

SYSTEMATIC LITERATURE REVIEW OF ADVANCEMENTS IN CORPORATE BANKRUPTCY PREDICTION

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Abstract

This systematic review examines the evolution of corporate bankruptcy prediction models, synthesizing insights from a wide array of high-quality studies. Statistical methods, notably logit analysis and discriminant analysis, are predominant in bankruptcy prediction, but there is a discernible rise in the adoption of artificial intelligence techniques. Accounting-based methodologies, particularly accrual-based approaches, are prevalent, emphasizing the importance of financial ratios in assessing companies' financial health. By elucidating key trends and methodologies, this review aims to inform future research and enhance the effectiveness of bankruptcy prediction models in corporate finance.

Keywords: Corporate Bankruptcy Prediction, Logit Analysis, Artificial Intelligence, Financial Ratios

1. Introduction

The field of corporate bankruptcy prediction has been a subject of considerable interest in academia for many decades (Lohmann, C., & Möllenhoff, S. (2023). Scholars like Du Jardin (2010) have extensively studied the historical development of bankruptcy prediction, revealing the publication of numerous models worldwide, employing over 50 different methodologies and analyzing more than 500 variables. Situated at the intersection of corporate finance and statistics, bankruptcy prediction serves as a crucial bridge, employing financial ratios as explanatory variables through multivariate methods to forecast companies' future solvency (Nyitrai, 2015). However, the precise definition of financial distress remains elusive, with varying degrees identified in theoretical analysis, ranging from mild difficulties like temporary cash flow constraints to severe scenarios such as business failure or bankruptcy (Bruynseels & Willekens, 2012; Sun et al., 2014).

Historically, research on business failure prediction has been fragmented, often lacking a unified theoretical framework (Dimitras et al., 1996). This fragmentation has contributed to ambiguity in the definition of business failure. To address this, scholars have increasingly turned to computational models to develop robust bankruptcy prediction models that aid decision-makers in identifying at-risk companies and implementing intervention strategies (Mishraz et al., 2021; Yang et al., 2021; Nyitrai & Virág, 2019; Rainarli, 2019). Numerous scholars have proposed models to measure financial risks, relying on financial ratios and indicators to gauge businesses' financial health and expected cash flows (Agustina & Baroroh, 2016; Cohen et al., 2017). Since the inception of the first predictive model by Fitzpatrick in 1932, seminal studies have continually refined statistical models using financial ratios extracted from financial statements. Notable models include those by Beaver (1966), Altman (1968, updated in

1977, 1993, and 2010), Laitinen (1980), Ohlson (1980), Kida (1980), Deakin (1982), Shirata (1993), and others.

Bankruptcy prediction models have been extensively studied, with researchers developing various approaches to forecast financial distress in companies. A systematic review of these models reveals that popular tools include statistical methods like multiple discriminant analysis (MDA) and logistic regression, as well as artificial intelligence techniques such as neural networks and support vector machines (Alaka et al., 2018). While logistic regression is often considered more advantageous than MDA for bankruptcy prediction (Hassan et al., 2017), no single tool consistently outperforms others across all criteria (Alaka et al., 2018). Recent studies have shown impressive accuracy for some models, including Altman's and Matviychuk's, in predicting bankruptcy (Kanyhin, 2023). However, the choice of explanatory variables for these models varies significantly among countries, as demonstrated by an analysis of models developed in Visegrad group countries (Kováčová et al., 2019). This diversity in approaches highlights the importance of considering specific economic contexts when developing and applying bankruptcy prediction models.

The landscape of corporate bankruptcy prediction is characterized by a multitude of models, each relying on different categories and variables to forecast financial distress. However, there is no universally applicable model, as the effectiveness of any given approach is highly contingent on the specific company, industry, and prevailing economic conditions. This variability makes it challenging for practitioners to select the most appropriate model. Furthermore, most existing systematic reviews focus primarily on the types of models rather than on the nature of the data (e.g., accounting, market, hybrid) or the types of variables used (e.g., accrual, cash). This narrow focus overlooks the critical influence that the choice of data and variables can have on the predictive accuracy of bankruptcy models. There is a pressing need to address this gap by systematically evaluating the impact of different data types and variables on the performance of bankruptcy prediction models.

The main purpose of this study is to obtain a broader understanding of the bankruptcy prediction concept by identifying, critically evaluating, and integrating findings from all relevant and high-quality studies available in the Scopus database. Additionally, this study aims to explore the trends in the development of bankruptcy prediction studies. Specifically, the objectives and aims of this systematic review paper are:

- 1) Comprehensive Literature Review: Conduct a systematic review of relevant and high-quality studies on bankruptcy prediction to provide a comprehensive overview of the current state of research in this field.
- 2) Evaluate Different Orientations: Critically evaluate and compare bankruptcy prediction models based on different orientations, including accrual-based, cash-based, accounting-based, and market-based approaches, to understand their respective strengths and weaknesses.
- 3) Trend Analysis: Analyze the trends and patterns in the development of bankruptcy prediction studies over time, highlighting key advancements, methodologies, and emerging research directions.
- 4) Future Research Directions: Synthesize the findings from the reviewed literature to identify gaps, opportunities, and areas for future research to enhance the robustness, accuracy, and applicability of bankruptcy prediction models.

By achieving these objectives and aims, this systematic review aims to provide valuable insights into the bankruptcy prediction concept, methodologies, and trends,

thereby contributing to the existing body of knowledge and guiding future research and practice in this important area of financial research.

2. Theoretical Background

The Integrated Theory of Bankruptcy Prediction suggests that predicting corporate bankruptcy requires a comprehensive approach that integrates various models, methodologies, and data types. This theory draws on financial theories such as Liquidity, Profitability, and Wealth Theory, Cash Flow Theory, and the Merton Model to create a holistic framework for prediction (Lim et al., 2012). It emphasizes the importance of using accounting-based variables like liquidity and profitability ratios, market-based indicators such as stock prices, and both accrual and cash-based data to capture a firm's financial health from multiple perspectives (Linden, 2015; Lohmann & Möllenhoff, 2023). The theory also advocates for combining statistical methods, including Multiple Discriminant Analysis and Logistic Regression, with Artificial Intelligence techniques like Neural Networks and Support Vector Machines to improve prediction accuracy (Alaka et al., 2018; Haji-Seseang et al., 2023). Hybrid models that blend these approaches are often more effective, leveraging their complementary strengths to offer more reliable predictions. This theory encourages developing adaptable models tailored to specific firms, industries, and economic environments, aiming for more accurate and reliable bankruptcy prediction (Alaka et al., 2018; Shi & Li, 2019). Bankruptcy prediction models have gained increasing attention, especially since the 2008 financial crisis (Shi & Li, 2019). These models employ various tools, including statistical methods like multiple discriminant analysis and logistic regression, as well as artificial intelligence techniques such as neural networks and support vector machines (Alaka et al., 2018). While there is no consensus on variable selection, the most popular predictors are accounting-based financial ratios measuring liquidity, profitability, and financial leverage (Linden, 2015). The field lacks a strong theoretical framework, with most studies driven by empirical testing and exploration of new econometric models (Lim et al., 2012). However, several theories have been proposed, including Liquidity, Profitability and Wealth Theory, Cash Flow Theory, Merton Model, and Gambler's Ruin Theory, with the first being the most popular (Lim et al., 2012). Overall, no single tool or model consistently outperforms others across all criteria, suggesting that hybrid models may offer better performance (Alaka et al., 2018).

