Özparlak, G. / Journal of Yasar University, 2022, 17/65, 249-276

Validity Analysis of Financial Failure Prediction Models During the Covid-19 Pandemic

Finansal Başarısızlık Tahmin Modellerinin Covid-19 Salgını Dönemindeki Geçerlilik Analizleri

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Abstract: Unexpected bankruptcies of companies cause significant damage to company partners, investors, employees, countries, commercial and financial creditors. In this context, the financial failure risks should be constantly measured and controlled. However, it is important to constantly check the validity of financial models that measure the risk of the financial failure of companies. Because the higher the validity rates of these models, the higher the probability of investors and researchers to make the right decision according to the results obtained from these models. In this context, validity tests are widely used in the literature, namely Altman (1968), Springate (1978), Ohlson (1980), Fulmer (1984), Zmijewski (1984), Canada (1987) and Grove (2001) models, were applied in this study. *The sample of this study consists of 16 companies that operate in the energy sector in the US markets. The universe of the study includes all companies that operate in the energy sector. The research results have shown that the Zmijewski model has been the most successful model for predicting company bankruptcies in the energy sector in the USA. The model that best predicted bankrupt and non-bankrupt companies 1 year and 3 years before the bankruptcy is again the Zmijewski model. However, Fulmer is the best bankruptcy predictor 2 years before the bankruptcy. On the other hand, according to other results of the research, the accuracy rate of Altman, Springate, Canadian, Fulmer and Grover models is well below the average compared to other studies in the literature.*

Keywords: Financial Failure Prediction Models, Financial Performance, Company Bankruptcies, Energy Sector, US Markets

JEL Classification: G33, C53, C52

Öz: Firmaların beklemedik iflasları, şirket ortaklarına, yatırımcılara, çalışanlara, devlete, ticari ve finansal alacaklılara büyük zarar vermektedir. Bu kapsamda, şirketlerin finansal başarısızlık risklerinin sürekli ölçülerek kontrol edilmesi gerekir. Fakat firmaların finansal başarısızlık riskini ölçen finansal modellerin de geçerliliklerinin sürekli olarak kontrol edilmesi önemlidir. Çünkü bu modellerin geçerlilik oranları ne kadar yüksek olursa, yatırımcı ve araştırmacıların bu modellerden elde edilen sonuçlara göre doğru karar verme ihtimalleri de o kadar yükselmiş olur. Bu bağlamda, bu çalışmada literatürde yaygın olarak kullanılan Altman (1968), Springate (1978), Ohlson (1980), Fulmer (1984), Zmijewski (1984), Kanada (1987) ve Grove (2001) modellerinin geçerlilik testleri yapılmıştır. Bu çalışmanın örneklemini, ABD'de enerji sektöründe faaliyet gösteren 16 şirket oluşturmaktadır. Araştırmanın evreni ise, enerji sektöründe faaliyet gösteren tüm şirketleri kapsamaktadır. Araştırma sonuçları, Zmijewski modelinin ABD'de enerji sektöründe faaliyet gösteren şirketlerin iflaslarını tahmin etmede en başarılı model olduğunu göstermiştir. İflas eden ve iflas etmeyen şirketleri iflastan 1 yıl ve 3 yıl önce en iyi tahmin eden model de Zmijewski modeli olmuştur. Ancak Fulmer, iflastan 2 yıl önce en iyi iflas tahmincisidir. Araştırmanın diğer sonuçlarına göre, Altman, Springate, Canadian, Fulmer ve Grover modellerinin doğruluk oranı literatürdeki diğer çalışmalara göre ortalamanın oldukça altındadır.

Anahtar Kelimeler: Finansal Başarısızlık Modelleri, Finansal Performans, Şirket İflasları, Enerji Sektörü, Amerikan Piyasaları

JEL Sınıflandırması: G33, C53, C52

Makale Geçmişi / Article History

Başvuru Tarihi / Date of Application : 19 Ekim / October 2021

Kabul Tarihi / Acceptance Date : 31 Ocak / January 2022

1. Introduction

Recent global crises and natural disasters have seriously damaged the economies of countries. Especially during the Covid-19 pandemic, the slowdown in the industry and travel restrictions resulted in significant damage to companies, while leading some of them to bankruptcy. These unexpected bankruptcies of companies caused grave consequences for their partners, investors, employees, commercial & financial creditors and countries. Therefore, the financial failure risks of companies should be continuously measured and controlled. There are many models in the literature, which can predict the financial failure risks of companies. However, the most famous bankruptcy prediction model is undoubtedly still Altman's model (1968). Altman caused a small revolution in the perception of bankruptcy with his study. After Altman, Springate (1978), Ohlson (1980), Fulmer (1984), Zmijewski (1984), Canada (1987) and Grove (2001) models are some of the commonly used models for measuring the probability of financial failure risk of companies (Gunawan et all, 2016; Karamzadeh, 2013; Purnajaya, 2014; Wulandari, 2014). In addition, after 2003, there are also other methods based on artificial intelligence and machine learning adopted by many authors in the bankruptcy prediction field (Mckee, 2003; Xiao et al., 2012; Wang & Wu, 2017). Especially, the researchers have got a good prediction capability using the neural network models (ANN). However, Ohlson (1980), Zmijewski (1984), Altman (1968), Springate (1978), Ohlson (1980), Fulmer (1984), Zmijewski (1984), Canada (1987) and Grove (2001) are the most cited ones that are based on accounting variables in the literature. These bankruptcy prediction models use different financial ratios and statistical techniques in order to evaluate the company's financial issues. On the other hand, it is also important to constantly check the validity of these models as investors and researchers can make the right decisions when these models have higher validity rates. Thus, the purpose of this research is to analyse the validity of financial failure models with the historical data from 8 companies in the United States, which were declared bankrupt and 8 American companies which are non-bankruptcy as a control group.

As of October 2021, The United States of America is reported to have the highest number of Covid-19 positive cases (World Health Organization, 2021). The US economy suffered dramatic losses during the pandemic. The USA ranks second after France, in the ranking of the countries with the highest number of corporate bankruptcies in the world in 2021 (Statista, 2021)[1]. Many American companies, especially those in the energy sector, had to declare

[1] According to the "Forecasted Number of Business Insolvencies Worldwide in 2021" report in Statista (2021), 50 thousand companies in France and 32 thousand companies in the USA are expected to go bankrupt.

bankruptcy during the pandemic. The decline in oil and natural gas demand has caused energy prices to drop, which has led to the bankruptcy of many energy companies in the USA (Fu and Shen, 2020). The world's largest energy producer companies in the USA declared their bankruptcies one by one during this period (Reuters, 2020). In addition, according to the Global Bankruptcy Index report prepared by one of the world's leading financial service providers, a 15% increase in bankruptcies is expected in 2022 (Euler Hermes, 2021, p. 3). During the pandemic, the US energy sector is the most suitable market for testing the validity of financial failure models. Thus, the sample of this research has been chosen as companies that operate in the US energy sector.

This research aims to determine the validity results of widely used financial failure models and inform investors and researchers accordingly. In this study, Altman (1968), Springate (1978), Ohlson (1980), Fulmer (1984), Zmijewski (1984), Canada (1987) and Grove (2001) models were chosen as methods for conducting validity tests. These models were chosen because they are suitable for analyzing the financial failure probabilities of companies in the energy sector (Ko et all, 2017; Siyamni et al., 2018). This study's most important contribution to the literature will be testing the accuracy rate of seven commonly used financial failure models during a time when company bankruptcies are increasing across the world. The study is important as it conducts such a comprehensive validity test for the first time in the literature. In the research, seven financial failure models were tested separately on 16 energy companies. The sample of the study, as seen in Table 1, consists of 16 energy companies operating in the US markets and energy sector. Half of the companies in the sample of the study consist of companies that have declared bankruptcy officially between 2018 and 2021. The other half consists of financially successful (control group) companies.

