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The Role of Managerial Ability, Enterprise Risk Management (ERM) in Reducing the Business Continuity Risk Using the Support Vector Machine (SVM) Model

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ABSTRACT

Background: This research examines the role of managerial ability in relation to integrated risk management and business continuity risk of companies through the use of the support vector machine (SVM) model to determine the business continuity risk index.

Methods: The support vector machine has been used to determine business continuity. The number of 180 companies listed on the Tehran Stock Exchange and 2160 years/ company observations from 2008 to 2020 (12 years) were investigated. The support vector machine model was used to measure the business continuity risks. The Ordinary Least Squares regression (OLS) was used to test the research hypothesis. The support vector machine (SVM) model was used to measure business continuity risks.

Results: The results indicate that the greater the managerial ability, the lower the business continuity risks. They also confirm that managerial ability is an important indicator in reducing business continuity risks. In addition, the managerial ability has a positive and significant relationship with Enterprise Risk Management.

Keywords: Managerial Ability, Business Continuity Risks, Enterprise Risk Management (ERM), Risk-Based Approach, Support Vector Machine (SVM).

1. Introduction

Businesses generally operate in unsafe environments. The increase and severity of uncertainty at the level of catastrophic events casts doubt on the executive continuity of organizations. The end result of such events is loss of revenue, customers, reputation, access to facilities, capital, and so on. To minimize the impact of these outcomes, and ensure business continuity, organizations must strategically use prevention, mitigation, preparation, accountability, and recovery (Singh, 2002).

Based on traditional models, it is obvious that the behavior of company managers is considered rational and it is assumed that they always maximize the value of the company. Thus, managerial heterogeneity is unlikely to play an important role in corporate decisions (Berk, 2007).

Evidence from research on corporate behavior has shown that managerial characteristics are one of the main determinants of corporate behavior (Graham, 2012. Kaplan, 2012). Among the various variables, the managerial ability also has a significant impact on the quality of corporate profits (Demerjian, 2017. Choi, 2015), including innovative activities (Chen, 2015). Creating bank liquidity (Andreou, 2016) and entering strategic markets (Goldfarb, 2011).

The role of controlling and reducing that risk has become so important that risk management has become a mandatory and vital issue (Blue, 2019). To meet their goals, companies face volatile conditions that may affect their success or failure. The rapid development of external and internal conditions also leads to more complex business risks (Sanjaya, 2015). To deal with such situations, companies must be able to provide appropriate management tools to manage risk (Shahsahebi, 2020) .

Effective risk management not only leads to more confidence in the business, but also increases the competitive advantage and value of the company. In fact, risk management is an integral part of corporate strategy. Such a measure is necessary to prevent and reduce risk to the lowest level of risk so that the company can survive in the competition. Improving the quality of risk management implementation can be done through integrated risk management (IRM), or the implementation of enterprise risk management (ERM) (Widjaya, 2013).

The purpose of implementing ERM is to create systems or mechanisms in the organization to be able to anticipate and manage adverse risks to increase company value (Iswajuni, 2018).

Companies have developed their strategies based on risk management and taking advantage of opportunities in the business environment, they can reduce risks as much as possible and use the opportunities to create value in the company. For this purpose, managers must have the ability to use appropriate frameworks to optimize company strategies and performance. Therefore, companies whose managers have the ability to deploy the Enterprise Risk Management (ERM) framework or key components such as risk appetite documents have achieved greater success in achieving the company's goals. Risk appetite at the board level is the amount of risk that an organization is willing to accept in order to create value (Hoyt, 2011).

The present study is an applied research, quasi-experimental and its methodology is post-event. Data collection tools included the codal comprehensive information network of and CDs of the Tehran Stock Exchange that were extracted manually. All research data are organized in Excel software and finally for multiple analysis as well as testing each of the hypotheses in this research, multiple regression and Stata Statistical Software have been used.

The research hypotheses were as follows:

- There is a significant relationship between managerial ability and Enterprise Risk Management (ERM)
- There is a significant relationship between Enterprise Risk Management (ERM) and business continuity risks.
- The managerial ability has a significant effect on the relationship between Enterprise Risk Management (ERM) and business continuity risks of the company.
- There is a significant relationship between managerial ability and business continuity risk of the company.

