

# Strategic management of organizational resources using predicting the organization's bankruptcy level: New approach using Monte Carlo simulation

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## Abstract

**Purpose:** There are several methods to predict organization bankruptcy; each of them has different accuracy. Another considerable note in investigating organization bankruptcy is the data considered for the study. The goal of this study is to determine which model is the most accurate in predicting organization bankruptcy.

**Research methodology:** In this study, the initial data were used to compare predicting Monte Carlo processes that simulate bankruptcy models to compare models and results more accurately. Simulated data coefficient modification of McKee, CA-SCORE, Springate, Zmijewski, Shirata, and Altman methods were implemented in some healthy and bankrupt organizations. After that, the results of each modified model were considered to determine the predicting bankruptcy accuracy.

**Results:** Using the final McKee's method, predicting organization bankruptcy was done in an organization and the results show that the given organization is on a trend of bankruptcy in 2025.

**Limitations:** This research was only described in knowledge-based organizations.

**Contribution:** The McKee genetic method is more accurate than other methods. Also, modifying coefficient and by using simulated data shows that CA-SCORE and Shirata methods are not able to predict the organization's bankruptcy by using simulated data.

**Keywords:** Bankruptcy, Predicting bankruptcy models, Monte Carlo Simulation, Management system, Knowledge-based organizations

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## 1. Introduction

For many years, experts and scholars of management science and in particular human resources (HR) have recognized the importance of human capital or HR and acknowledged its superiority ([Ghorbani & Naghdi Khanachah, 2020](#)). Many terms such as today's business world, human, and HR is a distinction and excellence for an organization rather than technology and its advanced equipment" represent the importance of human and HR in the organizations' literature ([Zahedi & Naghdi](#)

[Khanachah, 2020](#)). Therefore, many management scholars prefer to use the term "human capital" instead of HR so that they have focused their attention on the importance of human and employee as a key capital of an organization and not just a source for increasing the income ([Fulmer & Ployhart, 2014](#); [MEHRANI, Mehrani, Monsefi, & Karami, 2005](#)).

Strategic management is an analysis of important issues of the organization. It is taken by senior managers of the organization on behalf of the owners to control resources in the environment outside the organization. This process includes defining the mission, vision, assets. Another definition of strategic management is the solutions and decisions that are supposed to help us and our organization move toward success and achievement of goals, or in a more straightforward definition, where we are and where we are going to go. In this direction, strategic management will help us and determine the long-term performance of a company. Strategic management includes environmental monitoring (external and internal), setting long-term goals, implementing, evaluating and controlling the strategy. Therefore, the study of strategic management emphasizes on monitoring and evaluating external opportunities and threats in the light of a company's internal strengths and weaknesses. Strategic management was originally called business policy. Topics covered in strategic management include strategic planning, environmental monitoring, and industry analysis.

Many concepts and techniques related to strategic management have been developed and successfully used by various business companies such as General Electric (GE) and the Boston Consulting Group (BCG). Over time, business professionals and academic researchers have developed and improved these concepts. Strategic management of large companies operating in multiple industries (such as specialized parent companies and commercial holdings) was used. Mistakes, costly mistakes and even economic crises are the reasons why professional managers in all organizations today take strategic management seriously in order to keep their organization competitive in a highly competitive environment. As managers strive to better adapt to the changing world, an organization can evolve through four stages of strategic management. These four steps are Strategic management planning based on financial foundations. This is the first of four stages in the development of strategic management. Managers are seriously planned when asked to propose next year's budget. Projects are often proposed based on information that is largely internally sourced and based on very little analysis. Even the forces employed in the sales department provide less environmental information. This method is simple operational planning that can not be considered as strategic management and at the same time is quite time-consuming. In this type of planning, the normal activities of the company are suspended for several weeks. During this time, managers are always trying to come up with a lot of ideas in the proposed budget. In this planning, the time horizon is usually one year and is not considered in the long run. Predictive strategic management planning When annual budgets are not very useful for long-term planning, managers propose five-year strategic management plans. In this case, they consider projects that last more than a year. In addition to internal information, managers collect any environmental data, usually specially and temporarily extends. Doing this step is time-consuming, so it includes a full month of managerial activity to ensure that all the proposed budgets fit with how it is done.

