Quantitative Credit Risk Analysis for BSE-listed Companies

Insights from the Merton and Altman Z-score models

by

Andrei-Lucian Cihó

MASTER'S THESIS

Lund University, School of Economics and Management

May 25th, 2024

Thesis coordinator

Professor Hans Byström

ACKNOWLEDGEMENTS

By this means, I would like to express my profound gratitute to the Romanian Ministry of Education for generously funding my participation in this master’s programme. It is of utmost importance to acknowledge that the 2,000 EUR monthly governmental scholarship, coupled with the provision return flight ticket, was graciously bestowed upon me by the National Agency for Credits and Study Scholarships (Agenția de Credite și Burse de Studii), subsequent to my success in the national selection process conducted in accordance with the provisions of Government Decision no. 118/2023. In light of the substantial discrepancy between the limited financial means of a Romanian student and the elevated living expenses inherent to Sweden, the financial support served as an ancillary resource in the pursuit of my envision objectives and the refinement of my academic competencies. In this context, it has notably alleviated my concerns regarding accommodation and transport costs, as well as other educational expenditures. Ultimately, by harnessing the monetary support provided, I have been afforded the opportunity to wholeheartedly immerse myself in the broad socio-academic spectrum, maintaining an unwavering focus on the research process.

TABLE OF CONTENTS

List of Tables

List of Figures

I. INTRODUCTION

1. Background and context

Credit activity stands as a constant focal point within the real of financial institutions, epitomizing the quintessential mechanism by which banks deploy their resources and ensure their primary revenue streams. Through lending, banks not only facilitate the provisioning of funds to enterprises seeking financial support to fuel their investment endeavors, but also act as enablers for capital holders, empowering them to strategically invest for profitable returns (Ionescu, 2004).

In the dynamic landscape of a competitive market economy, financial operations, regardless of their nature or intricacy, are inherently susceptible to risk. Hence, it becomes imperative for entities to cultivate a profound understanding of the parameters defining the scope of their activities, given the looming specter of risk. By acknowledging the implications posed by a wide array of risk factors, decision-makers within firms not only safeguard financial stability, but also foster the enduring viability and relevance within constantly evolving markets (Nagy, Ghica, & Tipărescu, 2023).

Corporate default represents a pivotal juncture in the financial life cycle of a company, stemming from its failure to honor contractual obligations to creditors. Serving as an indicator of financial distress, default often acts as a precursor to bankruptcy proceedings, being triggered by a plethora of factors, including deficient financial management, economic turndowns, industry-specific challenges. The severe repercussions of default across a broad spectrum of financial stakeholders, such as investors, creditors, regulators and policymakers, accentuated the compelling necessity within both academic discourse and practical business contexts to identify adequate strategies capable of mitigating and navigating the complexities of the phenomenon.

Credit risk embodies a bank's acknowledgement of the inherent uncertainties surrounding the probability of facing a loss whether through partial or complete non-recovery upon maturity of loan principal, along with the accrued interest and associated fees, solely due to the fault of the debtor. Therefore, financial institutions are compelled to meticulously assess a myriad of factors pertinent to risk quantification prior to enforcing lending decisions, a practice sustained throughout the entire credit lifecycle. These considerations typically reflect in an exhaustive evaluation of the client's financial performance, the reliability of repayment streams, the quality and structure of collateral, as well as the efficacy of managerial oversight within the borrowing entity (Sudacevschi, 2014).

Over the past decades, a discernible trend has emerged among several prominent international financial institutions, reflecting a heightened emphasis on the development of sophisticated warning systems aimed at modeling credit risk stemming from various lines of business. In this pursuit, notable efforts have been made to quantify, aggregate, predict and subsequently manage risk across various geographic and business segments (Codirlașu, 2007). The profound insights derived from such analytical frameworks have not only propelled the perpetual innovation within contemporary risk management practices, but also assumed a paramount role in critically assessing the efficacy and performance of corporate activities.

Since its original publication in the 2nd Issue of the Journal of Finance, the Merton model has stood as a seminal contribution within the field of finance, fundamentally reshaping the understanding and evaluation of credit risk. By introducing a structural approach that melds elements of option pricing theory with corporate finance principles, the model's enhanced efficiency lies in its unique ability to assess the probability of default, broadly defined as the "distance-to-default", by considering the intricate interplay between a firm's asset value, liabilities and volatility of its underlying assets (Merton R. , 1974). Over time, the methodology developed by Robert C. Merton has garnered significant attention from academics and field experts, given its intuitive appeal and practical applicability in both assessing and mitigating credit risk. In this context, the model has not only served as a theoretical bedrock for a plethora of subsequent studies but has also contributed to optimizing strategic decision-making processes across the globe, owing to its heightened accuracy in predicting corporate default.