Table 1. Eight Energy Companies Declared Bankruptcy in the USA between 2018 and 2021

	Bankrupt Firms				Non-Bankrupt Firms		
No	Bankruptcy Statement Date	Company Code	Company Name	Total Assets[2] ($)	Company Code	Company Name	Total Assets ($)
1	17.08.2021	BASXQ	Basic Energy Services Inc.	349.07	SNMP	Evolve Transition Infrastr. LP.	353.43
2	24.06.2020	FPPP	Fieldpoint Petroleum Corp	4.68	SBR	Sabine Royalty Trust	4.95
3	15.04.2020	YUMAQ	Yuma Energy Inc.	77.36	UGE	ProShares Ultra Cons. Goods	7.90

[2] Total assets are taken based on the balance sheet value one year before the company went bankrupt.

4	07.08.2019	BATL	Battalion Oil Corp.	2083.61	WLL	Whiting Petroleum Corp	2043.94
5	02.07.2019	WFRD	Weatherford International Pl	6601.00	CHK	Chesapeake Energy Corp	6584.00
6	22.10.2018	BIOF	Blue Biofuels Inc.	8.33	CEI	Camber Energy Inc.	9.70
7	06.07.2018	NES	Nuverra Environmental Solution	311.32	NGS	Natural Gas Service Group Inc.	306.80
8	25.04.2018	ERINQ	Erin Energy Corp.	251.13	ROYE	Royal Energy Resources Inc.	253.36

Source: The main format of the table is based on the study of (Gu, 2002; 31). Each of the non-bankrupt firms was drawn, based on the closest assets, from a sample of energy firms in existence in the same year as the bankrupt energy firm. * *Access Date*: October 2021

2. Literature Review

This section provides an overview of the current studies in the literature, which test the validity of financial failure models.

Ghodrati et all (2012) research the efficiency of Altman, Shirata, Ohlson, Zmijewsky, CA Score, Fulmer, Springate, Farajzadeh Genetic, and McKee Genetic Models. In conclusion, the authors found that these financial models are sufficient to assess the probability of financial failure of companies on the Tehran Stock Exchange. Husein et al. (2014) validated the performances of Altman, Springate, Zmijewski and Grover models as the best predictor of financial distress. As a result of their research, the authors showed that the Altman, Zmijewski, Springate and Grover model can be used to predict financial distress. In addition, the authors found that the Zmijewski model is the most appropriate model to be used to predict financial distress, as it has the highest level of significance compared to other models. Merza Radhi and Sarea (2019) tested the power of the Altman, Kida and Zmijewski models to predict financial failures on 122 industrial companies traded on the Saudi Stock Exchange. As a result of their research, the authors found that the Zmijewski model was much more successful than the Altman and Kida model in estimating the probability of financial failure. Manaseer and Al-Oshaibat (2020) analyzed insurance companies traded on the Jordan Stock Exchange between 2011 and 2016 to test the validity of the Altman Z-score model. As a result of their studies, the authors found that the Altman Z-score model had high predictive performance.

Furthermore, Karadeniz and Öcek (2020) tested the performance of financial failure prediction models by using historical data of a US company that had been declared bankrupt. The authors used Altman, Springate, Canada score, Fulmer and Ohlson models in their studies. As a result of their research, they indicated that the bankruptcy of the selected company could be predicted accurately in all financial models. Elviani et al. (2020) looked at which of the Altman, Ohlson, Springate and Zmijewski models is the most appropriate for

bankruptcy prediction. In their research including 53 trading companies operating in Indonesia, they figured out that Springate and Altman were the most appropriate models for predicting the bankruptcy of commercial companies.

In a study conducted in the American markets in this area, Laurila (2020) tested the validity of the Altman, Ohlson and Springate models on 33 bankrupt and 414 pending manufacturing companies traded on the American Stock Exchanges between 1990 and 2018. Based on the results the author found that one, two, and three years before the date of bankruptcy, the Altman model outperformed the Ohlson and Springate models in predicting bankruptcy. Azim and Sharif (2020) tested the performance of Altman's Z-score model with data from two companies that operated in the finance sector between 2011 and 2017. As a result of their analysis, the authors demonstrated that the Z-score was sufficient for predicting the failure probability. Fauzi et al. (2021) analyzed IT companies on the Indonesian Stock Exchange to determine the best performing financial failure prediction model. The authors used Altman, Zmijewski, Grover and Springate models in their studies. They stated that the Altman model was the most successful, in both explanatory and statistical terms.

Another study in this area, Daryanto et al. (2021) analyzed an Indonesian real estate company between 2015 and 2019 using Altman Z-score, Springate and Zmijewski X-Score models. The authors concluded that the overall financial performance of the real estate company was successful based on the arithmetic average for those 5 years. However, Altman, Springate, and Zmijewski suggested that using the models together with companies' financial report analyses would help decide about the company's improvement in profitability, financial position and strategy. Salim and Ismudjoko (2021) published an article where they investigated the financial failure probabilities of 22 coal mining companies on the Indonesian Stock Exchange using Springate, Zmijewski, Altman, Ohlson, Grover models. The authors presented that the modified Altman and Ohlson models had the highest success rate. Moreover, the authors suggested Zmijewski and Grover as the models with the second-highest success rate, whereas the Springate model had the lowest prediction rate.

3. Data and Methodology

3.1. Data

The sample of this study consists of 16 companies that operate in the energy sector in the US markets. The universe of the study includes all companies that operate in the energy sector. “The accuracy of financial failure models using the multiple discriminant analysis (MDA) method, such as the Altman (1968) model, is significantly reduced when the model is used in

another industry or a commercial field different (Wu et al., 2010; Pitrova, 2011; Wieprow et al., 2021). Therefore, the use of bankruptcy prediction models in different sectors and commercial environments may cause a decrease in successful performance. For this reason, only the energy sector was chosen as a sample in this study."

The financial ratios used in the study were the year-end financial statements of the companies between 2015 and 2020.

3.2. Methodology

In this research, Altman (1968) Z Score, Springate S Score (1978), Ohlson O score (1980), Fulmer F score (1984), Zmijewski J score (1984), Canadian Model Ca Score (1987), and Grove G Score (2001) models were tested for their validity.

3.2.1. Altman Model (1968) Z Score

Equation (1) demonstrates the formula developed by Altman (1968) for companies in the publicly traded industry sector. The accuracy rate of the Altman model is 94%.

$$\mathbf{Z} = 1.2 * \boldsymbol{Z_1} + 1.4 * \boldsymbol{Z_2} + 3.3 * \boldsymbol{Z_3} + 0.6 * \boldsymbol{Z_4} + 0.999 * \boldsymbol{Z_5} \quad (1)$$

$\boldsymbol{Z_1}$ =Working Capital / Total Assets
$\boldsymbol{Z_2}$ =Retained Earnings / Total Assets
$\boldsymbol{Z_3}$ =EBIT / Total Assets
$\boldsymbol{Z_4}$ =Market Value of Equity / Total Liabilities
$\boldsymbol{Z_5}$ =Sales / Total Assets

Table 2. Critical Values of Altman's Model

Z Score	*Possibility of Financial Failure*	*Risk Area*
2.99 < Z Score	Low	Trustworthy
1.81 ≤ Z score ≤ 2.99	Normal	Grey
Z score < 1.81	High	Dangerous

Source: (Altman,1968, s.606-607)

As shown in Table 2, the Z score demonstrates the degree of closeness of the firms to bankruptcy. (Altman, 1968). For that reason, this study proposes hypothesis as follows:

H1: The Altman model can be used to predict company bankruptcies.

3.2.2. Springate Model (1978) S Score

Springate (1978) composed the S score with four financial ratios to predict financially unsuccessful companies. He alleged that the accuracy rate of the model is 92.5%.

$$\mathbf{S} = 1.03 * \boldsymbol{S_1} + 3.07 * \boldsymbol{S_2} + 0.66 * \boldsymbol{S_3} + 0.4 * \boldsymbol{S_4} \quad (2)$$

$\boldsymbol{S_1}$ =Working Capital / Total Assets
$\boldsymbol{S_2}$ =EBIT / Total Assets
$\boldsymbol{S_3}$ =EBT / Current Liabilities

$\boldsymbol{S_4}$ =Sales / Total Assets

Table 3**.** Critical Values of Springate's Model

S Score	*Possibility of Financial Failure*
S Score > 0.862	Low
S Score < 0.862	High

Source: (Springate, 1978)

According to the Springate model, companies with a score lower than 0.862 are classified as failed. (Springate, 1978). As such, the hypothesis is proposed as the following:

H2: The Springate model can be used to predict company bankruptcies.

