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The Effect of Bankruptcy Probability on Firm Value: An Empirical Study in the Borsa Istanbul Manufacturing Sector

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Abstract: The aim of this study to investigate whether bankruptcy probability effective on firm value for manufacturing firms, which are centre of economic development and sustainable growth. The bankruptcy probability is a key strategic factor in determining importance of firms' market value. In this context, this study provides original evidence that the Z-score can be used in firm valuation processes beyond merely being an indicator that measuring the bankruptcy probability. In the study, data obtained from 98 manufacturing firms on the Borsa Istanbul (BIST) between 2003: Q1–2024: Q3 were analysed with panel data analysis methods. To measure bankruptcy probability the Altman Z-Score were used and Tobin's Q and the return on assets ratio used for firm value. Firm size and financial leverage ratios were used as control variables in the study. The results show that Z-score has a positive and statistically significant effect in both models and firm size has a negative effect on Tobin's Q and a positive effect on return on assets, while the effect of financial leverage ratio on firm value and profitability is not statistically significant. According to the results obtained, it is seen that effective risk management has a positive effect on the market value and firm's profitability and that firms with high Z scores are considered reliable and stable by investors because they have a lower bankruptcy probability and therefore this situation is directly reflected in the market value of firms.

Keywords: *Bankruptcy, firm value, manufacturing sector.*

Introduction

Having a strong and balanced financial structure is the most effective way for firms to protect themselves against financial risks. Weakeness in the financial structure can lead to financial difficulties and ultimately bankruptcy (Klepac & Hampel, 2018, p. 159). Bankruptcy is one of the important turning points that affects firms' operational, financial and strategic dimensions (Shireesha et al., 2024, p. 1819). The bankruptcy probability of is defined as the likilihood that a firm will not be able to meet its financial obligations, which may result from factors such as lack of liquidity, excessive debt, inadequate management, adverse market conditions and economic stagnation (Umobong, 2025, p. 3). Considered as a significant risk factor, especially in the manufacturing sector and various other sectors, bankruptcy has serious impacts on stakeholders and is increasing due to global market fluctuations, economic

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uncertainties and regulatory changes. Therefore, analyzing the bankruptcy possibility has critical importance not only for managers to make strategic decisions to prevent or reduce risks (Djonapura and Nadira, 2024, p. 387), but also for investors and creditors (Bărbuță-Mișu and Madaleno, 2020, p. 1). Serious financial losses resulting from strategic mistakes can lead to firm bankruptcy. Effective financial performance management supports the firm's growth and ensures control over net profit and cash flow. Moreover, successful financial performance can contribute to an increase in the firms'market value (Bilgin & Adıgüzel, 2021, pp. 19-20).

Bankruptcy prediction is globally significant for academic and applied studies. As stated in the Dun & Bradstreet (2025) report, global insolvencies increased by 5 per cent annually between 2012 and 2024, and this rate of increase doubled after Covid-19, rising to 10 per cent between 2021 and 2024 (pp. 7-17). According to data released by TOBB (2024), bankruptcies rose in 65% of the economies monitored in 2024. In Turkey, bankruptcies increased by 23%, with 31,416 companies closing, approximately 14% of which were in the manufacturing sector. While the manufacturing sector is strategic to economic growth and employment, the high rate of closures shows the sector's financial and structural challenges. Business closures in Türkiye's manufacturing sector necessitate a detailed examination of the sector's current structure and overall economic conditions. Furthermore, although there are various studies on the probability of bankruptcy in the existing literature, long-term financial data analysis for the manufacturing sector in Türkiye and research addressing the relationship between the probability of bankruptcy and firm value are limited. In the literature, studies that use financial indicators such as the Altman Z-Score and Tobin’s Q together are mostly short-term or focused on specific sectors. This emphasises the requirement for an extensive examination of the financial risk profile of the Turkish manufacturing sector and the relationship between bankruptcy probability and firm value

The study aims to reveal how the bankruptcy possibility effective on the firm value of manufacturing firms operating in Borsa Istanbul. In this context, Altman Z-Score values, Tobin’s Q and Return on Assets ratios for the periods 2003: Q1-2024: Q3 were used. The Altman Z-Score model is a commonly preferred tool to predict the bankruptcy probability, and it is associated with financial performance indicators. Tobin's Q and ROA measure firm value and profitability to analyse the effect of bankruptcy risk on firm performance. The study involves the literature review, methodology, dataset, and analysis, as well as policy and managerial recommendations based on the findings. This study is expected to make a contribution to the understanding of financial risks and firm value in the Turkish manufacturing sector and to enlighten decision-making processes in both academic and applied fields.

Theoretical Background

Firm value is described as future cash flows' present value and it is directly associated with the firm's financial stability, risk profile and market reliability (Modigliani & Miller, 1958, p. 263). The bankruptcy probability is the risk that a company will be unable to meet its financial obligations on time. This increased probability alters the risk perception among investors and creditors, increasing the firm's cost of capital, reducing operational flexibility, and finally reducing its firm value (Burgstahler et al., 1989, p. 207; Bernhardsen, 2001, p. 1). The bankruptcy probability is effective on firm value with three main mechanisms. First, it raises the capital cost. Because firms with a high bankruptcy risk are accepted as riskier by investors, they experience increases in both equity and debt costs. This increases the weighted average cost of capital, reducing the present value of future cash flows (Modigliani & Miller, 1963, p. 435). Second, rising transaction costs are assumed as a fundamental factor. When financial risk stress increases, lenders may enforce stricter contractual terms, make more stringent collateral requirements and loan terms. This decreases investment flexibility of firms and limits their value creation ability (Jensen & Meckling, 1976, p. 308). Finally, reputational damage and deterioration in market perception are important factors. Firms in financial distress lose confidence among investors, suppliers, and customers. This causes a decrease in sales, difficulty accessing financing, and a decrease in market value (Altman, 2000, p. 60; Burgstahler et al., 1989, p. 210). A firm does not suddenly go bankrupt in general; instead, it goes through a period of failure that varies widely in duration. Bankruptcy is also considered the final stage of a company's decline. The increased probability of bankruptcy declines a company's expected cash flows, increases capital costs, and harms market confidence. When all these mechanisms come together make bankruptcy risk becomes one of the key factors in determining firm value (Lukason & Hoffman, 2014, pp. 80-81). In this study, Altman’s Z-score (1968), which uses financial ratios of manufacturing firms, was utilised to determine the probability of bankruptcy. This model shows that bankruptcy probability can be measured through financial statements and is given in Equation 1 below (Altman, 1968, p. 594):

$$Z = 0{,}012X_1 + 0{,}014X_2 + 0{,}033X_3 + 0{,}006X_4 + 0{,}999X_5 \quad (1)$$

Where;

X_1= Net Working Capital / Total Assets

X_2= Retained Earnings / Total Assets

X_3= Earnings Before Interest and Taxes / Total Assets

X_4= Market Value of Equity / Total Liabilities

X_5= Net Sales / Total Assets

Z = Overall Index

The higher the Altman Z-score, the better the company's financial health and the lower the likelihood of bankruptcy. Companies with an Altman Z-score above three are expected to be able to pay their debts and continue their operations. Scores between 3 and 2.7 should alert investors to potential financial difficulties; scores between 2.7 and 1.8 indicate a clear risk of bankruptcy. Scores below 1.8 indicate that the company is highly likely to go bankrupt (Góis et al., 2020, p. 6).