Within the context of Romania's aspirations toward a competitive market environment, bankruptcy remains a barometer of the desolating economic situation, signaling the imperative need for restructuring and rectifying systemic imbalances and inefficiencies (Duran, 2007). The significant increase in nationwide defaults can be largely traced back to the repercussions of the revised 2006 Solvency Law, specifically to its simplified procedure. In essence, changes revolve around the improved conditions empowering creditors to initiate bankruptcy proceedings against debtors, as well as a more cohesive alignment of the normative framework with current debt recovery practice (National Bank of Romania, 2006) (Parlamentul României, 2006).

Upon conducting exhaustive analyses, both bank managers and financial experts conclude that credit activity remains the primary source of losses for Romanian banks. Although adopting internationally recognized methodologies, given the conspicuous lack of autonomous ones, would offer a concrete solution to mitigate credit risk, adverse selection, propelled by the ardent desire to maximize gains from relentlessly assuming credit risk, tends to prevail. Furthermore, numerous empirical studies attest the inherent benefits of more rigorous evaluation of potential debtors, internal evaluation of creditworthiness based on uniform criteria and well-established models, as well as maintaining a prudent margin for applied interest rates (Sudacevschi, 2014). Yet, amidst a prevailing lack of interest on behalf authorities in effectively steering the mechanisms of a capitalist system, pervasive knowledge gaps across various domains and decision-making processes primarily characterized by hazard, it becomes strikingly evident that the eradication of credit risk remains an elusive goal.

This discourse, coupled with the moral responsibility to contribute to both the societal and economic welfare upon a detached acknowledgement of the limitations within the Romanian system, has prompted my keen interest in exploring the intricate landscape of credit risk. Additionally, the preference for the Merton model stems from the absence of consolidated national default databases and Romania's relatively brief exposure to a capitalist framework, given the enduring legacy of a centralized communist regime, which has inherently hindered the development of a mature financial market. Despite being arguably modest in comparison to peer academic works produced at an international level, the current study can be viewed as both a bold attempt to apply established risk management strategies under constrained conditions, as well as a potential catalyst for future domestic research, thereby advancing Romania's alignment with the credit-scoring framework prevalent in advanced financial markets.

2. Research gap

Despite the enduring dedication of Western scholars and industry experts to develop innovative models aimed at enhancing the accuracy of credit-scoring methodologies, Romania's evolving economic landscape and its arguably nascent capital market contravenes with the thorough comprehension and assessment of credit risk. As detailed throughout the paper, the concerning reality reveals a significant knowledge gap, augmented by the lack of proactive measures to address systemic issues. Consequently, executing robust empirical research and comprehensive industry analysis becomes exceedingly challenging, as Romania struggles with digital transformation, evidenced by fragmented databases, outdated technical infrastructure and concerns regarding incomplete or manipulated information. The diverse array of constraints is further compounded by the marginal influence of global rating agencies within the local market, along with a prevailing hesitance in embracing advanced credit risk models, thus strengthening the inclination towards traditional account-based scoring systems. While some authors have explored the feasibility of applying structural models in the specific context of Romania, the practical implications of such theoretical frameworks remain limited.

From another perspective, domestic contributions to credit risk literature demonstrate a significant reliance on pre-existing international research, revealing a historical tendency towards prioritizing theoretical discourse over empirical validation. This can be partially attributed to a multitude of societal and economic factors, including insufficient financial resources to participate in international conferences and training programs, restricted accesses to selective bibliographic resources, as well as a pervasive stigma surrounding academic pursuits. Moreover, entrenched habits rooting from the communist era, such as resuming empirical testing to case studies encapsulating raw numerical interpretations of statistical information, inherently affect the caliber of the scholarly discourse, thereby furnishing a superficial analysis of causative factors and a purportedly inadequate substantiation for the formulated hypotheses.

In summary, Romania lacks a comprehensive framework capable of accommodating advanced credit-scoring models, thereby impeding the effective management of credit risk. While hindering generalized efforts towards fostering financial resilience and sustainable growth, the evident research gap in literature translates into numerous challenges for both financial institutions and corporations when exploring alternative methods to enhance the accuracy and reliability of credit risk information. In this context, this paper aims seeks to refine the theoretical framework of both the Merton (1974) and Altman Z-score models to better align with the constraints inherent in the Romanian operational framework, emphasizing the need for quantitative evaluation, as well as for the establishment of a robust informational infrastructure and a commitment to transparency and independence.

3. Research objectives and questions

The aim of this paper is to conduct a comprehensive assessment of credit risk within the context of publicly listed companies on the Bucharest Stock Exchange (BSE). Employing the framework of options pricing theory and drawing upon insights from a prominent structural credit risk model, originally formulated by Merton (1974) and subsequently refined by Kealhofer, McQuown, and Vasicek in the late 1990s through the development of the Moody's KMV Model, this study focuses on providing a robust understanding of credit risk dynamics. Moreover, by leveraging the analytical power and the extensions of the Merton model, the research also endeavors to offer valuable insights into the creditworthiness of BSE-listed entities, thereby enhancing the decision-making process for investors and financial institutions operating within the Romanian financial market.