3.2.3. Ohlson Model (1980) O Score

The Ohlson Score Model was developed by Dr James Ohlson (1980). The equation used by the model is as follows:

$$\mathbf{O} = -1.32 - 0.407 * \log(\boldsymbol{O_1}) + 6.03 * \boldsymbol{O_2} - 1.43 * \boldsymbol{O_3} + +0.0757 * \boldsymbol{O_4} - 1.72 * \boldsymbol{X} - 2.37 * \boldsymbol{O_5} - 1.83 * \boldsymbol{O_6} + 0.285 * \boldsymbol{Y} - 0.521 * \boldsymbol{O_7} \quad (3)$$

$\boldsymbol{O_1}$ = Log of Total Assets
$\boldsymbol{O_2}$ = Total Liabilities / Total Assets
$\boldsymbol{O_3}$ = Working Capital / Total Assets
$\boldsymbol{O_4}$ = Current Liabilities / Current Assets
$\boldsymbol{X}$ = 1 if Total Liabilities > Total Assets; 0 otherwise
$\boldsymbol{O_5}$ = Net Income / Total Assets
$\boldsymbol{O_6}$ = Cash flows from operation / Total Liabilities
$\boldsymbol{Y}$ = 1 a Net Loss for the last two years, 0 otherwise
$\boldsymbol{O_7}$ = (Net Income-Net Income $_{t-1}$) / (| Net Income | + | Net Income $_{t-1}$ |)

The O-score should be converted to a probability of failure using the following equation.

$$P(B) = \frac{e^{O\ Score}}{1+e^{O\ Score}} \quad (4)$$

Table 4. Critical Values of Ohslon's Model

That Score	*Possibility of Financial Failure*
O Score > 0.50	High
O Score < 0.50	Low

Source: (Ohlson, 1980, p.120)

According to the Ohlson model criteria, if the O score is > 0.50, businesses are at risk of financial failure. If the O score is < 0.50, the enterprises do not have the risk of financial failure. The accuracy rate of the Ohlson model was measured as 87.6% one year before the company goes bankrupt. Based on previous research, the proposed hypothesis is as follows:

H3: The Ohlson model can be used to predict company bankruptcies.

3.2.4. Fulmer Model (1984) F Score

Fulmer, Moon, Gavin, and Erwin (1984) published their article titled "A Bankruptcy Classification Model for Small Firms", where they calculated the parameter values of Fulmer's H score model as follows:

$$\mathbf{H} = 5.528\boldsymbol{F_1} + 0.212 * \boldsymbol{F_2} + 0.073 * \boldsymbol{F_3} + 1.270 * \boldsymbol{F_4} - 0.120 * \boldsymbol{F_5} + 2.335 * \boldsymbol{F_6} + 0.575 * \boldsymbol{F_7} + 1.083 * \boldsymbol{F_8} + 0.894 * \boldsymbol{F_9} - 6.075 \quad (5)$$

$\boldsymbol{F_1}$ = Retained Earnings/ Total Assets
$\boldsymbol{F_2}$ = Revenues / Total Assets
$\boldsymbol{F_3}$ = EBT / Equity
$\boldsymbol{F_4}$ = Cash Flows from Operations / Total Debt
$\boldsymbol{F_5}$ = Total Debt / Total Assets
$\boldsymbol{F_6}$ = Current Liabilities / Total Assets
$\boldsymbol{F_7}$ = log(Tangible Assets)
$\boldsymbol{F_8}$ = Working Capital / Total Debt
$\boldsymbol{F_9}$ = log(EBIT) / Interest Expense

Table 5**.** Critical Values of Fulmer's Model

F Score	*Possibility of Financial Failure*
F Score > 0	Low
F Score < 0	High

Source: (Fulmer et al., 1984: 25-37)

According to the model, if the firms have an H score that is less than zero, they may fall into financial distress or face the risk of bankruptcy. The accuracy rate of the model was calculated as 91% (Fulmer et al., 1984: 25-37). Based on previous research, the proposed hypothesis is as the following:

H4: The Fulmer model can be used to predict company bankruptcies.

3.2.5. Zmijewski Model (1984) X Score

The formula for the Zmijewski model developed by Zmijewski (1984) is presented as follows:

$$\mathbf{X} = -4.3 - 4.5 * \boldsymbol{X_1} + 5.7 * \boldsymbol{X_2} + 0.004 * \boldsymbol{X_3} \quad (6)$$

$\boldsymbol{X_1}$ =Net Income/ Total Assets
$\boldsymbol{X_2}$ =Total Liabilities / Total Assets
$\boldsymbol{X_3}$= Current Assets / Current Liabilities

Table 6. Critical Values of Zmijewski's Model

J Score	*Possibility of Financial Failure*
J Score ≥ 0.50	High
J Score ≤ 0.50	Low

Source: (Zmijewski, 1984, p.79)

According to the Zmijewski Model, if the J Score is equal to or higher than 0.50, the company is classified as either financially unhealthy or insolvent. If the J Score is equal to or less than 0.50, the company is classified as healthy. Zmijewski explained the accuracy rate of the model as 99%. For that reason, this study proposes hypothesis as follows:

H5: The Zmijewski model can be used to predict company bankruptcies.

3.2.6. Canada Model (1987) CA Score

The Canada model was developed by Jean Legault and A. Score in 1987 (Legault and Score, 1987). The ratio of the model to accurately predict the financial failure probability of enterprises was calculated as 83% (Karadeniz and Öcek, 2020: 400)[3]

$$CA = 4.59 * \boldsymbol{C_1} + 4.51 * \boldsymbol{C_2} + 0.3936 * \boldsymbol{C_3} - 2.76 \quad (7)$$

$\boldsymbol{C_1}$ = Stockholder Equity / Total Assets $_{t-1}$
$\boldsymbol{C_2}$ =(EBIT + Interest Expenses) / Total Assets $_{t-1}$
$\boldsymbol{C_3}$ = Revenues $_{t-2}$ / Total Assets $_{t-2}$

Table 7. Critical Values of Canadian Model

CA Score	*Possibility of Financial Failure*
CA Score > -0.3	Low
CA Score < -0.3	High

Source: (Black Sea & Öcek, 2020:401)

According to this model, it has been accepted that small companies may fall into financial distress or face the risk of bankruptcy in a few years (Aydın, Başar, & Coşkun, 2014). As such, the hypothesis is proposed as the following:

H6: The Altman model can be used to predict company bankruptcies.

3.2.7. Grover Model (2001) G-Score

The Grover Model was developed by Jeffrey S. Grover in 2001 and presented to the literature by Prihanthini and Sari (2013) with the parameters in equation (8).

$$\mathbf{G} = 1.650 * \boldsymbol{G_1} + 3.404 * \boldsymbol{G_2} - 0.016 * \boldsymbol{G_3} + 0.057 \quad (8)$$

$\boldsymbol{G_1}$ = Working capital / Total Assets
$\boldsymbol{G_2}$ = EBIT / Total Assets
$\boldsymbol{G_3}$ = Net Income / Total Assets (ROA)

Table 8. Critical Values of Grover Model

G Score	*Possibility of Financial Failure*
G Score ≤ - 0.02	High
G Score ≥ 0.01	Low

Source: (Prihanthini and Sari, 2013, p. 421)

[3] Since the accuracy rate of the Legault and Score's (1987) Canadian Score model was not available, a performance test result was taken as reference based on the studies in the literature.

According to the Grover model, if the G-Score is smaller than -0.02, companies may face bankruptcy. On the other hand, a G-Score higher than 0.01 indicates that the company does not have the risk of financial failure. Prihanthini (2013) applied the Grover Model to companies listed on the Indonesian Stock Exchange and he calculated the accuracy rate of the model as 100%.

H7: The Grover model can be used to predict company bankruptcies.

This study also attempts to test which model is found to be the best for predicting financial failure among the models used. Therefore, the research hypothesis can be formulated as follows:

H8: The Altman model predicts company bankruptcies better than the Springate, Ohlson, Fulmer, Zmijewski, Canada and Grove models.