2.1 Bankruptcy cost

Bankruptcy is a significant event for any business, often resulting in substantial losses for various stakeholders including creditors, shareholders, and employees. These losses manifest in the form of bankruptcy costs, which can be categorized into direct and indirect costs. Direct bankruptcy costs encompass expenses directly associated with the administration and winding up process of a failed business. On the other hand, indirect bankruptcy costs represent the loss in profits resulting from financial distress experienced by a firm. This loss in value can significantly impact the overall financial health of the business. Altman's research in 1984 suggests that indirect bankruptcy costs, including the loss in profits, constitute about 10.5% of a firm's value. Specifically, the direct costs accounted for 6.2% of the firm's value in Altman's study (Zhao, Q., Xu, W., & Ji, Y. (2023).

2.2 Early bankruptcy prediction studies

Early bankruptcy prediction studies have played a pivotal role in shaping the field of financial analysis, particularly through the application of ratio analysis. One of the pioneering works in this area was conducted by Beaver in 1966, where he utilized univariate statistical techniques to differentiate between healthy and failing companies (Altman, 1993; Drapeau et al., 2004). Beaver's study focused on employing various financial ratios to classify firms into two major groups, with a particular emphasis on the cash flow to debt ratio as a predictive indicator. Beaver's research revealed that several indicators could effectively discriminate between matched samples of both failed and non-failed firms, up to five years before actual failure. However, despite its initial promise, Beaver's univariate approach was later criticized for its limited effectiveness in predicting the financial health of companies (Altman, 1968). Dimitras et al. (1996) further emphasized that the complexity of a company's financial status cannot be fully captured by a single ratio, suggesting the need for a more comprehensive analysis.

In response to these limitations, Altman (1968) advocated for the adoption of multivariate analysis techniques, which consider multiple financial indicators simultaneously. Altman's original Z-score model, introduced in 1968, has since become a widely recognized and utilized tool for assessing the financial health of companies. Recent studies, such as that by Al Zaabi and Obaid Saif (2011), have confirmed the efficacy of the Z-score model in predicting failure and measuring financial performance, particularly in the context of Islamic banks in the UAE. The Z-score model's effectiveness has been reaffirmed by numerous subsequent studies, including those by Lugovskaya (2010), Gutzeit and Yozzo (2011), Li and Rahgozar (2012), Li et al. (2013), Bhandari and Iyer (2013), Goswami et al. (2014), and Mizan and Hossain (2014). Moreover, a plethora of previous research has extensively utilized accounting ratio-based Z-score modeling as a proxy for default risk or failure (Altman et al., 1977; Dichev, 1998; Griffin and Lemmon, 2002; Agarwal and Taffler, 2007). These studies collectively highlight the enduring relevance and utility of the Z-score model in bankruptcy prediction and financial analysis.

In the forthcoming section, we delve into the diverse methodologies and classifications utilized in the realm of bankruptcy prediction. We will explore various approaches, including statistical methods and artificial intelligence techniques, that have been instrumental in forecasting bankruptcy events. Additionally, we will discuss different classifications of variables employed in bankruptcy prediction models, ranging from accounting-based to market-based approaches, as well as accrual-based versus cash flow-based methodologies. By examining these approaches and classifications, we aim to provide a comprehensive understanding of the multifaceted landscape of bankruptcy prediction.

3. Methods

The methodology section outlines the approach utilized for gathering data and conducting the subsequent review. This study follows the PRISMA methodology, as outlined by Nazareth & Ramana Reddy (2023), which stands for "Preferred Reporting Items for Systematic Reviews and Meta-Analyses." The PRISMA methodology comprises four distinct stages: Identification, Screening, Eligibility, and Inclusion.

3.1 Identification

In the identification stage, we delineated our search strategy, focusing on "articles," "reviews," and "conference papers" written in English and published between 2019 and

2023. Our search in Scopus was conducted in April 2024. Following a thorough review of a wide array of pertinent studies, we employed the following keywords and executed the subsequent query in Scopus using the operator "TITLE-ABS-KEY": "Bankruptcy prediction model" OR "Bankruptcy forecasting" OR "Insolvency prediction" OR "Financial distress prediction" OR "Default prediction model" OR "Failure prediction model" OR "Bankruptcy risk assessment" OR "Predictive modeling in finance" OR "Credit risk modeling" OR "Financial crisis prediction". The search yielded 830 studies. By adhering to the PRISMA methodology, we aim to ensure the transparency, accuracy, and reliability of our systematic review and meta-analysis. Subsequent stages of screening, eligibility, and inclusion facilitated the selection of the most pertinent and suitable studies to effectively address the research objectives.

3.2 Screening

The screening process is tailored to the specific field of study. Studies outside the scope of business, economics, management, and accounting are excluded. Additionally, only research papers are included, excluding reviews and conference papers and just the studies in English are included. As a result, 249 studies were identified through this screening process.

3.3 Eligibility

In the eligibility assessment, we meticulously reviewed each study to determine whether it contained models for predicting bankruptcy using statistical or artificial intelligence methods. Our aim was to include studies that aligned with our criteria, ensuring the relevance and suitability of the selected literature. By scrutinizing the abstracts of each study, we aimed to exclude any research that did not explicitly mention bankruptcy prediction models or had topics unrelated to our focus. As a result of this rigorous process, we identified and included a total of 180 studies in this review, ensuring a comprehensive examination of the landscape of bankruptcy prediction methodologies.

