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Artificial Intelligence Approach Analyzing Management Ability Based on Accounting and Corporate Governance Criteria

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ABSTRACT

The aim of this research is the analysis of management ability using accounting and corporate governance criteria and also artificial intelligence. The primary independent variables in this study include regulatory variables (characteristics of corporate governance and audit committee) and accounting variables (performance and risk criteria). We took advantage of Demirjian index to measure management ability. The empirical findings Of 178 companies listed in Tehran Stock Exchange from 2011 to 2017 indicate that using least angle regression approach, systematic risk variables, management alteration, ownership concentration, financial expertise of the audit committee members and stock returns have a higher power explaining management ability. Analyzing these results, we can say that economic, political and regulatory issues can further affect management ability to measure their performance. Also among other results obtained here we can mention that in management and accounting, to explain and predict continuous financial variables such as management ability, we can take advantage of Fourier online gradient descent approach that has high predictive power.

Keywords

Management Ability, Accounting Variables and Corporate Governance, Artificial Intelligence Algorithm.

1. Introduction

Individual abilities and capabilities are important factors for success. In any business, managers can claim that they are capable if they exploit the company's existing resources efficiently and optimally to meet its goals. Effective managers have the ability to make better use of existing resources in the process of achieving organizational goals. In other words, effective manager is a manager who can get the most out of the least. Manager's ability in using corporate resources to maximize profits is of great importance. If the management isn't efficient enough, current shareholders would be eager to make some changes in the business entity management, or by running incentives and providing benefits and rewards would seek to improve management efficiency. Potential shareholders are also trying to evaluate management efficiency before investment, through evaluating the business entity stock. Anyway, efficiency criterion provides a basis for decision making, given that the development of capital markets through increasing shareholder awareness, puts a lot of pressure on companies to do better, and corporate executives face some issues these days, which require them to establish a new economic framework for companies through enhancing their abilities to represent value and profitability in the best way (Nikbakht & Ghasemi, 2018). In the meantime, stakeholders as business owners are seeking to increase their wealth, given that increasing their wealth, would happen as a result of the optimal performance of the business entity, therefore business unit measurement is of great importance to owners. In the modern literature of the management concept, working with others has been replaced by others working for you. This will add to management difficulties now or in the future. Thus, new paradigms have emerged in this field. Among these, the goal of creating value stands above it all. A value-creating manager must take advantage of management strategies and practices affective on value creation, and use them in practice. Success in value creation, to a large extent depends on the quality of performance measurement (Andreou, P. Et al., 2013). In this study we have tried to measure the relationship between accounting and regulatory variables (Corporate Governance and Audit Committee) and management ability using the stepwise least angle algorithm and the Fourier online gradient descent approach that is the innovation of this research, and predict the extent of management ability for the first time using linear and nonlinear artificial intelligence algorithms.

2. Literature Review

Managers with greater ability are becoming more and more important in organizations since organizations will face increasing competitive challenges in the future and need more competent and effective managers to deal with these challenges. Organizations are well aware today that for success in today's complex global economy as well as durability and survival in the business, they need to have the most talented and capable managers who can better measure the economic returns on investment and scheduling, and also combine information in reliable and forward-looking estimates of the risks and returns related to corporate investment (Moazeni & BadavarNahandi, 2016).

2.1. Accounting criteria and management ability

In accordance with resource-based theory, which is one of the most widely-used theories explaining the differences in the performance and the results, management ability is a valuable resource that provides companies with a sustainable competitive advantage. In this theory, corporations are considered as heterogeneous entities which are separated on the basis of available monopoly resources and their specific characteristics. And this statement is interpreted as such that strategy formulators need to tailor outsourced opportunities with the company's resources and capabilities, for the company to be successful. Based on this, much emphasis has been placed on the role of managers. Therefore, it is expected that management ability to use resources, through creating sustainable competitive advantage, be an important factor improving corporate performance and business success (Khajavi & Ghadirian Arani, 2018). Managers are different in terms of the ability to manage resources and coordinate management processes (Holcomb, T.R. et al. 2009). Effectiveness of experience on management ability and the fact that it can't be imitative indicates that management ability is regarded as an important and valuable resource (Kor, Y.Y., 2003). A manager can help the company undertake the appropriate tasks and processes to the production of products and provide new and up-to-date

services through promoting the use of resources and therefore create value for the company (Lepak, D.P., et al. 2007). Indeed managers and the resources under their control, play a key role in corporate success so, in other words, success requires effective and efficient application of resources by the management (Holcomb, T.R. et al. 2009). The results of most experimental research are also consistent with the resource-based perspective and underline the importance of management ability in companies' success (Chemmanur, T.J., Paeglis, I, Chemmanur et al. 2009, Andreou et al 2013, and Andreou et al. 2017). The results of some internal research also indicate that (such as Momtazian & Kazemnezhad, 2016), management ability is one of the factors influencing financial performance of the company. Therefore, in this study accounting metrics including performance and risk, are considered as the primary independent criterion.