H9: The Springate model predicts company bankruptcies better than the Springate, Ohlson, Fulmer, Zmijewski, Canada and Grove models.

H10: The Ohlson model predicts company bankruptcies better than the Altman, Springate, Fulmer, Zmijewski, Canada and Grove models.

H11: The Fulmer model predicts company bankruptcies better than the Altman, Springate, Ohlson, Zmijewski, Canada and Grove models.

H12: The Zmijewski model predicts company bankruptcies better than the Altman, Springate, Ohlson, Fulmer, Canada and Grove models.

H13: The Canada model predicts company bankruptcies better than the Altman, Springate, Ohlson, Fulmer, Zmijewski, and Grove models.

H14: The Grove model predicts company bankruptcies better than the Altman, Springate, Ohlson, Fulmer, Zmijewski, Canada and Grove models.

The analyzes of validity tests in the literature are generally made between companies that do not carry financial risks and companies that declare bankruptcy. Then, the accuracy rates of the models were made to identify the bankrupt and non-bankrupt companies. However, in this study, the results obtained from each model are taken with the values of the companies in the last three years.

$$\% A: 1 - (\frac{m}{N}) \quad (9)$$

In Equation (8), the *m* value represents the number of observations that correctly predict the total probability of financial failure of bankrupt companies over the last 3 years. *The N* value represents the total number of observations of financial failure value in the last 3 years before companies went bankrupt.

$$\% A: 1 - (\frac{m_{t-3}}{N_{t-3}}) \quad (10)$$

In Equation (9), the *m* value represents the number of observations that predict the probability of financial failure of companies accurately in the third year before the company declared bankruptcy. The *N* value represents the total number of observations in the third year before the company declared bankruptcy.

$$\% A: 1 - (\frac{m_{t-2}}{N_{t-2}}) \quad (11)$$

In Equation (10), the *m* value represents the number of observations that predict the probability of financial failure of companies accurately in the second year before the company declared bankruptcy. The N value represents the total number of observations in the second year before the company declared bankruptcy.

$$\% A: 1 - (\frac{m_{t-1}}{N_{t-1}}) \quad (12)$$

In Equation (11), the *m* value represents the number of observations that predict the probability of financial failure of companies accurately in the last year before the company declared bankruptcy. The *N* value represents the total number of observations in the last year before the company declared bankruptcy.

4. Findings

4.1.Descriptive Statistics

Table 9. Descriptive Statistics

Model	N	Minimum	Maximum	Mean	Std. Deviation
Altman	48	-44.0	1.45	-3.78	7.76
Springate	48	-10.05	0.59	-1.92	2.13
Ohlson	48	0.19	1.00	0.94	0.17
Fulmer	48	-103.91	-2.57	-13.92	19.33
Zmijewski	48	0.40	20.00	4.65	4.18
Canada	48	-10.10	-0.40	-3.72	2.38
Grove	48	-7.14	-0.01	-2.07	1.77

The descriptive statistical results of financial failure models are shown in table 9. According to the results, the Fulmer model is seen as the model that exhibits outlier values and has the highest standard deviation.

4.2. Hypothesis Testing

This section analyzes whether the financial failure models accurately predict the risk of financial failure. The scores provided by the financial failure models are presented in the tables below. The scores presented cover the period until the declaration of bankruptcy. Financial failure probabilities should be high in all scores shown in the table to ensure high accuracy rates for financial failure models.

Table 10. Bankruptcy Forecast Results of Energy Companies According to the Altman Model

Company Name	***Bankruptcy Declaration Date***	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***
ERINQ	25.04.2018	-6.52	-6.56	-8.92			
**SNMP	-	-1.06	0.49	0.72			
NES	6.07.2018	-5.14	-6.03	1.45			
**SBR	-	279.85*	40307*	403.07*			
BIOF	22.10.2018	-1.52	-152	-1.52			
**UGE	-	-4.39	-554	-1.20			
WFRD	2.07.2019		-0.02	-0.85	-2.06		
**WLL	-		-013	-0.52	0.46		
BATL	7.08.2019		-1.90	3.18*	0.52		
**CHK	-		-2.01	-0.83	-0.66		
YUMAQ	15.04.2020			-0.09	-1.47	-2.41	
**CEI	-			-22.58	-13.28	-44.00	
FPPP	24.06.2020			-2.22	-6.68	-7.06	
**NGS	-			6.38*	4.16*	3.47*	
BASXQ	17.08.2021				0.52	-0.18	-3.88
**ROYE	-				1.30	1.12	1.12

** According to the Altman model, scores with a low probability of financial failure*
*** Control group (2)- Non-bankrupt firms*

Table 10 shows the Z scores of 16 energy companies in the US stock markets between 2015 and 2020. The Altman model states that businesses with a Z-score smaller than 1.81 are financially risky. According to the results, BATL is the only company that is shown to have a low probability of financial failure in 2017 in bankrupt firms. On the other hand, SBR and NGS companies have a low probability of financial failure in non-bankrupt firms. In all the other results, the bankruptcy risks of the companies are calculated as high.

Table 11. Validity Results of the Altman Model for Energy Companies

Altman Model			**Measured Perceived**											
			Overall Accuracy Rate of the Companies			*Accuracy Rate of the Companies in the Last Three Years*			*Accuracy Rate of the Companies in the Last Two Years*			*Accuracy Rate of the Companies in the Last Year*		
			Bankrupt	Non Bankrupt	Total	Bankrupt	Non Bankrupt	Total	Bankrupt	Non Bankrupt	Total	Bankrupt	Non Bankrupt	Total
Reality	**Quantity**	Bankrupt	22	2*	24	7	1*	8	7	1*	8	8	0*	8
		Non-Bankrupt	18**	6	24	6**	2	8	6**	2	8	6**	2	8
	Percentage (%)	Bankrupt	91.7%	8.3%*	100	87.5%	12.5%*	100	87.5%	12.5%*	100	100%	0%*	100
		Non-Bankrupt	75.0%**	25.0%	100	75.0%**	25.0%	100	75.0%**	25.0%	100	75.0%**	25.0%	100
Overall Accuracy Rate			*58.3%*			*56.3%*			*56.3%*			*62.5%*		

** Type I Error **Type II Error*

Alareeni (2014) found that Altman Z-Score (1968) model works effectively in his article. The author stated that the overall classification accuracy rate of the model is 73.40%, 74.46% and 70.21% within the first, second and third year, respectively. In addition, Indriyanti (2019) found that the Altman model can predict with accuracy until 86,6%. Table 11 shows Type I -

II errors and the accuracy rates for the Altman (1968) model. Based on the general results, the overall accuracy rate of the Altman Z-score model is 58.3% in table 8. This rate is considerably lower than what Altman (1968) calculated as 94%. The observed rates aren't in the same line as the original Altman results. The accuracy rate of the model is 56,3% 3 years before and 2 years before the company goes bankrupt. In addition, the accuracy rate of the model is 62.5% 1 year before the company goes bankrupt.

The Type I error of the Altman Z-score (1968) model was 12.5%, 12.5% and 0% within three, two and one years before the failure. As for the Type II error, it amounted to 75.0%, 75.0% and 75.0% three, two and one years before the failure. When the overall average of the last 3 years of the model is considered, the type I error of the overall accuracy rate is %8.3 and the type II error is %75. The Type II error rate is somewhat higher in the model. Type I error is quite low. Thus, the model has a high predicting ability for the bankrupt group. However, the Type II error rate is quite high. The model has no high predicting ability for non-bankrupt companies. Alareeni (2013) stated that researchers have claimed that Type I errors are much more serious than Type II errors (Lee, Chiu, Lu, & Chen, 2002; Zhoh & Elhag 2007). Type I errors are likely to result in real losses for investors, banks and other interested parties. On the other hand, type II errors result in 'opportunity' losses: investors may lose the opportunity to make a good investment, banks may lose the opportunity to lend money to customers, and sellers may lose the opportunity to sell (Alareeni, 2013).