The primary objectives of the research can be summarized as follows:

- Present an overview of the historical development of credit risk models, with a particular emphasis on the Merton model and its subsequent extensions.
- Trace the evolution of the Romanian stock exchange, providing insights into its growth trajectory and regulatory framework.
- Establishing the necessary inputs for the application of both the Merton model and the Altman Z-score model, utilizing publicly available financial data pertaining to BSE-listed companies.
- Evaluate the performance of the Merton model within the Romanian financial market context, while increasing awareness among regulatory bodies and local risk management professionals regarding the advantages of structural models and other contemporary credit-scoring systems.
- Conduct a comparative analysis against the Altman Z-score model, alluding to the traditional credit-scoring methodologies prevalent within Romanian sphere for credit risk management.
- Analyze the applicability of the Merton model within the BSE framework, considering factors such as market dynamics and regulatory environments.
- Address theoretical obstacles, while raising awareness about systemic deficiencies potentially distorting the quality of decision-making processes for stakeholders operating within the Romanian financial market.

Upon closely considering the delineated research objectives and intricately examining the available informational infrastructure, the following research inquiries can be articulated for the present study:

Is the Merton model, and its extensions, capable to assess credit risk for publicly listed companies on the Bucharest Stock Exchange, and to what extent do the findings from its *application contribute to the broader understanding of credit risk management practices in emerging market economies? Is there any rationale for replacing conventional accounting-based credit-scoring systems, and what potential exists for the future adoption of structural models in Romania, given the inherent limitations within the operational framework?*

4. Thesis outline

The initial chapter aims to acquaint the reader with the subject of the thesis, employing a broad collection of conceptual elements to effectively frame the concept of credit risk mnagement within the operational framework of global enterprises. Particular emphasis will be placed on the models proposed by Robert C. Merton and Edward I. Altman, with a brief overview of the methodology employed in its development and implementation. Subsequently, the notional dimensions will be adapted to the economic landscape of Romania, highlighting a series of unique characteristics and prevalent trends within the local financial market. In the same section, clarifications regarding the existing research gap in Romania will be provided, along with the formulation of the research question associated with the presumed critical endeavor.

The second chapter delves into the rich conceptual treasury within the realm of credit risk management. By judiciously correlating notions drawn from literature, it aims at an in-depth exploration of the evolution of credit risk models, with a specific lens on their applicability to the specific context of Romania. Furthermore, it addresses various aspects regarding the current domestic knowledge landscape, highlighting noteworthy contributions of Romanians scholars to academic discourse. Ultimately, a deep dive into the Romanian capital market is envisaged, providing insights on its emergence, evolution and intrisic limitations.

Chapter 3 delineates the methodology employed throughout the present study, shedding light on the theoretical underpinnings essential for quantitative analysis. In this context, attention will be drawn to elements concerning sample selection, data collection procedures, establishment of the theoretical framework enabling the calculation of distance-to-default as proposed by Merton. In parallel, a comparative analysis will be undertaken, with a particular focus on delineating the conceptual framework intrinsic to the Altman Z-score. This latter accounting-based credit scoring method shall be scrutinized for its enhanced adaptability, considering the evident constraints posed by the Romanian operational landscape.

Chapter 4 aims to harmonize theoretical insights with a pragmatic approach, leveraging the informational arsenal available within institutional databases. Through the presentation of empirical findings linked to the presumed research question, it encapsulates the quintessence of the case study conducted for this research endeavor, facilitating the derivation of pertinent conclusions regarding the implementation of structural risk models in Romania and their reaction to market dynamics in comparison to account-based credit scoring systems.

The final formula of the thesis is centered on advancing insightful conclusions that may serve as a reference point for future academic endeavors, while contributing at the same time at anticipating the specific challenges that will shape the financial landscape in the immediate future.

II. LITERATURE REVIEW

1. A foray into the evolution of credit risk models

Over the past two decades, the financial sphere has witnessed an unprecedented evolution in credit risk measurement, prompted by numerous ongoing factors that have underscored the importance of the process. Among these secular dynamics we can point out a generalized increase in the number of bankruptcies across the globe, an overall predilection for direct lending by top-tier borrowers, heightened competition leading to tighter loan margins, diminishing value of tangible assets serving as collateral, as well as a notable expansion in off-balance sheet instruments carrying inherent default risks, (e.g., credit derivatives as noted by McKinsey in 1993) (McKinsey, 1993).