Methods

The present research is quasi-experimental, post-event, and applied. Data collection tools included the comprehensive information codal network and CDs related to the Tehran Stock Exchange Organization. All data are organized in Excel software and finally, multiple regression in Stata software was used for quantitative analysis and testing of each hypothesis.

The statistical population was all companies listed on the Tehran Stock Exchange. The study period included 2008 to 2020 (12 years). The sampling method was also screening or conditional. The screening was done through the following steps:

1) The statistical sample was only manufacturing and industrial companies.
2) The number of days of their trading interruption has been more than five days a year.
3) The studied companies have been members of the stock exchange since at least 2008.
4) The end of the fiscal year of the companies was March 20 or 30 of each year.
5) The information required by the company, especially the accompanying notes related to the financial statements, should be available.

Out of 871 member companies of the stock exchange, in this research, only 180 companies from 29 different industries were selected as a sample. Therefore, there were a total of 2160 items for each of the research variables. In other words 2160 years / company was analyzed.

The research model for testing the first hypothesis was as follows:

$ERM_{it} = \beta_0 + \beta_1 MA_{it} + \beta_2 SIZE_{it} + \beta_3 AGE^{1}_{it} + \beta_4 CASH_{it} + \beta_4 LEV_{it} + \beta_5 LOSS_{it} + \beta_6 OCF^{2}_{it} + \varepsilon_{it}$

The research model for testing the second hypothesis was as follows:

$BCR_{it} = \beta_0 + \beta_1 ERM_{it} + \beta_2 SIZE_{it} + \beta_3 AGE_{it} + \beta_4 CASH_{it} + \beta_4 LEV_{it} + \beta_5 LOSS_{it} + \beta_6 OCF_{it} + \varepsilon_{it}$

The research model for testing the third hypothesis was as follows:

$BCR_{it} = \beta_0 + \beta_1 MA_{it} * ERM_{it} + \beta_2 SIZE_{it} + \beta_3 AGE_{it} + \beta_4 CASH_{it} + \beta_4 LEV_{it} + \beta_5 LOSS_{it} + \beta_6 OCF_{it} + \varepsilon_{it}$

The research model for testing the forth hypothesis was as follows:

$BCRit = \beta 0 + \beta 1\ MAit + \beta 2\ SIZE\ it + \beta 3\ AGE\ it + \beta 4\ CASH\ it + \beta 4\ LEV\ it + \beta 5\ LOSS\ it + \beta 6\ OCF\ it + \varepsilon it$

In the above equation:

[1] - Firm age- The time between the initial creation of a firm and the present time (in years).

[2] - Operating Cash Flow (OCF): Measured by dividing cash flow from operating activities by the book value of total company assets.

The Enterprise Risk Management (ERM)

The Enterprise Risk Management (ERM) is introduced as an independent variable and the following four factors have been used to measure it:

ERM_{it} = Strategy $risk_{it}$ + Operational $risk_{it}$ + Reporting $risk_{it}$ + Compliance $risk_{it}$

Operational risk management is a variable that is measured as the input and output communication of the company in the company's operation process. Risk management of poor financial reporting increases the company's risk and will reduce the value of the company. The following relationship can be used to measure the reporting risk variable:

Reporting = |Normal Accrual| / | Normal Accrual+ Abnormal Accrual|

That Normal Accrual contains optional accruals that will be used to calculate the modified Jones model (1991) as follows:

$$TA_t / A_{i,t-1} = \alpha_1 \left(1 / A_{i,t-1} \right) + \alpha_2 \left(\Delta REV_t / A_{i,t-1} \right) + \alpha_3 \left(PPE_t / A_{i,t-1} \right) + \varepsilon_t$$

The nonaccrual loan also includes non-voluntary accruals that are calculated as follows:

$$NDA_t = \alpha_1 \left(1 / A_{i,t-1} \right) + \alpha_2 \left(\Delta REV_t - \Delta REC / A_{i,t-1} \right) + \alpha_3 \left(PPE_t / A_{i,t-1} \right)$$