2.2. Corporate governance criteria and the audit committee and management ability

Shleifer, A. and R. W. Vishny (1997) provided a very interesting and complete definition of corporate governance which states "a way for funders to make sure they get a return on their investments". They take many dimensions into account for this. One of these aspects that has been extensively studied in the corporate governance literature and has its roots in agent theory, is the control issue, which means balancing the interests of managers who make decisions for the organization with the interests of the investors affected by these decisions, and another key dimension, perhaps less discussed is the quality assessment of the decisions made by the management. Even if managers have good intentions towards investors, but lack proper competence and the requisite sufficiency, they may follow poor projects or apply the wrong strategies which may lead to a reduction in shareholders' value (Hermalin, B. E., & Weisbach, M. S, 2017). Today, proper management, controlling and overseeing the affairs of public corporations, is one of the fundamental issues raised in the economic system of different countries, including Iran. According to contemporary developments, striving to safeguard the interests of investors as providers of the capital, and also the most important group of users of accounting information and financial statements is felt more than ever. Establishing and expanding audit committees is one of the mechanisms that is expected to be useful in safeguarding the interests of different groups of users of accounting information and financial reports. In some developed countries, many companies have set up an audit committee to have a regulatory role in the procedures and practices of accounting and financial reporting of economic entities. The role of the audit committee as an influential factor increasing the utility of providing financial reports will go on, since an effective audit committee, has a very important position in filling the credit gap we see in financial reports today (Alavi Tabari & Asabakhsh, 2010). The quality of internal control is considered as the regulatory and control mechanisms in businesses. On the other hand, the audit committee is one of the corporate governance mechanisms and since 2012, companies listed in the stock exchange have been required to form this committee. Cohen, J. et al. (2012) indicated that managers ultimately determine the effectiveness and efficiency of the audit committee. Bruynseels, L., and E. Cardinaels (2014) believe that Companies with audit committees which have friendly relationships with the CEO, tend to get lower cost audit services as well as more profit management. Ling Lei Lisic et al. (2016) believe that managers' personal motivations and interests, would be a factor to counter the malfunction of an internal control system. When the quality of an internal control system is appropriate, the possibility of misusing the company's assets or resources would be less. On the contrary, the weakness of an internal control system causes managers to exercise their authority and discretion applying accounting procedures and estimates that may not be in line with shareholders' interests. For this reason, information asymmetry may increase and managers take advantage of an information advantage over other users. Lisic et al. (2016) also believe that reducing the effectiveness of the audit committee is considered to be a good factor concealing the poor and undesirable performance of an internal control system. Coles, J. L et al. (2014) believe that the intensity and the extent of the supervision by the board of directors has an indirect relationship with the power of the CEO. In other words, when the CEO has power, the board's ability to supervise the CEO will diminish and this is achieved through reducing the efficiency and effectiveness of

the audit committee. Therefore, in this study, the set of regulatory criteria including corporate governance and audit committee variables were selected as the primary independent variables.

2.3. Research background

Wei - Ling Song & Kam Ming Wan (2019) examine whether managers' rewards reflect their abilities and capabilities or not. The time domain of this research is from 1993 to 2012. They found that powerful executives are rewarded more than executives with fewer abilities. This additional amount is referred to as "power royalty" and they examine this power royalty based on two competing perspectives. Management ability perspective argues that power royalty compensates executives for their better management abilities while the power in management perspective argues that power royalty indicates CEO's ability to earn excessive rewards. In general, the above results are more consistent with the management ability view.Premkanth Puwanenthiren et al. (2019) carried out a study titled "do managerial abilities when selecting investor offers matter?" they provide evidence that management ability is positively and significantly related to seasonal shareholder capital decisions in the US market. After examining different internal and external control mechanisms, their research is based on the endogeneity problem and adopting a number of alternative features. Also the management ability is stronger for the selection of (SEO) for companies with higher information symmetry, management duality, and weaker governance settings. Generally, the findings of this study, confirm the concept that higher management capability is perceived as a positive quality in enterprise information environments. SeTin SeTin & Etty Murwaningsari (2018) examined the impact of managerial ability on profits quality with the audit committee. The data of this study are secondary data, analyzed from the audited financial statements of 53 Indonesian public utilities with 159 units for the period 2014-2016. Results indicate that management capability, has a positive and significant effect on profits quality and the audit committee increases the impact of management ability on the earnings quality. In a study titled "evidence of the relationship between management ability and timely financial reporting", Abernathy, J. L et al. (2018) came to the conclusion that considering the characteristics of the company, increasing management ability is significantly correlated to bridging the reporting gap and shortening the audit report. In general, the results indicated the positive effect of management ability on timely financial reporting. Chen, S. S. and C.Y. Lin, (2018), investigated the relationship between management ability and acquisition and merger returns concluded that there is a positive relationship between management ability and abnormal long-term buy-and-hold returns. Panayiotis C et al. (2017) performed research in the American economic environment applying the model of Demirjian et al (2012) entitled "The effect of management ability on company investment during the crisis period". Results indicated that management ability during crisis boosts performance, reduces information asymmetry, and increases company profitability. Lisic et al. (2016) investigated the relationship between the effectiveness of the audit committee, the power of the CEO, and the quality of internal control. The results indicated that when managers don't have much power, characteristics of the audit committee members including independence and financial expertise have an indirect relationship with weaknesses in the internal control system. On the contrary, when management has more power, the inverse relationship between the audit committee characteristics and the weaknesses in the internal control system is prolonged. Sayadi et al. (2019) examined the role of corporate risk management on the relationship between management ability and increased investment efficiency in a study. The sample of their research includes 106 companies selected among companies listed in Tehran Stock Exchange and the data were collected during the period 1380-2016. In general, results of the consolidated data estimation by the fixed-effects regression method indicate that corporate risk management will not affect the relationship between management ability solely to increase investment efficiency or reduce corporate investment inefficiency. Jamali and Alipour (2019) studied the relationship between managemant authority, net operating assets and returns on companies listed in Tehran Stock Exchange from 2011 to 2016 on 126 companies listed in Tehran Stock Exchange. The results of the study indicate that according to the original hypothesis, net operating assets have a significant and indirect effect on corporate returns and also according to the first and the third sub-hypotheses, investment decisions and

profit-sharing decisions have a direct and significant effect on the relationship between net operating assets and corporate stock returns and also according to the second sub hypothesis, financing decisions have a significant reverse effect on the relationship between net operating assets and corporate stock returns.

