatises & searching in electronic sites such as: SID, ELSEVIER, SCIENCE DIRECT. Then part of data are analyzed by tadbirpardaz, excel and MATLAB software. In data preparation stage, attempting to calculate the intellectual value added coefficient model structures are considered for all years & for each sample. The current research area is studying the effect of intellectual capital on financial distress in all Tehran stock exchange companies in a 7 time period from 2005-2011. The statistical community of research is all companies accepted in Tehran stock exchange. In this research, 55 qualified companies were selected: to select sample, we have used Systematic removal & the following screening:

1. The end of financial year of companies is 19th march.
2. Complete information and notes along with financial statements of companies are available.
3. These Companies have been accepted before 2006 in Tehran stock exchange.
4. Their transaction interruption isn't more than 270 days (nine months).
5. It isn't intermediation companies or banks.

In this research, variables are divided into 2 groups of independent and dependent one. Dependent variables are: return on equity, return on assets, employee productivity, the ratio of market value to office value of per share and interest of per share, the relationship of each one with independent variables is considered separately. Independent variables are main components of intellectual capital means that human capital efficiency, structural capital efficiency and applied capital efficiency.

Panel or combination regression models are based on panel data. Panel data are consisted of observations which have been made of sectional or single units within some time periods. Estimating relationships in which panel data are used (combining sectional and time series), face difficulties and complexities. The following relationship shows panel model in general state:

$$Y_{it} = \beta_{1it} + \sum_{k=2}^k \beta_{kit} X_{kit} + e_{it}$$

In which $i = 1, 2, \dots, n$ shows sectional units (for instance: companies in this thesis) and $t = 1, 2, \dots, T$ shows the time period of study. Y_{it} Shows dependent variable for I th sectional unit in T th year & X_{kit} shows K th non-random independent variable (descriptive) for I th sectional unit in T th year & e_{it} indicates regression disruption for I th sectional unit in T th year, so at first, we determine the characteristics of suitable four-layer perceptron for predicting companies bankruptcy, many structures were considered of the above model and 68 of them were registered in a table which showed better conditions in terms of prediction power; among them 4 layers structures, 4 layers perceptron with 3 neuron in the first hidden layer and 9 neuron in the second hidden layer showed the most prediction power. In this method, a special learning rate was used for each weight and during learning; the above rates are consistent with network error level constantly, if the partial derivative sign of $\frac{\partial E}{\partial W_{ij}}$ doesn't change within some stages (E is general error of network and W is individual weights of network), the rate of individual learning will be increased. If the mentioned sign changes, the learning will be decreased. Then regarding the given weights, conversion functions (activity functions) of sigmoid function have been applied, below is referred to them:

$$f(z) = \frac{1}{1 + e^{-z}}$$

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RESEARCH FINDINGS

We analyze data using Tehran stock exchange data and available software such as: tadbirpardaz. Hypothesis 1: intellectual capital has significant relationship with output equity. To test this hypothesis, we estimate the following panel data model:

$$LP_{it} = \alpha + \alpha_1 VAIC_{it} + \delta t + \epsilon_{it} \quad (1)$$

In which LP_{it} is output equity and $VAIC_{it}$ is the index of intellectual capital, it has been obtained from the sum of 3 variables of: structural capital efficiency, human capital efficiency & applied capital efficiency. We have used generalized squares least method to estimate model. If estimated coefficient is significant for intellectual capital variable statistically, we can conclude that intellectual capital has significant effect on output equity & in this case, the research hypothesis will be confirmed.