TA_t = the sum of accruals per year

NDAt = Nonaccrual Loan

Ai, $^{t-1}$ = Total assets of the company (i) per year (T-1)

ΔREV_t = changes in net revenue from year (t−1) to year (t)

ΔREC_t = changes in accounts receivable in year (t)

PPE_t = property, plant, and equipment per year (t)

3α, 2α, 1α. = The Firm-specific Parameters

Increasing compliance risk management reduces the level of risk and increases the value of the company. The assessment of tax avoidance is calculated by measuring the effective tax rate by dividing the cash tax paid on the pre-tax profit multiplied by -1.

Support Vector Machine (SVM) Model

To evaluate the business continuity risks in the support vector machine (SVM) model, This algorithm finds a special type of linear models that get the maximum cloud margin. Maximizing the margin of the cloud

page leads to maximizing the separation between classes. The nearest training point to the maximum margin of the superpower is called the support vector. These vectors are used only to define the boundary between classes (Shin et al., 2005).

If the data is linearly separated, the SVM trains linear machines to produce the optimal level that separates the data without error and with maximum distance between the page and the nearest training points (support vector). If we define the training points as [xi, yi] and the input vector xi Є Rn and the value of the yi class i=1… L = {-1, 1 ،, then in the case where the data can be linear. The rules that differentiate binary decision making are as follows:

$$Y=\text{sign}\left(\sum yi\ \alpha i\ (X, X) + b\right)$$

Where Y is the transaction output; yi is the class value of the instructional sample and xi represents the internal multiplication. The vector x = (x1, x2… x3) represents an input data and the vectors i = 1… N, Xi are backup vectors. In the following relation, the parameters ai and b determine the cloud page. If the data are not linearly separable, the above relation changes to the following relation:

$$Y=\text{sign}\left(\sum yi\ \alpha i\ K(X, Xi) + b\right)$$

The K (X, Xi) function is the kernel function that generates internal multiplications to create machines with different types of nonlinear decision levels in the data space. The polynomial kernel function for estimating the backup vector machine model is:

$$K(x, y) = [g(x, y) + c]\ d$$

The d also indicates the degree of the polynomial.

Measure Managerial Ability

In the present study, in order to measure managerial ability, the model of Demerjian et al. (2012) has been used. In this model, the managerial ability is evaluated by measuring the firm performance, entering the results in multivariate linear regression as an independent variable, and controlling the inherent characteristics of the firm.

$$\text{Max}\ {}_{v}\theta = \frac{sales}{v1\ COGS+v2\ SG\&A+v3\ net\ PPE+v4\ OpsLease+v5\ R\&D+v6\ Goodwill+v7\ Intan}$$

The variables of this model are:

Cost of Goods Sold (COGS), general, and administrative expenses (SG&A), Property, Plant & Equipment (PP&E), operating Leases (OpsLease), Research and development (R&D), Goodwill, purchased at the beginning of the year, and intangible assets (Intan) at the beginning of the year.

Demerjian et al. (2012) have divided company performance into two distinct parts, namely performance based on the inherent characteristics of the company and managerial ability. This process is done by controlling five intrinsic characteristics of the company, company size, company market share, company cash flow, listing process, and exports. Each of the inherent characteristics of the company may help the company's managers to make better decisions. In the following model presented by Demerjian et al. (2012), these five features can be evaluated and controlled. (Shahsahebi et al.,2020)

$$\text{Firm Efficiency} = a0 + a1\ \text{Size} + a2\ \text{Market Share} + a3\ \text{Free Cash Flow Indicator} + a4\ \text{Age} + a5\ \text{Foreign Currency Indicator} + \varepsilon$$

The above model, like Data Envelopment Analysis (DEA), must be evaluated at the industry level.

Research Findings

BCR variable estimation using SVM model:

To evaluate the business continuity risks in the support vector machine (SVM) model, its related equipment (zeros and ones) should be considered. Then, the business continuity risk values obtained from the first step must be entered into the support vector machine (SVM) model.

