

Using the Altman Z-Score Model to Identify Bankruptcy Risk Prior to Insolvency Proceedings

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Abstract. *This paper examines the use of the Altman Z-score model in identifying bankruptcy risk prior to the initiation of insolvency proceedings. The study adopts an empirical research design and applies the model to a sample of five economic entities operating in the same sector over the period 2021-2023. The analysis included four SMEs involved in bankruptcy proceedings, along with one financially stable company for comparison. Our analysis is based on information extracted from their annual financial statements, namely balance sheet and income statement data, to assess liquidity, solvency, and operational performance. The comparison between the companies analyzed points to a visible separation between firms in financial difficulty and the company used as a benchmark. For the distressed firms, the Altman Z-score was generally placed below the critical level, which suggests that the deterioration of their financial position could be observed before the formal opening of insolvency or bankruptcy proceedings. The stable company showed a different trend, with values remaining within the safe zone throughout the period examined. This suggests that accounting data, analyzed through financial ratios and bankruptcy-risk models, can help show when financial decline begins and how it progresses. In this sense, the Altman Z-score should be viewed not as a stand-alone proof of insolvency but as a supporting tool for forensic accounting reports in judicial cases.*

Keywords: forensic accounting, early detection, bankruptcy risk, Altman Z-score, financial risk, accounting information.

Introduction

Bankruptcy determines a set of complex procedures, with implications in the economic and legal spheres, to reflect the definitive inability of an economic entity to fulfill its financial obligations to creditors. The current economic context with multiple episodes of instability, intense competition and financial exposure leads to a resizing of bankruptcy cases that require more than a formal legal assessment. Accounting can examine insolvency through the lens of the financial developments that preceded it. Through accounting processes, it is possible to analyze how resources were managed, how key indicators evolved and whether internal dysfunctions or irregularities

contributed to the decline of the company. The main financial indicators become essential to assess whether the entity was able to continue its activity as a going concern (Beaver, 1966; Altman, 1968; Bologa & Dascălu, 2020).

Forensic accounting is developing as a new dimension of accounting that combines accounting knowledge, auditing skills, legal reasoning, and digital tools used to detect financial risks, financial misconduct, and fraud or "economic crimes" (Liță et al., 2025). Therefore, the accountant's analysis goes beyond the numbers to reconstruct the financial context in which the company's decline occurred. This means examining accounting records, identifying possible causes of financial difficulties, and detecting transactions or reporting practices that may indicate fraud, mismanagement, or non-compliance with legal and professional requirements. Through this study, we demonstrate that tools can be used by forensic accounting expertise to provide relevant evidence to the court, helping to clarify the underlying economic facts and support judicial decisions.

Forensic accounting has an evidentiary function in legal proceedings through the expertise performed. However, the specialized literature emphasizes the preventive role of forensic accounting expertise that leads to early warning through the application of structured financial analyses. Thus, the forensic accountant can contribute to identifying the premises of bankruptcy before the formal initiation of insolvency proceedings. For this purpose, bankruptcy risk assessment models can be used using the Altman Z-score model (Altman, 1968), the univariate analysis developed by Beaver (1966) and the logit model proposed by Ohlson (1980), models that provide an analytical framework for estimating the probability of bankruptcy based on accounting and financial information.

The extensive literature review conceptually addresses bankruptcy prediction models and the growing role of forensic accounting in assisting litigation. However, empirical research is relatively limited and examines how accounting-based early warning models can be operationalized as evidentiary analytical tools in bankruptcy proceedings (Anghel & Poenaru, 2023; Guellim et al., 2024). Some studies focus either on the accuracy of bankruptcy prediction or on the detection of fraud and forensic practices, while other contributions explicitly illustrate how such models can help forensic accountants document the evolution of financial distress using accounting evidence (Smith & Smith, 2024; Dumitrescu et al., 2025). The present study complements the research in the field and provides an empirical illustration of the evidentiary utility of the Altman Z-score model in forensic accounting expertise.

We believe that bankruptcy proceedings constitute a framework in which suspicions of financial reporting misstatement, asset concealment, liability understatement or identification of artificial transactions with affiliated parties can become decisive for establishing the judicial truth and determining liability. Therefore, this paper aims to examine the use of the Altman Z-score model in identifying bankruptcy risk before the initiation of insolvency proceedings, paying particular attention to its potential application as an analytical support tool in forensic accounting contexts.

Literature Review

The analysis of bankruptcy from the perspective of accounting interpretation has led to the identification of two related streams of literature. On one side, the literature introduces bankruptcy prediction models to identify financial indicators capable of signaling corporate difficulties, using accounting data and improving the analytical accuracy of predicting financial failure (Altman, 1968; Altman et al., 2017). On the other side, the specific literature examines how financial and accounting information can be investigated, interpreted and presented as evidence in legal and

judicial contexts, especially in cases involving financial litigation or fraud investigations and litigation assistance (Rezaee, 2005). Even though there are these two identified research streams, we find that they have a common analytical basis in the use of financial statements and accounting indicators. Understanding how financial analysis techniques used in bankruptcy prediction can inform forensic accounting expertise provides important insight into the evidentiary role of accounting information in bankruptcy court proceedings.