Table 1: estimating equation 1

variable	coefficient	Standard error	probability
intercept	16/26	0/042	0/0000
Intellectual capital	1/13	0/027	0/0000
Process variable	0/18	0/002	0/0000
R^2	0/99		
Watson camera	0/62		

The results of the above model show that research hypothesis is confirmed based on existing relationship between intellectual capital and output equity statistically. Explanatory power of the model (R^2) is completely acceptable. But the Watson camera parameters indicate their correlation among disturbing part of model in successive periods. To solve this problem we added the first pause of dependent variable to model as explanatory variable. The results of new model have been presented in table 5.4. It should be mentioned that to solve the problem of correlation in all next models, this approach has been used. So, next models will be reported after removing correlation and the first pause of dependent variable in model.

$$LP_{it} = \alpha + \alpha_1 VAIC_{it} + \delta t + \epsilon_{it} + \alpha_2 AR(1) \quad (2)$$

Table 2: Estimating equation 2

variable	coefficient	Standard error	probability
intercept	17/17	0/44	0/0000
Intellectual capital	0/93	0/025	0/0000
Process variable	0/13	0/003	0/0000
AR(1)	0/88	0/019	0/0000
R^2	0/99		
Watson camera	2/44		

The amount of Watson camera statistics show that the problem of correlation related to the above model has been removed. Since, estimated coefficient is positive for intellectual capital and its significant statistically, it was concluded that the research result was accepted perfectly. All models' coefficients have got significant in the level of 1%.

Secondary hypothesis

1. Structural capital efficiency has significant relationship with output equity.
2. Human capital efficiency has significant relationship with output equity.
3. Applied capital efficiency has significant relationship with output equity.

$$LP_{it} = \alpha + \alpha_1 HCE_{it} + \alpha_2 SCE_{it} + \alpha_3 CEE_{it} + \delta t + \epsilon_{it} + \gamma AR(1) \quad (3)$$

By applying panel model (3), the relationship of all independent variables or on the other hand, intellectual capital components (Structural capital efficiency, Human capital efficiency, applied capital efficiency) is considered with dependent variable of output equity in which LP_{it} is output equity, HCE_{it} is Human capital efficiency, SCE_{it} is Structural capital efficiency & CEE_{it} is applied capital efficiency. To estimate the model, the least generalized squares model was used. If estimated coefficient is significant statistically for Structural capital efficiency, Human capital efficiency & applied capital efficiency variables, we conclude that these variables have significant effect on output equity and in this case, secondary hypotheses of first hypotheses of research are confirmed.

Table 3: estimating equation 3

variable	coefficient	Standard error	probability
Intercept	18/31	0/52	0/0000
HCE_{it}	0/66	0/046	0/0000
SCE_{it}	0/09	0/074	0/2046
CEE_{it}	0/18	0/056	0/0012
Process variable	0/123	0/035	0/0007
AR(1)	0/89	0/019	0/0000
R^2	0/99		
Watson camera	52/4		

The above model shows that the research hypotheses based on relationship between output equity & Human capital efficiency, applied capital efficiency is confirmed statistically. The research hypotheses based on relationship between output equity & structural capital efficiency is rejected in significant level of 1%. Explanatory power of (R^2) model is completely acceptable. The amount of Watson camera statistics show that the problem of correlation related to the above model has been removed completely. Hypotheses 2: intellectual capital has relationship with assets output of bankrupted stock exchange companies.

To test this hypothesis, we estimated the following data panel model:

$$CP_{it} = \alpha + \alpha_1 VAIC_{it} + \delta t + \epsilon_{it} + \gamma AR(1) \tag{4}$$

In which CP_{it} is assets output, $VAIC_{it}$ is intellectual capital index which it has been obtained from the 3 variables of Structural capital efficiency, human capital efficiency & applied capital efficiency.

Table 4: estimating equation 4

variable	coefficient	Standard error	probability
intercept	-3/07	0/82	0/0002
VAIC	0/806	0/053	0/0000
Process variable	0/14	0/046	0/0019
AR(1)	0/90	0/010	0/0000
R^2	0/86		
Watson camera	2/054		

The results of the above model show that research hypotheses based on relationship between intellectual capital and assets output, is confirmed statistically.

