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Detecting and ranking cash flow risk factors via artificial neural networks technique☆

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ABSTRACT

Jensen (1986) predicts that managers with more free cash flows (FCF) available show an opportunistic behavior, which leads to the emergence of the FCF risk. Consequently, determining the relative importance of factors affecting the FCF risks is vital. The major purpose of this article is testing Jensen's assertion by identifying relative significance of the factors influencing FCF risks via artificial neural network (ANN). In effect, seven independent variables relating to FCF risks including debt policy, ownership concentration, ownership level, managerial ownership, state ownership, size of the firm, and profitability draw on the literature. The study collects 1224 company-year data from Tehran Stock Exchange (TSE) for the period 2001–2010. The study applies the Pearson's correlation and a three layer ANN. The results of testing the hypotheses show that, among the preceding 7 factors, profitability is the most important factor in determining FCF risks. Following profitability, the second and third most important factors are the debt policy and size of the company. Consequently, this finding posits a great implication for the stock markets and contradicts Jensen's (1986) study.

1. Introduction

Jensen (1986, p. 3) defines the free cash flow (FCF) as the "cash flow in excess of that required to fund all projects that have positive NPV". By applying the "asymmetric information theory" and "agency theory" (Fatma & Chichti, 2011; Namazi, 1985, 2013) Jensen predicts that when managers maintain more FCF in their hand, those managers present opportunistic behaviors such as investing in projects with fewer net present value, trying less for earning revenues, and committing extra expense. Jensen also predicts that an increase in the financial leverage, disciplines managements and lessens their opportunistic behaviors.

Since then, different studies examine firms' FCF risks and their effects on capital costs, values, and appropriate levels of the debt financing (Céspedes, González, & Molina, 2010; Chu, 2011;D'Mello & Mirand, 2010; Lang, Ofek, & Stulz, 1996). These studies, however, take place under the linearity assumption of the relationship between FCF risks and its influential factors. Nonlinear models are more powerful than linear models and have more conformity with real world problems (Höglund, 2012; Namazi & Sadeghzadeh Maharluie, 2015). However, few studies analyze FCF risks' effects with nonlinear approaches. In addition, studies just attempt to determine the positive or negative effect of various determinants of the FCF risks, and do no attempt to rank significant FCF risk factors.

The major aim of this study is to investigate the role of significant FCF risk factors, including debt policy, ownership concentration, ownership level, managerial ownership, state ownership, size, and profitability, ranking them via artificial neural networks (ANN). This study attempts to respond to this question: Among various factors, what is the relative importance of the determinants of the FCF risks? Consequently, the study identifies and ranks FCF risks factors by applying ANN in Tehran Stock Exchange (TSE). This study applies, for the first time, ANN for ranking FCF risks, and provides a more suitable FCF risks analysis. ANN is more appropriate than linear regression models because ANN captures decision-making complexities more clearly, predicts more accurately, is robust to missing data, and multicollinearity does not affect its performance (Bejou, Wray, & Ingram, 1996; Wong, Wong, & Chin, 2011). This study also provides unique empirical evidence relating to FCF risks in a growing stock market-TSE, which is useful for management and other stakeholders.

The organization of this research is as follows: Section 2 provides theory, literature review, and hypotheses. Section 3 explains the research method, data sample, research design, and research variables respectively. Section 4 describes the research model accordingly. Section 5 presents the results. Section 6 renders conclusion, discussion, limitations, and suggestions.

2. Theoretical background, literature review, and hypotheses

The examination of FCF risks is theoretically possible through the agency theory paradigm (Chen, Chen, & Wei, 2011; Jensen &

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Meckling, 1976; Jurkus, Park, & Woodard, 2011) because in these situations the interest of the shareholders and managers are incompatible, the separation of the ownership and management exists, and informational asymmetry between them are prevalent (Dey, 2008). Generally, agency relation exists when a person (the principal) employs another person (the agent) for performing some production of goods or services on his/her behalf and delegates the power of the decision-making to him/her (Namazi, 1985, 2013). Agency theory also ascertains that an optimal ownership and capital structure can minimize the agency costs and risks (Jensen & Meckling, 1976). The costs relate to divergent objectives between agents and owners; managers inherently generate costs when attempting to expend organizational resources for their own benefits rather than for maximizing shareholder wealth (Opler & Titman, 1993).