As managers compete for more financial resources, this strategic management planning becomes a highly political process, with lengthy meetings to evaluate proposals and justify assumptions. The time horizon is often considered to be three to five years Strategic management planning with an orientation to the external environment The third stage is the evolution of strategic management with an orientation towards the external environment; the five-year plans were neutralized and useless due to the policies of the managers; Accordingly, strategic management planning took over the process of strategic control to avoid such problems. The company seeks to increase markets and competition through strategic thinking, response to environmental changes and changing conditions. Planning is done away from the hands of lower-level managers and centrally by the planning staff, whose task is to plan and develop strategic management plans for the entire company. Consultants often provide advanced and innovative techniques that the planning staff uses to gather information and predict future trends and future research. Senior executives review the latest "review" conducted once a year by key members of the planning unit to evaluate and update the current strategic management plan.

Such top-down planning emphasizes strategy formulation and usually delegates strategy implementation issues to lower management levels. The senior management of an organization is usually prepared and developed with the help of consultants and with minimal information from the lower levels. Five-year plans apply.

Management style allows the organization to take the initiative and its activities to influence (not just react to actions) and thus determine its own destiny and control the future. Historically, the main benefit of strategic organizational management has been to help the organization choose strategic ways or options through a more systematic, sensible, and logical approach and thus formulate better strategies. This is no doubt one of the main benefits of strategic management, but current research results show that this process can play a more important role in strategic management. Managers and employees commit to supporting the organization by engaging in this process. Another important benefit of strategic management is that it leads to greater understanding and commitment of managers and employees. One of the great benefits of strategic organizational management is that it provides an opportunity to delegate authority to employees. Delegation is a practice by which employees are encouraged to participate in decision-making processes, practice creativity, innovation and imagination, and thus increase their effectiveness. In general, in addition to the above, there are other benefits for strategic management in the organization: Orientation of the future identifies priorities and makes today's decisions in the light of future consequences Performs the role of coordinator between the operational plans of the organization and puts the actions of different units in one direction Deals with situations that change quickly in an effective way and creates expert teamwork and expertise. Activities related to strategic management are guiding and determine the direction of activities and operations of the organization and act as a guide for the organization. Predicts the future with a long-term perspective and therefore contains information that is useful for the long-term actions of managers. Strategic management is available throughout the organizational units, including all administrative systems, and instead of being a mechanical action, it recognizes the central role of individuals, groups, and the influence of organizational culture.

Strategic management allows the organization to act in creative and innovative ways and not passively shape its future. This way of management causes the organization to have initiative and its activities in such a way that it not only reacts but also exerts influence. In this way, he determined his own destiny and took control of the future; The use of strategic management for organizations also has positive consequences such as the following: Reduces the risks of decision making; leads to more commitment of managers and employees; has a long-term attitude and ensures the success of actions based on approved strategies; creates an opportunity to delegate authority to employees and encourages employees; engages employees and managers with strategic planning increase the commitment and support of the organization; as the organization's guide, that is, it determines the direction and direction of the activities and operations of the organization; predicts the future and has information that is very useful for the long-term actions of managers; and performs the role of coordinator between the operational plans of the organization and directs the actions of different units in one direction.

In this regard, the first problems are the obstacles to creating and developing the strategic management process in organizations, which make this process difficult from the ground up. There are various reasons why some organizations do not show much desire to create and develop strategic management processes, the most important of which are: Past successes of the organization Failure to use urgent tasks Managers' attention to maintaining the status quo Lack of knowledge of high-level management about the real situation of the organization Self-deception of top managers collectively about the position of the organization A combination of common top-level management difficulties and day-to-day performance difficulties Misunderstanding any change in relation to what has been done in the organization in the past.

The strategic management orientation is designed and created to nurture the executive management staff of private, cooperative and government manufacturing and service enterprises and provide a manager and strategist for large development projects. But the realization of this depends on the

ancillary and practical skills of the graduates, so as the name of the field is given on the board, it is necessary for students to gain experience and effective communication and work skills such as language, ICDL, Ms Project. The set of executive management and its trends, with the aim of cultivating efficient and capable managers who have the ability to continuously improve organizational productivity, has been designed and is among the options available to continue studying for a master's degree. The courses of strategic management in universities are Management Accounting, Financial Management, Economics, Technology Management, and Economics management, Project Development, Marketing Management, International Business Operation, and others.