Tavangar Hamze Kolaee and Eskafi Asl (2018) studied the relationship between CEO power, characteristics of the audit committee and the quality of internal control. Results indicated that among the characteristics of the audit committee, accounting committee size and members' financial expertise have a significant relationship with the quality of internal control and independence has no significant relationship with the dependent variable. Results also indicated that the CEO power only has a moderating effect on the relationship between the audit committee size and the internal control quality. Badavar Nahandi and Heshmat (2018) studied the Effect of corporate governance mechanisms on the relationship between management ability and value creation for shareholders. To test this, a statistical sample consisting of 124 companies listed on the Tehran Stock Exchange were studied from 1385 to 2015. To test research hypotheses, multiple linear regression statistical analysis method was used. The test results of the research hypotheses show that management ability is positively associated with shareholder value creation, and corporate governance mechanisms also intensify this positive relationship. In other words, in companies with higher corporate governance rank, management ability, is more effectively enhancing shareholder value. Khajavi and Ghadirian (2018) studied management ability, financial performance, and bankruptcy risk. In this regard, the information on 103 non-financial companies listed in Tehran Stock Exchange during the period 1383-2015 has been reviewed. Management ability is measured using Demirjian et al. (2012). Also, the rate of return on assets is used as a measure of financial performance and the emerging market scoring pattern (Altman Z score) is used to measure bankruptcy risk. Research results show that there is a negative relationship between management ability and the risk of corporate bankruptcy, and financial performance plays the role of a full mediating variable here. In other words, management ability reduces the risk of bankruptcy by improving corporate financial performance. It was generally concluded that management ability is an important factor for the success of the companies listed on Tehran Stock Exchange. Harsini and Taghipoorian (2017) studied the effect of corporate governance over management ability during company life cycle, emphasizing opportunistic motivations. Results indicate that there is a significant relationship between corporate governance and management ability during the life cycle of the company.

Kooshafar et al. (2017) measured efficiency and management ability based on financial criteria. Models were evaluated using a sample of 22 pharmaceutical companies listed in Tehran Stock Exchange from 1388 to 2015. Results indicated that according to the test and according to Wang, using the criteria established has more explanatory power than the model of Demirjian et al. the model by Demirjian et al. only emphasized on the output of physical resources, that due to the monopoly market and the prices determination by the Food and Drug Administration, management effectiveness in generating revenue has reduced and relied more on physical resources and less on intellectual capital. The model presented emphasizes the added value created by the company and in addition to income, various factors are considered as outputs to determine efficiency and due to the limited statistical population, it doesn't have the problems related to data envelopment analysis and emphasizes on both physical and intellectual sources. Mohammadi & Karam Salehi (2017) examined the relationship between management ability and investment efficiency and the risk of stock price declines using data from 152 companies listed on Tehran Stock Exchange from 1385 to 2015. Demirjian et al.'s (2013) model, based on accounting variables, is also used to measure management ability. Data is analyzed using panel data method and multivariate regression. The results of the study show that there is no significant relationship between management ability and investment efficiency, however, there is a positive and significant relationship between management ability and the risk of falling stock prices. Momtazian and Kazemnezhad (2016) examined the relationship between management capabilities and performance measures with the help of data envelopment analysis. The statistical sample of the study consists of 161 companies from 2005 to 2014. The findings indicate that there is generally a direct and significant relationship between management ability and the firm's performance measures. That is,

through increasing management ability to make better use of resources and consequently increasing the overall efficiency of the company, corporate performance improves, and thereby shareholder wealth will increase.

3. Methodology

3.1. Research Hypotheses

Since artificial intelligence systems such as expert systems and data mining methods have been designed and introduced, their use in financial research and credit ratings has become commonplace and is rapidly expanding (Salehi Sadaghiani et al. 2012). According to the stated theoretical foundations and the purpose of the research, the following hypotheses have been formulated.

1) Accounting criteria can explain management ability using the stepwise least-angle regression algorithm.
2) Corporate governance and audit committee criteria are able to explain management ability using the stepwise least-angle regression algorithm.
3) Fourier online gradient descent non-linear algorithm is able to predict the management ability of the companies listed on Tehran Stock Exchange next year.
4) Fourier online gradient descent non-linear algorithm has the ability to predict the management ability of the companies listed on Tehran Stock Exchange for the next two years.

3.2. Statistical population and sample

This is an applied, library and field study using historical information as retrospective. The statistical population of this research includes all companies listed in Tehran Stock Exchange that meet the following criteria.

1) There should be no financial changes in the period under review.
2) It shouldn't be an investment firm, financial intermediary, bank, insurance, and leasing.
3) Necessary data should be available.

Finally, given the limitations mentioned above, 178 companies were selected as the statistical population from 2011 to 2017 and due to information availability, all companies were analyzed as statistical samples.

3.3. Research variables

The primary independent variables of this study divided into two groups of accounting criteria (performance and risk) and regulatory criteria (characteristics of the governance system and audit committee) are described in table 1:

Table 1: research variables

Quantitative variable	Operational definition
Performance and risk accounting criteria	
Return on assets	It is obtained by dividing the net profit by total assets.
Equity returns	It is obtained by dividing net profit by equity.
Tobin's Q	It is obtained by dividing the book value of assets. (Stock market value plus debt book value)
Sales returns	It is obtained by dividing the net profit by net sales.
Stock returns	Using stock returns published by Rahavard Novin software
Economic added value	EVA = NOPATt – (WACCt × Capitalt – 1) EVA economic added value, NOPAT Operating net profit after tax, Capital Capital applied to the company WACC Average cost of capital It is ultimately divided by the total assets of the company
Market value added	The result (the value of the stock market - equity) divided by total assets
Systematic risk	It is the systematic risk of the change degree in the return on a particular investment, relative to changes in return on market capitalization Aand is measured by the β index. $\beta = \frac{\mathrm{Cov}(R_m, R_i)}{\delta^2 R_m}$
financial risk	It is obtained by total debt divided by the sum of assets.