Literature Review

Numerous studies conducted to date on bankruptcy prediction have examined different sectors, with the manufacturing sector being one of the most frequently focused areas in this research. The effect of bankruptcy probability on firm value is not a new topic in the literature. Many studies have used different theoretical and empirical approaches and methods to analyse the effect of bankruptcy probability on firm value. This section provides a brief summary of some of these studies.

The relationship between firm bankruptcy risk and firm value has been extensively examined within both theoretical frameworks and applied studies. Merton (1974) developed a model linking the probability of firm bankruptcy to firm value and debt structure. He demonstrated that decreases in the firm's total value increase bankruptcy risk and negatively affect share value. Podobnik et al. (2010) examined the dependence of corporate bankruptcy risk on size and its stability over time in the US economy using Zipf scaling techniques; they found that smaller firms adjust their assets more during the bankruptcy process and that their asset-debt distributions follow a Pareto distribution. Realdon (2013) examined the effects of credit risk on firm valuation and equity and debt; he revealed that credit risk reduces P/E and P/B ratios and its effect on the financial analysis process. Similarly, Al-Kassar and Soileau (2014) emphasised that financial and non-financial performance indicators increase the accuracy in predicting bankruptcy and evaluating firm performance.

Sector-based studies indicate that bankruptcy risk varies across different economic and financial contexts. Aleksanyan & Huiban (2016) found that productivity declines in the French food sector increased the risk of bankruptcy, while the impact of credit costs had a limited effect. Nam and An (2017) found a significant relationship between the Altman K-Score and ROA in the Korean shipping and logistics sector, and they emphasızed the better financial health of high-performing firms and the importance of early warning mechanisms. Gleißner (2019) proposed integrating enterprise risk management with value-based management approaches and quantitatively assessed the effects of risk changes on firm value and bankruptcy probability through Monte Carlo simulations. Deb and Sreekumar (2021) found that a debt-heavy capital structure increases the bankruptcy risk and that companies in these sectors are less likely to resort to debt financing. Pacheco et al. (2022) developed a bankruptcy prediction model for SMEs in the Portuguese manufacturing sector, using a logit model. They found that profitability, payment capacity, and firm size were the most important determinants, and that the model had a prediction power of 82.3%.

Öget and Kaya (2023) investigated the link between bankruptcy probability and stock prices for firms listed on the Borsa Istanbul Tourism Index, employing the Altman Z-Score along with panel data methods, and reported a one-way causal effect running from the Z-Score to stock prices. Uslu (2024) assessed the bankruptcy risks of 18 companies in the Borsa Istanbul Main Metal Industry, identifying the most at-risk and the strongest performers among those whose financial ratios were below the sector average. Among firms with financial ratios above the sector mean, CEMTS emerged as the lowest-risk company. Delapedra-Silva (2021) investigated the bankruptcy probabilities of North American infrastructure firms by performing logit regression and the distance-to-default measure, while accounting for sector-specific differences. He revealed that firm size and the distance-to-default variable were significant across all sectors, though companies in the oil and gas sector were less sensitive to the latter.

Rubab et al. (2022) analysed the impact of financial distress on firm performance in manufacturing companies listed on the Pakistan Stock Exchange using the KMV model and a random-effects regression framework. They found that financial distress damaged performance, whereas firm size, net profit margin, and sales growth had positive effects. Research centred on financial performance and strategy highlights the role of strategic tools in managing firm risk effectively. Agustia et al. (2020) examined how earnings management and business strategies impact bankruptcy risk in Indonesia, finding that earnings management applies no direct effect, whereas strategic practices can lower the likelihood of bankruptcy. Sadiq et al. (2022) stated that credit and liquidity risks are essentially related to leverage ratios in Pakistan’s sugar and cement industries, and that managerial attention to firm risk and efficiency is vital for enhancing shareholder wealth. Kiracı (2021) revealed that leverage, asset structure, firm size, profitability, and liquidity materially affect bankruptcy risk during crisis periods in the airline industry. Using data mining methods, Zhang (2021) showed that low current ratios, liquidity, ROA, and cash ratios increased the probability of financial distress among small and medium-sized enterprises. There are also various studies assessing the predictive capabilities of the Z-score and similar models across several sectors. Voda et al. (2021) assess the Z-score model’s predictive power in Romania’s manufacturing and mining sectors via canonical discriminant and sensitivity analyses, confirming that the model reliably predicts both bankruptcy and insolvency risks. Similarly, Karadeniz et al. (2022) explored how financial distress risk effective on firm value in the European hospitality industry, while Fernandez & Sanchez (2023) found that optimal working capital enhances firm performance in the manufacturing sector.

Čavlin et al. (2023) found that ROA and current liquidity make statistically significant contributions to Altman Z-Score estimations. Ivanova et al. (2024) showed that risk-seeking managers are prone to raise their debt levels, thereby increasing bankruptcy risk; Zikri et al. (2024) revealed that large-scale firms are less likely to emerge from bankruptcy. A common conclusion across these studies is that corporate bankruptcy risk is strongly linked not only to financial indicators but also to managerial strategies, industry dynamics, and lifecycle factors. The literature further emphasised that Z-score and comparable models provided more dependable results when tailored to specific industries and countries, and that managerial interventions play a crucial role in alleviating bankruptcy risk. This study contributes uniquely to the literature by analysing the relationship between bankruptcy probability and firm value with a focus on the Borsa Istanbul Manufacturing Sector. Whereas prior research has generally analysed the overall market or various other industries, this work conducts sector-specific analyses and delivers findings distinctive to Borsa Istanbul within the Turkish context. Furthermore, the advanced econometric tools application such as panel data analysis and the use of long-term datasets, enables a more robust and detailed assessment of the direct effect of bankruptcy risk on firm value. In addition, the applied econometric framework sets this study apart from traditional Z-score analyses and offers fresh theoretical and practical insights to the literature.

Methodology

Research Design and Sample

Financial statement data of firms functioning on the BIST and operating in the manufacturing sector for the period 2003: Q1-2024: Q3 were used to analyse the effect of the bankruptcy probability of firms on firm value within the scope of the study. The data of the firms were obtained from the KAP (Public Disclosure Platform) and the Finnet platform. Using the data obtained, the required ratios for the research were calculated. Then, three different variables were created from these ratios: dependent, independent, and control variables. All variables were decided based on a literature review. During the period in which the data were prepared (December 2024), the manufacturing sector comprised nine sub-sectors, with a total of 240 firms operating within these sectors. In the next stage, to more accurately evaluate the results regarding firm values, the research was conducted by dividing the firms into sub-sectors. In this context, seven different sub-sectors were created in accordance with the firms' own categorical and sectoral activities. Information about the distribution of firms and sectors to be used in the study is presented in Table 1.