Table 12. Bankruptcy Forecast Results of Energy Companies According to the Springate Model

Company Name	***Bankruptcy Declaration Date***	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***
ERINQ	25.04.2018	-4.83	-2.65	-3.12			
**SNMP	-	-10.05	-2.25	-0.34			
NES	6.07.2018	-1.65	-2.42	-2.36			
**SBR	-	59.58*	41.57*	54.72*			
BIOF	22.10.2018	-4.79	-4.79	-3.17			
**UGE	-	-1.51	-1.23	0.07			
WFRD	2.07.2019		-0.91	-1.09	-1.22		
**WLL	-		-1.87	-1.18	0.52		
BATL	7.08.2019		-5.02	4.81*	0.52		
**CHK	-		-1.40	-0.20	0.24		
YUMAQ	15.04.2020			-0.57	-1.12	-1.12	
**CEI	-			-7.00	12.59*	-3.31	
FPPP	24.06.2020			-0.91	-3.31	-3.31	
**NGS	-			0.59	0.33	-1.74	
BASXQ	17.08.2021				-0.02	-0.14	-2.64
**ROYE	-				-0.52	-0.52	-0.52

** According to Springate model results, scores with a low probability of financial failure*
*** Control group (2)- Non-bankrupt firms*

The Springate model states that businesses with an S score smaller than 0.832, they can be financially risky. Table 12 shows the S scores of 16 energy companies in the US stock markets between 2015 and 2020. According to the results, BATL is the only company that is shown to have a low probability of financial failure in 2017 in bankrupt firms. On the other hand, SBR, NGS in all years and CEI company in 2018 have a low probability of financial failure in non-bankrupt firms. In all the other results, the bankruptcy risks of the companies are calculated as high.

Table 13. Validity Results of the Springate Model for Energy Companies

Springate Model			**Measured Perceived**											
			Overall Accuracy Rate of the Companies			*Accuracy Rate of the Companies in the Last Three Years*			*Accuracy Rate of the Companies in the Last Two Years*			*Accuracy Rate of the Companies in the Last Year*		
			Bankrupt	Non Bankrupt	Total	Bankrupt	Non Bankrupt	Total	Bankrupt	Non Bankrupt	Total	Bankrupt	Non Bankrupt	Total
Reality	**Quantity**	Bankrupt	23	1	24	8	0	8	7	1	8	8	0	8
		Non-Bankrupt	20	4	24	7	1	8	6	2	8	7	1	8
	Percentage (%)	Bankrupt	95.8%	4.2%	100	100.0%	0.0%	100	87.5%	12.5%	100	100.0%	0.0%	100
		Non-Bankrupt	83.3%	16.7%	100	87.5%	12.5%	100	75.0%	25.0%	100	87.5%	12.5%	100
Average Accuracy Rate			*56.3%*			*56.3%*			*56.3%*			*56.3%*		

** Type I Error **Type II Error*

According to the overall results, the accuracy rate of the Springate S score model is 56.3% in table 13. This rate is quite low compared to the rate that Springate (1978) calculated as 92.5%. In addition, Indriyanti (2019) found that the Springate model can predict with accurate until 70.0%. However, Astuti et al. (2021) found the accuracy rate of Springate is %47 in his article. The accuracy rate of the model is 56.3% for three years before the company goes bankrupt in this article.

The type I error of the Springate (1968) model was 0%, 12.5% and 0% within three, two and one years before the failure. As for the type II error, it amounted to 87.5%, 75.0% and 87.5% three, two and one years before the failure. When the overall average of the last 3 years of the model is considered, the type I error of the overall accuracy rate is %4.2 and the type II error is %83.3. The type II error rate is somewhat higher in the model. Type I error is quite low. Thus, the model has a high predicting ability for the bankrupt group. However, the Type II error rate is quite high. The model has no high predicting ability for non-bankrupt companies.

Table 14. Bankruptcy Forecast Results of Energy Companies According to the Fulmer Model

Company Name	***Bankruptcy Declaration Date***	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***
ERINQ	25.04.2018	-15.04	-21.97	-26.98			
**SNMP	-	-4.23	-4.03	-4.35			
NES	6.07.2018	-15.45	-26.59	-4.87			
**SBR	-	213.89*	173.59*	200.76*			
BIOF	22.10.2018	57.06*	57.06*	41.41*			
**UGE	-	-13.79	-11.12	-8.99			
WFRD	2.07.2019		-4.84	-4.46	-9.79		
**WLL	-		-4.24	-5.01	-4.88		
BATL	7.08.2019		-6.08	-2.78	-3.60		
**CHK	-		-9.30	-6.46	-9.56		
YUMAQ	15.04.2020			-5.49	-6.66	-6.66	
**CEI	-			-65.82	-103.91	-55.43	
FPPP	24.06.2020			-12.29	-16.53	-16.53	
**NGS	-			13.90*	-2.93	70.42*	
BASXQ	17.08.2021				-5.28	-9.06	-14.11
**ROYE	-				-2.57	-2.57	-2.57

** According to Fulmer model results, scores with a low probability of financial failure*
*** Control group (2)- Non-bankrupt firms*

Table 14 shows the F scores of 16 energy companies in the US stock markets between 2015 and 2020. The Fulmer model states that businesses with an F score smaller than zero, they can be financially risky. According to the results in Table 11, the BIOF company was considered financially risk-free in 2016, 2017, and 2018 in bankrupt firms. On the other hand, SBR in all years and NGS company in 2017 and 2019 have a low probability of financial failure in non-bankrupt firms. In all the other results, the bankruptcy risks of the companies are calculated as high.

Table 15. Validity Results of the Fulmer Model for Energy Companies

Fulmer Model			**Measured Perceived**											
			Overall Accuracy Rate of the Companies			*Accuracy Rate of the Companies in the Last Three Years*			*Accuracy Rate of the Companies in the Last Two Years*			*Accuracy Rate of the Companies in the Last Year*		
			Bankrupt	Non Bankrupt	Total	Bankrupt	Non Bankrupt	Total	Bankrupt	Non Bankrupt	Total	Bankrupt	Non Bankrupt	Total
Reality	**Quantity**	Bankrupt	21	3*	24	7	1*	8	7	1	8	7	1*	8
		Non-Bankrupt	13**	11	24	6**	2	8	1	7	8	6**	2	8
	Percentage (%)	Bankrupt	87.5%	12.5%	100	87.5%	12.5%	100	87.5%	12.5%	100	87.5%	12.5%	100
		Non-Bankrupt	54.2%	45.8%	100	75.0%	25.0%	100	12.5%	87.5%	100	75.0%	25.0%	100
Average Accuracy Rate			*66.7%*			*56.3%*			*87.5%*			*56.3%*		

** Type I Error **Type II Error*

Fulmer (1984) calculated the accuracy rate of his model as 91.0%. In addition, Astuti et al. (2021) found the accuracy rate of Fulmer is %80 in his article. Moreover, Indriyanti (2019) calculated the accuracy rate of the Fulmer model as 40.0%. According to the overall results in this article, the accuracy rate of the Fulmer F score model is 66.7%. This rate is an average rate when compared with other studies in the literature.

The Type I error of the Fulmer model was 12.5% for all years. As for the Type II error, it amounted to 75.0%, 12.5% and 75.0% three, two and one years before the failure. When the overall average of the last 3 years of the model is considered, the type I error of the overall accuracy rate is %12.5 and Type II error is %54.2. The type II error rate is somewhat higher in the model. Type I error is quite low. Thus, the model has a high predicting ability for the bankrupt group. However, the model has a moderate predictive ability for companies that do not go bankrupt.