The seven most common long-term goals are profitability, productivity, competitiveness, employee training, employee relations, technology leadership, and public accountability. These, or any other long-term goal, must be flexible, measurable over time, motivating, appropriate, and understandable. Big strategies are comprehensive approaches that guide the major actions designed to achieve long-term goals. The fifteen major strategy options discussed are Focused growth, Market Development, Product Development, Innovation, Horizontal Integration, Vertical Integration, Homogeneous Diversity, Heterogeneous Diversity, Redirection, Assignment, Liquidation, Bankruptcy, Joint Venture, Strategic Alliances, and coalition. Strategic managers are well aware that maximizing profit in the short term is rarely the best approach to achieving sustainable organizational growth and profitability. A repeated admonition says that if someone gives food to poor people, they will eat it and they will still be poor; But if someone gives them seeds and tools and teaches them how to grow grains, they will improve their situation forever. Resource Allocation What is clear to any company, large or small, is that resources are limited. Strategic goals choose what products and services and what market share we will have in the future and what we should not do! These kinds of decisions are critical to ensuring that limited resources are exposed to the best opportunities and the most benefits. Skills and knowledge, if someone knows where he wants to take his business in the long run, he will have a much better idea of the capabilities he needs to achieve his goals. Strategic goals define and guide the necessary decisions when designing an organization. So by scanning his skills and knowledge, he can prepare his organization for the next steps and increase his chances of success. Strengths and weaknesses at first glance, this seems very obvious, and he says to himself, "Of course we know our strengths and weaknesses." Yes! No one knows his business better than he does. Nevertheless, does he see his strengths as a competitive advantage and does he intend to eliminate the gaps in the organization (weaknesses)? Strategic goals create a high level of awareness and focus more on the activities that make the organization successful.

**Environmental Analysis** Many executives do not take the time to understand the external environment and its positive or negative effects on performance. This does not mean that leaders are not aligned with their customers or are unaware of their competition. The question is how they analyze this area. Being aware of and preparing for possible changes in the market or industry allows for appropriate action before changes occur. Planning is an essential management tool for any company to create and track an annual operational plan. However, what is often not given enough attention is the connection of these programs with the future. Annual action plans are often created with a retrospective view. What happened last year and where should we go now? These are good intentions. However, not having a clear picture of what you want to look like in the future makes you react more than you are active. Therefore, a long-term vision of 3 to 5 years should be available to be aware of the annual action plan.

Strategic management indicators include analysis, planning scope, flexibility, time horizon and control attitudes, which are explained below. A company's strategic management horizon refers to the length of time that decision-makers consider in their planning. The field of strategic management refers to the level of employee participation in the company's strategic planning activities. High employee involvement in planning engages those closest to customers (or outside streams) in the planning process, which can help identify opportunities. In addition, the wide scope of planning legitimizes the active participation of operational and middle managers in the process of implementing strategic management; Flexibility refers to the ability of a company's strategic plan to

make changes tailored to environmental opportunities/threats; In a way, companies in complex environments, by establishing flexible planning systems, optimize their performance. Analysis refers to learning about the events and environmental processes of the organization and is more of managerial activity. The analysis provides the necessary information about external environmental events and reduces uncertainty. Thus, the good ideas of these managers are not ignored. Another reason is that the wide range of planning increases the diversity of points of view in formulating a strategic plan. Control: The purpose of control systems is to ensure that the company achieves short-term and long-term goals in advance. Strategic controls emphasize the achievement of the company's strategies and goals. Such controls encourage creativity and provide the opportunity for innovation.

Numerous organizations are bankrupt and excluded from the competition ([Reiser & Dean, 2017](#)). This process makes fundholders and other stakeholders anguished. To prevent wasting principal and interest of capital, these investors are seeking methods to predict financial crises ([Boussabaine, 2013](#)). Predicting bankruptcy for several clusters such as stakeholders, insurance providers, lenders, financial analyzers, and ones working in integrating organizations is significant ([Mashrur, Luo, Zaidi, & Robles-Kelly, 2020](#)). [Eklund et al. \(2020\)](#) direct and indirect bankruptcy costs are high in the financial and social and political fields. Also, from the legal rule point of view, predicting bankruptcy is important, and legislators will implement legislation limiting credit risk ([Eklund, Levratto, & Ramello, 2020](#); [Hafiz, Oei, Ring, & Shnitser, 2020](#)). The main cause of organizational bankruptcy is mismanagement. [Fischer & Riedler \(2014\)](#) and [Kumar & Persaud\(2002\)](#) define bankruptcy as follows: organization value is less than a probable level. This probable level is defined by changes in interest rate structure and uncertainty in asset value ([Fischer & Riedler, 2014](#); [Kumar & Persaud, 2002](#)).