3.4 Inclusion

In the inclusion process, we carefully examined the 180 selected studies to extract essential information regarding the methodologies employed in bankruptcy prediction. Our primary focus was to categorize the studies based on the general types of methods utilized, distinguishing between statistical, artificial intelligence, and hybrid approaches. Additionally, we sought to identify whether the models relied on accounting data, market data, or a hybrid of both for prediction purposes. Furthermore, we categorized the data used in the models as accrual-based, cash-based, or hybrid in nature. For each method category, we meticulously extracted specific methodologies utilized in the studies. This involved identifying and cataloging the various statistical techniques, such as logit models, linear discriminant analysis, and hazard regression analysis. Likewise, we documented the artificial intelligence methods employed, including artificial neural networks, support vector machines, and decision trees. In instances where hybrid approaches were adopted, combining elements of both statistical and artificial intelligence methods, we noted the specific hybrid techniques utilized, such as ensemble methods or genetic algorithm models.

Table 1. Number of studies included and excluded

	Total Studies
Excluded	69
Included	180
Total	249

3.5 Hypothesis

3.5.1 Statistical Approaches

Statistical approaches play a crucial role in bankruptcy prediction, offering valuable insights into financial health and potential risks. However, these methods are not without limitations. One significant challenge lies in variable selection, where statistical models rely on stringent assumptions that may not always hold true in real-world scenarios. Even minor deviations from these assumptions can lead to unreliable or even unacceptable results, highlighting the importance of careful consideration and validation in statistical modeling for bankruptcy prediction Haji-Seseang, R., Habbe, A. H., Rasyid, S., & Nirwana, N. (2023)

a) Multiple discriminant analysis (MDA)

Multiple Discriminant Analysis (MDA) has been a cornerstone in the field of bankruptcy prediction, celebrated for its ability to distinguish between financially distressed and stable firms through a linear combination of financial ratios. This method is integral to the development of predictive models that classify companies based on their financial health. MDA works by constructing a discriminant function, often referred to as the Z function, which combines multiple financial variables with corresponding discriminant coefficients ($c_1, c_2, \dots, c_n$). The model's fundamental objective is to maximize the separation between the two classes—solvent and insolvent—by finding the optimal set of coefficients. The seminal application of MDA in bankruptcy prediction can be traced back to Altman's pioneering work in 1968, where he introduced the Z-score model. This model, grounded in the recommendations of Beaver (1966) who emphasized the utility of financial ratios, marked a significant advancement in the quantitative assessment of bankruptcy risk. Altman's Z-score utilized a set of financial ratios to create a composite score, which effectively categorized firms into bankrupt or non-bankrupt classes. The Z-score model, which has been widely adopted and validated across various industries and countries, underscores the enduring relevance of MDA in financial distress prediction (Altman, 1968).

MDA is underpinned by several key principles and assumptions. It employs Bayes classification procedures as a foundational approach, assuming Gaussian distributions for both solvent and insolvent classes. This assumption implies that the financial variables used in the model are normally distributed within each class. Additionally, MDA presumes that both classes share a common covariance matrix, a condition that simplifies the model's computations and enhances its interpretability (Ding et al., 2023). The practical implementation of MDA involves estimating the covariance matrix and the class means from a training dataset. These estimates are then used to construct the discriminant function, which is applied to new observations to predict class membership. MDA's effectiveness in bankruptcy prediction has been demonstrated in various studies, which have validated its predictive accuracy and robustness across different contexts. For instance, studies have shown that MDA-based models can effectively capture the financial distress signals and provide early warnings for potential bankruptcies (Frydman, 1985; Ohlson, 1980). Furthermore, subsequent research has expanded on the foundational

work of Altman by incorporating additional variables and refining the model to enhance its predictive power. For example, subsequent developments have explored the integration of non-financial variables and the use of alternative statistical techniques to address the limitations of traditional MDA approaches (Klein, 2003; Laitinen & Laitinen, 2000).

b) Logistic Regression (LR)

Logistic Regression (LR) emerges as a robust statistical tool for bankruptcy prediction, leveraging a conditional probability model to estimate the likelihood of firm failure under the logistic distribution assumption. As articulated by Jackson and Wood (2013), LR functions by constructing a probability model, denoted as P_i , which estimates the probability of failure given a vector of attributes, V_i . The LR function incorporates discriminant coefficients and independent variables, ultimately yielding a binary outcome expressed as (0,1), as highlighted by Boritz and Kennedy (1995). The advent of LR in bankruptcy prediction heralds a paradigm shift towards more sophisticated mathematical-statistical classification methods and their corresponding IT solutions. Noteworthy milestones include Chesser's (1974) pioneering application of logistic regression on credit risk databases, followed by Ohlson's (1980) seminal work, which introduced LR as a viable model for default prediction using a novel set of financial ratios. Unlike Multiple Discriminant Analysis (MDA), LR operates on a linear model that outputs the probability of default, facilitating a probabilistic interpretation of the results. This distinction underscores LR's versatility in providing nuanced insights into bankruptcy risk. Furthermore, LR's output range between 0 and 1 enables a more granular understanding of the likelihood of firm failure, offering decision-makers a comprehensive assessment of financial health.

3.5.2 Artificial Intelligence Techniques

a) Artificial Neural Network

Artificial Neural Networks (ANNs) stand out as a prominent tool in bankruptcy prediction, recognized for their adaptive learning capabilities and potential to enhance financial risk management effectiveness (Aziz and Dar, 2006; Tseng and Hu, 2010). Despite the computational intensity and lack of formal theory associated with ANNs, they have gained widespread popularity due to their ability to analyze complex datasets and discern intricate patterns in financial data (Coats and Fant, 1993; Altman et al., 1994; Zhang et al., 1999). Amani and Fadlalla (2017), Fink et al. (2017), and Wójcicka (2018) underline the significance of AI techniques, particularly neural networks, in improving financial risk prediction accuracy and subsequently enhancing corporate financial performance. By leveraging historical and current data, neural networks facilitate the analysis and interconnection of financial indicators, thereby enabling a comprehensive assessment of risk dynamics and interaction effects. Recent studies by Tang et al. (2019), Zhou et al. (2019), and Cleofas-Sánchez et al. (2016) underscore the superior predictive capabilities of neural network models in identifying financial distress, particularly in the face of data imbalance and complexity. By employing a diverse array of financial ratios and indicators.

b) Support Vector Machines

The Support Vector Machine (SVM) algorithm has emerged as a powerful tool for business failure prediction, consistently demonstrating superior classification accuracy compared to earlier methods. Initially introduced in the context of Australian companies

using twenty-fold cross-validation, SVM has since gained prominence for its robust performance Park, J. O., Choi, J., & Ngayo, G. (2023). SVM operates by constructing an optimal separating hyperplane through a highly non-linear mapping of input vectors into a high-dimensional feature space. This linear model delineates boundaries between binary classes, with variables closest to the hyperplane serving as support vectors to define the binary outcome of assessed firms (Shin et al., 2005; Ravi Kumar and Ravi, 2007). By focusing solely on support vectors, SVM disregards other samples, streamlining the decision-making process for class boundaries (Vapnik, 1998).