Table 1: Firms and Sectors Included in the Research

BIST-Manufacturing Industry Sub-Sectors	Firms in the Research	Total Firms
A- *Basic Metal*	11	28
B- *Food, Beverage, and Tobacco*	17	47
C- *Paper and Paper Products Printing*	7	14
D- *Chemicals, Petroleum, Rubber and Plastic Products*	17	46
E- *Fabricated Metal Products, Machinery, Electrical Equipment, and Transportation Vehicles*	17	44
F- *Non-Metallic Mineral Products*	15	27
G-*Textile, Wearing Apparel and Leather*	11	27
H- *Wood Products Including Furniture*	2	6
I- *Other Manufacturing Industry*	1	1
Total	**98**	**240**

(Source: KAP, 02-12-2024)

As shown in Table 1, among the 240 firms operating in the BIST Manufacturing Sector, 98 firms were operating continuously during the study period. Since there are not enough cross-sections in the "Wood Products and Furniture and Other Manufacturing Industries" sub-sectors in which these firms operate to make the analysis reliable, these sub-sectors could not be examined within the scope of the research. The firms that make up the dataset used in this study are listed in Appendix A.

Variables

The literature review played a key role in identifying the variables to be used in the study and in informing decision-making. Within the scope of the literature review, many national and international publications were carefully examined, and variables were determined.

In studies on firm value, researchers have used ratios representing firm value and performance as dependent variables. These variables have generally included the Tobin's Q ratio, price-to-earnings ratio, price-to-cash flow ratio, price-to-sales ratio, market value-to-book value ratio, return on assets, return on equity, and abnormal stock returns. In this context, Tobin's Q and Return on Assets ratios were selected as dependent variables used in the study, while Altman's Z-Score was determined as the independent variable. In addition, firm size and financial leverage ratio, which are frequently used in the literature, were included in the model as control variables. Information and abbreviations related to the dependent and independent variables of this study are presented in Table 2 below:

Table 2: Variables, Abbreviations, and Explanations

Variables	Abbreviation	Explanation
Independent Variable		
Probability of Bankruptcy	Z_SCORE	Altman Z-Score Value
Dependent Variables		
Tobin's Q	TBN_Q	(Market Value + Total Debt) / Total Assets
Return on Assets	RE_AS	Net Profit/Total Assets
Control Variables		
Firm Size	FI_SI	Natural Log of Total Assets
Financial Leverage	FIN_LE	Total Debt / Total Assets

A model has been created for each of the dependent variables, and the probability of bankruptcy (Z_SCORE) has been used as an independent variable in these models. Financial leverage and firm size, which are control variables, have been used in all models. All dependent and independent variables in the data set are ratio values calculated from financial data.

Empirical Models

Since more than one period was considered in this study, it was decided to use panel data analysis as a statistical method. Panel data refer to data that enable analysis by considering both time and unit dimensions together (Özden et al., 2022, p. 571). Panel data models are regression models based on estimated panel data. In general, a panel regression model is expressed as in equation (2):

$$Y_{it} = \alpha_{it} + \beta_{it}X_{it} + u_{it} \qquad (2)$$

Where,

Y_{it} and X_{it} are defined for $i=1, ..., N; t=1, ..., T$. The number of units is denoted by N, and T. Y denotes the number of time periods representing the dependent variable, X the independent variables, α_{it} the constant parameter, β_{it} the slope parameters, and u_{it} the error term. Moreover, in the equation, i denotes the number of cross-sectional units in the model (i=1…n) and t denotes the time dimension corresponding to each cross-section ($t=1,..., T$) (Güriş et al., 2018, p.7).

The application of panel data to investigate relationships among variables has broad utility within econometric research (Kennedy, 2008, p. 281). In this study, the models specified in

Equation (3) and Equation (4) were constructed to identify how the probability of bankruptcy influences firm value.

$$TBN\_Q = a_i + \beta_1 Z\_SCORE_{i,t} + \beta_2 FI\_SI_{i,t} + \beta_3 FIN\_LE_{i,t} + \varepsilon_{i,t} \quad (3)$$

$$RE\_AS = a_i + \beta_1 Z\_SCORE_{i,t} + \beta_2 FI\_SI_{i,t} + \beta 3FIN\_LE_{i,t} + \varepsilon_{i,t} \quad (4)$$

where, for firm *i* and period *t*

Z-Score = Altman's Z-Score calculated by Equation (1)

This study builds on the model introduced by Altman (1968), which predicts the risk of financial failure with high accuracy using the financial ratios of firms in the manufacturing industry. Owing to the model's dependability and broad adoption, the Altman Z-Score was selected to gauge financial failure risk in this research. In addition, because the Z-Score framework can be implemented directly with readily available coefficients, it provides a more practical and accessible approach than other bankruptcy prediction models (e.g., the Ohlson O-Score). In this vein, the effect of bankruptcy probabilities on the firm value of Borsa Istanbul manufacturing sector companies was investigated through panel data analysis spanning 2003: Q1–2024: Q3.

In the models, considering the simultaneous presence of autocorrelation, heteroscedasticity, and cross-sectional dependence, along with the condition $N<T$, the Generalized Least Squares (GLS) estimation method emerges as a powerful forecasting tool for models exhibiting these characteristics. Therefore, based on the inter-variable dependencies and the results of the diagnostic tests, GLS has been chosen for the forecasting process.

Results and Discussion

Descriptive Statistics

Table 3 presents the minimum, maximum, mean, standard deviation, skewness and kurtosis values for the BIST Manufacturing industry from 2003 to 2024.

Table 3: Descriptive Statistics of Variables

Variables	Min.	Max.	Mean	Standard Deviation	Skewness	Kurtosis
TBN_Q	0.12	61.7	1.685358	2.222819	11.70555	217.4818
RE_AS	-142.23	571.48	3.225764	11.29813	14.83345	770.118
Z_SCORE	-94.26	61.74	6.566114	5.437953	-3.59552	72.02063
FI_SI	15.6	26.93	19.9697	1.835225	0.5557142	3.235154
FIN_LE	0	1086.158	48.19113	48.57643	7.987539	117.3711

Descriptive statistics indicate that, although most manufacturing firms exhibit moderate levels of financial strength and leverage, there is significant variability in profitability and bankruptcy risk, as indicated by the extreme values and high skewness in TBN_Q, RE_AS, and FIN_LE. This indicates that a limited number of firms are undergoing pronounced financial distress and highlights the heterogeneity in firm stability. Taken together, these descriptive statistics emphasise the need to investigate the relationship between bankruptcy probability and firm value.