In their attempt of counteracting these far-reaching phenomena, both academic researchers and industry practitioners have demonstrated sustained efforts and perseverence in developing comprehensive credit-scoring and early-warning systems. Additionally, there has been a tendency for assessing the whole picture, with scholars shifting their attention from assessing individual loans or securities towards evaluating the overall credit concentration risk. Specifically, information about portfolios of fixed income securities where credit risk evaluation plays a pivotal role has been continuously disseminated. Ultimately, there has been a constant preoccupation for devising new models for pricing credit risk (e.g., the adoption of risk-adjusted return on capital – RAROC models), as well as for enhancing the measurement of credit risk associated with off-balance sheet instruments (Altman & Saunders, 1998).

As a reaction to the Basel Accord's emphasis on individual credit risk over the consecrated portfolio framework, financial institutions have also developed intrinsic credit risk models that account for the temporal aspect of the exposure, realistic default probabilities, as well as for cross-correlations. In this context, hedging and other exposure-altering techniques have been pointedly addressed, the inherent benefit of this approach lying in the enhanced accuracy in gauging the effects achieved through portfolio diversification (Codirlașu, 2007).

1.1. Expert systems (4C)

In a preliminary attempt of evaluating credit risk associated with corporate loans, financial institutions resorted to subjective analysis, thereby laying the groundwork for the what came to be known as banker "expert" systems. Allusively, risk experts would determine creditworthiness on specific measurable variables such as borrower reputation, leverage, earnings volatility, and collateral (Altman & Saunders, 1998). In addition to these four factors classified in existing literature as the "4 Cs" of credit, Mohammadi and Fathi (2016) have also discerned the current phase of the economic cycle as an important determinant in assessing an obligor's capacity to settle its debt.

However, given the considerable expertise demanded in credit control and the potential biases inherent in assessments reliant solely on subjective judgments, it is unsurprising that financial institutions have gradually renounced expert-driven systems, favoring more objectively grounded approaches (Chen & Fu, 2023). The points mentioned align with the conclusions drawn from a study conducted by Sommerville and Tafler (1995), which underscores that subjective ratings provided by bankers often exhibit unwarranted pessimism, particularly in emerging economies, as qualitative aspects such as reputation and the borrower-lender relationship tend to prejudice equitable quantification (Sommerville & Taffler, 1995).

1.2. Accounting based credit-scoring systems

The quintessence of accounting-based credit-scoring systems revolves around risk experts assessing prospective borrowers by measuring their key accounting ratios against industry or group benchmarks. By exploiting accounting variables, multivariate credit-scoring systems facilitate the calculation of either a credit risk score or a probability of default, which is eventually compared to a predefined threshold. Ultimately, applicants encounter rejection or increased scrutiny if their metric surpasses the designated benchmark.

When it comes to developing multivariate credit-scoring systems there are four distinct methodological approaches acknowledged within existing literature: the linear probability model, logit model, probit model, and discriminant analysis model. Prominent in existing research, the discriminant analysis model introduced by Altman et al. (1977) seeks to ascertain a linear relationship among accounting and market variables to further classify borrowers based on their likelihood of repayment or default (Altman, Haldeman, & Narayanan, 1977). Referred to as the "Zeta model", the Altman et al. (1977) seven-variable discriminant analysis model, exhibits enhanced performance compared to Altman's (1968) previous research focused solely on five variables (Altman E. , 1968). A notable application of the ZETA model is its private firm adaptation, which adjusts for the absence of the market value of equity. The logit approach can be perceived as esentially identical, with the key distinction lying in the additional assumption that the probability of default adheres to a logistic distribution inherently bounded between 0 and 1 (Altman & Saunders, 1998).

Over the past decades, numerous studies employing multivariate models have been conducted to forestall distinct financial phenomena. In a preliminary attempt, Martin (1977) utilized both logit and discriminant analysis to predict bank failures, highlighting the comporable performance of the two models in distinguishing between bank failures and non-failures (Martin, 1977). West (1985) complemented the logit model with factor analysis to assess the likelihood of a financial distress faced by banks, with results aligning closely with the CAMEL rating components used by credit risk experts (West, 1985). Further research carried out by Platt and Platt (1991) suggests that industry relative accounting ratios exhibit superior predictive power for corporate bankruptcy compared to simple firm-specific accounting ratios (Platt & Platt, 1991). Similarly, Lawrence et al. (1992) employed the logit model to forecast the probability of default on mobile home loans, identifying payment history as the most significant factor (Lawrence, Smith, & Rhoades, 1992).

Despite potential perceptions of obsolescence amid contemporary financial advancements, the Altman' Z-score continues to serve as an indispensible tool for predicting default risk due to its simplicity, exerting a significant influence on forecasts perfomed by a wide-range of market participants (Benzschawel, 2012).

1.3. Structural credit risk models

Although multivariate accounting based credit-scoring models are widespread on a global scale, demonstrating consistent performance across different time spans, an obvious drawback stems from their reliance on historical information, rendering them backward looking and intermittent (Zamore, Djan, Alon, & Hobdari, 2018). Notably, with accounting ratios being assessed at specific intervals, the scrutinized models may become unable to react to subtle and rapidly changing market conditions. Furthermore, within real-world contexts, relationships between variables often diverge from linear patterns. Consequently, discriminant analysis and probability models presuming linearity may fall short in accurately forecasting outcomes. Ultimately, a third constraint arises from the inevitable dependence of credit-scoring bankruptcy prediction models on their underlying theoretical frameworks, which could potentially lead to an unrealistic generalization of financial phenomena (Altman & Saunders, 1998).