Bankruptcy steps can be listed as follows:

- 1- The incubation period
- 2- Cash deficit
- 3- Lack of ability to pay the commercial and financial debt
- 4- Lack of ability to pay the complete debt
- 5- Bankruptcy

One of the approaches by which we can utilize the investment opportunities and prevent wasting resources is predicting bankruptcy ([Aghaie & Saeedi, 2009](#)). Thus, first, organizations are cautioned by necessary alarms concerning doing appropriate affairs ([Zahedi et al., 2020](#)). Second, investors recognize desirable investment opportunities from undesirable ones and invest their resources in suitable opportunities and places ([Floridi et al., 2018](#); [Lerbinger, 2012](#)). However, financial distress indications are not appeared quickly even remain hidden among a huge volume of financial and non-financial data ([Zahedi & Naghdi Khanachah, 2019](#); [Ghorbani & Naghdi Khanachah, 2020](#)). In this study, Monte Carlo simulation has been used ([Du Jardin, 2017](#); [Gebauer, Setzer, & Westphal, 2018](#); [Hollo, Kremer, & Lo Duca, 2012](#)). The purpose of this study is to design a predicting bankruptcy model by using predicting methods and statistical methods implemented by Monte Carlo simulation. Finally, to determine the bankruptcy time, we predict that for one of the organizations by applying the regression model ([de Andrés, Landajo, & Lorca, 2012](#); [Du Jardin, 2017](#); [Kirkos, 2015](#)).

## 2. Literature review

Analyzing financial statements has been mainly changed over time. This issue started in the mid-60, along with vast evolution and development that occurred in accounting and financial research literature. The first effort results to present a coherent series of financial statement analyses have been published by Bachler ([Tsirigotis, 2012](#)). The ratios are methods enabling organizations and shareholders to evaluate themselves against others. In summary, to ensure the organization's financial health, the financial statements need to be analyzed. Financial ratios are considered as one of the important tools for predicting an organization's financial crises ([Osadchy et al., 2018](#)). Analyzing financial statements needs tools and technics enabling analyzers to consider current and past financial statements in such a way that the situation and performance of an organization can be evaluated and the probability of future risks are predicted. Boiur started to predict bankruptcy models in 1966 ([Palepu, Healy, Wright, Bradbury, & Coulton, 2020](#)). The following are the literature of some

researches considered in this study. Altman used the ratios analysis method to predict bankruptcy. The constructed model consists of five financial ratios weighted by the discriminant analysis method and performed with the Z-square function in which financial statements are independent variables. This model obtained an accuracy of 95% in the first year, before the financial crises. Altman in 1983 modified this model and presented a new model, namely Z' ([Aaron, Nainggolan, & Trinugroho, 2017](#)). Živković can obtain the exact ratio of 78% for one year before bankruptcy by using a Profit analysis containing 40 companies with financial crises and 80 companies without financial crises ([Živković, Ivanov, Stojković, & Glamočlija, 2021](#)). Jo et al. presented a model by eliciting three financial ratios among nineteen financial ratios, which can obtain success of 92.5% in predicting. He adopts financial ratios used discriminant analysis ([Jo et al., 2021](#)). In Oh's model, a multi-variable analysis method is used in which 30 financial ratios are elicited from 173 instances of manufacturing firms having selling between 1 and 20 million dollars per year ([Oh, Koyanagi, Kelleher, & DeVyllder, 2018](#)). Moreover, this method is examined with an accuracy of 84%. Shirata presents a model predicting bankruptcy of manufacturing, commercial, and service organizations ([Bărbuță-Mișu & Madaleno, 2020](#)). The results obtained from this study showed that the proposed model could predict bankruptcy with an accuracy greater than 86.14%. Shitara used multiple discriminant analyses and his instances consist of 686 bankrupt organizations and 300 non-bankrupt organizations ([Bărbuță-Mișu & Madaleno, 2020](#)).

Mckee genetic is a model predicting the bankruptcy probability of each organization by using a series of financial ratios. [Kazemi et al. \(2021\)](#), in their research to predict organization bankruptcy, could predict the non-bankruptcy situation of organizations in four years with the confidence of 92% by using the Altman model and also could predict the bankruptcy situation of organizations with the confidence of 81% before bankruptcy correctly ([Kazemi, Bozorg-Haddad, Fallah-Mehdipour, & Chu, 2021](#)). Mehrani et al. worked on Shirata and Zmijewski models and implemented this model in companies working in the stock exchange and based on two proposed models, elicited a new model for the environment of Iran ([MEHRANI et al., 2005](#)). Results showed that two proposed models could separate organizations into bankrupt and non-bankrupt organizations ([MEHRANI et al., 2005](#)). Ghodratinad Manavi Moghadam in their research entitled predicting bankruptcy in Tehran stock exchange, can find that the Mckee Genetic, Farokhzade Genetic, CA-SCORE, Springate, and Zmijewski models are more efficient algorithms. The study assumptions are as follows: Mckee Genetic model with simulated data is the most accurate algorithm for predicting organization bankruptcy ([Kordestani & Manavi Moghadam, 2017](#)). If all models are considered by simulated data, proposed models can predict organization bankruptcy.