Table 16. Bankruptcy Forecast Results of Energy Companies According to the Zmijewski Model

Company Name	***Bankruptcy Declaration Date***	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***
ERINQ	25.04.2018	7.5	8.0	12.4			
**SNMP	-	1.0	-2.6*	-2.0*			
NES	6.07.2018	3.5	6.4	-4.8*			
**SBR	-	-37.2*	-27.0*	-32.8*			
BIOF	22.10.2018	4.0	3.4	4.2			
**UGE	-	-9.1*	3.3	2.9			
WFRD	2.07.2019		1.7	3.0	6.5		
**WLL	-		-1.0*	-0.6*	-1.9*		
BATL	7.08.2019		2.5	-3.8*	-2.0*		
**CHK	-		3.4	1.8	0.4		
YUMAQ	15.04.2020			-0.6*	0.7	0.7	
**CEI	-			20.0	-11.4*	-1.3*	
FPPP	24.06.2020			-1.5*	6.3	6.3	
**NGS	-			-3.8*	-3.4*	-3.3*	
BASXQ	17.08.2021				0.6	2.5	7.8
**ROYE	-				-1.1*	-1.1*	-1.1*

** According to Zmijewski model results, scores with a low probability of financial failure*
*** Control group (2)- Non-bankrupt firms*

Table 16 shows the J scores of 16 energy companies in the US stock markets between 2015 and 2020. The Zmijewski model states that if the J score of a firm is greater than or equal to 0.50, it may have a high probability of financial failure. According to the results in table 16, NES in 2017, BATL, FPPP in 2017 and 2018, YUMAQ in 2017, are shown to have low financial risk. On the other hand, SNMP in 2016 and 2017, SBR, NGS, ROYE in all years, UGE in 2015, WLL in all years and CEI in 2018 and 2019 have a low probability of

financial failure in non-bankrupt firms. In all the other results, the bankruptcy risks of the companies are calculated as high.

Table 17. Validity Results of the Zmijewski Model for Energy Companies

Zmijewski Model			**Measured Perceived**											
			Overall Accuracy Rate of the Companies			*Accuracy Rate of the Companies in the Last Three Years*			*Accuracy Rate of the Companies in the Last Two Years*			*Accuracy Rate of the Companies in the Last Year*		
			Bankrupt	Non Bankrupt	Total	Bankrupt	Non Bankrupt	Total	Bankrupt	Non Bankrupt	Total	Bankrupt	Non Bankrupt	Total
Reality	**Quantity**	Bankrupt	19	5*	24	6	2*	8	7	1*	8	6	2*	8
		Non-Bankrupt	6**	18	24	3**	5	8	2**	6	8	1**	7	8
	Percentage (%)	Bankrupt	79.2%	20.8%*	100	75.0%	25.0%*	100	87.5%	12.5%*	100	75.0%	25.0%*	100
		Non-Bankrupt	25.0%**	75.0%	100	37.5%**	62.5%	100	25.0%**	75.0%	100	12.5%**	87.5%	100
Average Accuracy Rate			*77.1%*			*68.8%*			*81.3%*			*81.3%*		

** Type I Error **Type II Error*

Zmijewski (1984) calculated the accuracy rate of his model as 99.0%. In addition, Indriyanti (2019) found the accuracy rate of Zmijewski is %85 in his research. According to the overall results in this article, the accuracy rate of the Zmijewski score model is 77.1%. This rate is relatively close to other studies in the literature.

The type I error of the Zmijewski (1984) model was 25.0%, 12.5% and 25.0% within three, two and one years before the failure. As for the Type II error, it amounted to 37.5%, 25.0% and 12.5% three, two and one years before the failure. When the overall average of the last 3 years of the model is considered, the type I error of the overall accuracy rate is %20.8 and the Type II error is %25.0. Type I and II error rates are relatively low in the model. Therefore, the model has a relatively high predictive ability for both bankrupt and non-bankrupt groups.

Table 18. Bankruptcy Forecast Results of Energy Companies by Canadian Score Model

Company Name	***Bankruptcy Declaration Date***	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***
ERINQ	25.04.2018	-6.1	-6.6	-10.1			
**SNMP	-	-6.50	-2.6	0*			
NES	6.07.2018	-3.5	-5.0	-0.20*			
**SBR	-	33.7*	24.1*	33.8*			
BIOF	22.10.2018	-4.7	-4.7	-3.2			
**UGE	-	-7.8	-5.5	-4.4			
WFRD	2.07.2019		-2.3	-3.3	-5.0		
**WLL	-		-0.7	-1.4	0*		
BATL	7.08.2019		-3.7	3.60*	1.10*		
**CHK	-		-3.8	-2.6	-1.3		
YUMAQ	15.04.2020			-1.2	-2.1	-2.0	
**CEI	-			-7.3	5.9*	-1.1	

FPPP	24.06.2020			-2.1	-5.4	-7.2	
**NGS	-			1.4*	1.3*	0.8*	
BASXQ	17.08.2021				-1.3	-2.1	-5.5
**ROYE	-				-0.8	-0.5	-0.4

** According to Canada model results, scores with a low probability of financial failure*
*** Control group (2)- Non-bankrupt firms*

Table 18 shows the Ca scores of 16 energy companies in the US stock markets between 2015 and 2020. The Canadian model shows that if companies have a Ca score less than -0.3, they may have a high risk of financial failure. According to the results, NES in 2017, BATL in 2017 and 2018 are shown to have low financial risk in bankrupt firms. On the other hand, SNMP in 2017, SBR and NGS in all years, WLL and CEI in 2018 have a low probability of financial failure in non-bankrupt firms. In all the other results, the bankruptcy risks of the companies are calculated as high.

Table 19. Validity Results of the Canada Model for Energy Companies

Canadian Model			**Measured Perceived**											
			Overall Accuracy Rate of the Companies			*Accuracy Rate of the Companies in the Last Three Years*			*Accuracy Rate of the Companies in the Last Two Years*			*Accuracy Rate of the Companies in the Last Year*		
			Bankrupt	Non Bankrupt	Total	Bankrupt	Non Bankrupt	Total	Bankrupt	Non Bankrupt	Total	Bankrupt	Non Bankrupt	Total
Reality	**Quantity**	Bankrupt	21	3*	24	8	0*	8	7	1*	8	6	2*	8
		Non-Bankrupt	15**	9	24	6**	2	8	5**	3	8	4**	4	8
	Percentage (%)	Bankrupt	87.5%	12.5%*	100	100.0%	0.0%*	100	87.5%	12.5%*	100	75.0%	25.0%*	100
		Non-Bankrupt	62.5%**	37.5%	100	75.0%**	25.0%	100	62.5%**	37.5%	100	50.0%**	50.0%	100
Average Accuracy Rate			*62.5%*			*62.5%*			*62.5%*			*62.5%*		

** Type I Error **Type II Error*

According to the overall results, the accuracy rate of the Canada model is 62.5%. This rate is below the 83% rate calculated by Karadeniz and Öcek (2020). The accuracy rate of the model is 100% three years before the company goes bankrupt, while the accuracy rate is 87.5% two years and 75% one year before the company goes bankrupt.

The type I error of the Canada model was 0%, 12.5% and 25.0% within three, two and one years before the failure. As for the type II error, it amounted to 75.0%, 62.5% and 50.0% three, two and one years before the failure. When the overall average of the last 3 years of the model is considered, the type I error of the overall accuracy rate is %12.5 and the type II error is %62.5. Type I error is very low. Type II error rate is slightly higher. Therefore, the model has a high predictive ability for the bankrupt group. However, the model has a moderate predictive ability for companies that do not go bankrupt.

Table 20. Bankruptcy Forecast Results of Energy Companies According to Ohlson Model

Company Name	***Bankruptcy Declaration Date***	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***
ERINQ	25.04.2018	1.0000	0.0000*	1.0000			
**SNMP	-	0.9998	0.0000*	1.0000			
NES	6.07.2018	0.0000*	0.0016*	0.0000*			
**SBR	-	0.0000*	0.0000*	0.0000*			
BIOF	22.10.2018	0.9998	0.9994	0.9999			
**UGE	-	1.0000	0.0001*	0.9914			
WFRD	2.07.2019		1.0000	0.0000*	0.9940		
**WLL	-		0.0000*	0.0000*	0.0000*		
BATL	7.08.2019		0.0000*	0.0000*	1.0000		
**CHK	-		0.0000*	0.0000*	0.0000*		
YUMAQ	15.04.2020			0.0000*	0.9978	0.9866	
**CEI	-			0.0000*	0.0000*	1.0000	
FPPP	24.06.2020			0.6531	1.0000	0.9998	
**NGS	-			0.0044*	1.0000	0.1901	
BASXQ	17.08.2021				1.0000	1.0000	1.0000
**ROYE	-				1.0000	0.7654	0.7654

** According to Ohlson model results, scores with a low probability of financial failure*
*** Control group (2)- Non-bankrupt firms*

Table 20 shows the Ohlson Model results of the companies included in the study between 2015 and 2020. The Ohlson model claimed if companies have an O score greater than 0.50, they may have a high risk of financial failure. According to the results in table 20, ERINQ and BATL in 2016, WFRD, BATL and YUMAQ in 2017 were calculated as having a low probability of financial failure in bankrupt firms. On the other hand, SBR, WLL, CHK in all years, SNMP and UGE in 2016, CEI and NGS in 2017 and CEI in 2018 have a low probability of financial failure in non-bankrupt firms. In all the other results, the bankruptcy risks of the companies are calculated as high.