Financial Control and the Emergence of Forensic Accounting

The reliability of economic information is a fundamental concern for organizations and regulatory authorities. To verify this, financial control mechanisms with a predominantly administrative and preventive role have been developed. However, traditional financial control and audit practices have focused mainly on verifying compliance with accounting standards and ensuring the accuracy of financial reporting. The systematic investigation of fraudulent intentions or the production of evidence for legal proceedings have been treated with greater ease (Power, 1997).

The complexity of the economic environments in which companies operate has generated increased information asymmetry in which the limits of classical financial control are clear. Audit procedures designed for assurance purposes are insufficient in situations involving litigation, insolvency or bankruptcy, where the reconstruction of the economic substance and the identification of intentional misstatements become essential (Humphrey et al., 2017).

To fill this gap, forensic accounting has developed as a distinct interdisciplinary field that integrates accounting, auditing, financial analysis, law and, increasingly, digital technologies. Unlike the traditional way of conducting an audit, forensic accounting adopts an investigative approach geared towards supporting litigation and judicial evidence. Recent literature confirms the growing relevance of forensic accounting in addressing fraud, insolvency, and bankruptcy, particularly in environments marked by financial instability and regulatory pressure (Rezaee, 2005; Liță et al., 2025).

Recent empirical and systematic studies highlight that forensic accounting enhances transparency and accountability by reducing the gap between accounting information and judicial decision-making. Thus, its role is outlined, which includes, in addition to detecting fraud and documenting financial difficulties, reconstructing financial flows and clarifying complex accounting issues for the courts (Guellim et al., 2024; Smith & Smith, 2024). This evolution reflects a shift from compliance-oriented verification toward evidence-oriented financial investigation.

Theoretical Foundations and Predictive Models for Insolvency and Bankruptcy

In the literature, insolvency and bankruptcy are widely treated as interconnected but distinct phenomena. Insolvency was initially defined as a persistent inability to meet financial obligations, while bankruptcy implied the formal legal recognition of this condition through judicial intervention (Altman, 1968; Ohlson, 1980). Therefore, early theoretical approaches focused on identifying accounting indicators capable of signaling financial difficulties before legal bankruptcy.

The landmark studies by Beaver (1966) and Altman (1968) reinforced the idea that financial indicators related to liquidity, solvency, and profitability provide a clear picture between distressed and non-distressed firms. These findings laid the foundation for bankruptcy prediction models based on accounting data and have been repeatedly validated in subsequent research.

Subsequent research has introduced probabilistic perspectives that demonstrate that bankruptcy is not a sudden event, but rather the result of a gradual process of financial deterioration

influenced by cumulative managerial and structural factors (Ohlson, 1980). The published literature adopts a multidimensional perspective on financial distress, integrating economic, institutional, and governance factors into the analysis of bankruptcy (Jones, 2023).

Published research confirms that the classic model based on the Altman Z-score remains analytically relevant and applicable in homogeneous economic contexts. At the same time, this research highlights that their effectiveness can be enhanced when combined with complementary indicators or advanced analytical techniques (Rahman & Zhu, 2024; Kristanti, 2025). Digital transformation and automation support accounting-based models that continue to be defined due to their transparency and suitability for professional and judicial applications (Dumitrescu et al., 2025).

Recent literature has reassessed the relationship between bankruptcy and accounting fraud following the rise in corporate insolvencies in Europe. Financial statement fraud is associated with unjustifiable economic losses and is closely linked to insolvency proceedings (ACFE, 2024). Thus, there are empirical studies that show that fraudulent financial reporting can delay the recognition of insolvency, distort bankruptcy risk indicators and undermine the protection of creditors' interests. Therefore, accounting information acquires a dual function in bankruptcy contexts. On one side, it serves as an analytical tool for assessing financial difficulties, and on the other side, it constitutes evidence of possible accounting irregularities (Popescu & Călin, 2021; Anghel & Poenaru, 2023).

At the same time, other recent studies highlight the fact that traditional audit mechanisms may fail to detect sophisticated forms of distortion of legislation when they focus strictly on formal compliance. This limitation has reinforced the need for forensic accounting approaches capable of examining transactions in depth, assessing economic substance, and identifying intentional distortions in financial reporting (Guellim et al., 2024; Becerra Huamán et al., 2025).

High-Profile Bankruptcies and the Accounting Forensic Perspective

Academic and professional debates on insolvency, auditing, and forensic accounting have been amplified by a series of corporate failures with societal impact. Such failures expose systemic deficiencies in financial reporting, audit analysis and oversight, or compliance with rules and regulations. The collapse of large corporations has highlighted the discrepancy between formal compliance with accounting standards and the underlying economic reality.

Studies have identified that in many insolvency cases, financial statements formally complied with reporting requirements, while hiding structural financial difficulties through aggressive accounting practices or complex transactions. This discrepancy between form and substance reinforces the need for investigative approaches distinct from traditional auditing, especially in judicial contexts where responsibility and causation must be established (Anghel & Poenaru, 2023).

Literature increasingly recognizes forensic accounting as an analytical tool for identifying misstatements and fraud, enabling courts to understand the dynamics of financial failure, track transactions, and assess the timing and causes of insolvency. By reconstructing financial reality, forensic accounting contributes to distinguishing between unavoidable economic failure and conduct that aggravated financial decline (Smith & Smith, 2024; Awwad, 2025).

