PREDICTION OF FINANCIAL DISTRESS BY ZMIJEWSKI'S X-SCORE MODEL IN SELECTED INDIAN IRON AND STEEL COMPANIES

Arshe AZAM[1], Syed Khaja SAFIUDDIN[2]
[1]Research Scholar, Department of Management and Commerce, Maulana Azad National Urdu University, Hyderabad, India
[2]Associate Professor, Department of Management and Commerce, Maulana Azad National Urdu University, Hyderabad, India
Corresponding author: Arshe Azam
Email: azamarshe0@gmail.com

Abstract:
The study delves into the intricate realm of financial distress prediction within the Indian Iron and Steel sector, employing Zmijewski's X-Score Model. The analysis encompasses five prominent companies – Jayaswal Neco Industries Ltd., Incredible Industries Ltd., Sarda Energy & Minerals Ltd., Kritika Wires Ltd., and Hariom Pipe Industries Ltd. – over five years from 2018 to 2022. The research uncovers nuanced insights into the financial health of these companies. Jayaswal Neco Industries Ltd., Incredible Industries Ltd., and Kritika Wires Ltd. showcase stability or improvement, indicating lower risks of financial distress. Conversely, Sarda Energy & Minerals Ltd. faces heightened risk, notably in 2022, while Hariom Pipe Industries Ltd. consistently exhibits financial vulnerability, worsening in the same year. The study employs robust statistical analyses, including multivariate tests and between-model effects analysis, revealing that specific financial ratios significantly impact Kritika Wires Ltd.'s stability. However, the complexity of financial distress becomes evident as other companies do not show significant impacts, underscoring the necessity for a nuanced understanding of diverse business dynamics. This research provides in-depth insights into financial distress prediction in the Indian Iron and Steel sector, offering valuable implications for industry practitioners and policymakers. By comprehending the complexities and adopting effective predictive models, companies can proactively manage risks, ensuring stability and contributing to overall economic growth.
Keywords: Zmijewski's X-Score, Financial Ratios, Iron and Steel Companies, Financial Distress, Model Effect

INTRODUCTION

Zmijewski's X-Score Model is a tool used to predict financial distress in companies. It combines multiple financial ratios to assess a company's financial stability (Lestari, R. M. E., et al. 2021). In the Indian Iron and Steel sector, it helps companies anticipate financial distress and take proactive measures (Firoz, A. S. 2014). By analyzing profitability, leverage, liquidity, and efficiency, the model helps companies make informed decisions, mitigate risks, and implement strategic financial planning, enhancing the sector's resilience and investor confidence (Viñals, J., Pazarbasioglu, C., et al. 2013).

Background Study of Financial Distress of Selected Model. When a company's solvency and financial stability are threatened, financial distress is a serious situation that can result in bankruptcy or insolvency. It is a state in which a business finds it difficult to fulfill its financial commitments, including servicing debt or covering operating expenses, as a result of a variety of internal and external reasons (Danilov, C. F. A., & Konstantin, A. 2014). Unexpected changes in market demand, fierce competition, economic downturns, bad management choices, and high debt levels can all lead

to financial difficulty (Wolf, M. 2014). The concept of financial hardship is a hot topic in the field of finance, drawing interest from academics, economists, and decision-makers alike (Opler, T. C., & Titman, S. 1994). When evaluating the viability and health of firms, creditors, investors, and financial analysts must have a thorough understanding of the signs, causes, and effects of financial crises (Wolf, M. 2014). Furthermore, businesses must identify the early indicators of financial difficulty to promptly and efficiently execute recovery and restructuring plans. This intricate issue has broad ramifications that impact entire economies in addition to specific businesses and their stakeholders (Sudarsanam, S., & Lai, J. 2001). A thorough understanding of financial markets, risk management strategies, and strategic planning is necessary for the effective management of financial crises (Lindgren, C. J. 1999). This research explores the many facets of financial distress, including its sources, consequences on different stakeholders, and methods used to lessen its negative effects. This study aims to provide significant insights into the domains of finance, economics, and business management by thoroughly analyzing financial hardship. This will lay the groundwork for well-informed decision-making in the dynamic environment of global markets (Wolf, M. 2014).