Quantitative variable	Operational definition
Operating cash ratio	It is obtained by dividing operating cash by total assets.
Corporate Governance and Audit Committee Criteria	
Board size	Number of board members
Non-executive directors	It is obtained by dividing the number of non-executive directors by the total number of board members
institutional owners ratio	according to paragraph 27 of act 1 of *Securities Exchange Act* Banks, corporations, and any person holding more than 5% of the issued shares is considered as a criterion for the calculation of institutional shareholders
Concentration of ownership	The Herfindahl-Hirschman index is used.
The dual role of CEO	If CEO of the company, is also the chairman or vice president of the board of directors we'll use the artificial variable 1, otherwise we'll use 0.
CEO changes	If the management has changed from last year, we'll use the artificial variable 1 and otherwise we'll use variable 0.
Audit committee independence	It is obtained from diving the number of non-executive members of the Audit Committee by the total number of members.
Audit committee expertise	It is obtained by dividing the number of members of the audit committee with financial expertise by the total number of members.
Dependent variable	
Management ability	Based on Demirjian et al.

Demirjian model:

To study management ability, we took advantage of the pattern presented by Demirjian et al. (relationship No. 1) which is based on accounting variables. In this model, we can measure management ability using the company's performance as the dependent variable and controlling the intrinsic characteristics of the company. Demirjian et al. (2012) used data envelopment analysis to measure corporate efficiency. The data envelopment analysis model is a type of statistical model used to measure system performance taking advantage of input and output data. In the model of Demirjian et al. (2012) used in this study revenue from selling the goods and services is considered as the output and another 7 variables namely cost of goods sold, general expenses, administrative and sales expenses, net properties, equipment, and machinery, operating lease costs, research and development costs, goodwill and intangible assets are considered as inputs that cover a great deal of management's choice of income.

Relationship No. (1)

$$\max_{v} \theta = \frac{sales}{v_1 coGS + v_2 SG\,\&\,A + v_3 NetPPE + v_4 Opslease + v_5 R\,\&\,D + v_6 Goodwill + v_7 In\tan}$$

in this model:

Sales is proceeds from the sale of goods and services; SG&A, is general, administrative and sales expenses in year t for company j; NetPPE is the net balance of property, plant, and equipment for company j at the beginning of the year t; Opslease is the operating lease costs of company j in year t; R&D, Research and development costs of company j in year t; Goodwill, is the goodwill bought by company j at the beginning of the year t; Intan, is the net intangible asset of company j at the beginning of the year t. Also in this model, a specific coefficient, v, is assumed for each of the input variables, because not all input variables have the same effect on output variables (proceeds from the sale of goods and services) the calculated value for the company's performance is also a number between zero and one where maximum efficiency is 1 and the lower the value obtained, the lower the efficiency of the company. In any industry the company that has the highest efficiency, is the industry leader. However, it should be noted that in this model, Opslease, the operating lease costs of

company j in year t, and R&D, the research and development expenses of company j at year t; and SG&A, the public, administrative and sales expenses of company j at year t are just applied and haven't been recalculated. The purpose of calculating the firm performance is measuring management ability and because in efficiency calculations (relationship No. 2) firm specific characteristics are also involved, you can't measure management ability properly, since management ability affected by these features, is calculated more or less than the actual value. For example, more capable managers, regardless of the size of their company, have a better understanding of the future prospects of the company and the industry while managers of larger companies potentially have greater bargaining power with other parties of the transaction. Demirjian et al (2012) have divided the company efficiency into two parts: efficiency based on the intrinsic characteristics of the company and efficiency affected by management ability. They have done this using 5 company-specific characteristics including company size, company market share, company cash flow, acceptance duration in the stock exchange and foreign sales (exports). Each of these 5 variables which are inherent characteristics of the company, can help management make better decisions or vice versa limit management ability. These 5 features are controlled in the following model presented by Demirjian et al. (2012).

Relationship No. (2)

$$FirmEfficiency = a_0 + a_1 Size_t + a_2 MarketShare + a_3 FreeCashFlowIndicator + a_4 Age + a_5 ForeignCurrencyIndicator + \varepsilon$$

Where

SIZE, is the company size; Market share, means company's market share; Free Cash Flow Indicator means an Increase (decrease) in Company's operating cash flow; Age, means company's duration of acceptance; Foreign Currency Indicator is company j export in year t and the remainder of relationship 2 indicates management ability. Relation # 2 the same as the data envelopment analysis model must be analyzed by the industry. That is why the variables of the whole industry level, such as competition, are not affected in the model.

4. Results

4.1. Descriptive Statistics

The descriptive analysis of this study includes data adjustment and classification and calculating values such as mean, median, and so on indicating the characteristics of each member of the community in question.

Table 2: Descriptive statistics of research variables

Variable	Mean	Median	Minimum	Maximum	Standard deviation	Skewness	Elongation
Asset return	0.101	0.088	-1.063	0.705	0.145	-0.294	5.546
Equity return	0.167	0.233	-72.696	10.045	2.450	-23.603	645.966
Tobin's Q	1.672	1.456	0.584	7.573	0.764	2.462	9.697
Sales return	0.128	0.111	-49.495	16.271	1.453	-25.614	927.845
Stock return	0.452	0.128	-0.725	8.595	1.007	3.080	14.164
Economic value added	-0.119	-0.059	-4.785	14.854	0.504	19.970	532.561
Market value added	0.672	0.456	-.416	6.573	0.764	2.462	9.697
Systematic risk	0.611	0.537	-3.785	5.942	0.936	0.434	2.462
Financial risk	0.609	0.604	0.072	4.003	0.264	2.734	23.764
Operating cash ratio	0.116	0.100	-1.000	1.049	0.139	0.226	4.847
Board size	5.064	5.000	5.000	7.000	0.353	5.306	26.188
Non-exceptive managers ratio	0.685	0.714	0.000	1.000	0.196	-0.495	0.205
Institutional owners ratio	71.759	76.800	0.000	99.569	20.265	-1.207	1.109
Ownership concentration	0.336	0.315	0.000	.989	0.206	0.723	0.264
Manager dual role	0.240	0.000	0.000	1.000	0.427	1.218	-0.517
CEO change	0.278	0.000	0.000	1.000	0.448	0.994	-1.014