The steps related to designing the business continuity risks forecast model (BCR variable) using the Support Vector Machines model were as follows:

1) In order to eliminate the effects of out-of-bounds or limit observations, all variables at the 95% level were vinified. We combined many selected models in one set and used this statistical conversion.

2) All input changes of the obtained models and changes with correlation above 0.8 were deleted.
3) Samples of the year - the company was divided into two parts: training (for model design) and experimental part (for model testing). In this division, we used 60% of the company's cases for training and 40% for testing.
4) Samples of the year - The Company used in the training department in order to better evaluate the balanced model and sampling of some of the target changes. In this research, the Random under-sampling method has been used for balancing.
5) Combining different modes of the selected models, 2047 hybrid models are made, from which the best model with the highest predictive power and higher accuracy is selected for the test sample.
6) The final model was selected after testing all the designated models for all observations and fabrication of BCR types.

Indicators required to build a BCR are;

- The Gross Profits to Assets (GPA)
- Asset turnover
- logarithm of Total tangible assets
- logarithm before interest and tax
- net income by total assets
- working capital to total assets ratio
- and the Earnings Before Tax (EBT) to current liabilities.

The selected model was able to **accurately predict 88.11%** of business continuity risks.

In this section, central **indicators such as** mean and scatter indices of standard deviation, skewness, and elongation are presented for each of the research variables.

The summary of the descriptive statistics related to the model variables is presented in the table below.

Variable	Number of observations	Mean	Standard Deviation	Minimum	Maximum
BCR	2160	1.472143	1.839636	12.22095	-1.358209
MA	2160	0.0000514	0.1965322	0.6971842	-0.4563244
ERM	2160	1.48408	1.120537	6.968603	0.12323
Size	2160	14.30044	1.68196	19.05065	10.03122
Age	2160	3.534712	0.4586938	4.204693	2.197225
Cash	2160	6.668735	7.808326	42.37449	0.1433678
Lev.	2160	0.5878946	0.2062185	2.077506	0.06106258
OCF	2160	0.3179998	0.5251614	3.643242	-1.040863
Loss	2160	0.1035354	0.3047338	1	0

Looking at table 1, it can be seen that among the variables, company size has the highest average value of 14.3. By considering the standard deviation of the variables, it is clear that the variable distribution of cash and the risk of continuity of activity with the values of 7.8 and 1.8 have more dispersion than the distribution of other variables, and this means that these variables have more severe fluctuations than to other variables.

Testing hypothesis

First hypothesis test

The **first** hypothesis states that there is a significant relationship between managerial ability and organizational risk management.

$$ERM_{it} = \beta_0 + \beta_1 MA_{it} + \beta_2 SIZE_{it} + \beta_3 AGE_{it} + \beta_4 CASH_{it} + \beta_4 LEV_{it} + \beta_5 LOSS_{it} + \beta_6 OCF_{it} + \varepsilon_{it}$$

The model with fixed effects

Firstly, we estimated the model with fixed effects modeling. In this model, it is assumed that each company has a certain width of origin. If this assumption is rejected, then instead of the fixed effects modeling, we should consider the model with integrated data, because the assumption of uniqueness and specificity of width is rejected from the origin (Table 1). Since the p-value is less than 5%, it can be said that the null hypothesis that all virtual variables related to companies are ineffective is not rejected and at least one of them is significant. Therefore, the fixed

effects modeling is preferable to the model with integrated data.

The model with random effects

In this estimation, it is assumed that the difference in width from the origin of the companies is randomly distributed. To examine whether there is any difference between the model and stochastic effects and the combined data for the sample under study, we use the Breusch–Pagan test (Table 2). The null hypothesis in this test is that the variance of random effects is zero. Given that the Prob-test is less than 5%, the null hypothesis is rejected and the model with random effects is preferred over the integrated model.

The Hausman test

In fact, the Hausman test examines the differences in the coefficients of these two regressions random and fixed effects models to panel data. The result of the Hausman test is given in the table below. The Hausman test results table for choosing between fixed and random effects modeling. The Hausman test identifies predictor variables in a regression model (Table 3).