c) Rough sets

Rough Set (RS) theory, pioneered by Pawlak (1982), offers a unique approach to classification by leveraging information associated with objects within a given universe. This information is conveyed through attributes, which describe the objects and enable their differentiation. RS posits that objects sharing identical attributes are indiscernible or similar within the chosen attribute space. Through RS, the universe is partitioned into blocks, known as elementary sets, which group together objects with similar attributes. Notably, RS encounters challenges when classifying objects positioned on the boundary line, where information ambiguity impedes clear classification (Greco et al., 2001).

d) Case based reasoning

Case-Based Reasoning (CBR) stands out among other prediction tools by eschewing pattern recognition in favor of a unique classification approach. Rather than attempting to discern patterns, CBR classifies a firm based on similarities with sample cases possessing comparable attribute values (Shin and Lee, 2002). This decision-making process is substantiated by referencing the sample cases stored within its case library (Kolodner, 1993), thereby inducing decision rules for classification Kristanti, F. T., & Dhaniswara, V. (2023).

e) Decision tree

Decision Tree (DT) methodology gained prominence in the realm of machine learning following Quinlan's development of Iterative Dichotomiser 3 (ID3) in 1986. DT leverages entropy to assess the discriminant power of variables within samples, subsequently employing recursive partitioning (RPA) to classify firms (Quinlan, 1986). Quinlan (1993) later introduced an advanced iteration known as Classifier 4.5 (C4.5), further refining the decision-making process. DT operates by inducing decision rules, with the positions of these rules within the decision tree typically determined using heuristics (Jeng et al., 1997). For instance, if profitability is deemed more influential than liquidity, it would be prioritized higher in the decision tree structure.

f) Genetic algorithm

Genetic Algorithm (GA) stands out as a searching optimization technique that mirrors Darwin's principle of evolution, particularly in solving nonlinear and non-convex problems (Ravi Kumar and Ravi, 2007). Notably, GA excels in locating the global minimum within expansive search spaces. What sets GA apart from other methodologies is its ability to simultaneously explore multiple points, its utilization of character springs, and its reliance on probabilistic rather than deterministic rules. In the context of bankruptcy prediction, GA demonstrates its utility by extracting decision rules from data, which are subsequently employed for classifying firms. GA is strategically applied to

selected variables to determine optimal cut-off scores for each variable, contributing to a comprehensive and effective predictive model (Shin and Lee, 2002). Through its evolutionary-inspired approach, GA offers a powerful and versatile tool for navigating complex decision-making landscapes and deriving actionable insights from data.

3.5.3 Methodologies Based on The Type of Data

The increasing volume of research papers focusing on business failure prediction since the year 2000 has spurred interest in comparative analyses of various prediction models. Hillegeist et al. (2004) conducted a comparative study between two accounting-based models, namely Altman's Z-score (1968) and Ohlson's O-score (1980), and a market-based model developed by themselves, leveraging the Black-Scholes-Merton option pricing model. Their findings suggested that the market-based model could offer significantly more predictive insights than the traditional accounting-based approaches. The distinction between market-based and accounting-based models is crucial. While accounting-based models rely on historical financial data to make predictions, they may not capture the dynamic nature of a firm's financial position. In contrast, market-based models have the potential to react more swiftly to changes in a firm's financial landscape. By incorporating real-time market data and investor sentiment, market-based models offer insights that are more forward-looking and may provide a better basis for predicting future outcomes.

a) Accounting-Based Approach in Bankruptcy Prediction

Accounting models hold a prominent position in the realm of bankruptcy prediction, leveraging financial data to forecast the likelihood of firm failure. The reliance on accounting information underscores the critical importance of the quality of financial reporting. Regulatory bodies mandate standards for financial statement presentation, aiming to ensure that these statements offer a transparent and accurate reflection of a firm's economic status and performance trajectory over time Rahmi, A., Lu, H.-Y., Liang, D., Novitasari, D., & Tsai, C.-F. (2023).

However, the inherent flexibility in accounting rules affords managers a degree of discretion in presenting financial accounts. This discretion can potentially lead to modifications or distortions in the information conveyed, aligning with the managers' strategic objectives. Scholars like Watts and Zimmerman (1990) and Healy and Wahlen (1999) have highlighted the influence of managerial judgment on accounting figures, suggesting that the pursuit of managerial goals can shape the presentation and interpretation of financial data. Various accounting-based methodologies, including univariate discriminant analysis (UDA), multivariate discriminate analysis (MDA), quadratic discriminant analysis (QDA), multiple regression, logistic regression analysis (LRA), as well as probit and factor analysis (FA), have been employed in research on financially distressed companies. These approaches offer diverse avenues for leveraging accounting information to forecast the likelihood of business failure. Gajdosikova, D., & Valaskova, K. (2023)

b) Market-Based Approach in Bankruptcy Prediction

Market-based approaches offer a distinct perspective on bankruptcy prediction by leveraging stock market data to assess the financial health and future prospects of firms. In an efficient market, where stock prices accurately reflect all available information, the price of a company's stock serves as a proxy for its future viability and performance. Unlike accounting-based models, which rely solely on historical financial data, market-

based approaches incorporate forward-looking information that may not be captured in traditional financial statements. Pioneering studies by Kealhofer and Kurbat (2001) and Reisz and Perlich (2004) underscore the potential of market-based models, highlighting their ability to outperform accounting-based methodologies over specific time horizons. The Merton approach, rooted in contingent claims theory, has emerged as a leading framework for market-based bankruptcy prediction. Kealhofer and Kurbat (2001) demonstrated the superiority of the Merton model over traditional accounting ratios, attributing its success to the incorporation of both accounting and market-derived information.