### 3. Research methodology

Using simulated data in modifying and determining coefficients for Mckee, CA-SCORE, Springate, Zmijewski, Shirata, and Altman methods. Comparing the models in predicting bankruptcy power by using simulated data. Determining and designing the final model and predicting one of the organization's bankruptcy by using that. Since we need the organization's financial statements for doing this study, the population of this study is the organization financial statements accepted in the Tehran stock exchange from 2012 to 2020. Considered organizations in this study are separated into bankrupt and healthy organizations so that the data of 10 bankrupt organizations and 10 healthy organizations are elicited for 8 years. Testing the healthy organizations is done by Tobin ratio in which an organization is healthy if its Tobin ratio is greater than 1 in three years in a row and regarding bankrupt organizations, if integrated loss of an organization is more than half of the organization investment, that organization is considered as a bankrupt organization and needs to either decrease its investment or stop its activity. Simple Tobin's ratio is calculated as follows:

$$\frac{\text{summation of Book Value of Debts and Market Value of Common and Preferred Stocks}}{\text{Book Value of Total Assets at the end of Fiscal Year}}$$

It should be emphasized here that this study is practical.



### ***Bankruptcy methods***

There are three methods for predicting the organization bankruptcy summarized as follows:

**Statistical methods:** This model concentrates on bankruptcy indications obtained from organization financial statements. These models are either single variables or multiple variables.

**Artificial intelligence methods:** This model concentrates on bankruptcy effects obtained from organization financial statements. These models are inherently multiple variables.

**Theoretical methods:** These models are inherently multiple variables and concentrate on qualitative factors affecting organization bankruptcy and focus on data by which the bankruptcy is logically justified.

### ***How to collect and analyze data***

Stock company's financial statements are collected from codal. These data are organized into the balance sheet and income statement in Excel software. The normality of data is checked by Shapiro-Wilk test in Excel software. Modifying and eliciting the appropriate coefficients is done by regression analysis and the Monte Carlo simulation process is done in Excel software concerning the data distribution type.

### ***Financial ratio and effective variables in predicting bankrupts***

McKee and Lensberg considered 28 variables for predicting bankruptcy, including financial and non-financial ratios and showed that accounting data for large organizations are more significant than for small organizations ([McKee & Lensberg, 2002](#)).

### ***Financial ratio and their classification***

**Liquidity ratios:** These ratios generally state whether or not the organization is in a good liquidity situation and whether the organization can pay short-term debts.

**Activity ratios:** These ratios evaluate the manager's performance in different departments.

**Financial leverage ratios (Investment structure):** Generally show the debt amount and state that the manager obtains and buys assets how much debt will need. The higher debt leverage is, the higher the organization's risk is, leading to organization bankruptcy. Analyzing this ratio shows the indication of bankruptcy.

**Profitability ratios:** Generally demonstrates the benefit and profitability of organizations and also is a criterion for evaluating managers concerning their profitability. The greater these ratios are, the more the investor eagerness for remaining and entering organizations is.

**Market ratio:** These ratios are based on market current prices. Shareholders generally consider market price and some ratios evaluating their condition concerning the market.

### ***Variables that affect bankruptcy prediction***

The variables used in all models are listed in table 1.

Table 1. Variables of each model

<b>Zmijewski Model</b>		<b>Altman Model</b>	
$C + \alpha_1 A + \alpha_2 B + \alpha_3 C$		$C + \alpha_1 A + \alpha_2 B + \alpha_3 C + \alpha_4 D + \alpha_5 E$	
the ratio of net profit to total assets	A	the ratio of working capital to total assets	A
the ratio of total debts to total assets	B	the ratio of retained profit to total assets	B
the ratio of current assets to current debts	C	the ratio of profit before imposing interest and tax to total assets	C
		the ratio of equity market value to the book value of debts	D