Since the test statistic was more than 5%, the null hypothesis was not rejected. Consequently, the model with fixed effects modeling is less efficient than random effects. We also used the robust standard deviation in interpreting the coefficients.

The results of the first hypothesis test

The results of the first hypothesis test show that the overall determination coefficient of the model is equal to 33%, which indicates that 33% of enterprise risk management (ERM) changes are correctly explained by the independent variables of the model. Since the p-value < 5% for managerial ability, the null hypothesis that indicates this variable is meaningless has been rejected. Accordingly, the p-value is considered significant and the hypothesis is confirmed. Its number means that if MA increases by one unit, ERM increases by 0.56 units. Since the p-value of the significance test of the coefficient of Age, loss and OCF is more than 5%, it can be said with a confidence level of 95% that the null hypothesis that the coefficient is meaningless has not been rejected, and therefore the coefficient is not statistically significantly different from zero. As a result, the variables of firm age, loss, and operating cash flow (OCF) have no effect on ERM (Table 4).

Second hypothesis test

The **second** hypothesis states that "there is a significant relationship between Enterprise Risk Management (ERM) and business continuity risks".

$BCR_{it} = \beta_0 + \beta_1 ERM_{it} + \beta_2 SIZE_{it} + \beta_3 AGE_{it} + \beta_4 CASH_{it} + \beta_4 LEV_{it} + \beta_5 LOSS_{it} + \beta_6 OCF_{it} + \varepsilon_{it}$

The overall design coefficient of the model is 54%, which indicates that 54% of the dependent variable (BCR) changes are explained by the model variables, especially Enterprise Risk Management (ERM (. Since the p-value of the ERM coefficient significance test is less than 5%, it can be said that the null hypothesis that the coefficient is meaningless at the 5% significance level is rejected and the relationship between Enterprise Risk Management (ERM) and business continuity risks are confirmed. This relationship is inverse and significant.

Since the p-value of the log of firm age is more than 5%, it can be said that with a 95% confidence level, the null hypothesis that the coefficient is meaningless is not rejected and therefore the coefficient is not statistically much different from zero. As a result, it can be said that the log of firm age has no effect on BCR (Table 5).

Interpretation of the activity continuity risk index for better understanding:

- BCR is the business continuity risk index that we made by SVM model. According to the SVM model, the higher the result on the right side (7 selected financial indicators), the lower the risk of the company's continued activity.
- The number of BCR should be in the same direction as ERM so that we can say that organizational risk management has an inverse relationship with business continuity risk.
- The smaller and more negative the BCR number is, the higher the risk of the company's continued activity.
- The higher the BCR number is, the lower the risk of the company's continued activity.

Third hypothesis test

The **third** hypothesis states that managerial ability has a significant effect on the relationship between Enterprise Risk Management (ERM) and business continuity risks.

$BCR_{it} = \beta_0 + \beta_1 MA_{it} * ERM_{it} + \beta_2 SIZE_{it} + \beta_3 AGE_{it} + \beta_4 CASH_{it} + \beta_4 LEV_{it} + \beta_5 LOSS_{it} + \beta_6 OCF_{it} + \varepsilon_{it}$

Since the p-value of the significance test of the lnage coefficient is more than 5%, it can be said with a confidence level of 95% that the null hypothesis that the coefficient is meaningless has not been rejected, and therefore the coefficient is not statistically significantly different from zero. As a result, it can be said that age has no effect on BCR.

The coefficient of determination of the model is equal to 54%, which indicates that 54% of changes in the dependent variable of the model (i.e. BCR) are explained by independent variables. Since the p-value of the ERM significance test is less than 5%, the null hypothesis that it is meaningless is not rejected at the 5% significance level and is therefore statistically significant.