In judicial bankruptcy proceedings, forensic accounting expertise assumes a central evidentiary role. Unlike audit opinions, which address the fairness of financial statements at a given point in time, forensic accounting analyses focus on retrospective investigation and documentation of financial events. Recent literature confirms that courts increasingly rely on forensic accounting

expertise to clarify complex accounting issues, quantify damages, and establish responsibility in insolvency cases (Anghel & Poenaru, 2023; Guellim et al., 2024).

More recent research confirms that accounting-based distress models remain analytically robust and interpretable, particularly in applied financial analysis contexts (Rahman & Zhu, 2024; Dumitrescu et al., 2025). At the same time, forensic accounting literature emphasizes the importance of structured financial analysis for reconstructing economic events, documenting financial irregularities, and supporting expert testimony in judicial proceedings (Anghel & Poenaru, 2023; Smith & Smith, 2024; Guellim et al., 2024). Despite these developments, relatively few empirical studies explicitly examine how bankruptcy prediction models can be operationalized as analytical tools within forensic accounting expertise to support the evidentiary process in judicial bankruptcy cases. Addressing this gap, the present study provides an applied empirical illustration of how the Altman Z-score model can assist forensic accountants in documenting the progression of financial distress and supporting evidentiary analysis in judicial bankruptcy proceedings.

Based on this review of the literature, this study does not aim to develop a new model for predicting bankruptcies or to present a comprehensive legal analysis of the practice of forensic accounting. The results position themselves at the intersection of these two approaches, focusing on how an established financial distress model can be applied as an analytical support tool in the context of forensic accounting. The paper therefore adopts an applied perspective, illustrating how accounting-based risk indicators can contribute to the documentation and interpretation of financial impairment in judicial contexts, without replacing the broader investigative and legal functions of forensic expertise.

Methodology

The present study adopts an empirical, quantitative research approach aimed at assessing bankruptcy risk based on financial and accounting information within the context of judicial bankruptcy proceedings. The methodological framework is built around the application of the Altman Z-score model, which is widely recognized in the specialized literature as an early warning instrument for financial distress. The choice of this model is justified by its extensive validation in prior studies and by its relevance for evaluating financial viability using accounting data.

The research design is longitudinal by analyzing financial data over three consecutive financial years, allowing for the observation of trends and dynamics of key financial indicators before the initiation of official bankruptcy proceedings. This approach is appropriate for the objectives of the study, as it allows for the identification of bankruptcy premises beyond a purely static assessment of insolvency.

The sample analyzed consists of five economic entities (coding A to E), of which four are subject to bankruptcy proceedings, while one operates under the going concern assumption and is used as a control firm. The selection of entities was based on qualitative and legal criteria, namely their procedural status (bankruptcy versus ongoing activity) and the availability of relevant financial and accounting information.

Given the limited number of firms included in the analysis ($n=5$), the results should be interpreted as an exploratory applied illustration rather than as a statistically generalized test. The small sample size does not allow the use of inferential statistical techniques, and the analysis therefore relies on descriptive comparison of financial indicators and Z-score trajectories across the analyzed firms. This approach is consistent with the objective of the study, which is to illustrate the evidentiary usefulness of accounting-based bankruptcy risk indicators within a forensic accounting context.

The study relies on secondary data extracted from annual financial statements, including the balance sheet, income statement, and cash flow statement, prepared and published in accordance with applicable accounting regulations. All five entities operate within the same economic sector (trade) and conduct their activities in the south-eastern region of the country, which ensures a relatively homogeneous economic environment and enhances the comparability of results.

The Altman Z-score model is based on multiple discriminant analysis and combines a set of relevant financial ratios into a synthetic score designed to assess bankruptcy risk. The model is extensively used in both academic research and professional practice, due to its ability to signal financial difficulties prior to the formal manifestation of insolvency.

In the present study, the model is operationalized using accounting data derived from the financial statements of the firms analyzed.

$$Z = 1,2 \cdot \frac{WC}{TA} + 1,4 \cdot \frac{RE}{TA} + 3,3 \cdot \frac{\text{Operating result}}{TA} + 0,6 \cdot \frac{MVE}{TL} + 1,0 \cdot \frac{S}{TA} \quad (1)$$

where WC denotes working capital, TA represents total assets, RE refers to retained earnings, Operating result captures earnings generated from core operating activities, MVE represents the market (or book) value of equity, TL denotes total liabilities, and S stands for sales revenue.

The present study applies the classical Altman Z-score framework using accounting data derived from financial statements. The book value of equity was used as a proxy for the equity component of the model, a practice commonly adopted in empirical applications involving firms.

The interpretation of the Z-score values follows the thresholds proposed by Altman, whereby scores below 1.81 indicate a high-risk zone associated with probable bankruptcy, values between 1.81 and 2.99 correspond to a grey area of uncertainty, and scores exceeding 2.99 reflect a zone of financial safety.

To strengthen the analysis and reduce the limitations associated with the use of a single predictive model, the research also integrates a set of complementary financial indicators frequently employed in bankruptcy risk assessment studies. These indicators address distinct dimensions of financial viability, such as liquidity, solvency, self-financing capacity, and operational performance.