Secondary hypotheses

1. Structural capital efficiency has significant relationship with assets output.
2. Human capital efficiency has significant relationship with assets output.
3. Applied capital efficiency has significant relationship with assets output.

$$CP_{it} = \alpha + \alpha_1 HCE_{it} + \alpha_2 SCE_{it} + \alpha_3 CEE_{it} + \delta t + \epsilon_{it} + \gamma AR(1) \tag{5}$$

Table 5: Estimating Equation 5

variable	coefficient	Standard error	probability
intercept	-0/05	0/50	-0/3233
HCE _{it}	0/25	0/057	0/0000
SCE _{it}	0/13	0/061	0/0281
CEE _{it}	0/54	0/076	0/004
Process variable	0/103	0/035	0/0007
AR(1)	0/89	0/014	0/0000
R ²	0/88		
Watson camera	2/15		

The results of the above model show that research hypotheses based on significant relationship between assets output & structural capital efficiency, human capital efficiency, applied capital efficiency is confirmed statistically.

Hypotheses 3: intellectual capital has relationship with staff's efficiency.

To test this hypothesis, we estimate the following data panel model.

$$RP_{it} = \alpha + \alpha_1 VAIC_{it} + \delta t + \epsilon_{it} + \gamma A R(1) \quad (6)$$

In which RP_{it} is staffs efficiency & $VAIC_{it}$ is intellectual capital index, it has been obtained from the sum of 3 variables of: structural capital efficiency, human capital efficiency & applied capital efficiency.

Table 6: Estimating Equation 6

variable	coefficient	Standard error	probability
intercept	17/14	0/42	0/0000
VAIC	0/91	0/023	0/0000
Process variable	0/12	0/02	0/0000
AR(1)	0/88	0/019	0/0000
R ²	0/99		
Watson camera	2/45		

The results of the above model show that research hypotheses based on relationship between intellectual capital and staffs efficiency, is confirmed statistically.

Secondary hypotheses

1. Structural capital efficiency has significant relationship with staff's efficiency.
2. Human capital efficiency has significant relationship with staff's efficiency.
3. Applied capital efficiency has significant relationship with staff's efficiency.

$$RP_{it} = \alpha + \alpha_1 HCE_{it} + \alpha_2 SCE_{it} + \alpha_3 CEE_{it} + \delta t + \epsilon_{it} + \gamma AR(1) \quad (7)$$

Table 7: estimating equation 7

variable	coefficient	Standard error	probability
intercept	18/21	0/51	0/0000
HCE _{it}	0/64	0/043	0/0000
SCE _{it}	0/13	0/061	0/0004
CEE _{it}	0/17	0/054	0/0011
Process variable	0/122	0/035	0/0007
AR(1)	0/89	0/018	0/0000
R ²	0/99		
Watson camera	2/45		

The results of the above model show that research hypotheses based on significant relationship between staff's efficiency & structural capital efficiency, human capital efficiency, applied capital efficiency is confirmed statistically.

Hypothesis 4: intellectual capital has relationship with the ratio of market value to office value of per share.

To test this hypothesis, we estimate the following data panel model.

$$NP_{it} = \alpha + \alpha_1 VAIC_{it} + \delta t + \epsilon_{it} + \gamma AR(1) \quad (8)$$

In which NP_{it} is the ratio of market value to office value & $VAIC_{it}$ is intellectual capital index, it has been obtained from the sum of 3 variables of: structural capital efficiency, human capital efficiency & applied capital efficiency.

Table 8: Estimating Equation 8

variable	coefficient	Standard error	probability
Intercept	17/11	0/39	0/0000
VAIC	0/90	0/020	0/0000
Process variable	0/13	0/03	0/0000
AR(1)	0/86	0/017	0/0000
R^2	0/98		
Watson camera	2/13		

The results of the above model show that research hypotheses based on relationship between intellectual capital and the ratio of market value to office value, is confirmed statistically.

Secondary hypotheses

1. Structural capital efficiency has significant relationship with the ratio of market value to office value of per share.
2. Human capital efficiency has significant relationship with the ratio of market value to office value of per share.
3. Applied capital efficiency has significant relationship with the ratio of market value to office value of per share.

$$NP_{it} = \alpha + \alpha_1 HCE_{it} + \alpha_2 SCE_{it} + \alpha_3 CEE_{it} + \delta t + \epsilon_{it} + \gamma AR(1) \quad (9)$$

Table 9: Estimating Equation 9

Variable	Coefficient	Standard error	Probability
intercept	18/33	0/51	0/0000
HCE_{it}	0/92	0/043	0/1235
SCE_{it}	0/23	0/061	0/0000
CEE_{it}	0/19	0/047	0/0001
Process variable	0/124	0/035	0/0007
AR(1)	0/89	0/018	0/0000
R^2	0/99		
Watson camera	2/45		

The results of the above model show that research hypotheses based on relationship between the ratio of market value to office value & structural capital efficiency & applied capital efficiency, is confirmed statistically.