Background Study of Selected Companies. Indian iron and steel industries have been at the forefront of the country's industrial growth for a long time, and they have had a significant impact on the infrastructure and economics of the nation (Pulicherla, K. K., Adapa, V., et al. 2022). India's iron and steel sector has a long history that dates back to antiquity, and it has seen incredible expansion and change over time. It is currently one of the biggest and most thriving economic sectors in India, making a considerable contribution to both local and international trade (Srinivasan, S., & Ranganathan, S. 2004). India's iron and steel industry has its origins in the ancient artisans who created iron objects during the Indus Valley Civilization (Kelly, G. I. O. 2013). However, the industry started to take on a more structured form in the 19th century, during the British colonial era (Srinivasan, S., & Ranganathan, S. 2004). The basis for the contemporary Indian steel industry was laid in 1907 with the founding of steel mills like Tata Iron and Steel Company (now Tata Steel) (Simmons, C. P. 1977). Since then, technological improvements and spectacular expansion have made Indian iron and steel businesses globally competitive participants in the market (Kling, B. B. 1998). These businesses include the whole range of operations, from mining coal and iron ore to manufacturing a large variety of steel products utilized in the manufacturing, automotive, infrastructure, and construction industries (Simmons, C. P. 1977). The iron and steel sector in India is distinguished by a heterogeneous array of enterprises, encompassing both major integrated steel producers and smaller, specialty firms serving niche markets. These businesses not only make major GDP contributions to the nation, but they also create jobs for millions of people nationwide (Muslemani, H., Liang, X., et al. 2021). To increase productivity and lessen its impact on the environment, the sector has adopted technical advancements and sustainable practices in recent years (Hsu, C. C., Quang-Thanh, et al. 2021). The iron and steel industry has grown significantly as a result of government efforts like "Make in India" and investments in infrastructure development, positioning it as a major force behind India's economic development (Popli, G. S., & Popli, R. 2015).

Background Study of Selected Companies Through Model. With a pivotal role in the industrial growth of the nation, the Indian iron and steel sector has long been regarded as the foundation of the nation's economic infrastructure. However, this important industry has had serious difficulties and financial hardship recently (D'Costa, A. P. 2009). The Indian iron and steel industries, which were once thriving and represented economic progress, are currently battling a complicated web of problems that jeopardize their long-term viability and sound financial standing (Mitra Debnath, R., & Sebastian, V. J. 2014). Given that the iron and steel sector play a major role in both global steel production and India's GDP, this financial crisis has sparked concerns on both a

national and worldwide scale (Firoz, A. S. 2014). To effectively revive the economy and protect the interests of the country's economy, it is imperative to comprehend the dynamics, underlying causes, and effects of this financial hardship (Acemoglu, D., et al. 2005). It explores the different aspects that lead to the difficulties the industry has, such as shifts in the economy, policy modifications, pressure from competitors, and environmental issues (Shrivastava, P. 1995). It also looks at how financial distress affects employment, global commerce, and the overall economy. We can find viable answers and policy suggestions to aid in the recuperation and rebirth of this vital sector by thoroughly examining these problems (Campello, M., et al. 2010).

Researchers have focused on reviews related to the selected topic. For reviewing, researchers have chosen many articles and books that are published in prestigious journals based on selected model, and selected companies and also find out research gaps.

Review Related to Selected Model. The study examines bankruptcy predictions of four Indonesian tobacco businesses from 2013 to 2017, using Altman and Zmijewski models. Results show PT. Sampoerna Tbk is not in danger, while Gudang Garam, Wismilak, and Bentoel are (Prabowo, S. C. B. 2019). Based on an analysis of four Indonesian shipping companies' financial difficulties, PT. MBSS is the most stable, while PT. BLT is the least stable. The findings recommend the use of a variety of techniques to predict financial hardship in shipping companies to verify findings (Manalu, S., Octavianus, et al. 2017). Using Zmijewski and Altman's models, the paper examines financial distress models in Indonesian retail enterprises from 2014 to 2018. When it came to predicting bankruptcy, the Zmijewski model achieved the greatest accuracy rate—90%—among a sample of 70 enterprises (Viciwati, V. 2020). The research looks at how well the X-Score, Y-Score, and Z-Score prediction models work to evaluate the health and financial performance of banks that are listed and delisted on the Indonesia Stock Exchange (Wati, M. W., Suhadak, et al. 2015). The research looks at PT Atlas Resources, Tbk's bankruptcy status from 2015 to 2017, while the company was listed on the Indonesia Stock Exchange. It displays a downturn in financial performance, indicating probable insolvency and a poor investment option, using audited financial accounts and the Altman Z-Score and Zmijewski X-Score models (Soelton, M., Muhsin, M., et al. 2019). Based on secondary data and observation techniques, the paper examines PT Pakuwon Jati Tbk's financial performance from 2015 to 2019 using three financial distress models, providing insights that might help with well-informed decision-making regarding future initiatives (Winarso, E., & Edison, T. A. 2019). The study reveals that the Springate model, with a high accuracy rate of 68.75%, is the most reliable financial distress analysis model in the Tourism, Hospitality, and Restaurant subsector (Lestari, R. M. E., et al. 2021). In the Indonesian Tourism, Hospitality, and Restaurant subsector, the study shows that the Springate model performs better than the other three financial distress analysis models, with a high accuracy rate of 68.75% (Daryanto, W. M., et al. 2021). Using the Zmijewski X-score model, the study assesses the financial health of Kuwaiti stock exchange businesses from 2010 to 2017. It identifies strong positions, but it is possible to delist if X-scores drop (AlAli, M. S., AlShamali, M. M. et al., 2018).