An entity is considered exposed to bankruptcy risk when the analyzed indicators converge in signaling the deterioration of these financial dimensions, in correlation with a Z-score situated within the risk zone. This combined approach allows for a more robust assessment of financial distress and supports the analytical relevance of the results from a forensic accounting perspective.

Results and discussions

The empirical analysis focuses on the assessment of bankruptcy risk for five economic entities operating in the same sector over the period 2021-2023, by applying the Altman Z-score model based on accounting data extracted from annual financial statements. Four of the firms analyzed are subject to bankruptcy proceedings, while one entity operates under the going concern assumption and serves as a control firm.

The financial position and performance of the firms analyzed are summarized using balance sheet and income statement data, which form the basis for the computation of the Altman Z-score.

The consolidated financial data presented in Table 1 summarize the key accounting indicators used in the analysis for the five firms over the period 2021–2023.

Table 1. Consolidated Financial Indicators for the Analyzed Firms (Romanian lei)

Firm	Indicator	2021	2022	2023
Firm A	Total Assets (TA)	8,744,708	8,496,321	8,249,571
	Current Assets (CA)	2,272,364	2,208,941	2,143,612
	Current Liabilities (CL)	3,529,016	3,486,204	3,427,948
	Working Capital (WC)	-1,256,652	-1,277,263	-1,284,336
	Retained Earnings (RE)	-1,621,749	-1,969,845	-2,316,508
	Operating Result (EBIT)	-436,480	-529,774	-623,912
	Total Liabilities (TL)	9,569,796	9,298,614	9,028,462
	Equity (Book Value)	-544,976	-701,293	-778,891
	Sales (S)	6,826,990	6,629,438	6,438,574
Firm B	Total Assets (TA)	9,874,615	9,595,241	9,318,284
	Current Assets (CA)	2,107,893	2,046,281	1,987,506
	Current Liabilities (CL)	3,428,516	3,294,760	3,156,692
	Working Capital (WC)	-1,320,623	-1,248,479	-1,169,186
	Retained Earnings (RE)	-1,390,102	-1,688,402	-1,986,294
	Operating Result (EBIT)	-402,887	-472,611	-548,194
	Total Liabilities (TL)	10,214,968	10,029,834	9,846,712
	Equity (Book Value)	-370,021	-452,917	-528,428
	Sales (S)	7,548,233	7,342,505	7,129,946
Firm C	Total Assets (TA)	8,383,247	8,134,926	7,896,413
	Current Assets (CA)	2,562,174	2,441,683	2,318,194
	Current Liabilities (CL)	4,021,369	4,012,980	3,985,314
	Working Capital (WC)	-1,459,195	-1,571,297	-1,667,120
	Retained Earnings (RE)	-1,919,774	-2,336,511	-2,742,918
	Operating Result (EBIT)	-503,662	-645,884	-782,441
	Total Liabilities (TL)	9,161,883	9,048,926	8,964,374
	Equity (Book Value)	-813,946	-913,999	-1,067,961
	Sales (S)	6,326,117	6,151,430	5,987,396
Firm D	Total Assets (TA)	6,851,172	6,664,330	6,472,864
	Current Assets (CA)	1,733,860	1,628,540	1,526,941
	Current Liabilities (CL)	2,899,408	2,824,911	2,742,563
	Working Capital (WC)	-1,165,548	-1,196,371	-1,215,622
	Retained Earnings (RE)	-1,302,788	-1,574,216	-1,863,526
	Operating Result (EBIT)	-341,552	-402,773	-468,483
	Total Liabilities (TL)	7,536,984	7,391,220	7,238,596
	Equity (Book Value)	-574,991	-646,890	-765,732
	Sales (S)	5,001,324	4,884,112	4,768,944
Firm E	Total Assets (TA)	10,375,021	10,472,884	10,587,492
	Current Assets (CA)	5,108,366	5,012,744	5,100,321
	Current Liabilities (CL)	2,095,714	2,034,880	2,000,123
	Working Capital (WC)	3,012,652	2,977,864	3,100,198
	Retained Earnings (RE)	2,942,417	3,084,291	3,200,455
	Operating Result (EBIT)	1,503,218	1,582,694	1,650,210
	Total Liabilities (TL)	3,874,926	3,956,110	3,950,880
	Equity (Book Value)	6,500,095	6,516,774	6,636,612
	Sales (S)	15,978,433	16,212,506	16,800,540

Source: Authors owns processing based on annual financial statements (<https://mfinante.gov.ro>).

A clear structural contrast can be observed between the four firms subject to bankruptcy proceedings and the control entity operating under the going concern assumption. The distressed firms display persistent negative working capital, reflecting chronic liquidity shortages and an inability to cover short-term obligations with current assets. In addition, these firms report negative retained earnings and declining operating results throughout the period analyzed, indicating the accumulation of losses and the progressive deterioration of operational performance. The capital structure of these firms is also characterized by negative equity and high leverage levels, which further amplify financial vulnerability.