		the ratio of sales to total assets	E
<b>Springate Model</b>		<b>Shirata Model</b>	
$C + \alpha_1 A + \alpha_2 B + \alpha_3 C + \alpha_4 D$		$C + \alpha_1 A + \alpha_2 B + \alpha_3 C + \alpha_4 D$	
the ratio of working capital to total assets	A	the ratio of retained profit to total assets	A
the ratio of Operating profit to total assets	B	the ratio of debts and equity of the current year to debts and equity of the previous year	B
the ratio of net profit before imposing a tax on the current debts	C	the ratio of interest costs to the sum of loans, debts	C
the ratio of sales to total assets	D	the ratio of accounts payable multiplied by 12 to the sales amount	D
<b>McKee Model</b>		<b>Ca-Score Model</b>	
$X = ((A + 0.85)B) - 0.85, Y = 1 + C$ $\rightarrow P(\text{bankruptcy}) = \frac{X^2}{X^2 + Y^2}$		$C + \alpha_1 A + \alpha_2 B + \alpha_3 C$	
the logarithm of total assets divided by 1000 to base 10	A	the ratio of The remaining equity from a prior period to total assets from a prior period	A
the ratio of net profit to total assets	B	the ratio of financial costs plus the profit before the remaining taxation from a prior period to the remaining total assets from a prior period	B
the ratio of Cash to current depts.	C	the ratio of The remaining sales of both prior period to the remaining total assets of both prior period	C

### **Monte Carlo Simulation:**

Monte Carlo methods are a group of computational and random algorithms. Monte Carlo methods are also applied to simulating mathematical and physical systems. Since this method uses repetitive computation and random & quasi-random numbers, they are suitable for computer computation. Moreover, it is not necessary to check if the data distribution is normal.

### **Study methodology**

In the classical methods, considering the variance of these ratios is significantly based on limited statistical assumptions such as financial ratio normality in bankrupt and non-bankrupt organizations. After testing the normality of the time series of financial ratios, 1000 data from each ratio are simulated by Monte Carlo simulation concerning distribution type. To modify the coefficient by using regression analysis, the qualitative variables convert to quantitative variables. Therefore, the variable, Z, is defined for each organization as follows:

$$Z = \begin{cases} 0 > & \text{if organization is bankrupt} \\ 1 < & \text{if organization is healthy} \end{cases}$$

Therefore, modified coefficients for each model are determined by using Z values and time series values of simulated data and regression analysis. Finally, by using modified models and time series data of simulated ratios and by using simulated data, we compare the efficiency results of these models with each other.



#### 4. Research results

Series time data of each financial ratio for testing bankruptcy need to be normally distributed. To test that, we utilize the Shapiro-Wilk test and its hypothesis is as follows:

$H_0$ : Selected sample is normally distributed

$H_1$ : Selected sample is not normally distributed

Table 2. Data normality test

Hypothesis	w	P-value	Variable	Method	Hypothesis	w	P-value	variable	Method
$H_0$	0.888	0.267	A	Shirata	$H_0$	0.970	0.900	A	Altman
$H_0$	0.876	0.250	B		$H_0$	0.888	0.267	B	
$H_0$	0.966	0.868	C		$H_0$	0.933	0.573	C	
$H_0$	0.936	0.607	D		$H_0$	0.942	0.652	D	
$H_0$	0.944	0.673	A	Zmijewski	$H_0$	0.822	0.067	E	Springate
$H_0$	0.933	0.573	B		$H_0$	0.970	0.900	A	
$H_0$	0.928	0.537	C		$H_0$	0.933	0.573	B	
$H_0$	0.965	0.857	A	Ca-Score	$H_0$	0.934	0.584	C	
$H_0$	0.882	0.279	B		$H_0$	0.822	0.067	D	
$H_0$	0.870	0.265	C						

From the table above, it can be seen that the financial ratios of each variable are normally distributed.

#### Modification of model coefficient by using regression analysis

Using Z value defined to convert qualitative data into quantitative data and simulated data constructed for each financial ratio as well as regression analysis, we do the significance test of the coefficients and modification of models and is then summarized in table 3.

Table 3. Testing regression coefficient significance

P-value	t Stat	Standard Error	Coefficients	
0.073975772	1.974384416	0.86108364	1.70011	<b>Intercept</b>
0.057627943	2.119420179	0.623372436	1.32119	<b>A Shirata</b>
0.155500173	-1.524925233	0.847889725	-1.293	<b>B Shirata</b>
0.886950298	-0.145497082	0.100958875	-0.0147	<b>C Shirata</b>
0.258075613	-1.192710323	0.000990504	-0.0012	<b>D Shirata</b>
P-value	t Stat	Standard Error	Coefficients	
0.787792458	-0.276502978	0.152320377	-0.0421	<b>Intercept</b>