Review Related to Selected Industries. Indian steel manufacturing firms, which generate over 50 crores in revenue annually, are in worse shape than private enterprises and have an inefficient rate of 45 per cent. The study recommends Performance benchmarking for long-term profitability (Mitra Debnath, R., & Sebastian, V. J. 2014). Following liberalisation, the manufacturing sector in India expanded, led by companies like Tata Steel Ltd., SAIL, JSW Steel Ltd., and Bhushan Power & Steel Ltd. However, as a result of heightened competition, employment decreased (Burange, L. G., & Yamini, S. 2010). The potential for collaboration between technology and innovation in sustainable industrialization is exemplified by the huge corporations in India that are putting technological

innovation efforts into practice to increase green steel production (Mallett, A., & Pal, P. 2022). This study highlights the capital-intensive nature of the Indian iron and steel industry by comparing the performance efficiency of individual and group enterprises (Ganguli, S. 2010). When comparing the pre-and post-recession periods, the study's analysis of the variables influencing profitability in the Indian iron and steel sector reveals that financial leverage, debt service capacity, and business size have a substantial impact on profitability (Burange, L. G., & Yamini, S. 2010). In Jamshedpur, the largest company town in India and the oldest company town still in existence worldwide, the 1907-founded Tata Iron and Steel Company is renowned for its paternalism (Kling, B. B. 1998). This study looks at how the Indian iron and steel sector performed after liberalization, showing increases in employment, pricing, foreign trade, output, and consumption (Parkinson, E. V. 1950). To reduce greenhouse gas emissions in capital-intensive sectors, the study proposes the sustainable-structure-conduct-performance (S-SCP) paradigm. It shows that this paradigm produces positive outcomes in green value-added but negative results in green R&D (Bali, N., Panta, et al. 2019). The study finds that in contrast to regulatory pressure, business size, age, and ownership are important factors in the adoption of environmental management systems (Haider, S., et al. 2020). The study shows that voluntary ISO 14001 compliance is positively correlated with better environmental performance in the Indian iron and steel industry, indicating that ISO 14001 has the potential to be a useful instrument for low-carbon growth policy (Prasad, M., & Mishra, T. 2017).

Research Gap. While there has been significant research conducted on financial distress prediction models globally, there exists a noticeable gap in the context of Indian Iron and Steel Companies specifically utilizing Zmijewski's X-Score Model. Despite the widespread application of various financial distress prediction models in the realm of corporate finance, the research community has paid limited attention to the practical implementation and effectiveness of Zmijewski's X-Score Model within the Indian iron and steel sector.

METHODS

Research methodology in a research paper outlines the systematic process undertaken to conduct a study. It encompasses the techniques, procedures, and tools used to gather and analyze data, ensuring the study's reliability and validity (Kitchenham, B., & Brereton, P. 2013). A robust research methodology is essential, as it enhances the credibility of the findings and enables other researchers to replicate or critique the study, thereby advancing scientific knowledge (Sovacool, B. K., et al. 2018). This section elucidates the research design, sampling methods, data collection techniques, and statistical analyses employed.

Sample Size. There are five selected Indian Iron and Steel companies for a period of five years from 2018 to 2022 using Zmijewski's X-Score model with three ratios for measuring selected companies' financial health as a sample.

Name of the selected Indian Iron and Steel companies:

(i) Jayaswal Neco Industries Ltd.
(ii) Incredible Industries Ltd.
(iii) Sarda Energy & Minerals Ltd.
(iv) Kritika Wires Ltd.
(v) Hariom Pipe Industries Ltd.

Name of the selected model with its ratios

- Zmijewski X-Score Model
(i) X1 = Net Income / Total Assets
(ii) X2 = Total Liabilities / Total Assets

(iii) X3 = Current Assets / Current Liabilities

Type and Method of Data Collection. This study depends on secondary data which are collected from the official websites of selected companies and these selected companies are listed in the Indian Stock Exchange. During data collection, researchers have used selected companies' official websites, moneymarket.com, Capitaline, Industry associations, Trade and industry bodies, Private companies, and Market research providers.

An Overview of the Selected Model. If researchers are going to measure the financial health of the selected companies through the selected model, then there are the following sources of ratios that measure the health of the companies . X-Score = -4.3 – 4.5X1 + 5.7X2 – 0.004X3 (Firmanzani, M. A., Rahmawati, et al. 2020).

X1 = Net Income / Total Assets

X2 = Total Liabilities / Total Assets

X3 = Current Assets / Current Liabilities

Zmijewski model categories, namely:

(i)   If the X-score > 0 the company is predicted to go bankrupt (Unhealthy).