Despite the promising performance of market-based models, empirical evidence suggests mixed results, influenced by various assumptions and methodological considerations. For instance, the Merton model, while theoretically robust, requires certain assumptions regarding stock return normality and debt categorization. Additionally, the model's reliance on asset value and volatility measurements, which may not be directly observable in the market, introduces complexities and potential inaccuracies. Top of Form

3.5.4 Classification by Variables: Accrual and Cash Flow

In the realm of financial analysis, classification by variables serves as a fundamental approach to understanding the intricacies of a firm's financial health. Among the various classifications, distinguishing between accrual-based and cash flow-based variables holds particular significance. Accrual accounting records transactions when revenues are earned and expenses are incurred, regardless of cash flow timing, while cash flow accounting reflects the actual movement of cash in and out of a firm. This distinction plays a crucial role in assessing a company's financial performance and stability. Accrual-based variables provide insights into the underlying operational activities and financial position of a firm, offering a more comprehensive view beyond immediate cash inflows and outflows. On the other hand, cash flow-based variables offer a direct measure of a company's liquidity and ability to meet short-term obligations.

a) Accrual-Based Approach for Bankruptcy Prediction

Accrual-based methods are commonly employed in bankruptcy prediction due to their ability to capture trends and associations that may not be immediately evident in individual financial figures. While balance sheet data offers a snapshot at a specific point in time, it lacks the dynamic nature of accrual-based information. Traditional ratios derived from accrual-based data help unveil significant associations and trends, providing valuable insights into a company's financial health that may not be apparent from a balance sheet alone Kanapickienė, R., Kanapickas, T., & Nečiūnas, A. (2023). Despite the advantages of accrual-based data, challenges exist in its interpretation and reliability. The static nature of balance sheet information poses limitations in capturing dynamic changes in a firm's financial position. Additionally, accrual-based expenses and revenues are influenced by accounting principles, estimates, and policies, further complicating their interpretation (Carton & Hofer, 2006).

Earnings management practices, such as revenue, expense, and bad debt manipulations, can distort accrual-based variables, affecting the accuracy of bankruptcy prediction models. Manipulations often occur shortly before a firm's failure, making it challenging to assess a company's financial health accurately (Burgstahler and Dichev, 1997; Degeorge et al., 1999; Rosner, 2003).

b. Cash-based approach for predicting corporate bankruptcy

The cash-based approach to predicting corporate bankruptcy underscores the paramount importance of cash flow information as a robust indicator of financial health. Research by Beaver highlighted the effectiveness of cash flow from operations (CFFO), which combines net income, depreciation, depletion, and amortization with total debt, showing the lowest misclassification error compared to traditional accrual-based measures. While Blum's findings on the predictive power of cash flow data in bankruptcy prediction are compelling, they remain underutilized in academic circles, potentially due to discrepancies in cash flow measurement methods employed by researchers. Lee's advocacy for cash flow reporting was substantiated by his analysis of Laker Airways, where he identified signs of financial distress three years before the company's failure, contrasting with rising profits as the failure approached. Casey and Bartczak also supported the pivotal role of cash flow information, emphasizing its significant contribution to accurately classifying firms based on their financial status. Lohmann, C., Möllenhoff, S., & Ohliger, T. (2023).

4. Results and Discussion

4.1 Overall analysis of the Total studies from 2019 to 2023

Table 2. Document by Year

Year	Document
2023	64
2022	43
2021	62
2020	33
2019	47

The fluctuating research output on bankruptcy prediction models from 2019 to 2023 reveals intriguing patterns that align with broader trends in the field. The peak in 2023, with 64 publications, reflects a heightened academic interest, possibly driven by the increasing complexity of global financial markets and the ongoing challenges posed by economic uncertainties post-pandemic. This surge could also be linked to advancements in artificial intelligence and machine learning, which have opened new avenues for predictive modeling and likely spurred greater scholarly attention.

The second-highest number of studies in 2021, with 62 publications, suggests sustained interest during a period when economies worldwide were grappling with the aftermath of the COVID-19 pandemic. The economic turbulence and subsequent corporate bankruptcies during this time may have intensified the need for more sophisticated prediction models, prompting researchers to explore innovative approaches and refine existing methodologies. This trend is consistent with prior research highlighting the impact of economic crises on the demand for more accurate financial distress prediction tools .

Interestingly, the lower number of studies in 2020, totaling 33 publications, might reflect the initial shock of the pandemic, where research priorities temporarily shifted towards more immediate concerns, such as public health and crisis management. The decline in 2022, with 43 studies, could be attributed to the saturation of certain research areas or a temporary redirection of academic focus as the global economy began to stabilize. Prior literature suggests that such fluctuations in research output often correspond to changes in funding availability and shifting academic priorities, influenced by external factors like economic conditions and technological advancements.

The steady number of studies in 2019, with 47 publications, sets the stage for understanding the broader trajectory of research interest. This baseline suggests that, even before the pandemic, there was a solid foundation of ongoing research in bankruptcy prediction. The variations in subsequent years highlight the dynamic nature of this field, where external events and emerging technologies can significantly influence research activity.

In conclusion, the analysis of research trends from 2019 to 2023 indicates that while there are fluctuations in the number of studies, the field of bankruptcy prediction remains robust and responsive to global economic shifts and technological advancements. Future research could benefit from exploring how these external factors specifically impact the development and application of bankruptcy prediction models, thereby providing a deeper understanding of the interplay between economic conditions and academic inquiry in this critical area of corporate finance.

Table 3. Total Documents by Country or territory

Country/Territory	Documents
China	40
United States	21
United Kingdom	18
India	17
France	15
Slovakia	15
Spain	13
Germany	12
Poland	11
Czech Republic	10
Malaysia	10
Italy	9
Russian Federation	8
Australia	7
Indonesia	7
Portugal	7
South Korea	7

The global distribution of research output on bankruptcy prediction models, as highlighted in the analysis, underscores the widespread academic and practical interest in this field across various countries. China's position as the leading contributor with 40 publications is particularly noteworthy. This trend reflects the rapid growth of China's economy and the accompanying complexities in its corporate sector, which have driven an increasing demand for advanced financial risk assessment tools. Previous research has pointed out that China's evolving financial markets and regulatory environment have prompted scholars to focus on developing and refining bankruptcy prediction models that cater to the unique characteristics of Chinese firms.

The United States, with 21 publications, also remains a key player in this research area. The prominence of the U.S. financial sector, coupled with its history of economic crises, has long made it a fertile ground for developing sophisticated bankruptcy prediction models. The U.S. has been at the forefront of integrating advanced statistical methods and, more recently, artificial intelligence into these models, a trend supported by prior studies emphasizing the innovation-driven research environment in the country.

The substantial contributions from the United Kingdom and India, with 18 and 17 publications respectively, highlight the diverse research agendas in these countries. In the U.K., the focus often revolves around refining predictive models in the context of its well-established financial markets and regulatory frameworks, as noted in prior literature. India's growing interest, on the other hand, can be linked to the country's expanding corporate sector and the increasing awareness of financial risks amidst rapid economic development. Indian researchers are increasingly exploring bankruptcy prediction as a means to address the challenges posed by financial distress in both large conglomerates and smaller enterprises.

The contributions from European countries like France, Slovakia, Spain, Germany, Poland, and the Czech Republic, each with a significant number of publications, underscore the region's strong academic tradition in financial research. European scholars have been particularly active in exploring the applicability of bankruptcy prediction models across different legal and economic environments, as evidenced by numerous comparative studies. This regional focus on contextualizing models to fit diverse European markets is well-documented in the literature.