Variable	Mean	Median	Minimum	Maximum	Standard deviation	Skewness	Elongation
Accounting committee independence	0.45	0.67	1.00	0.000	0.37	-0.20	-1.50
Accounting committee financial expertise	0.47	0.66	1.00	0.000	0.40	0.009	-1.59
Management ability	0.001	0.007	-0.601	0.408	0.114	-0.495	2.374

4.1. Variable selection(Stepwise least angle regression feature selection method)

Here, the same as a forward selection method, first we'll set all β_j coefficients equal to zero and then choose the variable which has the highest correlation with the goal (x_{j1}). Then we take the longest step possible in the direction of this variable until another variable such as x_{j2} has the same correlation with the current residual. This is indicated in figure 1. At this point, the stepwise least angle algorithm instead of carrying on in the direction of (x_{j1}), continues where it has an equal angle to both variables - until the third variable enters the "highest correlation set". We then proceed in the direction of the angle equal to all three x_{j2}, x_{j2}, x_{j2} variables which are called the Least Angle Direction and is indicated in figure 2.

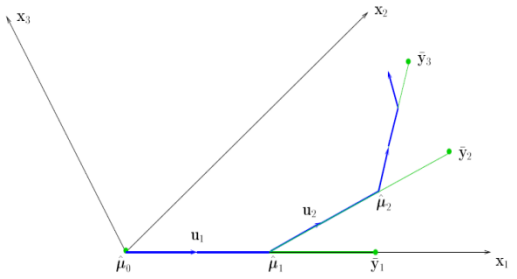

Figure 1: Geometric routines of the stepwise least-angle regression algorithm

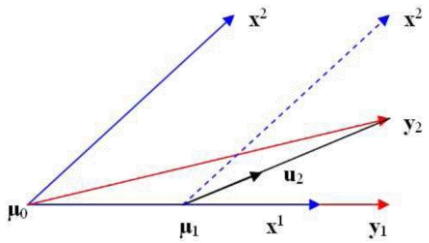

Figure 2: the equal angle between the two variables

In this algorithm, we only need m steps and m is the number of variables or problem features.

Implementation steps of stepwise least angle regression with necessary relationships

We said that in this model, possessing the following matrix and data normality assumption we're looking for a $\boldsymbol{\beta}$ so that we can have:

$$X\beta = y$$

$$X = \begin{bmatrix} x_{11} & x_{21} & x_{31} & \dots & x_{d1} \\ x_{12} & x_{22} & x_{32} & \dots & x_{d2} \\ \vdots & & & & \vdots \\ x_{1n} & x_{2n} & x_{3n} & \dots & x_{dn} \end{bmatrix}, \quad Y = \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix}$$

First company

X_1

Assume that $\boldsymbol{r_j}$ is the correlation between Y and X_j and matrix $R_x$is the correlation value of $X_1, X_2, \dots, X_d$. X_m has the highest correlation absolute value with Y and $S_m = sign(r_m)$. Therefore X_m is the first variable selected to be added to the set of active variables And we have to change the current approximation $\hat{\mu} \leftarrow 0$ by moving in the direction of $S_m X_m$. The magnitude of this variable will be γ which is obtained by the correlation between the variables. If we obtain γ, the stepwise least angle regression algorithm simultaneously specifies the second variable that will be added to the model, when computing the first variable selected to add to the model. Obtaining γ for an active variable is as follows. Assume that the first variable is $+X_m$. Therefore we must change the current approximation as $\hat{\mu} \leftarrow \gamma X_m$. The amount of γ must be in a way that the residual changed $y - \hat{\mu}$ has an equal correlation with $+X_m$ and another variable called X_j.

(2)

$$cor(y - \hat{\mu}, X_m) = \frac{X_m'(y - \gamma X_m)/n}{SD(y - \gamma X_m)} = \frac{r - \gamma}{SD(y - \gamma X_m)}$$

(3)

$$cor(y-\hat{\mu},+X_j)=\frac{X_j'(y-\gamma X_m)/n}{SD(y-\gamma X_m)}=\frac{r_j-\gamma r_{jm}}{SD(y-\gamma X_m)}$$

$$(3-1)=(3-2)\ \Rightarrow\ \frac{r-\gamma}{SD(y-\gamma X_m)}=\frac{r_j-\gamma r_{jm}}{SD(y-\gamma X_m)}$$

$$\Rightarrow r-\gamma=r_j-\gamma r_{jm}$$

$$\gamma(+X_j)=\frac{r-r_j}{1-r_{jm}}$$

If variable j is $-X_j$, we'll have:

(4)

$$\gamma(-X_j)=\frac{r+r_j}{1+r_{jm}}$$

According to equations (3) and (4) out of all the variables not selected so far we'll take minimum j. the second variable added to the model is determined at this stage. Once we have more than 1 active variable, the least squares regression algorithm changes the current approximation in the direction of equal angle (Equal angle: The direction in which the (correlation) angle is equal to all active variables). Moving in this direction ensures that the current correlation of each active variable with the residual is reduced to equal amounts. Assume that A is the index set of active variables and B_A is the vector of equal angle. Note that we don't need the direction of B_A to decide which variable to add, all we need is the correlation of all variables (active and inactive) with B_A. These correlations are defined using the variables correlation matrix below. The quantities related to B_A vector are calculated as follows.

Assume that A is the index set of active variables and $X_A=\{\dots s_l X_l \dots\}, l\in A$. $\boldsymbol{s_l}$ is the sign of X_i variable which is obtained when adding X_l. B_A is a linear combination of active approximates obtained using the following three states.

(5)

$$B_A=X_A w_A$$

W_A is the weight vector and B_A has a single variance.