(ii) If the X-score <0 the company is not predicted to go bankrupt (Healthy).

Data Analysis Technique. As 3.3, it is described that the financial health of the selected companies will be measured by a selected model namely the Zmijweski X-score model with the help of an Excel sheet and SPSS which will indicate whether companies are financially healthy or unhealthy. This research also uses descriptive statistics tools and Multivariate Tests to know the model's impact on the companies.

RESULT AND DISCUSSION

The study's findings and their implications are presented and analyzed. This section summarizes the data obtained from experiments or research activities and interprets the results in the context of the research question or hypothesis. It discusses the significance of the results, compares them with previous studies, and explores the underlying mechanisms. The section highlights the key patterns, relationships, and trends observed, providing a comprehensive understanding of the research outcomes.

Measurement of Financial Health of the Companies. The measurement of financial health assesses a company's stability and viability. Key indicators include liquidity ratios (like current and quick ratios), profitability ratios (such as net profit margin), leverage ratios (like debt-to-equity ratio), and efficiency ratios (such as inventory turnover). These metrics help investors and stakeholders gauge a company's fiscal strength and make informed decisions (Alarussi, A. S. A. 2021).

Table 1. Zmijweski X-score of Selected Indian Iron and Steel Companies

	Jayaswal Neco Industries Ltd.	Incredible Industries Ltd.	Sarda Energy & Minerals Ltd.	Kritika Wires Ltd.	Hariom Pipe Industries Ltd
2018	0.22	0.62	0.62	0.73	-0.02
2019	0.07	0.28	0.64	0.59	0.18
2020	0.53	0.25	0.84	0.67	0.08
2021	0.45	0.02	0.58	0.56	-0.07
2022	0.67	0.13	-3.61	0.79	-0.27

Source: SPSS & Excell

After calculating Table 1, X-scores for the selected Indian Iron and Steel companies namely Jayaswal Neco Industries Ltd., Incredible Industries Ltd., Sarda Energy & Minerals Ltd., Kritika Wires Ltd., and Hariom Pipe Industries Ltd. For a period of five years from 2018 to 2022, it has been observed that Jayaswal Neco Industries Ltd has an X-score that fluctuates over the years, but it generally remains positive, indicating a relatively stable financial position. In 2022, the company's X-score is 0.67, which suggests a lower risk of financial distress. Incredible Industries Ltd has an X-score for this company also varies but tends to stay positive. In 2022, the score is 0.13, indicating a relatively low risk of financial distress compared to the previous year. Sarda Energy & Minerals Ltd, this company shows a positive trend in the X-score, indicating an improvement in financial stability. However, in 2022, there is a significant drop in the X-score to -3.61, which is a cause for concern. A negative X-score suggests a higher risk of financial distress. Kritika Wires Ltd has an X-score for this company that fluctuates but remains positive throughout the years. In 2022, the score is 0.79, indicating a relatively low risk of financial distress compared to the previous year. Hariom Pipe Industries Ltd, this company's X-score is mostly negative, suggesting a higher risk of financial distress. In 2022, the score further decreases to -0.27, indicating a worsening financial position.

Jayaswal Neco Industries Ltd., Incredible Industries Ltd., and Kritika Wires Ltd. show relatively stable or improving financial positions over the years, with lower risks of financial distress. Sarda Energy & Minerals Ltd. experienced a significant drop in 2022, indicating increased financial risk. Hariom Pipe Industries Ltd. has consistently shown a higher risk of financial distress, and the situation worsened in 2022. These observations provide insights into the financial health and stability of these companies during the specified period.
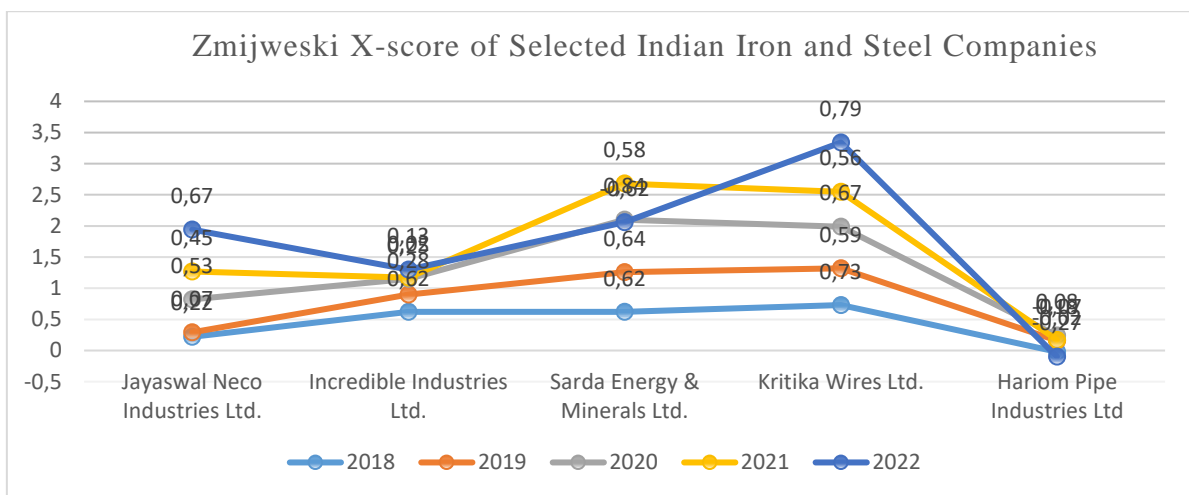