Table 21. Validity Results of Ohlson Model for Energy Companies

Ohlson Model			**Measured Perceived**											
			Overall Accuracy Rate of the Companies			*Accuracy Rate of the Companies in the Last Three Years*			*Accuracy Rate of the Companies in the Last Two Years*			*Accuracy Rate of the Companies in the Last Year*		
			Bankrupt	Non Bankrupt	Total	Bankrupt	Non Bankrupt	Total	Bankrupt	Non Bankrupt	Total	Bankrupt	Non Bankrupt	Total
Reality	**Quantity**	Bankrupt	16	8*	24	5	3*	8	4	4*	8	7	1*	8
		Non-Bankrupt	9**	15	24	3**	5	8	2**	6	8	4**	4	8
	Percentage (%)	Bankrupt	66.7%	33.3%*	100	62.5%	37.5%*	100	50.0%	50.0%*	100	87.5%	12.5%*	100
		Non-Bankrupt	37.5%**	62,5%	100	37.5%**	62.5%	100	25.0%**	75.0%	100	50.0%**	50.0%	100
Average Accuracy Rate			*64.6%*			*62.5%*			*62.5%*			*68.8%*		

** Type I Error **Type II Error*

Ohlson (1980) calculated the accuracy rate of his model as 87.6%. In addition, Indriyanti (2019) found the accuracy rate of Ohlson is %46.6 in his research. According to the overall results in this article, the accuracy rate of the Ohlson score model is 64.6%. This rate is at an average level compared to other studies in the literature.

The Type I error of the Ohlson (1980) model was 37.5%, 50.0% and 12.5% within three, two and one years before the failure. As for the Type II error, it amounted to 37.5%, 25.0% and 50.0% three, two and one years before the failure. When the overall average of the last 3 years of the model is considered, the type I error of the overall accuracy rate is %33.3 and the type II error is %37.5. Type I and II error rates are not very high in the model. Therefore, the model has a relatively high predictive ability for both bankrupt and non-bankrupt groups.

Table 22. Bankruptcy Forecast Results of Energy Companies According to the Grover Model

Company Name	***Bankruptcy Declaration Date***	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***
ERINQ	25.04.2018	-4.83	-3.06	-3.98			
**SNMP	-	0.07*	0.17*	-0.24			
NES	6.07.2018	-2.30	-3.31	-0.67			
**SBR	-	23.45*	18.83*	22.86*			
BIOF	22.10.2018	-3.52	-3.53	-2.39			
**UGE	-	-0.55	-3.86	-4.55			
WFRD	2.07.2019		-0.22	-0.42	-0.72		
**WLL	-		0.21*	0.05*	-7.14		
BATL	7.08.2019		-2.41	1.89*	0.21*		
**CHK	-		-0.01	-0.07	-4.92		
YUMAQ	15.04.2020			-0.36	-1.30	-1.30	
**CEI	-			-1.85	-1.85	-1.85	
FPPP	24.06.2020			-1.11	-3.54	-3.54	
**NGS	-			0.09*	0.35*	0.09*	
BASXQ	17.08.2021				0.11*	-0.03	-2.30
**ROYE	-				-0.23	-0.23	-0.23

** According to Grover model results, scores with a low probability of financial failure*
*** Control group (2)- Non-bankrupt firms*

Table 22 shows the Grover model results for the 2015−2020 period. According to this model, G score ≤-0.02 indicates a high probability of financial failure, while G score ≥0.01 implies a low risk of bankruptcy. Based on these guidelines, BATL and BASXQ in 2017 and 2018, BASXQ in 2018 were companies in the analysed sample with a low probability of financial failure in bankrupt firms. On the other hand, SBR, NGS in all years, SNMP in 2015-

2016, WLL in 2016 and 2017 have a low probability of financial failure in non-bankrupt firms. In all the other results, the bankruptcy risks of the companies are calculated as high.

Table 23. Validity Results of the Grover Model for Energy Companies

Ohlson Model			**Measured Perceived**											
			Overall Accuracy Rate of the Companies			*Accuracy Rate of the Companies in the Last Three Years*			*Accuracy Rate of the Companies in the Last Two Years*			*Accuracy Rate of the Companies in the Last Year*		
			Bankrupt	Non Bankrupt	Total	Bankrupt	Non Bankrupt	Total	Bankrupt	Non Bankrupt	Total	Bankrupt	Non Bankrupt	Total
Reality	**Quantity**	Bankrupt	21	3*	24	7	1*	8	7	1*	8	7	1*	8
		Non-Bankrupt	14**	10	24	4**	4	8	4**	4	8	6**	2	8
	Percentage (%)	Bankrupt	87.5%	12.5%*	100	87.5%	12.5%*	100	87.5%	12.5%*	100	87.5%	12.5%*	100
		Non-Bankrupt	58.3%**	41.7%	100	50.0%**	50.0%	100	50.0%**	50.0%	100	75.0%**	25.0%	100
Average Accuracy Rate			*64.6%*			*68.8%*			*68.8%*			*56.3%*		

** Type I Error **Type II Error*

Grover reported 100% accuracy for this model. In addition, Indriyanti (2019) found the accuracy rate of Grover is %96.6 i and Astuti et al. (2021) found the accuracy rate of Grover is %80 in their research. According to the overall results in this article, the accuracy rate of the Grover score model is 64.6%. This rate is at an average level compared to other studies in the literature. This rate is well below the average when compared to other studies in the literature.

The type I error of the Grover (2019) model was 12.5% for all years. As for the type II error, it amounted to 50.0%, 50.0% and 75.0% three, two and one years before the failure. When the overall average of the last 3 years of the model is considered, type I error of the overall accuracy rate is %12.5 and type II error is %58.3. The type I error rate in the model is very low. Therefore, the model has a high predictive ability to predict bankrupt companies. Type II error is not very high. Therefore, the model has a moderate predictive ability for non-bankrupt groups.

Table 24**.** The Comparison of Modelling Techniques and the Prediction Power of Model

No	*Financial Failure Models*	*Reference Values**	*Overall Accuracy Rate of the Companies*	*Accuracy Rate of the Companies in the Last Three Years*	*Accuracy Rate of the Companies in the Last Two Years*	*Accuracy Rate of the Companies in the Last Year*
1	*Zmijewski Model*	99.0%	77.1%	68.8%	81.3%	81.3%
2	*Fulmer Model*	91.0%	66.7%	56.3%	87.5%	56.3%
3	*Ohlson Model*	87.6%	64.6%	62.5%	62.5%	68.8%
4	*Grover Model*	100.0%	64.6%	68.8%	68.8%	56.3%
5	*Canada Model*	83.0%	62.5%	62.5%	62.5%	62.5%
6	*Altman Model*	94.0%	58.3%	56.3%	56.3%	62.5%

7	*Springate Model*	92.5%	56.3%	56.3%	56.3%	56.3%
Average		*92.4%*	*64.3%*	*62.5%*	*69.8%*	*63.4%*

**The correct prediction rates of financial failure calculated by the authors who created the financial failure models for these models*

Table 24 summarises the accuracy rates of all financial failure models examined in this study. As can be seen from the tabulated findings, the overall average accuracy rate of these financial failure models is 64.3%, which is well below the average of 92.4% obtained considering the rates reported in the related literature. In addition, when different periods are considered, the accuracy ranges from 56.3% to 87.5%.

Among the selected financial failure models, the Zmijewski model was the best predictor of corporate bankruptcies with an accuracy rate of 77.1%. In the same way, Husein (2015) found that the model of Zmijewski is the most appropriate model to be used for predicting financial distress.