Jensen (1986), building on the agency theory, hypothesizes with FCF risk factors and argues that paying debt's interests, dividends, and investments in projects with positive NPV decreases consumptions of the free cash. Since then, researchers attempt to extract significant factors affecting FCF risks.

A potent FCF risks' factor relates to debt financing (Hejazi & Saadati Moshtaghin, 2014). Grossman and Hart (1982) contend that more financial leverage may influence managers entailing to decrease agency costs. Jensen (1986) shows that firms with FCF and low growth opportunity must incur in debts for more monitoring. Jaggi and Gul (1999) and Stulz (1990) report a positive relation between leverages and FCF. Fleming, Heaney, and McCoske (2005) present advantages of the debt financing in controlling and reducing agency costs. Chu (2011), however, shows that FCF and debt ratios have a mutual negative effect. Fatma and Chichti's (2011) results show that debt policy can reduce FCF risks. Khan, Kaleem, and Sajid Nazir (2012) reveal that firms' leverage posits a significant role in the agency costs of the FCF. Hence,

H1. : A significant relation exists between debt policy and FCF risks.

Corporate governance literature indicates that ownership structure would also affect managers' behavior and FCF risks (Velury & Jenkins, 2006). Jensen and Meckling (1976) argue that an increase in managerial stock ownerships would increase the firm values and decrease the agency problems. Chung, Firth, and Jeong-Bon (2005) contend that if institutions own a large percentage of a company's shares, then those institutions have incentives to monitor management's actions and decisions. When institutional investors have substantial shareholdings, those investors find difficult to sell shares immediately at the prevailing price. This lack of liquidity provides incentives for them to monitor companies' FCF closely. Henry's (2010) results reveal that institutional ownership has a negative effect on agency costs, showing a nonlinear relation between managerial ownership and agency costs. Fatma and Chichti (2011) also show that managerial ownership causes reduction in the agency costs of the FCF risks, but institutional ownership concentration increases FCF risks. Gul, Sajid, Razzaq, and Afzal (2012), however, report that managerial stock ownership and institutional ownership will decrease agency problems.

According to agency theory, state ownership is inefficient because of the lack of the capital market monitoring. The state ownership in most cases is exclusive and achieving benefits is less important. In addition, in the state ownership, the focus is on political concerns. However, private ownerships would decrease the preceding issues and inefficiency because of the competition and shareholders' monitoring (Fatma & Chichti, 2011). Hence,

H2. : A significant relation exists between ownership concentration and FCF risks.

H3. : A significant relation exists between ownership level and FCF risks.

H4. : A significant relation exists between managerial stock ownership and FCF risks.

H5. : A significant relation exists between state ownership and FCF risks.

The third confounding factor affecting FCF risks relates to the size of the company. Jensen (1986) maintains that large firms would prefer debt financing to reduce FCF risks; the author argues that FCF effects are greater in large companies than in small companies. Doukas, McKnight, and Pantzalis (2005) argue that large firms are likely to incur in more agency problems because of the complexities of the operations. Ogundipe, Ogundipe, and Ajao's (2012) findings show that a negative relation exists between cash holdings and size of the firm. Hence,

H6. : A significant relation exists between firm size and FCF risks.

Previous research (Ahmed, 2009; Utami & Inanga, 2011) concludes that profitability of the firm relates positively to the FCF agency costs because profitable firms hold more free cash that the managers can expense to their own purposes. Hence,

H7. : A significant relation exists between *profitability* and *FCF* risk.

