

## Meta Analysis of the Impact of Factors Related to Research Structure on the Strength of Bankruptcy Prediction Models and Variables

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### ABSTRACT

bankruptcy is one of the most important challenges that firms and businesses in an economic system of any country confront. In this respect they are searching for methods for estimating financial bankruptcy of the firms. Many case studies have been performed in estimating firms' bankruptcy prediction models, while this article by using meta analysis approach, tries to recognize the impact of variables related to the existing research structure, i.e. kind of regression model, and type and number of independent variables used in models on the strength of bankruptcy prediction models and variables. The statistical populations of the survey are bankruptcy models performed during 1960 to 2011 published in article, thesis, and research report, or have been reached to the surveyor in other ways. Findings imply that the kind of regression model used in surveys impacts on the strength of prediction ( $R^2$ ) and effectiveness intensity (t-Statistic) of bankruptcy variables, while the type of independent variables does not influence and the number of independent variables does not impact on the strength of predicting bankruptcy models either.

**KEYWORDS:** Meta Analysis, Bankruptcy, Bankruptcy Prediction Models, Research Structure

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### 1. INTRODUCTION

Bankruptcy, economical failure or technical insolvency is one of the most important challenges that firms and businesses in an economical system of any country confront. Many direct and indirect expenses that bankruptcy imposes on firms clarify the necessity of special consideration towards it in scientific studies<sup>[1]</sup>. All the studies regarding bankruptcy models have been performed as case or field studies<sup>[2]</sup>. But restrictions of field studies has led this survey with a Meta analysis approach to introduce a more comprehensive and general model than field studies (that has been performed regarding to the defined research structure, and unique variables). Among weaknesses of field studies that can be removed in a Meta analysis is to investigate the impact of some of the justifying variables such as the number of samples, research methodology, analysis level, data analysis method, type of data, period of data collection, and the type of economical section and the features of country under study, and the results and strength of predicting bankruptcy models<sup>[3-5]</sup>.

As an example, Beaver (1966) is the first person who introduced a model for predicting firms' bankruptcy by using financial ratios. He used univariate analysis in his model<sup>[6]</sup>. In his way, a person called Altman (1968) introduced a model for predicting bankruptcy by using Multiple Discriminant Analysis (MDA). The mentioned model became a road map for introducing modified and more accurate models in future<sup>[7]</sup>. Taffler (1983) used the information related to England, by using Z-score model predicted bankruptcy of 99 percent of English firms one year before their bankruptcy<sup>[8]</sup>. Discriminant analysis, because of reduction of unilateralism errors has been used as a model for predicting firms' bankruptcy (in specific time, national, and research structure conditions) in a form of field or case study<sup>[7,9]</sup>.

The surveyor's major concern that made this survey is that the strength of predicting of models and variables of bankruptcy prediction can be improved? Thus, in this survey compared with other studies, the subject of bankruptcy and the models of predicting it are dealt with in different way. In fact in this survey by Meta analysis approach it is tried to analyze the field studies of predicting bankruptcy that has been performed previously and to identify the factors related to survey structure that are effective in models' strength of predicting. These factors that their samples have been mentioned will be introduced later and in the part of testing hypothesis, their impact would be measured.

On this basis, in the second part a review of bankruptcy concept and previous studies on bankruptcy prediction and also variables used in predicting models will be done. In the third part, factors related to research structure that impacts on the strength of predicting bankruptcy models are discussed and survey's pattern will be

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introduced. In the fourth part Meta analysis that has seldom been used in internal studies will be explained. The findings obtained from testing model will be presented and in the fifth part and in the sixth and seventh part conclusions obtained from this survey and applicable and researching suggestions will be proposed.