The correlation matrix (Appendix B) shows that bankruptcy probability (TBN_Q) and profitability (RE_AS) are largely independent of financial strength and leverage. The strong negative correlation between Z-SCORE and FIN_LE (-0.7001) indicates that higher leverage levels are associated with lower financial stability. In general, correlations between other variables are low to moderate, minimising concerns about multicollinearity in the models.

The results of the White test for heteroscedasticity applied in the models (Appendix C) indicate that, for all models, the p-value of the overall White test statistic is less than 0.05.

Therefore, the null hypothesis "H_0*: There is no heteroscedasticity in the series*" is rejected, and it can be concluded that heteroscedasticity is present in the series based on the White test results.

According to the Wooldridge autocorrelation test results (Appendix D), the p-value for all models is less than 0.05, leading to the rejection of the null hypothesis "H_0*: There is no first-order autocorrelation.*" This confirms the presence of autocorrelation in the series. The analysis will continue with the results of cross-sectional dependence tests. One of the critical issues in panel data analysis is the possibility of cross-sectional dependence in the data, which indicates the presence of common factors among the units. Cross-sectional dependence should be considered prior to empirical analysis because it can affect not only the results of unit root and cointegration tests but also the selection process of estimation techniques (Soydan & Bedir, 2015, p. 510). Additionally, the results regarding the differentiation of heteroscedasticity and autocorrelation by sub-sector are provided in Appendix E.

Table 4: Cross-Sectional Dependence Test Results

Variables	CD-test	p-value	Corr.
TBN_Q	199.81	0.000	0.314
RE_AS	96.46	0.000	0.152
Z_SCORE	96.46	0.000	0.152
FI_SI	594.26	0.000	0.934
FIN_LE	341.28	0.000	0.536

According to the results of the cross-sectional dependence test, the null hypothesis "H0: There is cross-sectional dependence between the series" is rejected, as the test statistics for the series are valid at the 1% significance level. This indicates that cross-sectional dependence exists between the series. Therefore, a shock in one cross-section will also affect other cross-sections. Due to cross-sectional dependence in the series, unit root tests will also exhibit variability. In cases where cross-sectional dependence is present, second-generation unit root test procedures are applicable for model estimation. Among second-generation unit root tests, the CIPS unit root test, developed by Pesaran (2007), is available. The results of the CIPS unit root test are provided.

Table 5: Unit Root Test Results

	Constant			Constant and Trend		
Variables	I(0)	I(1)		I(0)	I(1)	
TBN_Q	-3.000	-6.046		-3.152	-6.253	
RE_AS	-4.389	-6.178		-4.644	-6.400	
Z_SCORE	-2.629	-6.102		-3.263	-6.340	
FI_SI	-2.439	-6.091		-3.158	-6.296	
FIN_LE	-2.343	-6.173		-2.980	-6.398	
Critical Values	%10	%5	%1	%10	%5	%1
	-2.03	-2.08	-2.18	-2.52	-2.56	-2.65

According to the results of the CIPS unit root test, it can be concluded that for all variables, there is no unit root at the I(0) level at the 1% significance level in both the constant and constant-trend models. Therefore, the series are stationary at the level.

Empirical Results

This section presents the results of an empirical analysis (Table 6), calculated separately for the BIST manufacturing subsectors. The findings provide insights into the relationship between bankruptcy probability and firm value, based on panel data models estimated for the period under study. The explanations regarding the diagnostic tests are presented in the Appendix.

Table 6: *Analysis Results (Model 1&Model 2)*

Sectors		Model 1 (Generalized Least Squares)				Model 2 (Generalized Least Squares)			
		Z_SCORE	FI_SI	FIN_LE	Constant	Z-SCORE	FI_SI	FIN_LE	Constant
Basic Metal Industry	Coef.	0.0061	-0.018	-0.001*	1.516	1.141***	0.312**	0.0348***	-12.17***
	Std. Dev.	0.0069	0.0136	0.0009	0.306	0.103	0.128	0.0110	2.800
Food and Tobacco	Coef.	0.0158***	-0.0450*	0.002***	2.065***	0.922***	0.479***	0.00500	-13.41***
	Std. Dev.	0.005	0.0258	0.000862	0.536	0.0892	0.158	0.0110	3.345
Paper	Coef.	0.0143	0.00968	-0.00219	1.187	1.501***	-0.0774	0.0875***	-10.04
	Std. Dev.	0.0134	0.0408	0.00145	0.819	0.139	0.325	0.0163	6.329
Chemicals	Coef.	0.0205***	-0.062***	-0.00056	2.527***	1.586***	0.392***	0.0681***	17.84***
	Std. Dev.	0.00733	0.0175	0.00082	0.384	0.0915	0.134	0.00975	3.093
Metal Products	Coef.	0.0625***	-0.109***	-0.002***	3.347***	1.212***	0.230*	0.0301***	-11.26***
	Std. Dev.	0.0102	0.0326	0.000924	0.725	0.0807	0.118	0.00850	2.715
Non-Metallic Minerals	Coef.	0.0322***	-0.116***	-0.00103	3.421***	0.986***	0.806***	0.0330**	21.10***
	Std. Dev.	0.00877	0.0313	0.00131	0.652	0.0863	0.209	0.0135	4.253
Textiles and Apparel	Coef.	0.0223***	-0.243***	-0.00116	5.831***	0.542***	0.473***	0.0176	-11.25***
	Std. Dev.	0.00800	0.0376	0.00103	0.768	0.0948	0.171	0.0116	3.730

Table 6 presents the analysis results obtained from Model 1 and Model 2 estimation for Generalized Least Squares (GLS). The estimated coefficients, standard errors, and significance levels are reported for each model.

According to the findings of the first model for firms in the basic metals industry, among the variables, only financial leverage significantly affects the firms' Tobin's Q value at the 10% significance level, with a negative effect. The results of the first model suggest that a one-unit increase in financial leverage decreases the firms' Tobin's Q value by 0.0017589 units. The effects of the other variables are not statistically significant. In contrast, the findings of the second model indicate that all variables included in the model have statistically significant effects. Specifically, the Z-Score of the firms positively influences their return on assets at the 1% significance level. A one-unit increase in the Z-score of firms in the basic metals industry leads to a statistically significant 1.141 unit increase in their return on assets at the 1% significance level. Similarly, a one-unit increase in firm size is associated with a statistically significant 0.312-unit increase in return on assets at the 5% significance level, while a one-unit increase in financial leverage results in a statistically significant 0.0348-unit increase in return on assets at the 1% significance level.

According to the findings of the first model for firms in the food and tobacco industry, Z-Score values positively and statistically significantly affect the Tobin's Q value at the 1% significance level. Specifically, a one-unit increase in the Z-Score of food-tobacco firms results in a 0.0158-unit increase in their Tobin's Q value. On the other hand, an increase in firm size for food and tobacco firms listed on BIST negatively affects the Tobin's Q value at the 10% significance level a one-unit increase in firm size results in a 0.0450 unit decrease in the Tobin's Q value. Finally, a rise in financial leverage for food and tobacco firms listed on BIST exerts a positive effect on Tobin's q, significant at the 1% level. In particular, a 1-unit increase in financial leverage raises Tobin's q by 0.00277 units. Results from the second model show that the Z-Score values of these firms have a statistically significant positive impact on return on assets at the 1% level; a 1-unit increase in Z-Score lifts return on assets by 0.922 units. Moreover, an expansion in firm size also has a statistically significant positive effect on return on assets at the 1% level; a 1-unit increase in firm size increases return on assets by 0.479 units.