3. Method and research design

3.1. Research design and data collection

This research is a positive study that builds on historical data. The data derives mainly from audited financial statements and board's reports of the TSE, and Sahra and Tadbir Pardaz software. The population of the study encompasses all TSE companies for the period 2001–2010. However, the study compiles a purposive sampling; thus, financial firms such as banks and insurance companies are absent because they have different conditions in relation to leverages and cash flows. Listing companies must also have continuous operations during the period of the study, and their information must be available. Following these criteria, the study includes 134 companies (1224 company year-data).

3.2. Research variables

3.2.1. Free cash flow risk

Huffman (1990) argues that to calculate FCF, cash flow statement's information is more suitable. Hence, following Yuan and Jiang (2008), the study uses the following equation:

$$FCF_{i,t} = CFO_{i,t} - INT_{i,t} - DIV_{i,t} \quad (1)$$

Where FCF is the free cash flow of the company, CFO the net cash flow from operations, INT the interest on debts, and DIV the cash dividends.

Following Pindado and Torre (2005), and Fatma and Chichti (2011), this research employs FCF that is multiplied by reverse of the Tobin's Q.

Tobin's Q ratio (Eq. (2)) is a tool for measuring growth opportunities (Lang et al., 1996; Opler & Titman, 1993).

$$Tobin's\ Q = \frac{MVOCE + PSLV + BVOLTD - (BVOSHTA - BVOSHTL)}{BVOTA} \quad (2)$$

where:
MVOCE = market value of all common stocks,
PSLV = cash values of the preferred stocks,
BVOLTD = book values of the long debts,
BVOSHTA = book values of the current assets
BVOSHTL = book values of the current debts,
BVOTA = book values of the total assets, at the end of the fiscal year.
The risk variable in this study is as follows:

$$\text{Risk of the Free Cash Flow} = \frac{Free\ Cash\ Flow}{Tobin's\ Q}. \quad (3)$$

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3.2.2. Debt policy

Following Fatma and Chichti (2011), to determine the debt policy, the study uses long-term debt as follows, because long-term debt plays a more effective role in the firms' long term investments and profitability:

$$\text{Debt Policy} = \frac{\text{Long Term Liabilities}}{\text{Total Assets}}. \quad (4)$$

D'Mello and Miranda (2010), and Pöyry and Maury (2010) among others employ this measure.

3.2.3. Stock ownership

In this study, following Cornett, Marcus, Saunders, and Tehranian (2007), and Hasan and Butt (2009), managerial ownership appears as the percentage of the common stocks that belongs to the managers. Institutional ownership divides into "concentration" and "level of institutional" ownership. As in Cueto (2009) and Rubin (2007), the level of the institutional ownerships refers to the stocks belonging to the banks, insurance companies, holding corporates, investment firms, retirement funds, investment funds, government's companies, and organizations divided by all issued shares. Kumar (2004); Earnhart and Lizal (2006), and Namazi and Kermani (2013) use this variable too. Concentration of the institutional ownership constitutes the sum of the stocks on hand of the greatest institutional owners divided by all issued shares. Rubin (2007) also uses this variable. Consequently, the study exerts the following ratios:

$$\text{Institutional Ownership Level} = \frac{\textit{Sum of the stocks in hand of the institutional ownership}}{\text{All Issued Shares}} \quad (5)$$

$$\text{Institutional Ownership Concentration} = \frac{\textit{sum of the stocks in hand of the greatest institutional ownership}}{\text{All issued shares}} \quad (6)$$

The government's influence over the firms occurs because politicians or the state ownerships choose managers (Sari & Anugerah, 2011).

$$\text{State Ownership} = \frac{\text{Amount of shares that were owned directly or indirectly by the state}}{\text{Total of shares}} \quad (7)$$

3.2.4. Firm size

The logarithm of all assets and logarithm of the sales variables measure firms' size. The inflation situation of Iran, however, makes these factors irrelevant (Namazi & Kermani, 2013). Thus, this study employs the natural logarithm of the market size of the company at the end of the fiscal year. Boone, Casares Field, Karpoff, and Raheja (2007) and Guest (2008) employ this variable too. Hence,

$$\text{Size} = \text{Natural Logarithm of the Market Value of the Company} \quad (8)$$