In this context, the emergence of alternative credit risk models becomes iminent, reflecting scholars' sustained efforts to extend current knowledge to encompass various aspects of financial markets and overall investment decisions in a more realistic manner. Tracing their origins back to the pioneering works of Black and Scholes (1972, 1973) and Merton (1973, 1974), structural models are rooted in capital structure theory and assume that a firm defaults when the value of its assets falls below the value of its debt. Black and Scholes (1973) utilize the options pricing model to value debt and equity, showcasing the impact of call options on equity for debt valuation (Black & Scholes, 1972) (Black & Scholes, 1973) (Merton R. , 1974) (Merton R. , 1973). Nevertheless, a notable limitation of the Black-Scholes model lies in its inability of directly observing firm asset values. In response, Merton (1974) expands this framework, demonstrating that, under certain assumptions, the asset value of a firm can be derived to determine the probability of default, referred to as the "distance to default" (Zamore, Djan, Alon, & Hobdari, 2018).

Despite becoming one of the most influential models in credit risk modeling and serving as the theoretical groundwork for all subsequent structural models, the Merton model entails overly simplistic assumptions regarding the asset value process, interest rates and capital structure. Specifically, the assumption of a single zero-coupon bond for a firm's liabilities may be deemed unrealistic to a large extent (Laajimi, 2012).

A recent study conducted by Laajimi with particular emphasis on the assumptions concerning the default trigger delves into the advancements and extensions of the core Merton framework, leading to the classification of pricing models as either endogenous or exogenous.

At the outset, the research highlights value-based models such as Merton (1974), Brennan and Schwartz (1978), Longstaff and Schwartz (1995) and Briys and de Varenne (1997), all of which are characterized by a zero net worth trigger. A second group of structural models is referred to as cash-based models, reflecting cash flow insufficiency, where default is triggered by a liquidity shortage (Brennan & Schwartz, 1978) (Longstaff & Schwartz, 1995) (Briys & de Varenne, 1997). Notable contributions in this area include works by Kim, Ramaswamy and Sundaresan (1993), Anderson and Sundaresan (1996) and Ross (2005) (Kim, Ramaswamy, &

Sundaresan, 1993) (Anderson & Sundaresan, 1996) (Ross, 2005). Further advancements proposed by Acharya, Huang, Subrahmanyam and Sundaram (2006), Anderson and Carverhill (2007) and Asvanunt, Broadie and Sundaresan (2007) also consider the availability of external financing, thereby completing the spectrum of exogenous models (Acharya, Huang, Subrahmanyam, & Sundaram, 2006) (Anderson & Carverhill, 2007) (Asvanunt, Broadie, & Sundaresan, 2007).

The paper also examins endogenous default models, where default arises as a result of the firm's decision making process. A common framework within this group be considered the Black and Cox (1976) model which puts special emphasis on contingent claims, while integrating additional factors such as discreteness and safety coventants (Black & Cox, 1976). Later developments advanced by Leland (1994) and Leland and Toft (1996) adjust for the tax advantages of debt and bankruptcy costs (Leland, 1994) (Leland & Toft, 1996), while works by Hart and Moore (1994, 1998), Anderson and Sundaresan (1996), Mella-Barral and Perraudin (1997) and Mella-Barral (1999) also address strategic defaults by equity holders (Laajimi, 2012) (Hart & Moore, 1994) (Hart & Moore, 1998) (Anderson & Sundaresan, 1996) (Mella-Barral, 1999) (Mella-Barral & Perraudin, 1997).

A significant improvement within the structural approach pertains to the KMV model, developed and coined by Kealhofer, McQuown and Vasicek in 1995 and later acquired by Moody's (Kealhofer, 1995). Rooted in the original Merton framework, the model characterizes the probability of failure as an endogenous variable, intricately tied to a firm's assets and liabilities structure. (Spuchľáková, Frajtová Michalíková, & Birtus, 2014). The innovation with the KMV lies in its ability to predict the expected default frequency (EDF) for individual borrowers, rather than relying solely on the average historical transition frequencies provided by rating agencies for each credit class (Crouhy, Galai, & Mark, 2000). In this context, the widespread use of the KMV model is thoroughly comprehensible, especially when considering its capacity to continuously train and adjust the EDF on a daily basis (Chen & Fu, 2023). Nevertheless, the model continues to foster skepticism among critiques regarding its unconditional applicability due to its reliance on unobservable asset values in empirical settings and the relatively unrealistic core assumption that default can only happen at maturity (Jarrow, Credit Risk Models, 2009).