(6)

$$\frac{1}{n}B_A'B_A=1$$

B_A has an equal correlation to all active variables (a). Since the variables and B_A are standard we'll have:

(7)

$$\frac{1}{n}X_A'B_A=a1_A$$

Substituting (5) in (6) gives:

$$\frac{1}{n}B_A'B_A=1\ \Rightarrow\frac{1}{n}(X_A w_A)'(X_A w_A)=1$$

$$\Rightarrow\frac{1}{n}w_A'X_A'X_A w_A=1$$

$$\Rightarrow w_A'R_A^{(s)}w_A=1$$

Where $R_A^{(s)}$ is the correlation matrix of active variables. Substituting (5) in (7) gives:

(8)

$$\frac{1}{n}X_A'B_A=a1_A\ \Rightarrow\frac{1}{n}X_A'X_A w_A=a1_A$$

$$\Rightarrow R_A^{(s)}w_A=a1_A$$

Therefore we can define vector W_A as follows:

(9)

$$w_A=a(R_A^{(s)})^{-1}1_A$$

We assume that matrix R_A is the correlation matrix of active variables without any signs. It is, in fact, a subset of R_x. we'll consider S_A the sign vector of active variables (it is determined when it enters the model):

(10)

$$w_A=a(D_A R_A D_A)^{-1}1_A$$

Where D_A is a diagonal matrix including S_A members on its main diameter.

Finally substituting (10) and (8) gives:

$$w_A' R_A^{(s)} w_A = 1$$
$$\Rightarrow (a(D_A R_A D_A)^{-1} 1_A)' \cdot (D_A R_A D_A) \cdot (a(D_A R_A D_A)^{-1} 1_A) = 1$$
$$\Rightarrow 1_A'((D_A R_A D_A)^{-1})' a' \cdot (D_A R_A D_A) \cdot (a(D_A R_A D_A)^{-1} 1_A) = 1$$
$$\Rightarrow 1_A'(D_A R_A D_A)^{-1} a' a 1_A = 1$$
$$\Rightarrow a' a = \frac{1}{1_A'(D_A R_A D_A)^{-1} 1_A}$$
$$\Rightarrow a = \left(\frac{1}{1_A'(D_A R_A D_A)^{-1} 1_A}\right)^{\frac{1}{2}}$$
$$\Rightarrow a = \left[1_A'(D_A R_A D_A)^{-1} 1_A\right]^{-\frac{1}{2}}$$

We can define the correlation between inactive variable X_i with $(a_j)B_A$

$$a_j = \frac{1}{n} X_j' B_A = \frac{1}{n} X_j' X_A w_A = (D_A r_{jA})' w_A$$

Where r_{jA} is the correlation coefficient vector between inactive variables and Xj is the selected variable (without a sign). We found that to obtain these values we'll need the data correlation matrix (not the data itself). This is one of the benefits of the stepwise least angle regression algorithm. The least squares regression algorithm changes the current stepwise approximator angle in the direction B_A as much as $\boldsymbol{\gamma_A}$ obtained by the correlation of the variables. Obtaining the value for $\boldsymbol{\gamma}$ when we have two or more active variables. In equations (1) and (2) consider values r and r_j as follows:

$$r \leftarrow r - \gamma \quad , \quad r_j \leftarrow r_j - \gamma r_{jm}$$

Correlation between an active variable with the current residual means that $\boldsymbol{y - \hat{\mu}}$ equals $\boldsymbol{r/SD(y - \hat{\mu})}$ and the correlation between the active variable and the angle vector B_A equals a. Thus the correlation between an active variable and the residual has changed, ie, $y - \hat{\mu} - \gamma_A B_A$equals:

$$\frac{r - \gamma_A a}{SD(y - \hat{\mu} - \gamma_A B_A)}$$

The inactive variable $+X_j, j \in A^c$has $r_j/SD(y - \hat{\mu})$ correlation with the current residual and a_j has the same angle as B_A. Therefore correlation between $\boldsymbol{+X_j, j \in A^c}$ and the changed residual will be:

$$\frac{r_j - \gamma_A a_j}{SD(y - \hat{\mu} - \gamma_A B_A)}$$

By equating the above two equations we'll have:

(13)

$$r - \gamma_A a = r_j - \gamma_A a_j \qquad \Rightarrow \gamma_A(+X_j) = \frac{r - r_j}{a - a_j}$$

And similarly:

(14)

$$\gamma_A(-X_j) = \frac{r + r_j}{a + a_j}$$

Now we have to select the smallest possible $\boldsymbol{\gamma_A}$ value on all inactive variables.
In fact, when we have one variable, equations (13) and (14) are reduced to equations (3) and (4).

Now we can summaries the stepwise least angle regression algorithm considering the correlation between r_j and X_j and X_j and Y and correlation matrix R_x of the variables as follows:

1. $A = \varphi, \qquad s_A = \varphi$
2. $m = \arg \max |r_j|, \qquad s_m = sign\{r_m\}, \qquad r = s_m r_m$
3. $A \leftarrow A \cup \{m\}, \qquad s_A \leftarrow s_A \cup \{s_m\}$
4. *Calculate* $a == \left[1_A'(D_A R_A D_A)^{-1} 1_A\right]^{-\frac{1}{2}}$

   where $D_A = diag(s_A), \quad R_A \subset R_X$

   Calculate $w_A = a(D_A R_A D_A)^{-1} 1_A$

   and for $j \in A^c : a_j = (D_A r_{jA})' w_A$

Where $r_{jA}$is the correlation vector between X_j and active variables. When we only have one active variable:

$$a = 1, \quad w = 1, \quad a_j = r_{jm}$$

5. $for \;\; j \in A^c Calculate : \gamma_j^+ = \frac{r - r_j}{a - a_j}, \gamma_j^- = \frac{r + r_j}{a + a_j}$

$\gamma_j = \min(\gamma_j^+, \gamma_j^-)$, $\gamma = \min(\gamma_j, j \in A^c)$

If the index for *m* is *arg min*, we'll have $\gamma = \gamma_m$

$if \quad \gamma_m = \gamma_m^+ \quad then \quad s_m = +1 \quad esle \quad s_m = -1$

$for \quad j \in A^c \quad Modify \quad r \leftarrow r - \gamma a \quad , \quad r_j \leftarrow r_j - \gamma a_j$

Finally, 5 independent variables reflected in table 3 are selected. After selecting the independent variables of the problem, these independent variables are given to a FoGD algorithm. This algorithm is studied in the following

Table 3: Selected independent variables

Selected independent variable	Consistency with similar results
Systematic risk	Mohammadi & Karam.salehi (2017), Sayadi et al. (2019)
CEO change	Badavar Nahandi & Heshmat (2018), Lisic et al. (2016)
Ownership concentration	Harsini and Taghipoorian (2017)
Accounting committee members' financial expertise	Tavangar Hamze Kolaee & Eskafi asl (2018), Lisic et al. (2016), Sunti and Marvaning Sari (2018)
Stock return	Momtazian & Kazemnejad (2016)

After selecting the independent variables of the problem, these independent variables were given to the research algorithms to construct the model.