Table 1
Results of testing the hypotheses

Variables	Correlation	Sig	Results
Debt policy	.060*	.037	H_1 supported
Institutional ownership concentration	−.032	.261	H_2 not supported
Institutional ownership level	−.009	.744	H_3 not supported
Managerial stock ownership	−.001	.976	H_4 not supported
State ownership	.005	.869	H_5 not supported
Size	.110**	.000	H_6 supported
Profitability	.119**	.000	H_7 supported

* . Correlation is significant t the 0.05 level (2-tailed).
** . Correlation is significant at the 0.01 level (2-tailed).

3.2.5. Profitability

Firm's performance associates significantly with its agency costs (Bruton et al., 2002; Gompers et al., 2003). In this study, the ratio of income before taxes and interests divided by the total assets works as an index for profitability. The study selects this ratio because this ratio shows the results of a company's operations unambiguously, and other researchers such as Céspedes et al. (2010), and Margaritis and Psillaki (2010) employ this ratio in their research.

4. Research model

Because of the nature of the variables, the existence of the non-linear relations and potent advantages of the ANN, the study implements a Multilayer Perceptron (MLP) model, which posits three layers—input layer, hidden layer, and output layer (Höglund, 2012). The transfer function for the neurons in the hidden layer is set to tangent sigmoid and for the output neuron is set to purelin. Fig. 1 shows the structure of the model. For designing this model, this research uses 2011 edition of the MATLAB software.

5. Findings

The descriptive statistics show that the mean value of the FCF risk is 9667.283. The minimum value of the existing FCF risk is −495,250 and the maximum value is 497,391.6 with the standard deviation of 103,414.7. The mean value of the debt ratio (Debt Policy) is 0.07. The minimum value of using debt is 0 and the maximum value is 0.93 with the standard deviation of 0.08. The means of the institutional ownership level (54%) and institutional ownership concentration (46%) show that about half of the ownership in the sample belongs to institutional owners. The mean of the state ownership is 38.2.

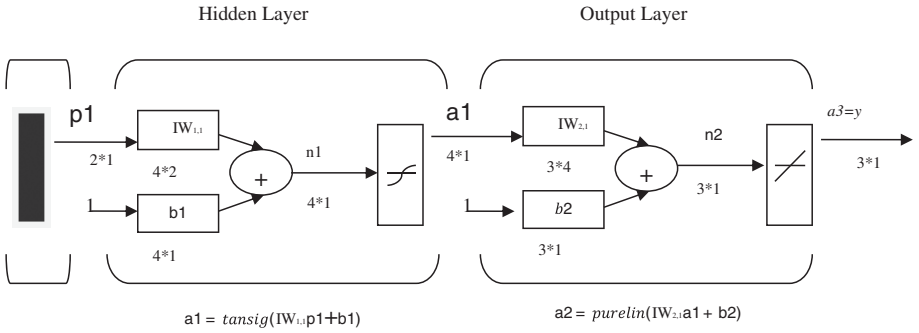

Fig. 1. The structure of the model. (Hudson, Hagan, & Demuth, 2012, p. 152).

Table 2
MSE for three-layer ANN

Sample	Number of neurons in hidden layer	Train performance	Validation performance	Test performance	Performance
1	2	0.0381	0.0358	0.0619	0.0414
2	3	0.0406	0.0456	0.0414	0.0415
3	4	0.0396	0.0463	0.0448	0.0414
4	5	0.0436	0.0468	0.0286	0.0418
5	6	0.038	0.0583	0.0476	0.0425
6	7	0.0398	0.0535	0.0365	0.0413
7	8	0.0426	0.0303	0.045	0.0411
8	9	0.0446	0.0404	0.0266	0.0413
9	10	0.0436	0.0419	0.0454	0.0436
10	11	0.0396	0.0419	0.0468	0.041
11	12	0.0418	0.0542	0.0252	0.0412
12	13	0.0374	0.0369	0.0994	0.0466
13	14	0.0379	0.0432	0.0575	0.0416
14	15	0.0416	0.0432	0.0566	0.0441
15	16	0.0394	0.0385	0.0503	0.0409
16	17	0.0384	0.0376	0.1071	0.0486
17	18	0.0421	0.0298	0.0531	0.0419
18	19	0.0426	0.0404	0.03	0.0404
19	20	0.0436	0.0479	0.0357	0.043