Likewise, the p-value of the significance test of ERM related to MA is less than 5%. Therefore, the null hypothesis that the coefficient is meaningless at a significance level of 5% is not rejected and the coefficient is statistically significant. Considering the significance of these two coefficients, it can be said that the effects of an increase in ERM on BCR are a function of MA and can be rewritten as follows.

$$\frac{\Delta BCR}{\Delta ERM} = 0.23 + .24MA$$

It can be concluded that the MA variable has a positive effect on the relationship between ERM and BCR. Since the p-value of the log of firm age significance test is more than 5%, it can be said that with a 95% confidence level, the null hypothesis that it is meaningless is not rejected and therefore is not statistically much different from zero. As a result, it can be said that the firm age has no effect on BCR (Table 6).

Forth hypothesis test

The **forth** hypothesis states that "there is a significant relationship between managerial ability and business continuity risks".

BCRit =β0 + β1 MAit + β2 SIZE it + β3 AGE it+ β4 CASH it+ β4 LEV it+ β5 LOSS it+ β6 OCF it + εit

In the estimation table of the model with fixed effects, the F test indicates that at least one of the sources has a significant difference from zero, since the p-value of the test is less than 5%, it can be said that the null hypothesis is that all virtual variables related to Companies are not rejected and at least one of them is significant. Therefore, the model with fixed effects is preferred over the model with pooled data. The zero assumption in Pagan Brosh test means that the variance of the random effects is zero. Considering that the test prob is less than 5%, the null hypothesis is rejected and the model with random effects is preferred over the integrated model. Considering that the test statistic is more than 5%, it can be said that the null hypothesis that there is no systematic difference in the coefficients has not been rejected, and therefore the model with fixed effects is less efficient than the random effects model, and in the following we will use regression with random effects. . Since there is group variance heterogeneity in panel data with random effects, we use robust standard deviation to solve such a problem in interpreting coefficients.

The interpretation of the model has shown that the overall determination coefficient of the model is equal to 56%. In other words, 56% of dependent variable changes (BCR) are explained by model variables, especially managerial ability.

Since the p-value is less than 5%, it can be said that the null hypothesis is rejected at this level of significance and the relationship between managerial ability and risk of continuing activity is confirmed. Therefore, this relationship is inverse and significant.

Since the p-value of the significance test of the coefficient of the firm age is more than 5%, it can be said that with a confidence level of 95%, the null hypothesis is not rejected and therefore the coefficient is not statistically much different from zero. As a result, it can be said that the firm age has no effect on Business Continuity Management (BCR) (Table 7).

In fact, the Business Continuity Management (BCR) is built on the SVM model. According to Support Vector Machine (SVM), the more selected seven financial indicators, the lower the risk of the company continuing to operate. The BCR should be in line with managerial ability (MA) so that managerial ability is inversely related to the risk of continuing activity. The smaller and negative the BCR, the higher the Risks of Business Continuity and vice versa.

Conclusion

In order to be successful in today's markets, organizations must take an integrated approach, so that they can invest in the values gained from promoting risk management. Such an approach should balance

financial and non-financial risks in the short and long term, take into account emerging legal and managerial expectations, produce tangible results, and maximize the benefits associated with the costs incurred. This approach is called “Risk Governance". Many bankruptcies have been caused by the accumulation of undiagnosed risks over time and eventually by exceeding the system tolerance threshold. This factor has played a decisive role in the crisis of 2008-2009.

Numerous studies show that after the global financial crisis, risk appetite and integrated risk management have been widely considered important concepts, and the framework of “Risk appetite” have become a key to linking “Company's Strategy” with risk management (Lawson. 2013. Kaplan, 2012).

Risk appetite and managerial ability in order to respond transparently, are the focus of the competent authorities on attracting more capital and liquidity to reduce business continuity risks. Senior managers should consider risk appetite in the context of Enterprise Risk Management (ERM) implementation and define operational objectives, formulate strategy, allocate resources, determine risk tolerance levels and develop risk management capabilities.

The findings of this study show that managerial ability is very important in reducing the business continuity risks of companies by applying the concept of risk appetite. The more capable the management is in developing and using risk appetite documents, the more activities are covered by the risk management process and the more parts of the company are involved in preventing and counteracting the risks of continuing operations. Therefore, managerial ability is defined as the main indicator of reducing business continuity risks.

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