4.2. Data segmentation using a 10-point cross-validation method

Before entering data into the model, we need to divide them into two categories of training data and test data. For this purpose, a 10-step cross-validation method is used. In this method, the data set (a set of companies) is randomly divided into 10 equal parts, so that for the data of this study which is a total of 1246 samples, there are about 125 samples in each section which were randomly selected from 208 companies from 2011 to 2017. 10 pair sets of $\{x_i, y_i\}_{i=1}^{10}$ are randomly extracted where x_i is the independent variable and y_i is the dependent variable of the ith sample. In each run, 10 parts (10% of the data) are used for testing, the remaining 9 parts (90% of the data) are used as the training data. At each iteration, a prediction error rate for the training data and a prediction error rate for the test data are calculated and finally the average error rates are assigned as the error rates of the training data and the test data and the results are shown in the table.

4.3. Fourier online gradient descent approach (FOGD) and least absolute shrinkage and selection operator (Lasso)

Fourier online gradient descent approach seeks to solve the optimization problem (Relation No. 15) to obtain w_t online so that $\phi(x_t)$ from relation (16) is obtained and t indicates time.

(15)

$$f_t(x_t) = w_t^T \phi(x_t)$$

(16)

$$\min_{w} \quad {}_{inst}(\mathbf{w}, \lambda, t) = \ell\left(f_t(\mathbf{x}_t), y_t\right) + \frac{\lambda}{2}\|\mathbf{w}\|^2$$

To solve this problem, the Fourier online gradient descent approach uses the random descent gradient method. The updating rule of estimating the weights of the decision function is obtained by relation (17):

(17)

$$\mathbf{w}_{t+1} = (1 - \mu\lambda)\mathbf{w}_t - \mu\ell'\left(f_t(\mathbf{x}_t), y_t\right)\varphi(\mathbf{x}_t)$$

Where loss function MSE is defined as follows (relationship 18):

(18)

$$\ell'\left(f_t(\mathbf{x}_t), y_t\right) = \left(y_t - f_t(\mathbf{x}_t)\right)^2$$

Inserting relationship (17) in (18) we'll have the weight updating law as follows (relationship 19).
Relationship No.

(19)

$$\mathbf{w}_{t+1} = \mathbf{w}_t + \mu(y_t - f_t(\mathbf{x}_t))\varphi(\mathbf{x}_t)$$

The algorithm of this method is indicated in Figure 4. In this algorithm, the company-years of individual training enter the algorithm, respectively and the model weights are updated over time.

Input: the number of Fourier components D, step size η, kernel function k;
Initialize $\mathbf{w}_1 = 0$.
Calculate $p(\mathbf{u})$ for kernel k as (2).
Generate random Fourier components: $\mathbf{u}_1, ..., \mathbf{u}_D$ sampled from distribution $p(\mathbf{u})$
for $t = 1, 2, \ldots, T$ **do**
  Receive $\mathbf{x}_t$;
  Construct new representation:
  $\mathbf{z}_t(\mathbf{x}_t) = (\sin(\mathbf{u}_1^\top \mathbf{x}_t), \cos(\mathbf{u}_1^\top \mathbf{x}_t), ..., \sin(\mathbf{u}_D^\top \mathbf{x}_t), \cos(\mathbf{u}_D^\top \mathbf{x}_t))^\top$
  Predict $\hat{y}_t = \mathrm{sgn}(\mathbf{w}_t^\top \mathbf{z}(\mathbf{x}_t))$;
  Receive y_t and suffer loss $\ell(\mathbf{w}_t^\top \mathbf{z}(\mathbf{x}_t); y_t)$;
  if $\ell(\mathbf{w}_t^\top \mathbf{z}(\mathbf{x}_t); y_t) > 0$ **then**
    $\mathbf{w}_{t+1} = \mathbf{w}_t - \eta \nabla \ell(\mathbf{w}_t^\top \mathbf{z}(\mathbf{x}_t); y_t)$.
  end if
end for

Figure 3 - Fourier online gradient descent approach

4.4. Evaluation criteria for predicting management ability

FOGD algorithm was used to predict the dependent variable. Also, a 10-point cross-validation method is used for implementation and evaluation. In addition, without losing generality, the company—year folds divided in the 10-point cross-validation method are considered similarly for all the models. After dividing the company-years into two categories of training data and test data using the 10-point cross-validation method two evaluation criteria, namely Mean Absolute Error (MAE) and Mean Squared Error (MSE), were used to evaluate the models that are calculated based on relationships 20 and 21 below.

(20)

$$MSE = \frac{1}{n}\sum_{i=1}^{n}(y_i - d_i)^2$$

(21)

$$MAE = \frac{1}{n}\sum_{i=1}^{n}|y_i - d_i|$$

Where y_i and d_i are the real dependent variable and the dependent variable predicted by the algorithms for the ith year-company, respectively and n is the number of company-years (in the learning or evaluation phase) and $\bar{y}$ and $\bar{d}$ indicate average actual and predicted dependent variables respectively. After running the models learning process, in order to check how well the models have successfully completed the learning process, first, the same training data previously given to algorithms to learn their model parameters, is given as an evaluation sample to the model with learnt parameters, with the exception that this time the models predict the value of the dependent variable, then the average of 10error criteria of the10 cross-validation method is calculated and reported in table 4. In this table, only MSE-MAE errors are indicated. The closest these errors are to zero.