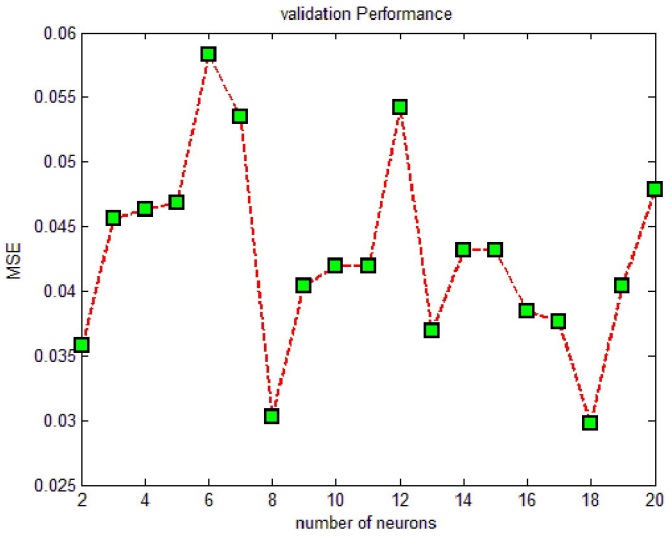

Fig. 3. MSE of the validation data versus the number of neurons.

5.1. Inferential statistics

This research uses Pearson correlation to test the significance of the variables. Table 1 shows the results. The results support H1, H6, and H7; and reject H2, H3, H4, and H5. Hence, the study chooses only debt policy, size, and profitability variables because they present a significant relation as input variables in the ANN model.

A three-layer ANN has one input layer, one hidden layer, and one output layer. The number of neurons in input layer for this study is equal to 3 because the number of neurons in input layer must be equal to the number of independent variables. The number of neurons in the hidden layer follows trial and error and, in this study, ranges from 2 to 20. The study chooses the model with the lowest mean square error (MSE). The number of neurons in the hidden layer is different, to control the accuracy of the model and choose the optimal model. This study expands 19 instances of this model to find out the optimal model and to control the accuracy of the model.

The problem that an ANN may face is overtraining. During repeating periods, MSE of the training set declines monotonically, as well as the validation data set. After a certain degree of training, however, the MSE of the validation data set would generally begin to increase. In this case, the study over trains the ANN model, because the ANN model is adjusting to specific characteristics of the training data set and not to the overall patterns the data presents. Training stops when the MSE of the ANN output using the validation data set begins to increase (Kemp et al., 2007). The data set test calculates the general effectiveness of the ANN model by calculating MSE of the ANN model output versus the target values. To solve this problem, data is divided into three groups: train data, validation data, and test data. The percentage of them is 70, 15, and 15 respectively. For each of the instances, an ANN appears separately. The mean square error (MSE) for each of the preceding instances appears in Table 2.

Fig. 2 shows the performance of the neural networks with the train data indicating the least MSE in the neural networks contains 2, 6, 13, and 14 neurons. The increase in the number of neurons would not result in achieving better performance in a row, presenting some anomaly.

Fig. 3 shows the validation data performance demonstrating that the models with 2, 8, 13, and 18 posit the best MSE among all samples.

Fig. 4 shows MSE for the test data illustrating the models with 5, 9, and 12 neurons present the best MSE among all models.