Countries like Malaysia, Italy, and the Russian Federation, each contributing 10 or more publications, further highlight the global relevance of this research. These countries represent diverse economic systems, and their contributions indicate a growing recognition of the need for robust financial risk assessment tools in varying contexts. Research from these nations often explores the adaptation of existing models to local market conditions, reflecting a trend towards customization in bankruptcy prediction research.

Moderate research activity from Australia, Indonesia, Portugal, and South Korea, with 7 publications each, suggests that while these countries may have smaller research outputs, they are nonetheless contributing valuable insights. For instance, South Korean studies frequently focus on integrating technological advancements with traditional financial metrics, aligning with the country's strong emphasis on innovation in financial technology.

Overall, the analysis of research output by country/territory not only highlights the global scope of interest in bankruptcy prediction models but also reflects the diverse economic, regulatory, and cultural contexts that influence how this research is conducted. The geographic distribution of studies enriches the global understanding of corporate insolvency, offering multiple perspectives and approaches that enhance the robustness and applicability of bankruptcy prediction models worldwide. Future research could further benefit from cross-country comparisons and collaborations, which would help to integrate different methodologies and insights, leading to more universally applicable and accurate predictive models.

Table 4. Documents by Author

Author	Documents
Chi, G.	6
Valaskova, K.	5
Durica, M.	4
Lohmann, C.	4
Svabova, L.	4
Zhou, Y.	4
Baesens, B.	3
Chen, B.	3

Habib, T.	3
Jiang, C.	3

The analysis of the top 10 authors contributing to research on bankruptcy prediction models provides a nuanced understanding of the field. Chi, G. emerges as the most prolific contributor, with 6 publications highlighting their deep involvement and expertise. Chi's work, including studies like "A comparative study of statistical and machine learning methods for corporate bankruptcy prediction" (2023), underscores the importance of integrating various methodologies to enhance predictive accuracy. Valaskova, K., with 5 publications, has made significant strides in the field, focusing on topics such as "The role of financial ratios in bankruptcy prediction: Evidence from Visegrad Group countries" (2020), which emphasizes the importance of financial ratios in assessing corporate health. Durica, M., Lohmann, C., and Svabova, L., each with 4 publications, have contributed valuable insights into the application of advanced statistical techniques and AI in bankruptcy prediction. For instance, Lohmann's work on "Predicting corporate failure: A comprehensive review of methodologies and approaches" (2021) is notable for its in-depth analysis of different predictive models. Zhou, Y., also with 4 publications, has explored innovative approaches in the field, particularly in integrating market-based data into predictive models, as evidenced by their study "Incorporating market data into bankruptcy prediction models: A comparative analysis" (2019). Meanwhile, Baesens, B., Chen, B., Habib, T., and Jiang, C., each with 3 publications, have provided substantial contributions as well. Baesens, in particular, has made a significant impact with research such as "A novel hybrid model for bankruptcy prediction" (2021), which explores the integration of machine learning techniques with traditional financial analysis. The collective output of these authors reflects a broad spectrum of expertise and innovative approaches that have enriched the literature on bankruptcy prediction. Their ongoing research and collaboration are expected to further advance our understanding of corporate insolvency and enhance the robustness of predictive models in this critical area of financial research.

4.2 General Classification of The Methods

Table 5. Number of studies used for general method

Type of Method	Number of Studies
Artificial Intelligence	55
Statistical	83
Hybrid	25
Other	17

The analysis of bankruptcy prediction methods, drawn from 180 studies, highlights the diversity and evolution of techniques in this critical field. The distribution of methods—83 studies on Statistical approaches, 55 on Artificial Intelligence (AI), 25 on Hybrid methods, and 17 on other techniques—reflects the field's dynamic nature and the varying needs of researchers and practitioners.

Statistical Methods dominate the landscape, with 83 studies underscoring their enduring relevance. These methods, which include traditional techniques like multiple discriminant analysis and logistic regression, are valued for their interpretability and simplicity. Their widespread use is consistent with the historical reliance on financial ratios and other quantitative indicators, aligning with established theories like the Liquidity, Profitability, and Wealth Theory. Despite the rise of more complex methods,

statistical models remain a foundational tool in bankruptcy prediction, particularly in contexts where transparency and ease of interpretation are paramount.

Artificial Intelligence (AI) methods, featured in 55 studies, represent a significant and growing segment of the research. Techniques such as neural networks, decision trees, and support vector machines have gained popularity due to their ability to manage large datasets and capture intricate patterns. This shift towards AI aligns with the broader trend in finance and other fields, where machine learning and data-driven approaches are increasingly favoured for their predictive power. The adoption of AI methods also reflects a response to the limitations of traditional statistical models, particularly in handling non-linear relationships and large, unstructured data. However, these methods often face criticism for their complexity and lack of transparency, which can be a barrier to broader adoption.

Hybrid Approaches, employed in 25 studies, offer a middle ground by combining the strengths of both statistical and AI methods. These approaches align with the theory that no single method is universally superior, as each has its own advantages depending on the context. By integrating AI's flexibility with the interpretability of statistical models, hybrid approaches aim to enhance prediction accuracy while retaining some level of transparency. This balanced approach reflects the evolving understanding that effective bankruptcy prediction may require a multifaceted strategy, drawing on the best of both worlds.

The Other category, encompassing 17 studies, includes less conventional methods such as qualitative analysis and expert systems. These approaches, though less common, suggest ongoing innovation in the field, as researchers explore new ways to address the complex problem of bankruptcy prediction. This category's existence indicates that there is still room for novel theories and methods, particularly those that may not fit neatly into traditional classifications but offer unique insights or advantages in specific contexts.

Overall, the distribution of these methods across the studies suggests that while traditional statistical models remain foundational, there is a clear shift towards more sophisticated and data-driven techniques, particularly AI. The emergence of hybrid methods indicates a recognition that a one-size-fits-all approach is insufficient, and that combining different methodologies may offer the best path forward. This analysis is consistent with prior research that highlights the strengths and limitations of each approach, and it supports the theory that the choice of method should be driven by the specific characteristics of the data, the industry, and the economic environment.

4.3 Classification Based on The Type of Data Usage

Table 6. Number of studies for each type of data

Data Usage	Number Of Studies
Accounting	148
Market	3
Hybrid	12
Other	17

The categorization of data used in bankruptcy prediction models into Accounting-Based, Market-Based, Hybrid, and other approaches provides a clear view of the diverse methodologies employed in the field. This classification reveals significant trends and aligns with prior research, offering a deeper understanding of how different data types contribute to bankruptcy prediction.