0.211985916	-1.333371939	0.908364749	-1.2112	<b>An Altman</b>
0.501866021	0.696696578	0.701853153	0.48898	<b>B Altman</b>
0.003504002	3.796821461	0.41415048	1.57246	<b>C Altman</b>
0.01042005	3.145063834	0.087589307	0.27547	<b>D Altman</b>
0.095973241	-1.837610959	0.161622092	-0.297	<b>E Altman</b>

<b>P-value</b>	<b>t Stat</b>	<b>Standard Error</b>	<b>Coefficients</b>	
0.053557831	-2.890726244	0.177816363	-0.514	<b>Intercept</b>
0.691532694	-0.406498165	1.265059953	-0.5142	<b>A Zmijewski</b>
0.070685634	1.983367641	0.704681108	1.39764	<b>B Zmijewski</b>
<b>0.014705708</b>	2.846953076	0.210820536	0.6002	<b>C Zmijewski</b>
<b>P-value</b>	<b>t Stat</b>	<b>Standard Error</b>	<b>Coefficients</b>	
0.305932569	1.073731659	0.139430933	0.14971	<b>Intercept</b>
0.404227958	-0.867438624	0.338779929	-0.2939	<b>A Springate</b>
0.792146403	0.270016139	0.667999777	0.18037	<b>B Springate</b>
0.003945517	3.631611079	0.322548353	1.17137	<b>C Springate</b>
<b>0.069417887</b>	-2.01153179	0.147292638	-0.2963	<b>D Springate</b>
<b>P-value</b>	<b>t Stat</b>	<b>Standard Error</b>	<b>Coefficients</b>	
0.948408216	0.066072399	0.245538864	0.01622	<b>Intercept</b>
0.117955521	1.684184781	0.63094533	1.06263	<b>A Ca-Score</b>
0.286479536	1.115493983	1.925157967	2.1475	<b>B Ca-Score</b>
0.610073739	-0.523624875	0.284410385	-0.1489	<b>C Ca-Score</b>

Statistical parameters were calculated for estimating the coefficients are summarized in table 4.  
Table 4. Statistical parameters

Statistical parameters	Shirata	Altman	Zmijewski	Springate	Ca-Score
Multiple R	0.7978	0.98049	0.9639	0.97849	0.8909
R Square	0.63648	0.96136	0.9291	0.95744	0.7937
Adjusted R Square	0.5043	0.94205	0.91137	0.94196	0.74212
Standard Error	0.36358	0.12432	0.15373	0.12441	0.26223
Observations	2000	2000	2000	2000	2000

Considering the specified confidence level of 95%, the stock hypothesis is rejected if the P-value amount is less than 0.05 for one coefficient. In other words, this coefficient is significant in the model and the modification has occurred. The hypothesis of the coefficients is as follows:

$$\begin{cases} H_0: \text{coefficient is not significant} \\ H_1: \text{coefficient is significant} \end{cases}$$

From the proposed hypothesis and results obtained from regression analysis of simulated data, it can be seen that C Altman, D Altman, ZmijewskiC, and D Springate are significant coefficients. In other words, these variables can describe the depicting organization bankruptcy.

C Altman	the ratio of profit before imposing interest and tax to total assets
D Altman	the ratio of equity market value to the book value of debts
Zmijewski	the ratio of current assets to current debts
D Springate	the ratio of sales to total assets

#### ***Altman, Zmijewski, Springate, and Mckee genetic models accuracy in predicting bankruptcy***

From 10 financial ratios related to bankrupt and healthy organizations, 1000 data are simulated by which the coefficients are obtained. Using simulated data (1000 data for each ratio), we can obtain the accuracy of each model. The value of accuracy for each model is shown in the tables below.

Table 5: Altman's model accuracy by using Monte Carlo simulation process

Method accuracy		Altman method by using simulated data				
Percent	Number	Healthy company		Bankrupt company		
		Percent	Number	Percent	Number	
0.824	1000	0.176	176	0.824	824	Bankrupt company
0.878	1000	0.878	878	0.122	122	Healthy company

Table 6: Springate's model accuracy by using Monte Carlo simulation process

Method accuracy		Springate method by using simulated data				
Percent	Number	Healthy company		Bankrupt company		
		Percent	Number	Percent	Number	
0.893	1000	0.107	107	0.893	893	Bankrupt company
0.902	1000	0.902	902	0.098	98	Healthy company

Table 7. Zmijewski's model accuracy by using the Monte Carlo simulation process

Method accuracy		Zmijewski method by using simulated data				
Percent	Number	Healthy company		Bankrupt company		
		Percent	Number	Percent	Number	
0.857	1000	0.143	143	0.857	857	Bankrupt company
0.848	1000	0.848	848	0.152	152	Healthy company