1.4. Reduced form models

Proposed by Fons in 1994, the reduced form methodology is based on corporate ratings, historical default statistics, recovery rates and the risk-free interest rate (Fons, 1994). Credited for its reliance on readily observable input data, the model offers a significant benefit by decoupling the default process from asset valuation (Khindanova, Knoch, Rachev, & Schwartz, 1999). Extensions to the reduced form approach can be found in more recent studies conducted by Jarrow and Turnbull (1995), Duffie and Singleton (1999) and Hull and White (2000), further emphasizing the model's increased mathematical tractability (Jarrow & Turnbull, 1995) (Duffie & Singleton, 1999) (Hull & White, 2000) (Zamore, Djan, Alon, & Hobdari, 2018).

Following the principles of risk-neutral pricing, where risky assets are valued by discounting future cash flows at the risk-free rate, reduced-form models show predictive capability in assessing default probabilities without making any assumptions regarding the origin of credit risk premiums (Benzschawel, 2012). The reduced form approach stands appart from structural models, as it does not necessitate direct economic derivation or additional information beyond market data. Earning recognition for enhanced flexibility and precision, these models define default as an unpredictable event associated with a hazard rate process, thereby surpassing the overgeneralization inherent in their structural counterparts and portraying credit risk in a rather realistic manner (Reinwald, 2021).

Despite becoming a dominant paradigm in credit risk modelling (Weigel & Gemmill, 2006), the reduced form approach is not exempt from certain theoretical constraints. These include the absence of a clear economic rationale for defining the default process, poor out-of-sample performance stemming from its flexibility in functional form, as well as intricacies in interpreting results, particularly when dealing with extensive arrays of debt instruments which feature substantial variations in credit quality. Additionally, there are several challenges associated with empirically testing reduced form models, especially in the context of default intensity processes. Specifically, the lack of sufficient theoretical guidance, the instability of parameter estimates when using a square-root process (Duffee, 1999), along with the indicative nature of bond data and information being gradually incorporated into the price may lead to potentially biased estimates. Ultimately, it becomes exceedingly challenging to discern the efficacy of the modeling framework from the reliability of the underlying data, as bond data serves the dual purpose of both fitting and testing the model (Arora, Bohn, & Zhu, 2005).

1.5. Internal models and acturial credit risk methodologies

Pursuing the goal of attaining financial stability, the enforcement of new capital requirements by the BIS in 1998 has mandated banks to employ internal mechanisms to assess their financial soundness and comply with regulatory capital standards pertaining to both overall market risk and credit risk (Crouhy, Galai, & Mark, 2000). In this context, the increasing emphasis on internal ratings becomes prominent, driving the advancement of more intricate risk measurement techniques (Michalíková, Spuchľáková, & Cúg, 2014). Consequently, various industry-endorsed tools have been devised, notable examples including CreditMetrics by JP Morgan, CreditRisk+ by Credit Suisse, and CreditPortfolioView by McKinsey.

Taking into account all possible transitions from a given credit rating to another over a predetermined risk horizon, the CreditMetrics is categorized as a “mark-to-market mode” model. Its computation encompasses two main methods: an analytical approach and a Monte Carlo simulation which estimates the regulatory capital requirement based on the value-at-risk. Despite exhibiting numerous theoretical advantages such as evaluating credit risk across the entire portfolio and accommodating a wide-range of financial instruments, constraints such as its reliance on extensive information and historical records to predict future events, as well as the intricate nature of calculations necessary to determine the correlations between multiple instruments in the portfolio, restrict the model's applicability to mature capital markets (Michalíková, Spuchľáková, & Cúg, 2014).

Belonging to the "default-mode" category, the CreditRisk+ model operates under the assumption that individual borrowers may either default or remain solvent within a specific time frame (Michalíková, Spuchľáková, & Cúg, 2014). CreditRisk+ does not account for the underlying cause of the default event, failure risk being thus not linked to the capital structure of the firm or determined based on historical data. Instead, the model posits that banks possess a general understanding of each debtor's creditworthiness and that the probability of default follows a Poisson distribution. In this context, the approach endorsed by Credit Suisse proves suitable for assessing credit risk within portfolios comprising a large number of borrowers, each characterized by a low probability of default (Crouhy, Galai, & Mark, 2000).

Originally developed by Wilson (1987, 1997) and later brought forward by McKinsey, CreditPortfolioView is a multi-factor risk assessment model that simulates joint conditional distribution of default and transition probabilities across various rating groups, industries, countries and classes of obligors (Wilson, 1987) (Wilson, 1997). By incorporating macroeconomic variables such as unemployment rates, GDP growth, long-term interest rates, foreign exchange rates, government expenditures and aggregate savings rates, it establishes a strong relationship between credit rating migrations and economic cycles. In this context, CreditPortfolioView exhibits enhanced precision when applied to speculative grade obligors, in comparison to investment grade obligors (Crouhy, Galai, & Mark, 2000). Nevertheless, an obvious drawback of the model arises from its considerable emphasis on systemic risk, while completely overlooking specific or diversifiable risk (Chen & Fu, 2023).