For the first model, estimated for firms in the paper products industry, the relationships between Tobin's q and the Z-Score, firm size, and financial leverage were not statistically significant. The second model's results show that the Z-Score values of paper products firms listed on BIST positively affect return on assets at the 1% significance level; a 1-unit increase in the Z-Score raises return on assets by 1.501 units.

Furthermore, an increase in financial leverage also has a positive impact on return on assets at the 1% statistically significant level; a 1-unit increase in financial leverage increases return on assets by 0.0875 units.

According to the results of the first model created for companies operating in the chemical industry, Z-Score values have a positive effect on Tobin's Q at a statistically significant level of 1%; a 1-unit increase in Z-Score increases Tobin's Q by 0.0205 units. However, an increase in firm size has a negative effect on Tobin's Q at a statistically significant level of 1%; a 1-unit increase in firm size decreases Tobin's Q by 0.0627 units. Changes in financial leverage have no significant effect on Tobin's Q. The findings of the second model indicate that Z-Score values of chemical industry companies have a positive effect on return on assets at a statistically significant level of 1%; a 1-unit increase in Z-Score increases return on assets by 1.586 units. Furthermore, an increase in firm size also has a positive effect on return on assets at a statistically significant level of 1%; a 1-unit increase in firm size increases return on assets by 0.392 units. It was also determined that a 1-unit increase in financial leverage increased return on assets by 0.0681 units at a statistically significant level of 1%.

According to the results of the first model, created for firms operating in the metal goods industry, Z-Score values have a positive effect on Tobin's Q at the 1% statistically significant level; a 1-unit increase in Z-Score increases Tobin's Q by 0.0625 units. On the other hand, an increase in firm size has a negative effect on Tobin's Q at the 1% statistically significant level; a 1-unit increase in firm size decreases Tobin's Q by 0.109 units. Moreover, a 1-unit rise in financial leverage reduces Tobin's Q by 0.00263 units, reflecting a negative relationship significant at the 1% level. The second model's results show that the Z-score values of metal goods firms have a positive effect on return on assets at the 1% significance level; a 1-unit increase in the Z-score increases return on assets by 1.212 units. The impact of firm size on return on assets is positive at the 10% significance level, with a 1-unit increase in firm size boosting return on assets by 0.230 units. Lastly, a 1-unit increase in financial leverage lifts return on assets by 0.0301 units, and this effect is positive at the 1% significance level.

According to the first model's results for firms in the non-metallic products industry, Z-Score values exert a positive and statistically significant influence on Tobin's Q at the 1% level. Specifically, a one-unit rise in the Z-Score of non-metallic product manufacturing firms leads to a 0.0322-unit increase in their Tobin's Q. Conversely, for non-metallic product manufacturers listed on BIST, an increase in firm size negatively affects Tobin's Q at the 1% significance level a one-unit increase in firm size produces a 0.116-unit decline in Tobin's Q. Finally, changes in financial leverage for non-metallic product manufacturers listed on BIST do not have a statistically significant effect on Tobin's Q. According to the second model's findings, the Z-Score values for non-metallic product manufacturers listed on BIST have a positive and statistically significant impact on return on assets (ROA) at the 1% level. A one-unit increase in the Z-score results in a 0.986-unit increase in the firm's ROA. Additionally, for these firms, an increase in firm size positively affects ROA at the 1% significance level. A one-unit increase in firm size yields a 0.806-unit rise in ROA. Lastly, for these firms, an increase in financial leverage has a positive effect on ROA at the 5% significance level. A one-unit increase in financial leverage leads to a 0.0330-unit increase in the firm's ROA.

According to the first model's results for firms in the textile industry, Z-score values have a positive and statistically significant effect on Tobin's Q at the 1% significance level. Specifically, a one-unit increase in the Z-score of textile firms produces a 0.0223-unit increase in their Tobin's Q. Conversely, for textile firms listed on BIST, an increase in firm size has a negative effect on Tobin's Q at the 1% significance level. A one-unit increase in firm size results in a 0.243-unit decrease in Tobin's Q. Finally, for textile firms listed on BIST, changes in financial leverage have no statistically significant effect on Tobin's Q. According to the second model's findings, the Z-score values for textile firms listed on BIST have a positive and statistically significant effect on return on assets (ROA) at the 1% significance level. A one-unit increase in the Z-score leads to a 0.542-unit increase in the firms' ROA.

Additionally, for these firms, an increase in firm size has a positive effect on ROA at the 1% significance level. A one-unit increase in firm size results in a 0.473-unit rise in ROA. Finally, for these firms, changes in financial leverage have no significantly effect on ROA.

Table 7-8 presents the quantile regression results for Model 1 and Model 2, which include all sectors in the model.

Table 7: Analysis Results (All Sectors, Model 1 For Quantile Regression)

Variables	(1) q10	(2) q20	(3) q30	(4) q40	(5) q50	(6) q60	(7) q70	(8) q80	(9) q90
Z_SCORE	0.00798***	0.00708***	0.0148***	0.0190***	0.0242***	0.0318***	0.0399***	0.0530***	0.0603***
	(0.00199)	(0.00194)	(0.00198)	(0.00310)	(0.00368)	(0.00428)	(0.00483)	(0.00601)	(0.0115)
FI_SI	0.0217***	0.0160***	0.0287***	0.0309***	0.0305***	0.0307***	0.0352***	0.0184**	-0.0513**
	(0.00204)	(0.00330)	(0.00253)	(0.00305)	(0.00351)	(0.00534)	(0.00665)	(0.00902)	(0.0210)
FIN_ LE	0.00518***	0.00683***	0.00496***	0.00525***	0.00535***	0.00532***	0.00594***	0.00657***	0.00803***
	(0.000279)	(0.000257)	(0.000278)	(0.000382)	(0.000503)	(0.000681)	(0.000747)	(0.00103)	(0.000888)
Constant	0.0916**	-0.00245	0.107**	0.114*	0.191**	0.274**	0.278**	0.821***	2.836***
	(0.0434)	(0.0707)	(0.0486)	(0.0625)	(0.0758)	(0.108)	(0.140)	(0.193)	(0.421)
Obs.	8,439	8,439	8,439	8,439	8,439	8,439	8,439	8,439	8,439

Table 8: Analysis Results (All Sectors, Model 2 For Quantile Regression)