The main balance sheet and income statement indicators for Firm A over the period 2021-2023, revealing persistent negative working capital, accumulated losses, negative equity, and declining operating results, which indicate severe and progressive financial deterioration consistent with a high risk of bankruptcy. The data presented for Firm B, characterized by negative working capital, sustained operating losses, and insufficient capitalization, suggesting a persistent inability to restore financial equilibrium throughout the analyzed period. Firm C records negative equity, increasing accumulated losses, and deteriorating operating performance, indicating that economic bankruptcy was effectively installed prior to the formal initiation of judicial proceedings. The financial indicators of Firm D show a continuous decline in financial condition, reflected by negative working capital, persistent operating losses, and a weakening capital structure, which signal the loss of business continuity and a high probability of bankruptcy. The financial data of Firm E, which contrast sharply with the bankrupt entities, as positive working capital, retained earnings, stable operating profitability, and a balanced capital structure confirm the firm's financial viability and absence of bankruptcy risk during the period analyzed. Positive working capital, accumulated retained earnings, and consistent operating profitability reflect a balanced financial structure and the capacity to sustain ongoing business operations. The comparative interpretation of these indicators highlights the underlying financial mechanisms explaining the divergence in Z-score values between the distressed entities and the viable firm. While the distressed firms present structural imbalances affecting liquidity, profitability, and capitalization, the control entity maintains a stable financial profile consistent with the financial safety zone identified by the Altman model.

The working capital to total assets ratio (WC/TA) represents an important indicator of short-term financial stability and liquidity. It reflects the extent to which an entity's current assets exceed its short-term liabilities and therefore indicates the firm's capacity to cover immediate financial obligations using internally available resources (Figure 1). Within the Altman Z-score framework, this ratio captures the liquidity position of the firm and its ability to sustain operational continuity without excessive reliance on external financing. Persistent negative values of this indicator typically signal structural liquidity deficits and may represent early warning signs of financial distress.

The results reveal a clear divergence between the distressed entities and the control firm. Firms A, B, C, and D exhibit consistently negative values throughout the entire period, indicating persistent liquidity shortages and structural imbalances between current assets and short-term obligations. In several cases, the ratio deteriorates further over time, suggesting a progressive weakening of the firm's short-term financial position. In contrast, Firm E maintains stable positive values of the indicator across all three years, reflecting a balanced liquidity structure and an adequate capacity to meet short-term liabilities. This contrast highlights the role of liquidity constraints as one of the key financial characteristics associated with the distressed firms in the sample.

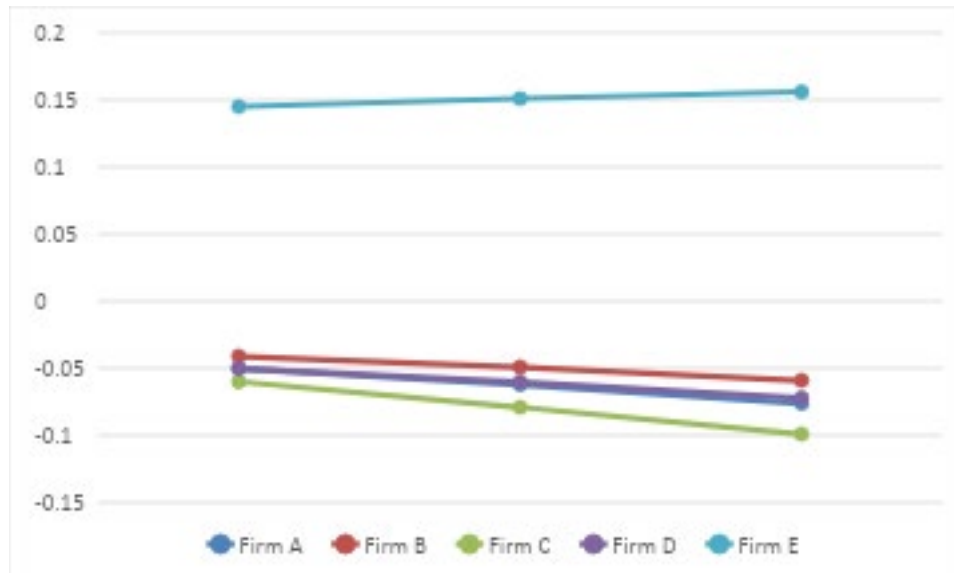


Figure 1. Evolution of the Working Capital Ratio (WC/TA) for the analyzed firms (2021–2023)

Source: Authors' results.

In Figure 2, the operating result to total assets ratio (EBIT/TA) was used to measure the capacity of a firm to generate operating profits from the resources employed in its activities. This indicator reflects operational efficiency and the firm's ability to convert its asset base into operating income. As one of the core components of the Altman Z-score model, this ratio contributes to capturing the profitability dimension of financial viability.