## 2. Financial Failure or Bankruptcy and its Models

Among different studies in respect of goals and study area, there are various definitions for business bankruptcy<sup>[7,10]</sup>. Tavlin *et al.* (1989) to show business bankruptcy have used three terms: economical failure, technical insolvency in paying operational liabilities, and bankruptcy. While economical failure means that business expenses exceed revenues of the firm, technical insolvency refers to a situation in which the firm has positive net worth and profits but has insufficient liquidity to meet current liabilities insolvency in paying operational debts. Bankruptcy is a condition in which the firm has negative net worth as well as illiquidity and is in the legal process of reorganization or dissolving<sup>[11,12]</sup>.

Based on the United States Trade Law, when a firm confronts with bankruptcy, it should follow these steps: firstly it reconstructs its structure and provided that the problem still remains the firm inevitably is dissolved and should fulfill settlement process. Based on paragraph 7 of United States Trade Law (that is related to firms' dissolution and its settlement process) firms' assets subsequently will be dissolved for paying unsettled liabilities by spectators, and finally the firm's legal life will be terminated. However many large firms when confronting with bankruptcy choose paragraph 11 (reorganization). Based on paragraph 11 a bankrupted firm can still continue control and business beneficiary and is allowed to compile and formulate reorganization plan. The major content of paragraph 11 indicates that provided that a firm confronts with bankruptcy (and it is unable to pay its debts), it can pay all its debts by reorganization, and withdraw itself from among bankrupted firms, and is regarded as sustainable firm<sup>[13]</sup>. Those firms that are unable to reorganize themselves should ultimately fulfill the process of firm's dissolution that is mentioned in paragraph 7<sup>[12]</sup>.

In Tehran Stock Exchange, amendment article 141 of Trade Law is the criteria of bankruptcy and exiting of firms from it. This article says: provided that at least half of the firm's assets are lost because of damages incurred, board of directors is required to invite stockholders immediately for an extraordinary general assembly to consult and judge about firm's dissolution or survival. Whenever the general assembly does not poll dissolution of the firm, it should reduce the firm's capital to the amount of available capital at the same session observing the regulations of article 6 of this Law<sup>[14]</sup>. Bankruptcy studies indicate that almost all bankrupted firms are not bankrupted overnight, but factors impacting on firms' bankruptcy are resulted in a period of time. These factors in the years leading to bankruptcy are used as the signs used in predicting bankruptcy. Thus using alarming signs created before bankruptcy would definitely prepare the firms to prohibit bankruptcy and managing its expenses.

Van Horne (1998) refers to the point that analyzing financial ratios assists considerably predicting firms' bankruptcy. In many studies it has been specified that the probability of firms' bankruptcy is embedded in their financial statements and this probability can be recognized by analyzing financial statements<sup>[15]</sup>.

Later the factors of bankruptcy prediction are briefly introduced to be discussed in continuation as one of the factors impacting on the strength of bankruptcy prediction models.

Some of the surveyors to identify the factors of predicting firms' bankruptcy have categorized the firms under study into two groups of bankrupted and non-bankrupted and have investigated the differences between them in respect of firms' features and financial characteristics. Many of these studies have evaluated financial ratios as the most effective factors on bankruptcy<sup>[3, 5, 16-20]</sup>. Altman (1968) by calculating the firms' bankruptcy score known as Z-score designed a special model for predicting firms' bankruptcy by using their financial performance<sup>[7]</sup>. Then in later studies the method and model of Altman was developed<sup>[21-23]</sup>. The criteria used in bankruptcy prediction models include simple financial ratios and compound financial ratios (ratios obtained by combining several simple ratios). The criteria used by Altman for bankruptcy prediction is the weight average of five financial ratios that their coefficients or the weight of each one of ratios has been obtained in one experimental study (by Discriminant Analysis method). These five ratios are: Working capital to total assets, Retained earnings to total assets, Earnings before Interest and Taxes (EBIT) to total assets, Market value equity to book value of total assets, and Sales to total assets<sup>[24]</sup>. For predicting the failure of firms, Bevear (1966) also investigated 30 financial ratios related to five years before their failure. The results indicated that only five financial ratios were useful for predicting firms' failure that are: Cash-flow to total debts, Net-income to total assets, Total debts to total assets, Working capital to total assets, and Current ratio<sup>[6]</sup>. Many other studies have been performed since then<sup>[3, 9, 19, 25-31]</sup> and since Meta analysis nature of this survey and different views that it has towards bankruptcy, there is no room to discuss more about them.