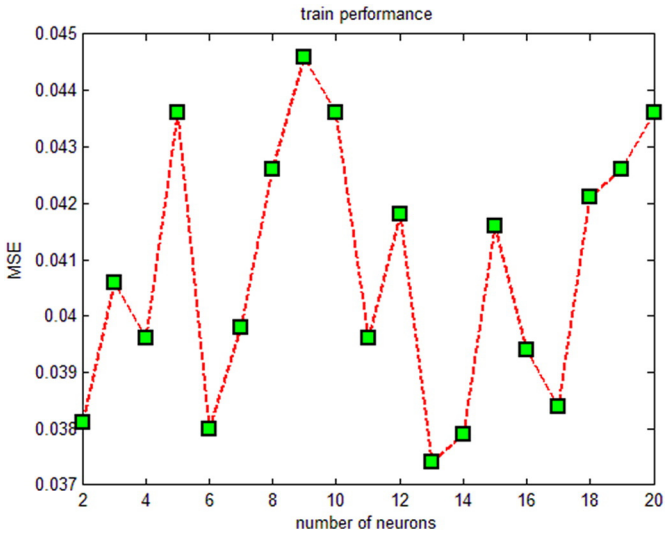

Fig. 2. MSE of the train data versus the number of neurons.

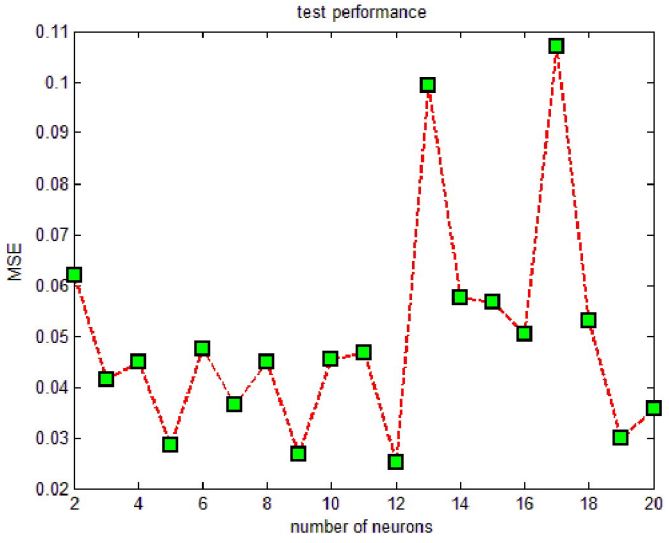

Fig. 4. MSE of the test data versus the number of neurons.

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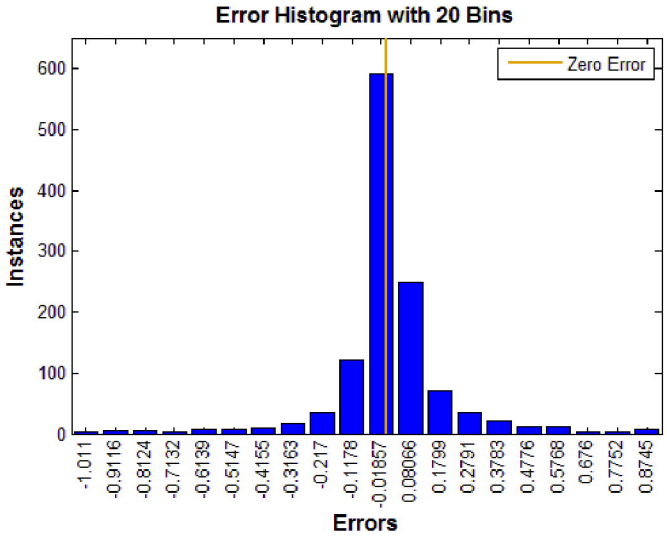

Fig. 5. Error histogram with 20 bins.

In sum, the optimal model with a three-layer ANN contains one input layer with 3 neurons, one hidden layer with 12 neurons and tangent sigmoid as a transfer function, and one output layer with 1 neuron and purelin as a transfer function. The MSE of the test data for this model is 0.0252.

Error histogram for the chosen model appears in Fig. 5, revealing the zero-error line is between the data, and the mean of the error is quite near zero.

Fig. 6 shows MSE changes among the three group data: train data, validation data, and test data in the chosen model.