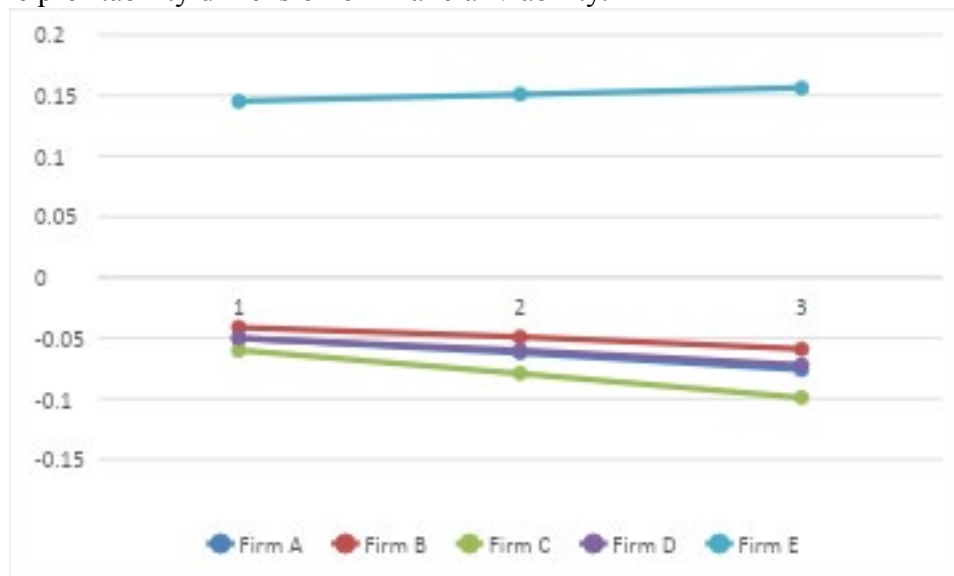


Figure 2. Evolution of Operating Profitability (EBIT/TA) for the analyzed firms (2021–2023)

Source: Authors' results.

Firms A, B, C, and D display negative operating profitability throughout the period analyzed, with several firms showing a gradual deterioration in operating performance over time. This pattern indicates a persistent inability to generate operating income sufficiently to sustain the asset base of the firm. By contrast, Firm E records consistently positive and stable values of the

EBIT/TA ratio, confirming the presence of sustainable operating profitability. The comparison suggests that the deterioration of operating performance constitutes a central mechanism underlying the financial distress observed in the bankrupt firms.

Based on the financial data of Table 1, the Altman Z-score was calculated for each firm and year. The formula and interpretation thresholds follow the original model proposed by Altman, whereby values below 1.81 indicate a high probability of bankruptcy, values between 1.81 and 2.99 correspond to a grey zone, and values above 2.99 signal financial stability.

The results summarized in Table 2 provide a clear empirical illustration of the discriminatory capacity of the Altman Z-score model when applied to accounting data extracted from annual financial statements. The consistent positioning of Firms A, B, C, and D below the critical threshold of 1.81 throughout the period 2021-2023 confirms the structural and persistent nature of financial distress in these entities. The evolution of the Z-scores over time further reveals a progressive deterioration rather than isolated financial shocks. The results illustrate that financial distress signals can be identified several periods prior to the formal initiation of insolvency proceedings.

Table 2. Altman Z-Score and Bankruptcy Risk Classification

Firm	Z-score 2021	Z-score 2022	Z-score 2023	Risk Zone
Firm A	0.15	0.04	-0.10	Severe Risk
Firm B	0.28	0.19	0.09	Severe Risk
Firm C	-0.06	-0.21	-0.38	Extreme Risk
Firm D	0.06	-0.06	-0.19	Severe Risk
Firm E	3.71	3.80	3.88	Safe Zone

Source: Authors owns processing based on annual financial statements.

For Firm A, the decline of the Z-score from 0.15 in 2021 to -0.10 in 2023 reflects the cumulative impact of negative working capital, recurring operating losses, and negative equity. The transition into negative territory in the final year indicates that the combined effect of liquidity shortages, insufficient retained earnings, and operating inefficiency outweighed any stabilizing components of the model. In terms of the Z-score structure, the negative contribution of the working capital to total assets ratio and the operating result to total assets ratio reduced the overall score, signaling imminent bankruptcy well before the formal judicial procedure.

Also, Firm B exhibits a similar pattern, with Z-scores decreasing from 0.28 to 0.09 over the analyzed period. Although slightly higher than those of Firm A, the values remain firmly within the severe risk zone. The persistence of negative working capital and operating losses suggests structural non-viability rather than temporary financial imbalance. In the context of the Altman model, the low profitability and weak capitalization ratios constrained the firm's ability to generate a recovery in the composite score.

Firm C presents the most critical situation among the analyzed entities, with negative Z-scores throughout the entire period (-0.06, -0.21, -0.38). This trajectory reflects a sustained erosion of financial capacity, characterized by accumulated losses, high leverage, and declining operational performance. From a theoretical standpoint, such consistently negative scores align with the process-oriented view of bankruptcy advanced in the literature, according to which financial failure develops gradually through persistent imbalances (Ohlson, 1980; Jones, 2023). The results suggest that economic bankruptcy was effectively installed prior to its legal recognition.

Firm D also remains in the severe risk zone, with a downward trend culminating in negative Z-scores in 2022 and 2023. The continuous decline reflects an inability to restore liquidity and

operational profitability, while the capital structure remained fragile. In all four distressed firms, the interaction between liquidity deficits, accumulated losses, and weak operating performance generated reinforcing negative effects within the Z-score formula, amplifying the overall risk signal.

In contrast, Firm E maintained Z-scores of 3.71, 3.80, and 3.88, consistently above the safety threshold of 2.99. The stability and slight upward trend of these values demonstrate balanced contributions from liquidity, retained earnings, profitability, and asset turnover components. The positive working capital to total assets ratio, strong operating result, and solid equity base generated cumulative positive effects in the model, confirming the firm's financial viability. The inclusion of this control entity strengthens the robustness of the analysis by clearly differentiating financially sustainable structures from structurally distressed ones.