2. Applicability of credit risk measurement models in Romania

Complementary to the widespread adoption and integration of the aforementioned credit risk management methodologies within both financial literature and empirical studies, a persistent commitment among Western scholars and industry experts prevails to continuously refine the precision of credit risk forecasts. In this context, a proactive stance in developing innovative models characterized by a diminishing number of theoretical constraints has become evident across various fronts. Specifically, the oversaturation of financial journals with thought-provoking and visionary ideas, the increased participation and engagement witnessed at prestigiuous international conferences, as well as the the substantial allocation of funding by both governmental bodies and private entities all ascertain to the collective endeavor within advanced economies towards the pursuit of fostering financial resilience and growth on a global scale. Nevertheless, amidst the perpetually prolonging transition from a centralized economic framework and nascent nature of the Romanian capital market, notable deficiencies remain prevalent in both the comprehension and assessment of the credit risk concept, despite its pivotal importance within contemporary banking systems.

Each year, national statistics depict a stark and sobering tableau – numerous financial institutions struggle with insolvency and subsequently default due to poor risk management (Anghel, Popescu, Sfetcu, & Mirea, 2018). The recurring pattern of failure has paradoxically become a shaping catalyst of the Romanian reality, highlighting the lack of experience, the mutual disinterest and an apparently irredeemable knowledge gap. Regardless, both authorities and field experts appear more inclined to engage in rhetorical explanations, rather than taking concrete action for the alarming, yet unpardonable state of affairs. Conceived as a framework intended to shape bank operations and mitigate exposure to risks, the Basel II Accord was published almost two decades ago. By endorsing the development of early warning indicators, it aimed at preventing banks from traversing unsafe paths detrimental to their financial stability. Despite, the prompt reaction of the National Bank of Romania (BNR) in issuing the norms derived from the Basel II requirements and current banking legislation mandating greater prudence in credit lending and adapting capital to the client's risk profiles employing well-established methodologies, there persists a prevailing reluctance within the Romanian sphere, even towards fundamental structural models like Merton (1974) for estimating the probability of default. The results of an impact study conducted by BNR show that only a limited number of financial institutions would consider embracing an internal model-driven approach when determining minimum capital prerequisities for both credit and operational risk (Ciurlău, 2007). In this context, traditional accounting-based scoring systems, such as financial equilibrium analysis, profitability analysis and cash flow analysis remain the preferred method for assessing credit risk (Munteanu, 2010).

As highlighted throughout the literature review section, both CreditMetrics and CreditRisk+ models rely heavily on extensive historical default records, as well as comprehensive specialty expertise provided by rating agencies. Similarly, CreditPortfolioView utilizes a robust database to validate the correlations between systemic factors and default events. Another prevalent aspect of the Romanian reality underscores the constant struggle of authorities with the digital transformation process. This becomes notably evdent with the absence of consolidated and standardized databases across all administrative tiers, as well as with the outdated technical infrastructure supporting official software packages and online platforms. Furthermore, even in cases where national databases do exist, the lack of a uniform normative framework and regular control performed by competent organisms, leads to issues such as incomplete, flawed or artificially manipulated information. Such limitations contravene the realistic depiction of financial phenomena, thereby restricting the execution of any pertinent empirical research. Additionally, within the framework of an emerging capital market, composed by a limited number of firms listed on the Bucharest Stock Exchange, the data at hand would remain inadequate for conducting any comprehensive industry or peer group analysis, even under the assumption of absolute accuracy and completeness in the inputs provided. Ultimately, the limited influence exercised by worldwide reputed credit rating agencies such as Standard & Poor's or Moody's leads to a heavy reliance on local credit-scoring agencies which are inherently vulnerable to pervasive corrupt practices and conflicts of interest. Despite regulatory bodies being completely aware of the imperfect nature of the system, their failure to enact concrete measures to mitigate abuse in various forms, including bribery, extortion, patronage, nepotism and favoritism, perpetuates the skewed information provided by credit rating entities.

Considering the aforementioned arguments, it becomes strikingly evident that Romania lacks a comprehensive framework to accommodate the calculation of the CreditMetrics, CreditRisk+ and CreditPortfolioView models. Instead, a more attainable goal would involve employing

Merton-based models, which utilize publicly accessible stock market data and financial statements. Nonetheless, it must be acknowledged that the broad applicability of even such fundamental models remains contentious, given the inherent constraints of the Bucharest Stock Exchange database.