Hypothesis 5: intellectual value added coefficient has relationship with the interest of per share.

To test this hypothesis, we estimate the following data panel model.

$$SP_{it} = \alpha + \alpha_1 VAIC_{it} + \delta t + \epsilon_{it} + \gamma AR(1) \quad (10)$$

In which SP_{it} is the interest of per share and $VAIC_{it}$ is the index of intellectual capital, it has been obtained from the sum of 3 variables of: structural capital efficiency, human capital efficiency & applied capital efficiency

Table 10: Estimating Equation 10

variable	coefficient	Standard error	probability
intercept	16/87	0/36	0/0000
VAIC	0/87	0/017	0/0000
Process variable	0/11	0/01	0/0000
AR(1)	0/85	0/015	0/0000
R^2	0/97		
Watson camera	2/14		

The results of the above model show that research hypotheses based on relationship between intellectual capital & the interest of per share, is confirmed statistically. The explanatory power of model is completely acceptable.

Secondary hypotheses

1. Structural capital efficiency has significant relationship with the interest of per share.
2. Human capital efficiency has significant relationship with the interest of per share.
3. Applied capital efficiency has significant relationship with the interest of per share.

$$SP_{it} = \alpha + \alpha_1 HCE_{it} + \alpha_2 SCE_{it} + \alpha_3 CEE_{it} + \delta t + \epsilon_{it} + \gamma AR(1) \quad (11)$$

Table 11: Estimating equation 11

variable	coefficient	Standard error	probability
Intercept	18/11	0/53	0/0000
HCE_{it}	0/61	0/041	0/0000
SCE_{it}	0/16	0/067	0/0008
CEE_{it}	0/19	0/051	0/0011
Process variable	0/124	0/034	0/0007
AR(1)	0/91	0/017	0/0000
R^2	0/98		
Watson camera	2/15		

The results of the above model show that research hypotheses based on relationship between the interest of per share & human capital efficiency, structural capital efficiency & applied capital efficiency, is confirmed statistically.

Presenting neural network model for forecasting financial distress of companies

Regarding these characteristics, RMS of test acquired the least amount (0.1688) after 233600 learning courses. In table 12, the amounts of test errors will be mentioned in different learning courses. As it can be seen, the amount of above error has the least amount in the 123200 courses.

Table 12: Test Error in Different Learning Courses in 4 layers Perceptron

Epoch	RMS test Error	Epoch	RMS test Error
100	0/3215	96800	0/2545
6500	0/3515	104000	0/2325
13000	0/2638	110400	0/2211
19400	0/2894	116800	0/2193
26000	0/3353	123200	0/1688
32400	0/3005	129600	0/2168
38800	0/2836	136000	0/2153
45200	0/2819	142400	0/2132
52000	0/2522	148800	0/2107
58400	0/2598	155200	0/2083
64800	0/2620	161600	0/2048
71200	0/2630	168000	0/2011
77600	0/2478	220800	0/1763
84000	0/2513	227200	0/1760
90400	0/2607	233600	0/1757