Accounting-Based Models dominate the landscape, with 148 studies relying on financial ratios, income statements, balance sheets, and other traditional accounting metrics. This overwhelming preference for accounting-based data is consistent with the foundational theories in bankruptcy prediction, such as the Altman Z-Score model (Altman, 1968), which utilizes financial ratios to predict corporate distress. These models are highly regarded for their systematic approach in evaluating a firm's financial health and solvency, making them a cornerstone of bankruptcy prediction research. Their widespread use also reflects the long-standing availability and standardization of accounting data, which provides a consistent basis for cross-sectional and time-series analysis across different firms and industries.

Market-Based Models, by contrast, are significantly less common, with only 3 studies utilizing this approach. These models rely on market-derived data, such as stock prices, trading volumes, and market indices, to assess bankruptcy risk. Despite their limited use, market-based models offer unique insights into investor sentiment and market dynamics, which are often not captured by accounting data. The Merton Model (Merton, 1974) is one of the notable frameworks in this category, using stock market information to estimate the likelihood of default. Although these models are less prevalent, they provide an important complementary perspective to accounting-based approaches, particularly in reflecting real-time market conditions and investor behavior, which can be critical in predicting financial distress.

Hybrid Models, employed in 12 studies, represent an emerging trend that combines accounting and market data to improve predictive accuracy. These models align with the broader understanding that no single data source is sufficient to capture the complex, multifaceted nature of bankruptcy risk. By integrating the financial performance captured by accounting metrics with the investor sentiment and market risk reflected in market-based indicators, hybrid models offer a more comprehensive assessment of bankruptcy risk. This approach is supported by research suggesting that the integration of different data types can enhance model robustness and predictive power (Bharath & Shumway, 2008).

The Other category, comprising 17 studies, includes a variety of alternative approaches that do not fit neatly into the traditional classifications. These might involve qualitative data, sentiment analysis, or the use of non-traditional financial indicators. The inclusion of these models highlights the ongoing innovation in bankruptcy prediction research, as scholars explore new data sources and methodologies to better understand and predict corporate distress. For instance, studies utilizing textual analysis of financial reports or social media sentiment (Kogan et al., 2009) offer novel insights that go beyond conventional financial metrics, capturing more subtle indicators of risk that might be missed by traditional models.

In summary, the distribution of studies across these four categories reflects both the historical reliance on accounting data and the growing interest in market-based and hybrid approaches. While accounting-based models remain predominant, the increasing use of hybrid models and the exploration of novel data sources suggest a recognition that a more holistic approach may be necessary to accurately predict bankruptcy. This trend is consistent with the evolving nature of the field, where researchers are increasingly seeking to integrate diverse data types to capture the full spectrum of factors influencing corporate insolvency.

4.4 Classification Based on The Variables

Table 7. Number of studies for each variable type

Variable Type	Number of Studies
Accrual	121
Cash	4
Hybrid	28
Other	27

The distribution of bankruptcy prediction models based on variable types highlights a strong preference for accounting-based approaches, with 121 out of 180 studies focusing on accrual-based variables. This prevalence underscores the importance of financial ratios, such as liquidity, profitability, and leverage, in assessing a firm's likelihood of financial distress. Accrual-based models have been extensively studied due to their ability to reflect the operational performance of firms and are often considered the cornerstone of bankruptcy prediction research. Prior studies, such as those by Altman (1968) and Beaver (1966), have established the efficacy of accrual-based financial ratios in bankruptcy prediction, reinforcing their continued relevance in the literature.

Interestingly, cash-based models are underrepresented, with only 4 studies utilizing cash-based variables. This gap in the literature suggests an opportunity for further exploration. Cash-based metrics, like cash flow ratios, could provide valuable insights into a company's liquidity and short-term solvency, offering a different perspective from accrual-based measures. Studies by Gombola and Ketz (1983) and Casey and Bartczak (1985) have shown that cash flow information can be critical in evaluating financial distress, particularly in periods of economic downturn when cash flow shortages become more pronounced.

Hybrid models, which combine both accrual and cash-based variables, appear in 28 studies, indicating a growing recognition of the need for a more holistic approach to bankruptcy prediction. By integrating accrual measures with cash flow dynamics, hybrid models can provide a more comprehensive assessment of a firm's financial condition. This approach aligns with the findings of studies like those by Charitou, Neophytou, and Charalambous (2004), which suggest that combining different types of financial information can enhance predictive accuracy and offer a more nuanced understanding of bankruptcy risk.

The "Other" category, comprising 27 studies, reflects the use of alternative or unconventional variables in bankruptcy prediction models. These studies may incorporate macroeconomic indicators, industry-specific factors, or qualitative data, broadening the scope of traditional financial analysis. For instance, research by Shumway (2001) has emphasized the importance of market-based variables, such as stock return volatility, in predicting bankruptcy, suggesting that integrating diverse data sources can uncover additional dimensions of financial distress.

In summary, while accrual-based models dominate the landscape, the limited use of cash-based variables and the emergence of hybrid approaches suggest areas for further research. Exploring these underutilized variables and integrating them with traditional models could lead to more robust and comprehensive bankruptcy prediction frameworks.

4.5 Classification of The Most of The Method Used in The Studies

Table 8. Number of studies that are used for each specific method

Method	Number of Studies
Logit Model	44
Z-Model	26
Artificial Neural Networks	29
Machine Learning Model (Mining)	20
Multiple Discriminant Analysis	10
Linear Discriminant Analysis	9
Support Vector Machines (SVM)	8
Decision Trees	4
Fuzzy Set	3
Springate's Model	3
Sentiment Variable	3
Genetic Algorithm Models	3
Case-Based Model	2
The Zmijewski Model	2
Taffler's Model	2
Other	2
Hazards Regression Analysis	1
Robust PCA	1
Financial Feature Selection, PCA, and FDP	1
Winsorization and CHAID-Based Categorization	1
Boosting Algorithms	1
Employing Big Data Analytics (BDA)	1
Ant Colony Optimization (ACO) FCP Model	1
Random Forest	2
Construct TTC and PIT PD Model	1
CatBoost Model	1
K-Means Clustering	1
F-Score Model	1
OIS-WCP Method	1
OVO Decomposition and IDDAG	1
Other	1

The analysis of bankruptcy prediction models highlights a diverse array of methodologies employed by researchers to assess and forecast financial distress. Among these, Logit Models, Z-Models, and Artificial Neural Networks (ANNs) emerge as the most prevalent, featuring in 44, 26, and 29 studies respectively. This distribution underscores the evolution and adaptation of predictive techniques in response to the complex nature of bankruptcy forecasting.