Variables	(1) q10	(2) q20	(3) q30	(4) q40	(5) q50	(6) q60	(7) q70	(8) q80	(9) q90
Z_SCORE	0.726***	0.714***	0.751***	0.793***	0.860***	0.961***	1.077***	1.224***	1.427***
	(0.0528)	(0.0855)	(0.0392)	(0.0318)	(0.0398)	(0.0381)	(0.0409)	(0.0523)	(0.0757)
FI_SI	0.746***	0.702**	0.457***	0.395***	0.346***	0.332***	0.337***	0.241***	0.224**
	(0.0701)	(0.284)	(0.0284)	(0.0293)	(0.0410)	(0.0448)	(0.0539)	(0.0686)	(0.0947)
FIN_LE	0.00599	-0.0322	0.0189***	0.0174***	0.0179***	0.0194***	0.0265***	0.0398***	0.0648***
	(0.00879)	(0.0239)	(0.00344)	(0.00334)	(0.00340)	(0.00422)	(0.00521)	(0.00717)	(0.0126)
Constant	-23.71***	-30.19***	-14.58***	-12.50***	-10.91***	-10.17***	-9.879***	-7.379***	-5.575***
	(1.801)	(6.641)	(0.643)	(0.624)	(0.825)	(0.838)	(1.096)	(1.295)	(1.884)
Obs.	8,439	8,439	8,439	8,439	8,439	8,439	8,439	8,439	8,439

According to the quantile regression test results, for all firms in Model 1, the Z-score has a positive effect on the Tobin's Q value at all quantile levels. The positive effect is especially higher at the lowest and highest quantiles, i.e., for firms with the lowest and highest Tobin's Q values, compared to other firms. Firm size has a positive effect on the Tobin's Q value at all quantile levels, except at the highest quantile (q90), where it has a negative impact on the

Tobin's Q value. The effect is more pronounced at the middle quantiles. For firms with the highest Tobin's Q values, firm size has a negative effect. Financial leverage has a positive effect on the Tobin's Q value at all quantile levels, although the positive effect of financial leverage is lower than that of other variables. The positive effect is relatively higher in the middle and high quantiles, i.e., for firms with middle and high Tobin's Q values, compared to other quantiles.

Based on the quantile regression results, for all firms in Model 2, the Z-score positively influences return on assets (ROA) across every quantile level. As the quantile level increases, the magnitude of the positive effect also increases. In other words, the positive effect of the Z-score on the return on assets is more pronounced for firms with the highest return on assets compared to other firms. Firm size has a positive effect on the return on assets at all quantile levels. The effect is higher at the lower and middle quantiles compared to the higher quantiles. Financial leverage has a positive effect on the return on assets in the Q30-Q90 quantiles, with the positive effect of financial leverage increasing as the quantile level rises. Among the variables, the Z-score has the largest impact on return on assets.

Table 9: Robustness Check For Model 1

		Model 1							
Sectors		**FE**				**RE**			
		Z-SCORE	FI_SI	FIN_LE	Constant	Z_SCORE	FI_SI	FIN_LE	Constant
Basic Metal Industry	Coef.	0.935***	-0.510	-0.0297	6.279	0.971***	-0.250	-0.0313	0.711
	Std. Dev.	0.200	0.429	0.0228	8.276	0.145	0.332	0.0218	6.792
Food and Tobacco	Coef.	1.553***	0.877	0.142***	32.26*	1.228***	-0.884***	0.083***	27.19***
	Std. Dev.	0.414	0.615	0.0456	15.59	0.356	0.265	0.0311	5.942
Paper	Coef.	1.898***	0.139	-0.124**	18.98*	1.865***	0.0926	0.122***	17.77**
	Std. Dev.	0.281	0.345	0.0465	8.774	0.275	0.330	0.0469	8.787
Chemicals	Coef.	1.653***	0.231	0.095***	16.09*	1.661***	0.222	0.094***	15.90**
	Std. Dev.	0.260	0.414	0.0196	8.464	0.248	0.368	0.0196	7.500
Metal Products	Coef.	0.988***	0.659	0.042***	-17.85*	1.024***	0.573	0.038***	-16.18**
	Std. Dev.	0.294	0.510	0.0129	9.729	0.265	0.408	0.0124	7.341
Non-Metallic Minerals	Coef.	0.788**	0.197	-0.0236	5.178	0.812***	0.258	-0.0211	6.671
	Std. Dev.	0.277	0.346	0.0393	8.200	0.269	0.336	0.0386	7.117
Textiles and Apparel	Coef.	0.468	0.930	-0.029**	18.10	0.437*	-0.959*	-0.021**	18.78*
	Std. Dev.	0.272	0.567	0.0106	11.35	0.261	0.562	0.0101	11.09
All Sectors	Coef.	1.131***	0.438**	0.0787**	-16.74***	1.139***	0.448***	0.074***	-16.80***
	Std. Dev.	0.209	0.190	0.0320	5.369	0.196	0.152	0.0281	4.301

Table 10: Robustness Check For Model 2

		Model 2							
Sectors		**FE**				**RE**			
		Z_SCORE	FI_SI	FIN_LE	Constant	Z_SCORE	FI_SI	FIN_LE	Constant
Basic Metal Industry	Coef.	0.00873	0.119***	0.00144	-1.369	0.0087	0.104***	0.00131	-1.043
	Std. Dev.	0.0115	0.0371	0.00193	0.807	0.0116	0.0356	0.00198	0.765
Food and Tobacco	Coef.	0.0375*	0.385	0.013***	-6.541	0.035*	0.372	0.013***	-6.234
	Std. Dev.	0.0196	0.274	0.00364	5.683	0.0180	0.266	0.00323	4.986
Paper	Coef.	0.0373	-0.304**	0.00330	-4.706	0.039*	-0.301**	0.00315	-4.645*
	Std. Dev.	0.0228	0.123	0.00219	2.473	0.0210	0.123	0.00201	2.406

Chemicals	Coef.	-0.00365	0.263***	0.00243	4.14***	-0.0016	0.243***	0.00225	3.735***
	Std. Dev.	0.0345	0.0743	0.00240	1.408	0.0340	0.0705	0.00244	1.270
Metal Products	Coef.	0.000902	0.450**	0.00719	-6.481	0.0124	0.403**	0.00796	-5.557*
	Std. Dev.	0.0313	0.212	0.00711	4.090	0.0323	0.190	0.00736	3.118
Non-Metallic Minerals	Coef.	-0.0693	0.197	0.0104	-1.355	-0.0676	0.175	-0.0106	0.936
	Std. Dev.	0.0556	0.130	0.00743	2.231	0.0576	0.123	0.00765	2.112
Textiles and Apparel	Coef.	0.00278	0.190**	0.00272	-1.934	0.0029	0.189**	0.00269	-1.916
	Std. Dev.	0.0248	0.0779	0.00417	1.500	0.0247	0.0776	0.00412	1.507
All Sectors	Coef.	-0.00604	0.290***	0.00545*	-4.337***	-0.0045	0.277***	0.00531*	-4.063***
	Std. Dev.	0.0120	0.0661	0.00311	1.337	0.0120	0.0629	0.00318	1.150

According to the robustness analyses, the GLS estimates and the robust FE and RE results show a consistent pattern across industries.