Thus, it rejected H8, H9, H10, H11, H12, H13, H14.

H12: The Zmijewski model predicts company bankruptcies better than the Altman, Springate, Ohlson, Fulmer, Canada and Grove models. H12 hypothesis is accepted.

Otherwise, the accuracy rate of the Fulmer Model, Ohlson Model, Grover Model, Canadian Model, Altman Model and Springate Model varies between 56.3% and 66.7%. Compared to other studies in the literature, the overall performance of the financial failure models in this study was below the average.

However, these models need to be statistically significant. Therefore, Sensitivity and Specificity tests have been applied for these models.

4.3. Sensitivity and Specificity Tests (ROC Curve Analysis)

Sensitivity and specificity tests analyze the performance of financial failure prediction models to classify successful and unsuccessful companies. ROC analysis evaluates the probability of a test predicting a financially unsuccessful company (which is about to go bankrupt) as unsuccessful. The specificity test measures the probability of distinguishing an unsuccessful company from a successful one.

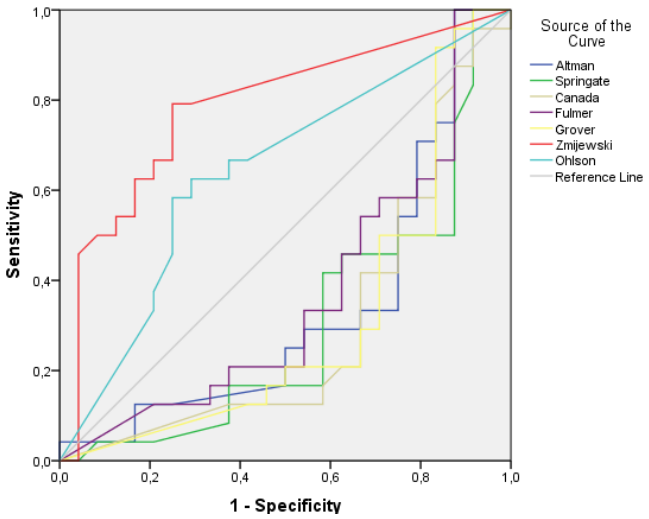

Figure 1. ROC Curve

In Figure 1, the results of the evaluation made using the ROC curve analysis are given. The green and the linear line indicates the reference line. A higher sensitivity value for a given specificity value indicates the higher performance of the function. The area under the curve (AUC) is a widely used measure to evaluate the performance of the function (Li et al., 2017, p.792).

Table 25. Area Under the Curve (AUC)

Test Result Variable(s)	**Area**	**Std. Error[a]**	**Asymptotic Sig.[b]**	**Asymptotic 95% Confidence Interval**	
				Lower Bound	Upper Bound
Altman	.337	.082	.053	.176	.498
Springate	.305	.078	.020*	.152	.458
Canada	.299	.079	.017*	.145	.454
Fulmer	.367	.083	.115	.205	.529
Grover	.309	.081	.023*	.151	.467
Zmijewski	.785	.069	.001*	.650	.920
Ohlson	.642	.081	.091	.483	.802

[a] *Under the nonparametric assumption* [b] *Null hypothesis: true area:0.5* * *p<0.05*

According to the results of the analysis, the AUC (Area Under the Curve) value was calculated as 0.337 for Altman, 0.305 for Springate, 0.299 for Canada, 0.367 for Fulmer, 0.309 for Grover, 0.785 for Zmijewski, and 0.642 for Ohlson. *P* values of p<0.05 indicate that the generated functions are usable. According to the research results, our Springate, Canada, Grove and Zmijewski models show statistical significance. In addition, the significance level of the Altman model was calculated slightly above the 0.05 level.

Thus, it rejected H8, H9, H10, H11, H12, H13, H14.

Table 26. Coordinates of the Curve

Test Result Variable(s)	Positive if Greater Than or Equal To	Sensitivity	1 - Specificity	LR
Altman	-11.1	1	0.875	1.14
Springate	-6.01	1	0.917	1.09
Canada	-7.25	0.958	0.917	1.04
Fulmer	-41.205	1	0.875	1.14
Grover	-3.7	0.917	0.833	1.10
Zmijewski	3.45	0.458	0.042	10.90
Ohlson	0.9927	0.583	0.25	2.33

Table 17 shows the coordinates of the Curve values of the models. Likelyhood Ratio (LR) level of 5 indicates an intermediate test, and a level of 10 or higher indicates an excellent test. But a test below level 2 is not very successful. According to the data in table 17, Zmijewski was calculated as the model with the highest LR with a level of 10.70. This means that the Zmijewski model alone is so perfect that it can be used to detect financial success and failure. Zmijewski (1984) determined the cut-off point of the model as 0.50. However, if the Zmijewski model has a (3.45) cutoff level, it may provide better results with a sensitivity of 30.4% and a specificity of 95.7% for energy companies in the USA. Except for Zmijewski, the test results of other financial failure models (LR) were not found successful enough. Thus, it rejected H1, H2, H3, H4, H6, H7. H7 hypothesis is accepted.

H5: The Zmijewski model can be used to predict company bankruptcies.

However, these hypotheses are restricted to companies in the energy sectors in the US during the pandemic.

5. Conclusion and Discussion

Recent global crises and natural disasters have caused significant damage to the economies of the countries. Especially during the Covid-19 pandemic, the slowdown in the industry and travel restrictions resulted in significant damage to companies, while leading some of them to bankruptcy.

These unexpected bankruptcies result in grave consequences for company partners, investors, employees, commercial & financial creditors, and countries. Therefore, the financial failure risks of companies should be continuously measured and controlled. It is important to constantly check the validity of these models, too. Because investors and researchers rely on higher validity rates of these models to be able to make the right decisions. Thus, this research aims to test the validity of financial failure models based on the historical data of 8 American companies whose bankruptcies were announced and 8 American companies which are non-bankruptcy.

This research aims to determine the validity results of widely used financial failure models and to inform investors and researchers accordingly. In this study, Altman (1968), Springate (1978), Ohlson (1980), Fulmer (1984), Zmijewski (1984), Canada (1987) and Grove (2001) models were chosen as methods for conducting validity tests. The most important contribution of this research to the literature is testing the successful performances of seven commonly used financial failure models during a time when company bankruptcies are increasing across the world. The study is important as it conducts such a comprehensive validity test for the first time in the literature. In the research, seven financial failure models were tested separately on 16 energy companies. The sample of this study consists of 16 companies that operate in the energy sector in the US markets. The universe of the research is restricted to companies in the energy sector.

According to the results of the research, the Zmijewski model has been the most successful model for predicting company bankruptcies in the energy sector in the USA. Zmijewski is the model that best predicts bankruptcy and non-bankrupt companies 1 year and 3 years before the bankruptcy. However, Fulmer is the best bankruptcy predictor 2 years before the bankruptcy. Although the Springate, Canada, Zmijewski, and Grover models were statistically significant, only the Zmijewski model was highly successful in identifying bankrupt and non-bankrupt companies. On the other hand, the success rate of the Altman, Springate, Canadian, Fulmer and Grover models was well below the average when compared to other studies in the literature. The average success rate of Fulmer, Ohlson, Grover, Canada Model, Altman, Springate models was 62.2%. Compared to other studies in the literature, this rate was below expectations. The reason why bankruptcy forecasting models fail maybe that all companies in the energy sector are experiencing financial difficulties. For example; CHK (Chesapeake Energy Corp) company was randomly selected among the successful companies in this study. However, the bankruptcy plan of the company was approved by a U.S. judge in January 2021(Reuters, 2021). This company has not been changed in order to maintain the objectivity of the study.

Estimating the financial positions of companies is important in terms of protecting the rights of company beneficiaries. For this reason, auditors, investors and researchers need to use financial failure models in conjunction with other financial ratios regarding company investments or evaluations. However, the validity of models that predict the financial situation of companies should be constantly updated for different sectors and different times. Because only models with strong predictive ability can contribute to the environment of trust in the economy.

Researchers who want to work on financial bankruptcy predictions can use artificial neural network (ANN) models, which have higher classification success and can operate without requiring any model.

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