Overall, the comparative interpretation of Table 2 confirms that the Altman Z-score model captures not only the presence of financial distress but also its trajectory and intensity over time. The fact that four firms subsequently entered insolvency proceedings in 2024-2025 provides ex post contextual support for the model's analytical relevance. The analysis of Z-score values across consecutive periods highlights the progressive development of financial distress prior to the initiation of insolvency proceedings. These findings are consistent with classical bankruptcy prediction literature (Beaver, 1966; Altman et al., 2017) and recent research emphasizing the continued robustness of accounting-based distress models in applied contexts (Rahman & Zhu, 2024; Dumitrescu et al., 2025).

The application of accounting-based early warning models has an important preventive dimension. By systematically analyzing financial indicators and composite indicators using the Altman Z-score, signals of financial distress can be detected well before the formal initiation of insolvency proceedings. The results of this study illustrate how persistent negative working capital, accumulated losses and declining operational performance generate early warning signals that may indicate the progressive deterioration of a firm's financial position. This early identification can facilitate timely corrective measures, improved financial monitoring or increased scrutiny of financial reporting practices, thereby contributing to mitigating financial losses for creditors and other stakeholders. The analytical framework used in this study should not only be interpreted as an ex post diagnostic tool, but also as a potential tool for early detection of financial vulnerability and prevention of a severe financial collapse.

The results demonstrate that the Z-score model can serve as an evidentiary analytical tool in bankruptcy proceedings. By quantifying the progression of financial deterioration, the Z-score model supports the reconstruction of the financial timeline preceding insolvency and increases the transparency of expert testimony. Although the Z-score cannot establish legal liability, it provides structured and objective indicators that help courts distinguish between temporary financial difficulties and structural insolvency.

Through the results of the Z-score analysis, we believe that such models can be directly integrated into expert assessment procedures in judicial contexts. A forensic accountant could use the evolution of Z-score values and underlying financial indicators to document the timing and progression of financial deterioration before the initiation of insolvency proceedings. This illustrates whether financial difficulties have developed gradually or have been associated with sudden changes that may require further investigation. In addition, the identification of persistent negative liquidity and profitability patterns can guide judicial examination towards areas of increased financial risk, including potential mismanagement, delayed recognition of insolvency or

irregular financial reporting. The empirical results of the study can be interpreted as analytical data that support, rather than replace, professional judgment in forensic accounting expertise.

The predictive model can help support the expert's assessment by providing quantifiable and transparent measures of financial impairment. However, their interpretation must be integrated with additional documentary evidence, professional judgment and, where appropriate, legal considerations, to ensure compliance with the procedural and evidentiary requirements applicable in judicial contexts.

The present study is subject to several limitations inherent to empirical research based on historical accounting data. First, the size of the sample analyzed is relatively limited, which restricts the generalizability of the findings. Although the use of firms operating within the same sector enhances comparability, broader samples across multiple industries would allow for more robust conclusions. Second, the analysis relies exclusively on published financial statements, which may be affected by accounting discretion or intentional misrepresentation. Third, although the Altman Z-score model is well established and widely validated, it captures only quantitative dimensions of financial distress and does not incorporate qualitative or behavioral factors, such as corporate governance quality, managerial incentives, or institutional constraints. Consequently, the results should be interpreted as indicative rather than deterministic.

Future research may address these limitations by expanding the sample size and incorporating firms from different economic sectors and jurisdictions. Further studies could also integrate accounting-based models with qualitative forensic techniques, such as transaction tracing or governance analysis, to enhance the evidentiary value of forensic expertise. Additionally, combining traditional bankruptcy prediction models with advanced statistical methods or machine learning approaches may offer promising avenues for improving the early detection and documentation of financial distress in judicial contexts.

Conclusion

The findings demonstrate that accounting information provides consistent and objective signals of financial distress prior to the formal initiation of insolvency proceedings, reinforcing its relevance within judicial contexts. The empirical results obtained for the analyzed sample provide a clear illustration of the analytical capacity of accounting-based indicators to differentiate between financially distressed firms and a financially viable entity. The four firms subject to bankruptcy proceedings displayed consistently low Z-score values throughout the analyzed period, while the control firm maintained stable scores within the financial safety zone. Within the limits of the sample analyzed, these findings confirm that accounting indicators derived from financial statements can capture patterns of financial deterioration associated with elevated bankruptcy risk.

From a forensic accounting perspective, the results highlight the usefulness of structured financial analysis as a complementary analytical instrument in judicial bankruptcy proceedings. Indicators such as the Altman Z-score can assist forensic accountants in documenting the evolution of financial distress and in presenting structured financial information that supports expert interpretation.

The study also highlights the importance of integrating structured financial analysis into forensic accounting practice to enhance transparency and objectivity in judicial decision-making. While accounting-based models cannot replace comprehensive legal assessment or investigative judgment, they provide a replicable and interpretable analytical framework that strengthens the quality of judicial evidence.