Figure 1. Zmijweski X-score of Selected Indian Iron and Steel Companies

Graph 1 presents the whole selected Indian Iron and Steel companies report for a period of five years from 2018 to 2022 related to the Zmijweski X-score where Jayaswal Neco Industries Ltd., Incredible Industries Ltd., and Kritika Wires Ltd. have a positive result for the selected period or improving financial positions over the years, and rest of the two companies namely Sarda Energy & Minerals Ltd. experienced a significant drop in 2022, indicating increased financial risk.

Testing the Selected Model by Statistics Tools

Table 2. Descriptive Statistics of Zmijweski X-score of Selected Indian Iron and Steel Companies

Name of the companies	N	Minimum	Maximum	Mean	Std. Deviation
Jayaswal Neco Industries Ltd.	5	.07	.67	.3880	.24129
Incredible Industries Ltd.	5	.02	.62	.2600	.22616
Sarda Energy & Minerals Ltd.	5	-.62	.84	.4120	.58559
Kritika Wires Ltd.	5	.56	.79	.6680	.09550
Hariom Pipe Industries Ltd	5	-.27	.18	-.0200	.16956

Source: SPSS

Table 2 provides the descriptive statistics of Zmijweski X-scores for selected Indian Iron and Steel Companies. Now researchers have N, this column indicates the number of variables (samples) for each company. In this case, there are 5 variables for each company. Minimum, this column shows the minimum Zmijweski X-score recorded for each company. For example, the lowest score for Jayaswal Neco Industries Ltd. is 0.07, while for Sarda Energy & Minerals Ltd., it is -0.62. Maximum, this column displays the maximum Zmijweski X-score observed for each company. For Jayaswal Neco Industries Ltd., the highest score is 0.67, and for Sarda Energy & Minerals Ltd., it is 0.84. Mean, this column represents the average (mean) Zmijweski X-score for each company. Jayaswal Neco Industries Ltd. has an average score of 0.3880, Incredible Industries Ltd. has an average score of 0.2600, Sarda Energy & Minerals Ltd. has an average score of 0.4120, Kritika Wires Ltd. has an average score of 0.6680, and Hariom Pipe Industries Ltd. has an average score of -0.0200. Std. Deviation, this column indicates the standard deviation of the Zmijweski X-scores for each company. It shows the amount of variation or dispersion from the mean score. Companies with higher standard deviations have more variability in their X-scores. For example, Jayaswal Neco Industries Ltd. has a standard deviation of 0.24129, indicating relatively low variability, whereas Sarda Energy & Minerals Ltd. has a higher standard deviation of 0.58559, indicating more variability in its X-scores.

Table 3. Multivariate Tests

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	.999	442.494[b]	4.000	1.000	.036
	Wilks' Lambda	.001	442.494[b]	4.000	1.000	.036
	Hotelling's Trace	1769.975	442.494[b]	4.000	1.000	.036
	Roy's Largest Root	1769.975	442.494[b]	4.000	1.000	.036

a. Design: Intercept
b. Exact statistic

Source: SPSS

Table 3 presents the results of a multivariate analysis. In this analysis, different multivariate test statistics are calculated to assess the effects of the model. Here's an interpretation of the table. Effect, the variable or factor under consideration in the analysis is the Intercept. Value, this column shows the values of the multivariate test statistics calculated for the Intercept. The specific values are provided for Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root. Pillai's Trace, A measure of the overall effect size of the Intercept variable on the multivariate response. The value is very close to 1 (0.999), indicating a strong effect. Wilks' Lambda is another measure of effect size, with a value very close to 0.001. This indicates that the Intercept variable explains a very small proportion of variance in the multivariate response. Hotelling's Trace, A statistical measure used to test the significance of the effect. The value is 1769.975, indicating a large test statistic. Roy's Largest Root, another statistical measure for testing the effect, with the same value as Hotelling's Trace

(1769.975). F, The F-statistic associated with the multivariate tests. This statistic is used to determine whether there are significant differences among the group means. The high F-statistic (442.494) suggests that there are significant differences in the means. Hypothesis df, Degrees of freedom associated with the hypothesis being tested. In this case, there are 4 degrees of freedom for the Intercept variable. Error df, Degrees of freedom associated with the error term, indicating the variability within the groups. There is 1 degree of freedom for the error term. Sig, the p-value associated with the multivariate tests. The p-value is 0.036, which is less than the typical alpha level of 0.05. Therefore, the multivariate effect of the Intercept variable is statistically significant at the 0.05 level, suggesting that there is evidence to reject the null hypothesis and conclude that the Intercept variable has a significant effect on the multivariate response.