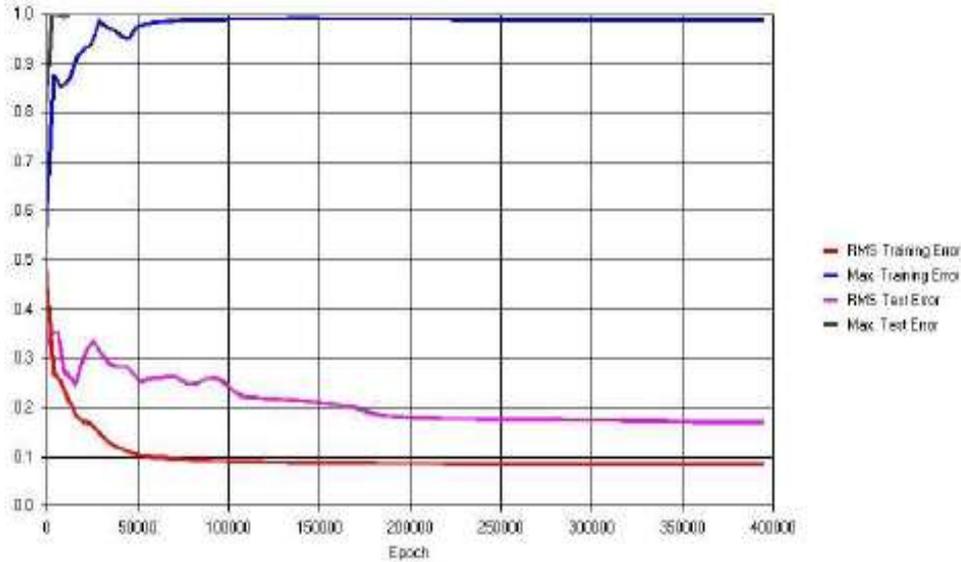


Diagram 1: Shown RMS & the max learning & test error.

The process of economic bankruptcy of the stock market companies within 2005-2014.

To determine the process of economic bankruptcy of the stock market companies within 2005-2014, at first, the total number of companies in the stock market and the number of bankrupt companies in each of the above years were identified, and then the ration of bankrupt companies to all companies in these years was computed.

Table 13: bankruptcy of the stock market company's ratio

year	The number of total companies	bankrupt companies	The ratio of bankrupt companies to total companies
2005	98	7	0/0714
2006	121	9	0/0743
2007	154	10	0/0649
2008	191	11	0/0575
2009	240	11	0/0458
2010	297	17	0/0572
2011	299	26	0/0869
2012	304	35	0/1151
2013	369	31	0/0840
2014 prediction	369	24	0/0650

DISCUSSION & CONCLUSION

Regarding the research results and confirming the first hypothesis, we can say that by increasing & improving the level of intellectual capital of desired companies, output equity is increased as well. Regarding confirmation of hypothesis 2, we conclude that by increasing & improving the level of intellectual capital of desired companies, asset's output is increased as well. Regarding hypothesis 3, we conclude that by increasing & improving the level of intellectual capital of desired companies, staffs efficiency is increased as well. Regarding hypothesis 4, we conclude that by increasing & improving the level of intellectual capital of desired companies, the ratio of market value to office value of per share is increased as well. Regarding hypothesis 5, we conclude that by increasing & improving the level of intellectual capital of desired companies, the interest of per share is increased as well. The results of the third hypothesis of the current research is aligned with the research of Ahangar [4], which studies the relationship between intellectual capital and financial performance and also with the researches of Chen, Cheng and Huang, which studies the relationship between intellectual capital and market value of company & financial performance & workforce efficiency. The results of fifth hypothesis (there is significant & positive relationship between intellectual capital efficiency & the interest of per share) are

aligned with the results of Johnny Wisanen, Pelakoojansivoo & Lanquist's researches. The important economic factors which can be stated in interpreting the process of companies' bankruptcy are: it is the impact of economic clarifying politics on companies' bankruptcy as follow:

- A) Gradual reduction of state subsidies, Staff salary incensement along with the lack of improvement in the efficiency of production factors increase the production costs, high costs of production, the cost of paying interest & production bureaucracy are the main reasons for the economic bankruptcy of companies in Iran.
- B) Releasing import of goods by decreasing tariffs along with lack of improvement in internal products quality decrease the competitive power of manufacturing firms & increase the process of companies' bankruptcy.
- C) Passing from multiple exchange rates along with subsidies to the unit exchange rate inclining to free market has decreased various subsidies of exchange rate & has clarified the production costs more.
- D) Sanctions and political issues
- E) Lack of proper support by government

1. Applicable suggestions

- Promoting intellectual capital and its superiority
- Investment has the most impact on the efficiency level of human force capital.

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