Table 4- MAE-MSE error mean to evaluate the amount of training in management ability model

Period	Current year		Next year		The year after next	
Error	MSE	MAE	MSE	MAE	MSE	MAE
Fold	FoGD	FOGD	FoGD	FOGD	FoGD	FOGD
1	0.0041	0.458	0.011	0.078	0.0097	0.0736
2	0.0041	0.0462	0.010	0.0777	0.0102	0.0744
3	0.0042	0.0463	0.011	0.078	0.0100	0.0740
4	0.0041	0.0461	0.010	0.078	0.0099	0.0738
5	0.0041	0.0458	0.010	0.076	0.0104	0.0739
6	0.0040	0.0453	0.011	0.078	0.0099	0.735
7	0.0041	0.0462	0.010	0.076	0.0100	0.07731
8	0.0040	4.0453	0.010	0.077	0.0101	0.0740
9	0.0039	0.0450	0.011	0.077	0.0101	0.0736
10	0.0041	0.0460	0.011	0.078	0.0098	0.0789
Mean	0.0041	0.0458	0.0105	0.0775	0.0100	0.0742

But what we have to worry about is the phenomenon of over-fitting. Therefore to test the generality of the provided model, MSE error rate for predicting the dependent variable of management ability for firms-years are excluded by the 10-step validation method. For each error criterion, there are 10 errors, each reported by the 10 cross validation method the average of which is shown in table 5. Similar to the previous one, it is concluded that the obtained models have generality, that is, they even work well for company-years that have never been seen before and also the problem of over-fitting hasn't happened, since the difference between the error criteria of the training data and the test data is negligible. The FOGD algorithm is the best predictive algorithm, followed by the Lasso algorithm.

Table 5 - Mean MAE error for evaluating the predictive power of management ability

Period	Current year		Next year		The year after next	
Error	MSE		MAE		MSE	
Fold	FoGD	FoGD	FoGD	FoGD	FoGD	FoGD
1	0.0039	0.0456	0.0095	0.0727	0.012	0.078
2	0.0038	0.0423	0.0018	0.0812	0.008	0.068
3	0.0029	0.0414	0.0082	0.0696	0.010	0.072
4	0.0038	0.0431	0.0110	0.0770	0.011	0.073
5	0.0036	0.0455	0.0154	0.0899	0.009	0.072
6	0.0049	0.0505	0.0077	0.0695	0.010	0.075
7	0.0041	0.0428	0.0115	0.0851	0.010	0.079
8	0.0084	0.0502	0.0120	0.0807	0.009	0.071
9	0.0052	0.0526	0.0098	0.0794	0.009	0.075
10	0.0037	0.0443	0.0083	0.0705	0.011	0.075
Mean	0.0041	0.0458	0.0108	0.0779	0.0100	0.0737

5. Discussion and Conclusions

More efficient and intrinsically capable executives can quickly gain an insight into their entity's business and industry, and select projects of higher quality and lower risk, therefore, management ability directly influences corporate sustainability (Delkhoushi & Farokhi, 2016). The importance of management is to the extent that in case of leadership crisis, the founders of the business and industrial units, provide the ground for starting the next evolution, namely growth through guidance by attracting capable executives. In the past, however, some believed that employees could perform managerial duties themselves and there is no need for an independent management unit. But according to historians and sociologists, not many institutions are found to have remained stable without administrative hierarchy (Glueck, 1977). In this research, using two groups of accounting and supervisory variables (corporate governance and audit committee), we attempt to explain and predict the amount of management ability using machine learning methods. Preliminary results indicated that systematic risk variables, CEO change, ownership concentration, financial expertise of the audit committee members and stock returns are more powerful explaining management ability using the least angle regression method. Analyzing these results, it can be stated that economic and market issues that happen as a result of external factors can greatly affect management ability. Also, since changing the CEO changes management ability, it can be concluded that management personality traits more than performance characteristics of the company, affect management ability and in addition, regulatory variables such as the characteristics of audit committee members and ownership concentration have been identified as factors influential on management ability. Generally, it can be stated that the role of market economics and management personality and supervisory characteristics of the company and finally, the performance criteria of the company influence management ability. With these results it can be said that corporate governance and oversight issues affect management ability beyond financial issues. According to our investigation, no similar studies were found but the results indicated here are in line with Mohammadi & Karam Salehi (2017), Sayadi et al. (2019), Badavar Nahandi & Heshamt (2018), Lisic et al. (2016), Harsini and Taghipoorian (2017), Tavangar Hamze Kolaei and Eskafi asl (2018), Lisic et al. (2016), Sunti and Marvaning Sari, Momtazian and Kazem Nejad (2016). Among other results we can mention the fact that in accounting issues to explain and predict continuous financial variables such as management ability, if the proper method is chosen for variable selection and the variables are correctly selected, the predictive power of the artificial intelligence algorithm would be very high. According to our evaluation, no research has been done to predict management ability using artificial intelligence algorithms and machine learning methods, but in the field of accounting, results of the research by Salehi and Farokhi (2018), Hejazi et al. (2012), Chlaki and

Yousefi (2012) are in line with this research and indicate that artificial intelligence algorithms have the ability to predict accounting variables with more power. The results indicated that systematic risk and corporate governance criteria have more power explaining management ability, therefore, it should be suggested to the decision makers of the company to expect efficiency and effectiveness through predicting the future economic and political conditions of the market correctly along with the regulatory features of the governance system, because management ability is largely influenced by economic and political conditions out of company control. The results of this research can also be applied by Tehran Stock Exchange managers. So that though analyzing the factors affecting management ability in companies and working on them, enhance management ability and avoid major loss by appropriate decisions.

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