Table 4. Tests of Between-Model Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	JNIL	.000a	0	.	.	.
	IIL	.000a	0	.	.	.
	SEML	.000a	0	.	.	.
	KWL	.000b	0	.	.	.
	HPIL	.000a	0	.	.	.
Intercept	JNIL	.753	1	.753	12.929	.023
	IIL	.338	1	.338	6.608	.062
	SEML	.849	1	.849	2.475	.191
	KWL	2.231	1	2.231	244.640	.000
	HPIL	.002	1	.002	.070	.805
Error	JNIL	.233	4	.058		
	IIL	.205	4	.051		
	SEML	1.372	4	.343		
	KWL	.036	4	.009		
	HPIL	.115	4	.029		
Total	JNIL	.986	5			
	IIL	.543	5			
	SEML	2.220	5			
	KWL	2.268	5			
	HPIL	.117	5			
Corrected Total	JNIL	.233	4			
	IIL	.205	4			
	SEML	1.372	4			
	KWL	.036	4			
	HPIL	.115	4			

a. R Squared = .000 (Adjusted R Squared = .000)

b. R Squared = .000 (Adjusted R Squared = .000)

Source: SPSS

Table 4 appears to show the results of a between-model effects analysis, which is often used in statistics to assess the impact of different variables (in this case, models) on a dependent variable. Source, this column indicates the different models being tested, JNIL, IIL, SEML, KWL, and HPIL. The dependent variable under consideration is labeled as JNIL, IIL, SEML, KWL, and HPIL,

corresponding to each model. Type III Sum of Squares, this column represents the sum of squares attributed to each model after accounting for the effects of other variables in the analysis. It is a measure of the variability explained by each model. df (Degrees of Freedom), This column shows the degrees of freedom associated with each model, which is an important parameter in statistical analyses. Mean Square is calculated by dividing the Type III Sum of Squares by the corresponding degrees of freedom. It represents the average variance within each group of data. F-statistic (F-ratio) is a ratio of variances and is used to test the significance of the overall model (combination of independent variables) in predicting the dependent variable. Higher F-values indicate more significant results. Sig. (Significance Level), This column provides the p-value associated with the F-statistic. It indicates the probability of obtaining the observed results by chance. Smaller p-values (usually less than 0.05) indicate statistical significance. For the Intercept term, only the KWL model shows a significant impact on the dependent variable (F = 244.640, Sig. = 0.000). None of the other models (JNIL, IIL, SEML, HPIL) have a significant impact on the dependent variable, as their F-values are not statistically significant ($p > 0.05$). The R-squared values for all models are 0.000, suggesting that the models do not explain much of the variance in the dependent variable. Adjusted R-squared values are also 0.000, reinforcing the lack of explanatory power in the models.

CONCLUSION

Financial distress is a complex phenomenon influenced by various internal and external factors, making it essential for companies to anticipate and manage it effectively. The study focused on five selected Indian Iron and Steel companies - Jayaswal Neco Industries Ltd., Incredible Industries Ltd., Sarda Energy & Minerals Ltd., Kritika Wires Ltd., and Hariom Pipe Industries Ltd. - over five years from 2018 to 2022. The analysis of the companies' financial health using the X-Score Model revealed interesting insights. Jayaswal Neco Industries Ltd., Incredible Industries Ltd., and Kritika Wires Ltd. exhibited relatively stable or improving financial positions over the years, with lower risks of financial distress. On the contrary, Sarda Energy & Minerals Ltd. experienced a significant drop in its X-Score in 2022, indicating increased financial risk, while Hariom Pipe Industries Ltd. consistently displayed a higher risk of financial distress, worsening in 2022. These findings provide valuable information for investors, stakeholders, and policymakers, enabling them to make informed decisions about these companies. the study employed robust statistical analyses, including multivariate tests and between-model effects analysis, to assess the effectiveness of the X-Score Model in predicting financial distress within the selected companies. The results indicated that the Intercept term in the model significantly impacted the financial health of Kritika Wires Ltd., emphasizing the relevance of specific financial ratios in evaluating the company's stability. However, the models for the other companies did not exhibit significant impacts, highlighting the complexity of financial distress and the need for a nuanced understanding of different businesses' dynamics. This research addresses a notable gap in the literature by providing a detailed analysis of financial distress prediction within the Indian Iron and Steel sector using Zmijewski's X-Score Model. The findings contribute to the academic discourse on corporate finance and offer practical insights for industry practitioners and policymakers. By understanding the intricacies of financial distress and adopting effective predictive models, companies can proactively mitigate risks, ensure stability, and contribute to the nation's overall economic growth.