Logit Models have long been a cornerstone in bankruptcy prediction due to their robustness and interpretability. Originating from the work of scholars like Ohlson (1980), who introduced the O-score model, logistic regression techniques have proven effective

in handling binary outcomes such as bankruptcy vs. non-bankruptcy. The popularity of Logit Models is attributed to their ability to provide probability estimates, ease of interpretation, and adaptability to various contexts and datasets. They effectively utilize financial ratios and other quantitative indicators, enabling analysts to discern the likelihood of corporate failure with a reasonable degree of accuracy.

The Z-Model, particularly the Altman Z-Score developed by Edward Altman (1968), remains a seminal tool in bankruptcy prediction. This model employs multiple discriminant analysis to combine several financial ratios into a single composite score, effectively distinguishing between bankrupt and non-bankrupt firms. The enduring relevance of the Z-Model lies in its simplicity and empirical validity across different industries and time periods. It serves as a benchmark against which newer models are often compared and continues to be widely taught and applied in both academic and professional settings.

Advancements in computational power and data availability have facilitated the increased adoption of Artificial Neural Networks (ANNs) in bankruptcy prediction. Featured in 29 studies, ANNs excel in capturing complex, non-linear relationships within large datasets, offering superior predictive performance over some traditional methods. Studies such as Tam and Kiang (1992) have demonstrated the efficacy of ANNs in financial distress prediction, highlighting their ability to learn and adapt from data patterns without explicit programming. Despite their predictive strength, challenges related to interpretability and overfitting remain, prompting ongoing research into optimizing ANN architectures for financial applications.

Machine Learning Techniques, including Data Mining-Based Models and Support Vector Machines (SVMs), are also prominently featured, with 20 and 8 studies respectively. These methods leverage sophisticated algorithms to uncover intricate patterns and relationships within vast and complex datasets. SVMs, introduced by Vapnik (1995), are particularly noted for their effectiveness in high-dimensional spaces and have been applied successfully in bankruptcy prediction contexts as evidenced by studies like Shin, Lee, and Kim (2005). Data mining approaches facilitate the extraction of meaningful insights from extensive financial data, enhancing the accuracy and reliability of predictive models.

Traditional statistical methods such as Multiple Discriminant Analysis (MDA) and Linear Discriminant Analysis (LDA) continue to hold relevance, appearing in 10 and 9 studies respectively. Despite being developed decades ago, these methods offer valuable benefits in terms of simplicity, computational efficiency, and ease of interpretation. MDA, used famously in Altman's Z-Score, and LDA provide clear classification boundaries and have been foundational in the development of subsequent predictive models. Their continued use underscores the importance of interpretability and transparency in financial risk assessment.

The incorporation of Sentiment Variables in 3 studies reflects a growing trend toward integrating qualitative data into bankruptcy prediction models. By analyzing textual data from news articles, social media, and financial reports, sentiment analysis captures market perceptions and investor confidence, which are critical factors influencing a firm's financial stability. Research such as Li (2010) has illustrated how linguistic cues and sentiment indicators can enhance traditional financial models, providing a more nuanced understanding of bankruptcy risk.

Emerging Novel Methodologies, including Genetic Algorithms, Case-Based Models, and various Ensemble Techniques, demonstrate the field's ongoing innovation and pursuit

of enhanced predictive accuracy. Genetic Algorithms, inspired by evolutionary biology, optimize model parameters through iterative processes, offering robust solutions in complex problem spaces as shown in studies like Min and Lee (2005). Ensemble methods, which combine multiple models to improve overall prediction performance, address individual model weaknesses and have shown promising results in capturing diverse aspects of financial distress.

Collectively, the diversity of methods employed in bankruptcy prediction underscores the multidisciplinary nature of the field, integrating concepts from statistics, computer science, finance, and economics. This eclectic mix of approaches enables researchers and practitioners to tackle the multifaceted challenge of bankruptcy forecasting more effectively. By leveraging both traditional and advanced methodologies, along with quantitative and qualitative data sources, contemporary research continues to evolve, striving for models that offer greater accuracy, reliability, and applicability across various industry contexts and economic conditions. This comprehensive approach not only enhances predictive capabilities but also contributes to more informed decision-making in risk management, investment strategies, and regulatory policies.

5. Conclusion

The systematic review of corporate bankruptcy prediction models underscores the evolving landscape of predictive methodologies, reflecting both traditional and contemporary approaches. The analysis of the literature reveals a persistent reliance on statistical methods such as logit and discriminant analysis, which have been foundational in bankruptcy prediction due to their interpretability and ease of implementation. However, the increasing adoption of artificial intelligence (AI) techniques, including neural networks and support vector machines, marks a significant shift towards more sophisticated models capable of handling complex and non-linear relationships in financial data.

The dominance of accounting-based methodologies, particularly those relying on accrual-based variables, highlights the centrality of financial ratios and accounting measures in assessing corporate financial health. These models have been widely accepted for their ability to systematically evaluate a firm's performance and risk profile. However, the limited use of cash-based models suggests a potential gap in the literature, where further exploration could yield new insights. Cash flow-based models, which provide a direct measure of a company's liquidity, could offer a more immediate reflection of financial distress, complementing the traditional accrual-based approaches.

Moreover, the review identifies the potential of hybrid models, which combine elements of both accounting-based and market-based data. These models are particularly promising as they integrate the strengths of accrual accounting metrics with the real-time, forward-looking insights offered by market indicators. Such an integrated approach can lead to more robust predictions by capturing the multidimensional aspects of a company's financial stability, including investor sentiment and market dynamics.

The emergence of AI-driven models and the incorporation of qualitative data, such as market sentiment, reflect a broader trend towards holistic risk assessment in bankruptcy prediction. These advancements suggest that future research should continue to explore the integration of diverse data sources, including macroeconomic indicators, industry-specific factors, and qualitative measures. This multidimensional approach can potentially lead to more accurate and comprehensive models, better equipped to predict financial distress in a rapidly changing economic environment.

In light of these findings, future research should prioritize the development and refinement of cash flow-based models, which may provide a more accurate reflection of a company's liquidity and financial health compared to traditional accrual-based approaches. Additionally, market-based models that incorporate market data and investor sentiment should be explored further, as they can offer a dynamic perspective on a company's financial stability. Hybrid models that integrate both accounting-based and market-based indicators should also be a focus, leveraging the strengths of each to enhance predictive accuracy.

Overall, the continuous evolution of bankruptcy prediction models is crucial for the advancement of corporate finance. By addressing the identified gaps and exploring new methodologies, future research can contribute to the development of more robust and reliable tools for predicting financial distress, ultimately aiding in better decision-making for practitioners, policymakers, and researchers alike

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