The Z-Score increases firm value by alleviating financial distress risk, lowering the cost of capital, enforcing investor confidence, and conferring a long-term competitive edge. A high Z-score indicates a low likelihood of financial failure, which, in turn, bolsters investor trust and decreases information asymmetry (Altman, 1968; Ohlson, 1980). It also increases firm value by curbing agency costs and refining capital structure efficiency (Jensen & Meckling, 1976; Myers, 1984). Financial stability enables companies to undertake long-horizon investments and capitalise on strategic opportunities, thereby lifting market valuation and increasing Tobin's Q (Fama & French, 1992; Altman, 2000). In sum, by reducing risk and improving managerial effectiveness, the Z-Score has a positive influence on firm value.

For firms in the BIST manufacturing sector, strengthening financial health, lowering bankruptcy risk as reflected by the Z-Score, and its desirable effect on Tobin's Q are critical for both managerial and investor standpoints. Effective application of financial policies (liquidity management, prudent leverage, profitability-oriented strategies) increases a firm's market value while decreasing risk and creating opportunities for investors to construct safer portfolios. As a consequence, financial management practices can be reconsidered as a strategic instrument that both elevates firm value and strenghtening market confidence in the Turkish manufacturing sector.

Conclusion

The aim of this study is to investigate the relationship between the bankruptcy probabilities of firms operating in the manufacturing sector of Borsa Istanbul (BIST) and firm values. The research focuses on the manufacturing sector and examines the impact within this context. In the study, financial data for the period 2003: Q1-2024: Q3 were used. To analyse the effect of bankruptcy probability on firm value, two econometric models, including a dynamic panel data model, were developed and applied.

When the seven sub-sectors included in the research on the nanufacturing sector are analysed separately, the findings of the study can be summarised as follows:

- In the model explaining the return on assets in *Basic Metal Industry firms*, Z-score, financial size, and financial leverage variables show significant and positive effects.
- In *Food and Tobacco industry* firms, Z-score has a positive and significant effect on both Tobin's Q and return on assets.
- No variable was found to be significant in the Tobin's Q model for *Paper and Paper Products industry* firms.
- In *Chemical and Pharmaceutical Industry* firms, the Z-score shows strong and positive effects in both models. Firm size has a negative effect on Tobin's Q and a positive effect on return on assets.

- In *Fabricated Metal Products Industry* firms, the Z-score has a positive and significant effect on both Tobin's Q and return on assets.
- In *Non-metallic Mineral Products Industry* firms, the effect of Z-score on both Tobin's Q and return on assets is positive and significant.
- In *Textiles and Wearing Apparel Industry* firms, the Z-score has a positive and significant effect in both models.

When these findings are evaluated in general, it is seen that the bankruptcy probability score increases the firm value (measured by the Tobin's Q and Return on Assets ratios). To reduce the possibility of bankruptcy, the primary goal should be to increase the firm's value. The directly proportional relationship between the bankruptcy probability score and firm value was revealed in this study, specifically in the Borsa Istanbul Manufacturing sector.

In practical terms, the results of this study carry important implications for stakeholders and establish a basis for subsequent research. The positive effect of the Altman Z-Score on the Tobin's Q ratio suggests that firms' financial stability directly affects their market valuations. Firms with higher Z-Scores and thus lower bankruptcy risk are observed by investors as more dependable and resilient, which in turn increases their market value. This indicates that investors evaluate firms with an eye to financial failure risk, while for managers, it highlights that strategies aimed at strengthening the financial structure are vital for risk management and for enhancing firm value.

Future research can elaborate on this study in several directions. Utilising alternative bankruptcy prediction frameworks or machine learning methods could increase the precision and robustness of the results. By comparing different sectors or markets, one can analyse whether the observed relationships hold across varying economic contexts. Moreover, integrating qualitative elements such as corporate governance arrangements, managerial choices, or macroeconomic shocks into the analysis could provide a more comprehensive understanding of the determinants of financial distress risk and its implications for firm value.

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Appendix

Appendix A: Firms That Make Up the Study's Data Set

No	Code	Firm	No	Code	Firm
1	ADEL	Adel Kalemcilik	50	FROTO	Ford Otosan
2	AFYON	Afyon Çimento	51	FRIGO	Frigo Pak Gıda
3	AKCNS	Akçansa Çimento	52	GENTS	Gentaş
4	ATEKS	Akın Tekstil	53	GOODY	Good-Year
5	AKSA	Aksa	54	GOLTS	Göltaş Çimento
6	ALCAR	Alarko Carrıer	55	GUBRF	Gübre Fabrik.
7	ALKA	Alkim Kâğıt	56	HEKTS	Hektaş
8	ALKIM	Alkim Kimya	57	IHEVA	İhlas Ev Aletleri
9	AEFES	Anadolu Efes	58	IZMDC	İzmir Demir Çelik
10	ASUZU	Anadolu Isuzu	59	KAPLM	Kaplamin
11	ARCLK	Arçelik	60	KRDMA	Kardemir (A)
12	ARSAN	Arsan Tekstil	61	KARSN	Karsan Otomotiv
13	AYGAZ	Aygaz	62	KRTEK	Karsu Tekstil
14	BAGFS	Bagfaş	63	KARTN	Kartonsan
15	BAKAB	Bak Ambalaj	64	KENT	Kent Gıda
16	BANVT	Banvit	65	KERVT	Kerevitaş Gıda
17	BTCIM	Batı Çimento	66	KLMSN	Klimasan Klima
18	BSOKE	Batısöke Çimento	67	KNFRT	Konfrut Gıda
19	BRSAN	Borusan Boru Sanayi	68	KONYA	Konya Çimento
20	BFREN	Bosch Fren Sistemleri	69	KORDS	Kordsa Teknik Tekstil
21	BOSSA	Bossa	70	KRSTL	Kristal Kola
22	BRISA	Brisa	71	KUTPO	Kütahya Porselen
23	BURCE	Burçelik	72	LUKSK	Lüks Kadife
24	BUCIM	Bursa Çimento	73	MRSHL	Marshall
25	CELHA	Çelik Halat	74	MNDTR	Mondi Türkiye
26	CEMTS	Çemtaş	75	OTKAR	Otokar
27	CMBTN	Çimbeton	76	OYAKC	Oyak Çimento
28	CMENT	Çimentaş	77	PARSN	Parsan
29	CIMSA	Çimsa	78	PENGD	Penguen Gıda
30	DARDL	Dardanel	79	PETKM	Petkim
31	DMSAS	Demısaş Döküm	80	PINSU	Pınar Su
32	DERIM	Derimod	81	PNSUT	Pınar Süt
33	DEVA	Deva Holding	82	SARKY	Sarkuysan