The study uses the change of the MSE method (Sung, 1998; Wong et al., 2011) to rank statistically the importance of the inputs. In brief, for the change of the MSE method, researchers should measure the change (increase or decrease) in the prediction mean square error of an ANN after the elimination of an input unit from the input layer of that ANN. Thus, the study retrains each ANN model with (N - 1) inputs each time after the elimination of an input unit, whereas the chosen network results from a simulation, and then the study computes the change in MSE for the reduced ANN model relative to the full ANN model with N input units. Table 3 shows the results of the MSE. The study ranks the input variable whose deletion causes the largest changes in the MSE as the most important input variable, because its exclusion from the full ANN deteriorates prediction accuracy the most. The quantification of the relative importance of each factor builds on the proportion of the changes that each factor introduces relative to total changes in the MSE induced by all factors. The results appear in Table 3 and Fig. 7. Results clearly demonstrate that the most important variables are profitability, debt policy, and firm size respectively.

Table 3
Change of MSE computation for the three-layer ANN.

	MSE	Change	RI	Rank
All variable	0.0411724	–	–	–
Omit profitability variable	0.1489460	0.1077735	0.46521688	1
Omit debt policy variable	0.1449440	0.1037715	0.44794176	2
Omit size variable	0.0612904	0.0201179	0.08684135	3

6. Discussion and conclusion

The results of this study show that, in TSE market, the most significant factors affecting FCF are (1) profitability (0.46521688), (2) debt policy (0.44794176), and (3) size of the firm (0.08684135) respectively. This finding contrasts with Jensen's (1986) study. Part of the inconsistency may owe to the TSE market characteristics. The findings of this research also differ from prior studies (Ang, Cole, & Lin, 2000; Chu, 2011; D'Mello & Miranda, 2010; Fatma & Chichti, 2011; Gul et al., 2012; Henry, 2010; Khan et al., 2012) because those studies only attempt to determine the positive or negative effects of the significant variables relating to FCF risks. This study, however, concentrates for the first time on the identification and ranking of significant factors that affect FCF risks through ANN. Thus, this study extends previous empirical works and existing literature on the FCF subject. In addition, the ranking can also help managers and capital markets participants to identify and analyze the most important determinants factors affecting FCF risks.

The following limitations appear throughout of this study:

1) Non-availability of some characteristics of the boards' members and institutions.
2) Undisclosed factors by the firms, which affect their future events.

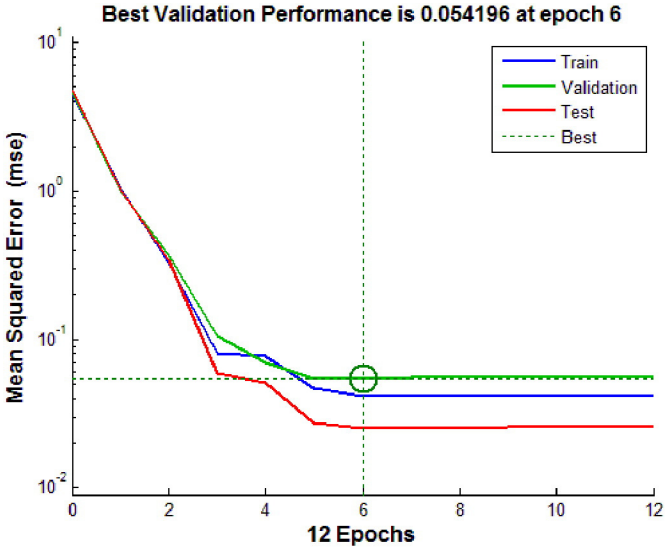

Fig. 6. MSE of the best validation performance.

Fig. 7. Relative performance versus omitting variables.

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3) Limitations of the artificial neural networks techniques such as picking samples at random as a train and testing and validation of data.

The study makes the following suggestions:

1) Investigating the effect of FCF risks on the stock prices.
2) Ranking FCF risks among other variables affecting the attitude of the financial statements users.
3) Studying the effect of FCF risks on firm's bankruptcy.

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