Another method in studying firms' bankruptcy is those studies that compare prediction methodologies. As an example Alfaro *et al.* (2008) performed a comparative study between Neural Network Model and Decision Tree in order to predict firms' bankruptcy<sup>[33]</sup>.

Others have compared regression based methods with neural network based method or other methods. Anyway, in this survey the analysis level is only based on bankruptcy prediction models that have used regression method for estimating coefficients.

### 3. Effective factors on the strength of bankruptcy prediction models

As it was stated before, common studies related to bankruptcy divide the firms into bankrupted and non-bankrupted, and then using logistic regression method or Discriminant Analysis, the bankruptcy is defined as dependent variable, and a series of variables some of which were mentioned in the previous part are defined as independent variable. By estimating the coefficient effect of these variables on bankruptcy in a statistical population of firms, bankruptcy prediction model is designed. Then by using the data of next years' or some other firms that did not exist in the major sample and by assistance of the designed model, the firms' bankruptcy is predicted and is compared with real conditions that in few percent of cases have been recognized correctly by the mentioned bankruptcy model. In performing regression based models, the determination coefficient value indicates the strength of model as a whole in bankruptcy prediction and the amount of test statistic  $t$  for estimating impact coefficient of each one of the independent variables demonstrates the role of that variable in bankruptcy prediction. It is obvious that each one of the mentioned studies of bankruptcy prediction is in a unique condition in respect of the number of used variables, country under study, the year of study, and so on. Since the subject of this survey is to find out how performing conditions of bankruptcy models impact on the strength and role of variables of bankruptcy prediction, two questions should be answered. Firstly how strong each one of the models or variables of bankruptcy prediction performed in the previous studies has been (determination coefficient of the whole model)? Secondly, how effective the variables used in the mentioned model has been in bankruptcy prediction (the amount of test statistic for each variable); and how were the conditions of performing each model? On this basis, the impact of conditions of performing the model on the strength of model and the role of independent variables can be measured. Now the question is that what are the conditions of performing model that impact on the strength of model or the strength of variable (the results of previous field studies)? This has not been performed regarding bankruptcy studies yet. Thus in this part of the article referring to the previous Meta analysis actions in various subjects and experts' viewpoints, it is tried to design some of these recognition conditions for planning the major model of survey (that its independent variable is the conditions of performing model and its dependent variables are the strength of model and variables).

Many researchers including Kazuyuki (2003), Landauer (1995), Mahmood and Swanberg (2001) believe that the method of survey impacts on the results of studies that measure relationship between two variables<sup>[34-36]</sup>. Bevear's findings (1966) indicate that univariate analysis of financial ratios can be applied in predicting firms' failure five years before failure<sup>[6]</sup>. Unlike Bevear's studies that has used univariate analysis; many of the studies about firms' failures have used multivariate analysis method that can consider the impacts of several variables in predicting firms simultaneously.

On this basis, the first and second hypotheses of this survey are:

1. The designed regression model in the surveys of bankruptcy prediction impacts on determination coefficient ( $R^2$ ) of the model.
2. The designed regression model in the surveys of bankruptcy prediction impacts on effectiveness intensity ( $t$ -Statistic) of dependent variables applied in the existing models.