34	DITAS	Ditaş Doğan	83	SASA	Sasa Polyester
35	DGNMO	Doğanlar Mobilya	84	SELGD	Selçuk Gıda
36	DOGUB	Doğusan	85	SKTAS	Söktaş
37	DOKTA	Döktaş Dökümcülük	86	SNPAM	Sönmez Pamuklu
38	DURDO	Duran Doğan Basım	87	TBORG	T. Tuborg
39	DYOBY	Dyo Boya	88	TATGD	Tat Gıda
40	EGEEN	Ege Endüstri	89	TOASO	Tofaş Oto. Fab.
41	EGGUB	Ege Gübre	90	TUKAS	Tukaş
42	EGPRO	Ege Profil	91	TUPRS	Tüpraş
43	EGSER	Ege Seramik	92	PRKAB	Türk Prysmian Kablo
44	EPLAS	Egeplast	93	USAK	Uşak Seramik
45	EREGL	Ereğli Demir Çelik	94	ULKER	Ülker Bisküvi
46	EMKEL	Emek Elektrik	95	VESTL	Vestel
47	ERBOS	Erbosan	96	VKING	Viking Kâğıt
48	ERSU	Ersu Gıda	97	YATAS	Yataş
49	FMIZP	F-M İzmit Piston	98	YUNSA	Yünsa

Appendix B: Correlation Matrix of Variables for Model 1 and Model 2

	Variables	*TBN_Q / RE_AS*	*Z-SCORE*	*FI_SI*	*FIN_LE*
Model 1	*TBN_Q*	1.0000	0.0281	-0.0125	0.0422
	Z-SCORE	0.0281	1.0000	0.0744	-0.7001
	FI_SI	-0.0125	0.0744	1.0000	-0.1036
	FIN_LE	0.0422	-0.7001	-0.1036	1.0000
Model 2	*RE_AS*	1.0000	0.3716	0.0962	-0.1204
	Z-SCORE	0.3716	1.0000	0.0744	-0.7001
	FI_SI	0.0962	0.0744	1.0000	-0.1036
	FIN_LE	-0.1204	-0.7001	-0.1036	1.0000

Appendix C: Results of the Heteroscedasticity Tests

For Model 1

Test	Chi2	df	Prob.
Heteroskedasticity	61.87	9	0.0000
Skewness	18.72	3	0.0003
Kurtosis	5.35	1	0.0207
Total	85.94	13	0.0000

For Model 2

Test	Chi2	df	Prob.
Heteroskedasticity	2767.85	9	0.0000
Skewness	254.45	3	0.0003
Kurtosis	1.03	1	0.3109
Total	3023.32	13	0.0000

Appendix D: Results of the Autocorrelation Tests

For Model 1

F(1,96)	17.557
Prob>F	0.0001

For Model 2

F(1,96)	12.315
Prob>F	0.0007

Appendix E: Separation of Heteroscedasticity and Autocorrelation by Sectors

Basic Metal Industry:

For Model 1

Test	Chi2	df	Prob.		
Heteroskedasticity	91.92	9	0.0000	F(1,10) Prob>F	16.813 0.0021
Skewness	31.29	3	0.0000		
Kurtosis	12.10	1	0.005		
Total	135.31	13	0.0000		

For Model 2

Test	Chi2	df	Prob.		

Heteroskedasticity	184.24	9	0.0000	F(1,10) Prob>F	427.987 0.0000
Skewness	19.92	3	0.0002		
Kurtosis	5.23	1	0.0222		
Total	209.39	13	0.0000		

Food and Tobacco:
For Model 1

Test	Chi2	df	Prob.		
Heteroskedasticity	13.21	9	0.0215	F(1,16) Prob>F	483.023 0.0021
Skewness	6.19	3	0.0452		
Kurtosis	3.21	1	0.0732		
Total	22.61	13	0.0039		

For Model 2

Test	Chi2	df	Prob.		
Heteroskedasticity	540.33	9	0.0000	F(1,16) Prob>F	56.464 0.0000
Skewness	118.59	3	0.0000		
Kurtosis	1.03	1	0.3106		
Total	659.95	13	0.0000		

Paper:
For Model 1

Test	Chi2	df	Prob.		
Heteroskedasticity	38.39	9	0.0000	F(1,16) Prob>F	56.169 0.0003
Skewness	9.98	3	0.0188		
Kurtosis	1.44	1	0.02294		
Total	49.82	13	0.0000		

For Model 2

Test	Chi2	df	Prob.		
Heteroskedasticity	153.02	9	0.0000	F(1,16) Prob>F	62.291 0.0002
Skewness	8.75	3	0.0328		
Kurtosis	5.71	1	0.0169		
Total	167.47	13	0.0000		

Chemicals :
For Model 1:

Test	Chi2	df	Prob.		
Heteroskedasticity	168.05	9	0.0000	F(1,16) Prob>F	25.073 0.0001
Skewness	57.75	3	0.0000		
Kurtosis	6.96	1	0.0083		
Total	232.76	13	0.0000		

For Model 2:

Test	Chi2	df	Prob.		
Heteroskedasticity	212.45	9	0.0000	F(1,16) Prob>F	83.528 0.0000
Skewness	14.20	3	0.0026		
Kurtosis	6.76	1	0.0093		
Total	233.41	13	0.0000		

Metal Products:
For Model 1

Test	Chi2	df	Prob.		
Heteroskedasticity	55.36	9	0.0000	F(1,16) Prob>F	744.316 0.0000
Skewness	29.24	3	0.0000		
Kurtosis	7.48	1	0.0063		
Total	92.08	13	0.0000		

For Model 2:

Test	Chi2	df	Prob.		

Heteroskedasticity	222.68	9	0.0000	F(1,16)	40.509
Skewness	16.52	3	0.0009	Prob>F	0.0000
Kurtosis	14.45	1	0.0001		
Total	253.65	13	0.0000		

Non-Metallic Minerals:

For Model 1:

Test	Chi2	df	Prob.		
Heteroskedasticity	125.41	9	0.0000	F(1,14)	14.707
Skewness	40.52	3	0.0000	Prob>F	0.0018
Kurtosis	5.26	1	0.0219		
Total	171.19	13	0.0000		

For Model 2:

Test	Chi2	df	Prob.		
Heteroskedasticity	269.17	9	0.0000	F(1,14)	36.563
Skewness	58.18	3	0.0000	Prob>F	0.0000
Kurtosis	9.29	1	0.0023		
Total	336.64	13	0.0000		

Textiles and Apparel:

For Model 1:

Test	Chi2	df	Prob.		
Heteroskedasticity	50.95	9	0.0000	F(1,10)	176.162
Skewness	65.63	3	0.0000	Prob>F	0.0000
Kurtosis	29.46	1	0.0000		
Total	171.19	13	0.0000		

For Model 2:

Test	Chi2	df	Prob.		
Heteroskedasticity	72.08	9	0.0000	F(1,10)	36.563
Skewness	16.34	3	0.0010	Prob>F	0.0001
Kurtosis	8.42	1	0.0037		
Total	96.84	13	0.0000		