Table 8. Mckee's model accuracy by using the Monte Carlo simulation process

Method accuracy		Mckee method by using simulated data				
Percent	Number	Healthy company		Bankrupt company		
		Percent	Number	Percent	Number	
0.935	1000	0.065	65	0.935	935	Bankrupt company
0.934	1000	0.934	934	0.066	66	Healthy company

Table 9. The expected predicting bankruptcy accuracy by using the Monte Carlo simulation process

Expected prediction accuracy by using simulated data			
Mckee model	Zmijewski method	Springate method	Altman method
0.9345	0.8525	0.8975	0.851

In the Mckee model, first, the value of  $P(\text{bankruptcy}) = \frac{x^2}{x^2 + y^2}$  is calculated and if this value is greater than 0.5, the given organization is bankrupt, otherwise is healthy.

#### *Predicating the bankruptcy of a healthy organization by using the Mckee model*

In this section, we predict the bankruptcy time of a healthy organization by using regression analysis. Table 9 displays the related data of bankruptcy prediction.

Table 10. Related data of bankruptcy prediction

Year	A	B	C	X	Y	P(X)	Bankruptcy probability
2003	3.4905	0.4173	1.1336	0.9614	2.1336	0.1688	Bankruptcy probability in 2006
2004	3.5893	0.4425	1.3783	1.1144	2.3783	0.1800	Bankruptcy probability in 2007
2005	3.6640	0.4534	1.5809	1.1967	2.5809	0.1769	Bankruptcy probability in 2008
2006	3.8132	0.4710	3.1598	1.3463	4.1598	0.0948	Bankruptcy probability in 2009
2007	3.8132	0.5166	3.1598	1.5592	4.1598	0.1232	Bankruptcy probability in 2010
2008	3.8128	0.5158	3.2832	1.5552	4.2832	0.1165	Bankruptcy probability in 2011
2009	3.8551	0.4099	6.9054	1.0784	7.9054	0.0183	Bankruptcy probability in 2012
2010	3.8034	0.3634	2.0906	0.8411	3.0906	0.0690	Bankruptcy probability in 2013
2011	3.9427	0.4323	4.9494	1.2217	5.9494	0.0405	Bankruptcy probability in 2014
2012	4.0025	0.4044	5.8609	1.1123	6.8609	0.0256	Bankruptcy probability in 2015
2013	4.0728	0.3605	6.9165	0.9249	7.9165	0.0135	Bankruptcy probability in 2016
2013	4.1664	0.2886	8.1109	0.5976	9.1109	0.0043	Bankruptcy probability in 2017
2014	4.3742	0.1766	10.4771	0.0728	11.4771	0.0000	Bankruptcy probability in 2018
2015	4.7223	0.0277	14.1916	-0.6956	15.1916	0.0021	Bankruptcy probability in 2019
2016	5.3257	- 0.2025	20.3723	-2.1009	21.3723	0.0096	Bankruptcy probability in 2020
2017	6.4592	- 0.6913	35.0271	-5.9030	36.0271	0.0261	Bankruptcy probability in 2021
2018	8.5600	- 1.6877	58.9662	-16.7313	59.9662	0.0722	Bankruptcy probability in 2022
2019	12.8702	- 3.6250	108.8314	-50.5861	109.8314	0.1750	Bankruptcy probability in 2023
2020	21.9250	- 7.6800	213.6821	- 175.7618	214.6821	0.4013	Bankruptcy probability in 2024
2021	41.6608	- 16.514	442.4705	- 702.8819	443.4705	0.7153	Bankruptcy probability in 2025

From the table, we can find that the probability of bankruptcy prediction is greater than 0.5 in 2025 from which it can be seen that the given organization in 1403 and then is under bankruptcy.

## 5. Conclusion and recommendations for future research

The results show that the Mckee genetic method done by simulated data and the Monte Carlo simulation process is more accurate than other methods. Therefore, the null hypothesis is accepted, demonstrating the Mckee genetic method is the best. The null hypothesis also indicates that if

simulated data consider all models, these models can predict the organization's bankruptcy. Considering the results, this hypothesis is acceptable for Altman, Zmijewski, and Springate models. Some recommendations for future works are as follows: In the financial market, there always exist risks which the most important one is liquidity risk. One of the main causes of this case is the lack of liquidity and organizational bankruptcy. Accordingly, we propose to use McKee genetic method to predict the organization's bankruptcy. It is recommended for future researchers to deal with newly predicting bankruptcy models by using non-parametric and artificial intelligence techniques. Then, the result obtained from a new method is compared with McKee genetic method.

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