REFERENCES

Acemoglu, D., Johnson, S., & Robinson, J. A. (2005). Institutions as a fundamental cause of long-run growth. *Handbook of economic growth, 1*, 385-472.

AlAli, M. S., AlShamali, M. M., AlAwadhi, K. M., & AlSabah, A. M. (2018). The use of Zmijewski model in examining the financial soundness of oil and gas companies listed at Kuwait Stock Exchange. *International Journal of Economics, Commerce and Management Research Studies, 1*(2), 15-21.

Alarussi, A. S. A. (2021). Financial ratios and efficiency in Malaysian listed companies. *Asian Journal of Economics and Banking, 5*(2), 116-135.

Bali, N., Panta, M. P., & Antelo, M. (2019). Sustainable performance-oriented production practices in the Indian iron and steel industry: An empirical investigation. *Journal of Cleaner Production, 226*, 379-391.

Banerjee, A., & De, A. (2014). Determinants of corporate financial performance relating to capital structure decisions in Indian iron and steel industry: An empirical study. *Paradigm, 18*(1), 35-50.

Burange, L. G., & Yamini, S. (2010). Competitiveness of the firms in Indian iron and steel industry. Working Paper UDE 33/2/2010. Department of Economics, University of Mumbai, India.

Campello, M., Graham, J. R., & Harvey, C. R. (2010). The real effects of financial constraints: Evidence from a financial crisis. *Journal of financial Economics, 97*(3), 470-487.

D'Costa, A. P. (2009). Economic nationalism in motion: Steel, auto, and software industries in India. *Review of International Political Economy, 16*(4), 620-648.

Danilov, C. F. A., & Konstantin, A. (2014). Corporate bankruptcy: Assessment, analysis and prediction of financial distress, insolvency, and failure. Analysis and Prediction of Financial Distress, Insolvency, and Failure (May 9, 2014).

Daryanto, W. M., Pricillia, M., & Andarini, K. (2021). Financial Report Analysis of Pt Pakuwon Jati Tbk Using Z-Score Altman, S-Score Springate, And X-Score Zmijewski Models to Analyze Company" s Bankruptcy. *South East Asia Journal of Contemporary Business*, 87-91.

Firmanzani, M. A., Rahmawati, W., Santosa, D. T., Kisya, A. A., & Hendiarto, R. S. (2020). Analysis of Zmijewski Method to Predict Bankruptcy in Service Industry Companies (Case Study in Sub Sector Retail Trade Companies Listed on Indonesia Stock Exchange Period 2015-2019).

Firoz, A. S. (2014). Long term perspectives for Indian steel industry. Ministry of Steel, Economic Research Unit mimeo, New Delhi, May.

Ganguli, S. (2010). Performance Comparison of Group Firms and Individual Firms in the Indian Iron and Steel Industry. *IUP Journal of Business Strategy, 7*(3), 26.

Haider, S., Adil, M. H., & Mishra, P. P. (2020). Corporate environmental responsibility, motivational factors, and effectiveness: A case of Indian iron and steel industry. *Journal of Public Affairs, 20*(2), e2032.

Hsu, C. C., Quang-Thanh, N., Chien, F., Li, L., & Mohsin, M. (2021). Evaluating green innovation and performance of financial development: mediating concerns of environmental regulation. *Environmental Science and Pollution Research, 28*(40), 57386-57397.

Kelly, G. I. O. (2013). Craft specialization, technology and social change: A study of material culture in Iron Age and Early Historic South India (c. 1200 BCE-400 CE) (Doctoral dissertation, The University of Wisconsin-Madison).

Kitchenham, B., & Brereton, P. (2013). A systematic review of systematic review process research in software engineering. *Information and software technology, 55*(12), 2049-2075.

Kling, B. B. (1998). Paternalism in indian labor: the tata iron and steel company of jamshedpur. *International Labor and Working-Class History, 53*, 69-87.

Kumar, N. (2008). Internationalization of Indian enterprises: patterns, strategies, ownership advantages, and implications. *Asian Economic Policy Review, 3*(2), 242-261.

Lestari, R. M. E., Situmorang, M., Pratama, M. I. P., & Bon, A. T. (2021). Financial distress analysis using altman (Z-score), Springate (S-score), Zmijewski (X-score), and Grover (G-score) models in the tourism, hospitality and restaurant subsectors listed on the Indonesia Stock Exchange period. In Proceedings of the 11th Annual International Conference on Industrial Engineering and Operations Management Singapore (pp. 4249-4259).

Lindgren, C. J. (1999). Financial sector crisis and restructuring: lessons from Asia.