Another effective factor that seems to impact on the strength of the bankruptcy prediction models is the number and type of dependent variable used in the survey. In this regard Garcia-Meca & Sánchez-Ballesta (2006) claim that in order to understand the reasons of change in the results of experimental studies, these studies should be classified based on the chosen type of dependent and independent variables. On the other hand, in regression equation literature this point is discussed that increasing the number of independent variables changes the amount of determination coefficient<sup>[37]</sup>. In Bevear's study the firm's failure had a wide definition that includes unpaid bonds, non-payment of the profit of preferred stock, excessive withdrawals from firm's bank account, and bankruptcy<sup>[6]</sup>. On this basis, other hypotheses of this survey are as follows:

3. The number of independent variables used in the surveys of bankruptcy prediction impacts on determination coefficient ( $R^2$ ) of the model.
4. The type of independent variables used in the surveys of bankruptcy prediction impacts on the effectiveness intensity ( $t$ -Statistic) of independent variables used in the existing models.
5. The type of independent variables used in the surveys of bankruptcy prediction impacts on determination coefficient ( $R^2$ ) of the model.

### 4. META ANALYSIS AND RESEARCH METHOD

Fitzgerald and Rumrill (2003) quoting Glass(1976) in defining Meta analysis writes: Meta analysis is the "statistical analysis of a large collection of analysis results from individual studies for the purpose of investigating the findings"<sup>[38,39]</sup>.

Because of novelty of Meta analysis as a research approach, it is essential in this part to provide working method with more detail than what is common in articles.

Meta analysis is a research approach that assists much the surveyor to access an appropriate combination of quantitative results of previous conflicting and non-conflicting studies, to describe paradoxes, and to recognize justifying structural variables in the results of previous studies. Meta analysis assists surveyors to reach to more accurate and more reliable results than what has been obtained in each one of the field studies or quantitative survey of all previous studies. Meta analysis has many applications in correlation and cause analysis, investigating effects, and recognizing components of one phenomenon and can provide valuable information for scientists of a subject to orient future studies. This approach provides opportunity for surveyors to recognize mentioned paradoxes and also describe its reasons, whereby minimize more effectively errors of types one and two, and from executive dimension suggest conditions to the executors of developmental plans that by observing them the desired results are usually obtained from relations between variables <sup>[40]</sup>. The first Meta analysis has been performed by Karl in 1904. About two decades after twenty century it was also developed in fields like biomedicine, and behavioral sciences <sup>[40]</sup>.

In order to understand Meta analysis method better, it is essential to describe its major phases. The major phases in Meta analysis are: 1) Definition of subject, 2) Systematic collection of performed studies, 3) Screening the studies and choosing studies appropriate for Meta analyses <sup>[41]</sup>. In order to purify the articles two main indicators were considered: A) The articles should solely measure the relationship between dependent and independent variables of this survey, B) The articles should provide necessary information for extracting the effect size (relationship strength). 4) Collecting information related to the results of each study and conditions governing it, 5) Investigation of the relationship between survey's conditions and its results.

Because of special nature of Meta analysis studies, in continuation the survey method in this article will be described based on Meta analyses phases. In this survey, analysis unit is regression models in bankruptcy prediction so as independent variable is model's features and dependent variable is the strength of predicting model as a whole, and the strength of predicting each one of model's variables. The statistical populations of survey are performed bankruptcy models in the article, thesis, research report that published or have been reached to the surveyor in other ways. Since determining the total number of society is impossible, in this approach generally those studies are contended that have been reached to the surveyor. In this survey 118 experimental studies have been collected in which bankruptcy prediction model has been applied. But in screening these 118 studies, 50 studies has used regression method in order to estimate model among which the information of 30 studies for Meta analysis have been distinguished appropriate, and in these studies 40 bankruptcy prediction models have been recognized for investigating tests related to determination coefficient. Moreover, totally 242 independent variables have been applied in these models that have been used in order to investigate tests related to effectiveness intensity of independent variables. Information obtained from various studies is the year of publication, author's name, title of article, number of samples, time period under study, country, analysis method, the number of variables used in prediction, determination coefficient value of prediction, amount of test statistic related to the impact of each variable in model and so on. Survey's independent variables include test statistic of each bankruptcy prediction variables and determination coefficient of performed models. Independent variables according to the compiled hypothesis in the previous part also include the designed regression model type, the number of independent variables and type of independent variable. In order to test each one of the hypothesis, regarding the type and scale of independent variables, various methods according to the table 1 have been used:

**Table 1: Method of information analyses for each one of survey's hypothesis**

Hypothesis Number	Independent Variable	Dependent Variable	Scale of Independent Variable	Applied Analyses Method
1	Regression Model Type	Determination Coefficient (R2) of Bankruptcy Prediction Model	Nominal, Two Values	Independent-Sample T-test
2	Regression Model Type	Effectiveness Intensity of Independent Variables Applied in Bankruptcy Prediction Models (criterion test: t-Statistic)	Nominal, More than Two Values	Independent-Sample T-test
3	Independent Variables Type	Determination Coefficient (R2) of Bankruptcy Prediction Model	Nominal, More than Two Values	ANOVA
4	Independent Variables Type	Effectiveness Intensity of Independent Variables Applied in Bankruptcy Prediction Models (criterion test: t-Statistic)	Nominal, More than Two Values	ANOVA
5	Number of Independent Variables	Determination Coefficient (R2) of Bankruptcy Prediction Model	Continuous	Correlation

## 5. FINDINGS

### Hypothesis 1:

In numerous articles applied in this survey, two simple and logistic regression models have been used to estimate bankruptcy prediction models [4, 5, 17, 42]. Therefore from now on articles are categorized into two groups. In order to investigate the hypothesis related to the impact of regression model type designed in surveys of bankruptcy prediction on model's determination coefficient, the equality test of the average of two communities has been used.

The obtained results of test (Table 2) indicates that significant related to Levene's test equals 0.009 and is less than 5 percent significant level, leading to rejection of the hypothesis of equal variance, therefore aforementioned information, assuming variances to be unequal, has been used for conclusion about the above hypothesis. Significant equal test of averages, assuming that unequal variances are less than 5 percent, then this claim that the impact of regression model type used in bankruptcy prediction models on determination coefficient value model is accepted, and considering obtained values in confidence distance of this test, the impact that logistic regression method has on model's determination coefficient is more than the impact of simple regression method.

**Table 2: Findings related to the first hypothesis**

Hypothesis	Significant	Accepted	Rejected	Low Confidence Distance	High Confidence Distance
No. 1	0.011	✓		0.46456	3.52283

### Hypothesis 2:

In order to investigate the hypothesis related to the impact of designed regression model type in the surveys of bankruptcy prediction on effectiveness intensity of model's independent variables, the equality test of the average of two communities has also been used. Since the significant related to Levene's test equals to 0.000 and is less than 5 percent significant level, the hypothesis of equal variances is rejected and considering the significant ratio related to equality test of the averages, assuming variances to be unequal that is equal to 0.002, it can be concluded that the applied regression model type in designing bankruptcy prediction models impacts on effectiveness intensity of model's independent variables, and the impact ratio of simple regression method is more than logistic regression (Table 3).

**Table 3: Findings related to the second hypothesis**

Hypothesis	Significant	Accepted	Rejected	Low Confidence Distance	High Confidence Distance
No. 2	0.000	✓		-9.93857	-2.52868

### Hypothesis 3:

Independent variables applied in bankruptcy prediction models can be categorized in groups as follows:

- Ratios indicating the structure of firm's capital (Capital structure ratios).
- Ratios indicating firm's resources circulation (Performance ratios).
- Ratios indicating firm's profitability (Profitability ratios).
- Ratios investigating liquidity ratio and working capital in the firm (Liquidity ratios).
- Ratios indicating firm's external affairs and variables that are not under direct control of firm's managers (National environment variables).
- Other variables not suitable to be placed in the above groups.

In order to investigate this claim that the type of independent variable used in bankruptcy prediction model will impact on determination coefficient of the model, analyses of variance test has been used.

The results of table 4 indicate that regarding the amount of test significant, this hypothesis is not accepted. In other words the type of independent variables in bankruptcy prediction models has no impact on determination coefficient of the model.