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References

- Altman, E. I. (1968). Financial ratios, discriminant analysis and the prediction of corporate bankruptcy. *The Journal of Finance*, 23(4), 589-609. <https://doi.org/10.1111/j.1540-6261.1968.tb00843.x>
- Altman, E. I., Iwanicz-Drozdowska, M., Laitinen, E. K., & Suvas, A. (2017). Financial distress prediction in an international context: A review and empirical analysis. *Journal of International Financial Management & Accounting*, 30(2), 131-171. <https://doi.org/10.1111/jifm.12053>
- Anghel, G., & Poenaru, C.-E. (2023). Forensic accounting, a tool for detecting and preventing economic fraud. *Valahian Journal of Economic Studies*, 14(2). <https://doi.org/10.2478/vjes-2023-0018>
- Association of Certified Fraud Examiners. (2024). Occupational fraud 2024: A report to the nations. ACFE. Retrieved from <https://www.acfe.com/report-to-the-nations/2024>
- Awwad, A. (2025). Digital evidence in forensic accounting: A study in Saudi Arabia. *Cogent Business & Management*. <https://doi.org/10.1080/23311886.2025.2522958>
- Beaver, W. H. (1966). Financial ratios as predictors of failure. *Journal of Accounting Research*, 4, 71-111. <https://doi.org/10.2307/2490171>
- Becerra Huamán, C., De la Cruz-Montoya, D., Gutierrez-Cuadros, J., Pilco Labajos, S., & Lopez-Almeida, M. (2025). Financial auditing as an effective tool for fraud detection: A systematic review. *Journal of Risk and Financial Management*, 18(9), 523. <https://doi.org/10.3390/jrfm18090523>
- Bologa, R., & Dascălu, E. D. (2020). Financial reporting quality and insolvency risk. *Amfiteatrul Economic*, 22(55), 744-758. Retrieved from <https://www.amfiteatrueconomic.ro/ArticolRO.aspx?CodArticol=2942>
- Dumitrescu, D., Bobitan, N., Popa, A. F., Sahlian, D. N., & Stănilă, C. A. (2025). Signaling financial distress through Z-scores and corporate governance compliance interplay: A random forest approach. *Electronics*, 14(11), 2151. <https://doi.org/10.3390/electronics14112151>
- Eurostat. (2025). Quarterly registrations of new businesses and declarations of bankruptcies statistics. Statistics Explained. Retrieved from https://ec.europa.eu/eurostat/statistics-explained/index.php/Quarterly_registrations_of_new_businesses_and_declarations_of_bankruptcies_-_statistics
- Guellim, N., Yami, N., Freihat, A. F., Alshurafat, H., Alkababji, M. W., Alzahrane, M., Gad, W. N.-E.-D., & Mostafa, R. M. A. (2024). Evaluating the perceived value of forensic accounting: A systematic review method. *Discover Sustainability*, 5, 351. <https://doi.org/10.1007/s43621-024-00431-y>
- Humphrey, C., O'Dwyer, B., & Unerman, J. (2017). Re-theorizing the configuration of organizational fields: The IIRC and the pursuit of “enlightened” corporate reporting. *Accounting and Business Research*, 47(1), 30-63. <https://doi.org/10.1080/00014788.2016.1198683>

- Jones, S. (2023). A literature survey of corporate failure prediction models. *Journal of Accounting Literature*, 45(2), 364-405. <https://doi.org/10.1108/JAL-08-2022-0086>
- Kristanti, F. T. (2025). Financial distress prediction in emerging markets using a machine learning approach for financial sustainability. *Discover Sustainability*. <https://doi.org/10.1007/s43621-025-02199-1>
- Liță, A.-N., Stoica, S. I., Grigorescu, P.-A., & Radu, V. (2025). Forensic accounting in the knowledge and innovation society: A bibliometric approach. *Proceedings of the International Conference on Business Excellence*, 19(1), 5627-5647. <https://doi.org/10.2478/picbe-2025-0431>
- Organisation for Economic Co-operation and Development. (2024). Financing SMEs and entrepreneurs 2024: An OECD scoreboard. OECD Publishing. Retrieved from https://doi.org/10.1787/fin_sme_ent-2014-en
- Ohlson, J. A. (1980). Financial ratios and the probabilistic prediction of bankruptcy. *Journal of Accounting Research*, 18(1), 109-131. <https://doi.org/10.2307/2490395>
- Popescu, D., & Călin, A. C. (2021). Corporate governance failures and financial reporting quality. *Amfiteatrul Economic*, 23(57), 579-596. Retrieved from <https://www.amfiteatrueconomic.ro/ArticolRO.aspx?CodArticol=3066>
- Power, M. (1997). *The audit society: Rituals of verification*. OUP Oxford.
- Rahman, M. J., & Zhu, H. (2024). Predicting financial distress using machine learning approaches: Evidence from China. *Journal of Contemporary Accounting & Economics*, 20(1), 100403. <https://doi.org/10.1016/j.jcae.2024.100403>
- Rezaee, Z. (2005). Causes, consequences, and deterrence of financial statement fraud. *Critical Perspectives on Accounting*, 16(3), 277-298. [https://doi.org/10.1016/S1045-2354\(03\)00072-8](https://doi.org/10.1016/S1045-2354(03)00072-8)
- Smith, K. T., & Smith, L. M. (2024). Examining documentation tools for audit and forensic accounting investigations. *Journal of Risk and Financial Management*, 17(11), 491. <https://doi.org/10.3390/jrfm17110491>