Mallett, A., & Pal, P. (2022). Green transformation in the iron and steel industry in India: Rethinking patterns of innovation. Energy Strategy Reviews, 44, 100968.

Manalu, S., Octavianus, R. J. N., & Kalmadara, G. S. S. (2017). Financial distress analysis with altman z-score approach and zmijewski x-score on shipping service company. *Jurnal Aplikasi Manajemen, 15*(4), 677-682.

Mitra Debnath, R., & Sebastian, V. J. (2014). Efficiency in the Indian iron and steel industry–an application of data envelopment analysis. *Journal of Advances in Management Research, 11*(1), 4-19.

Muslemani, H., Liang, X., Kaesehage, K., Ascui, F., & Wilson, J. (2021). Opportunities and challenges for decarbonizing steel production by creating markets for 'green steel' products. *Journal of Cleaner Production*, 315, 128127.

Opler, T. C., & Titman, S. (1994). Financial distress and corporate performance. *The Journal of finance, 49*(3), 1015-1040.

Popli, G. S., & Popli, R. (2015). Research paper on investment opportunities in the steel sector of India on the concept of Make in India. Available at SSRN 2596549.

Prasad, M., & Mishra, T. (2017). Low-carbon growth for Indian iron and steel sector: exploring the role of voluntary environmental compliance. *Energy Policy*, 100, 41-50.

Parkinson, E. V. (1950). The Development of the Iron and Steel Industry in India. *Journal of the Royal Society of Arts, 98*(4824), 668-685.

Prabowo, S. C. B. (2019). Analysis on the prediction of bankruptcy of cigarette companies listed in the Indonesia Stock Exchange using altman (z-score) model and zmijewski (x-score) model. *Jurnal Aplikasi Manajemen, 17*(2), 254-260.

Pulicherla, K. K., Adapa, V., Ghosh, M., & Ingle, P. (2022). Current efforts on sustainable green growth in the manufacturing sector to complement "make in India" for making "self-reliant India". Environmental Research, 206, 112263.

Simmons, C. P. (1977). Vertical Integration and the Indian Steel Industry: The Colliery Establishment of the Tata Iron and Steel Company, 1907—56. *Modern Asian Studies, 11*(1), 127-148.

Soelton, M., Muhsin, M., Saratian, E. T. P., Arief, H., & Vizano, N. A. (2019). Analysis of Bankruptcy Prediction With Altman Z-Score And Zmijewski X-Score Model In Coal Mining Industry Listed In Indonesia Stock Exchange 2015-2017 Period. South East Asia Journal of Contemporary Business. *Economics and Law, 20*(5), 158-166.

Sovacool, B. K., Axsen, J., & Sorrell, S. (2018). Promoting novelty, rigor, and style in energy social science: Towards codes of practice for appropriate methods and research design. *Energy research & social science, 45*, 12-42.

Srinivasan, S., & Ranganathan, S. (2004). India's legendary wootz steel: an advanced material of the ancient world (pp. 1-153). National Institute of advanced studies.

Sudarsanam, S., & Lai, J. (2001). Corporate financial distress and turnaround strategies: An empirical analysis. *British Journal of Management, 12*(3), 183-199.

Sultana, S., Azam, A., & Shareef, M. S. Perception of Borrowers Towards Housing Finance A-Case Study of Select District in Housing Finance Institution.

Viciwati, V. (2020). Bankruptcy prediction analysis using the Zmijewski model (X-Score) and the Altman model (Z-Score). *Dinasti International Journal of Economics, Finance & Accounting, 1*(5), 794-806.

Viñals, J., Pazarbasioglu, C., Surti, J., Narain, A., Erbenova, M. M., & Chow, M. J. T. (2013). Creating a safer financial system: will the Volcker, Vickers, and Liikanen structural measures help?. International Monetary Fund.

Wati, M. W., Suhadak, S., & Hidayat, R. R. (2015). The Analysis of Bank Health Levels Using X-score (Zmijewski), Y-score (Ohlson), and Z-score (Altman)(Case Study at Banking Sector in Indonesian Stock Exchange Periods of 2011-2013) (Doctoral dissertation, Brawijaya University).

Winarso, E., & Edison, T. A. (2019). Perbandingan Analisis Model Z"-Score Altman Modifikasi, Model X-Score Zmijewski, Model G-Score Grover, Dan Model S-Score Springate Untuk Menganalisis Ketepatan Prediksi Kebangkrutan:(Studi Pada Perusahaan Manufaktur Sektor Industri Pelengkap Otomotif Yang Terdaftar di BEI periode 2016-2017). *Journal of Accounting, Finance, Taxation, and Auditing (JAFTA), 1*(2), 1-13.

Wolf, M. (2014). The shifts and the shocks: What we've learned–and have still to learn–from the financial crisis. Penguin UK.