**Table 4: Findings related to the third hypothesis**

Hypothesis	Accepted	Rejected	Significant
No.3		✓	0.607

### Hypothesis 4:

Regarding Table 5 It is obvious that the type of independent variables used in bankruptcy prediction models has no impact on effectiveness intensity of independent variables.

**Table 5: Findings related to the forth hypothesis**

Hypothesis	Accepted	Rejected	Significant
No.4		✓	0.301

Hypothesis5:

Regarding the number of independent variables used in various models and the results obtained from coefficient correlation test (Table 6) it is obvious that there is not relationship between independent variables of bankruptcy prediction models and their determination coefficient.

**Table 6: Findings related to the fifth hypothesis**

Hypothesis	Accepted	Rejected	Significant
No.5		✓	0.601

## 6. DISCUSSION

Predicting firms' financial bankruptcy is regarded as one of the important subjects in financial decision making domain and regarding the effects and consequences of this phenomenon in micro and macro levels considerable models and tools (that each one of them is different in terms of method and prediction variable) have been proposed. Reviewing studies related to bankruptcy prediction, it became clear that many researchers have already introduced only models in this respect and Meta analysis approach has not been used for determining the impact of different factors on the prediction strength of such models except only in one case. Hite (1987) in a survey entitled "An application of Meta analysis for bankruptcy prediction studies" explains the reasons of difference due to various surveys of bankruptcy prediction. He investigated the time period used for estimating models, and ultimately concluded that the time period used in bankruptcy prediction models is the most important factor impacting on the model's accuracy reliability. In fact the most important factor making difference between the results of bankruptcy prediction models, according to this survey, is the time period of using it <sup>[43]</sup>. But in this survey it is tried to investigate the survey structure such as type, and number of independent variables and regression type used for estimating models.

Considering the obtained results of hypotheses test of this survey, using logistic regression compared with simple regression results in estimating models with higher determination coefficient and regarding the importance of bankruptcy subject for investors, institutions, and commercial firms, it is recommended to prioritize applying logistic regression method by designers of bankruptcy models. Considering the obtained results of the hypotheses related to the type and number of independent variables, and regarding the point that a good bankruptcy prediction model can alarm stakeholders on time in dangerous conditions, it is also suggested that considering situation and conditions of active industry in that field, the most accessible financial ratios existing in line with designing a bankruptcy prediction model is applied, so as designing an appropriate model in shortest period of time informs the firm's stakeholders about bankruptcy hazard.

## 7. Conclusions and Empirical suggestions

One of the routes of assisting investors is to provide prediction models about firms' financial condition. The more realistic the prediction is, it would be considered as the basis of more accurate decisions. The bankruptcy prediction models are the tools of estimating the firms' future situation. The more realistic the prediction is, it would be more considered as bases of accurate decisions. Bankruptcy prediction models are the tools of estimating firms' future situation. Investors and creditors highly tend to predict business bankruptcy, because if it happens they would be suffered from high expenses.

Till now by using numerous techniques various models for firms' bankruptcy prediction is introduced and in this article by using Meta analyses approach and with the aim of quantitative combination of the results of performed surveys, it is tried to investigate the impact of variables related to survey structure on the strength of prediction models and bankruptcy variables. The obtained results from testing hypothesis indicate that the type of regression model that is used in various surveys impacts on the strength of prediction models and also on the effectiveness intensity of independent variables existing in those models, but the type of independent variable used in this survey does not impact on the strength of prediction and effectiveness intensity of model's independent variables and the number of independent variables does not impact on the models' strength of prediction.

Finally the future surveyors are recommended to:

- Meta analytically investigate the impact of other factors related to survey structure such as the number of samples used in bankruptcy prediction models on the strength of those models.
- Meta analytically investigate the impact of factors related to survey environment such as period of time, country, industry, and... in bankruptcy prediction models on the strength of those models.

- c) Meta analytically investigate the impact of using other various methods such as Neural network models, Genetic programming, and also other statistical techniques such as Discriminant Analysis in estimating models on the strength of those models.

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