3. Domestic contributions to credit risk literature and empirical research in Romania

In assessing the landscape of credit risk modeling within domestically produced literature, one may find a notable lack of original contributions, along with an exclusive reliance on international research summaries. Specifially, indigenous financial journals would solely encompass Romanian renditions of fundamental theoretical models, yet conspicuously lacking practical implementations thereof. This tendency can be traced back to a longstanding tradition of prioritizing a pure theoretical approach, a legacy of the communist era and an inherent limitation of the contemporary Romanian education system.

To illustrate the prevailing reluctance towards exploiting the benefits of empirical testing, one may refer to a recent study conducted by Duran. Throughout his thesis, the author underscores the uncertainty surrounding the enhanced accuracy of a financial ratio based credit risk evaluation, in comparison to a methodology which solely accounts for non-financial variables. Regardless, the incorporation of other types of information, such as those related to the audit certification, board composition and debt structure, ensures a qualitative improvement of the scrutinized models (Duran, 2007). Thus, with scholars and researchers perpetuating an academic framework wherein theoretical discourse reigns supreme over pragmatic application, efforts to leverage historical data for the nuanced assessment of economic and financial phenomena remain an underexplored frontier.

From another perspective, Codirlaşu's 2006 study remains one of the most complex investigations carried within Romanian sphere in the sphere of credit risk valuation work. Upon meticulously outlining the original methodology established by Merton (1974), the author delves into a comprehensive analysis and validation of the model's domestic application. Specifically, the distance-to-default for a selection of firms listed on the Bucharest Stock Exchange is estimated, leveraging quarterly data spanning from 1998 to 2006. The findings show that financial investment companies exhibit the lowest probabilities of default, underscoring the benefits of highly diversified portfolios and a minimal level of indebtedness. Conversely, Oltchim (OLT), a company notable for scoring negative capital from 2001 to 2004 and Impact (IMP), which pursued aggressive expansion without due consideration for increased indebtedness, registered the highest probabilities of default. Despite being a commendable attempt of empirically testing credit risk models under constrained circumstances, Codirlaşu's perspective remains largely unilateral, lacking any subsequent comparative analysis regarding the individual performance of the described credit risk assessment approaches. Moreover, the choice for employing the Merton model appears to stem from personal intrigue rather than a deliberate selection based on comparative discriminatory power or suitability within the Romanian framework (Codirlaşu, 2007).

While traditional credit risk models hold promise even in emergent financial markets, other scholars have explored alternative paths to assess the probability of default among local companies. In a recent study, Dardac and Moinescu employ a real default database to perform a quantitative analysis of credit risk in the context of the Basel II regulations. Upon deriving a multivariate logit function, the authors conclude that the greatest influence on the probability of default is exerted by the short-term debt coverage ratio, whereas the impact of the accounts receivable turnover ratio on a firm's capacity to honor its debt remains limited. The explanatory power of the selected variables is underscored by the substantial values of the corresponding t-statistic indicators, the ROC curve further attesting the model's proficiency in furnishing an accurate estimation of default probability. Ultimately, the discourse articulated throughout the paper leads to the conclusion that quantitative evaluation of credit risk, coupled with the establishment of external credit rating agencies in Romania, stands not only as desirable, but also feasible. With a universally applicable pattern governing debt reimbursement, the prospects for the future of credit risk modeling appear promising. Nevertheless, the objectivity and credibility inherent in external credit risk assessment, as well as the attainment of a high level of automation in credit scoring are contingent upon establishing an informational infrastructure that ensures the consistent influx of valid and comprehensive data for appropriate methodological calibrations, under the auspices of absolute independence and transparency (Dardac & Moinescu, 2006).

4. A deep dive into the Romanian capital market: emergence, evolution, and inherent limitations

The origins of stock exchanges in Romania trace back to the enactment of "Commercial Code of Wallachia" in 1840, emphasizing the pivotal importance of commercial exchanges. The nation's first stock exchange was established in 1881, following the adoption of the Law on stock exchanges, brokers and merchandise intermediaries. Nevertheless, due to scarcity of liquid capital the period between 1882 and 1904 recorded a shortfall in stock market activity.

The regulatory framework improved significantly with the 1904 "Law on Commodity Exchanges" which defined operations more clearly and facilitated the establishment of various stock exchanges across the country. Specifically, Bucharest emerged as a multifaceted hub encompassing securities, effects, grains, and merchandise, while regional centers specialized in grain and merchandise exchanges, responding to local exigencies. The legislative framework was eventually consolidated and unified in 1929 under the famous "Madgearu Law".

Following the conclusion of the 1929-1933 economic crisis, the "Bucharest Stock Exchange for Securities, Shares and Exchange" underwent substantial growth, encompassing no less than 56 investment assets by 1939. The end of World War II, followed by the rapid establishment of the communist regime, inherently marked the demise of the capital market and stock exchange in Romania. The onset of the nationalization process in 1948, characterized by the consolidation of state ownership, led to the disappearance of various financial instruments, including shares, corporate bonds, as well as both domestic and foreign government securities (Radu, 2015). Despite the notable success of Romanian state-owned enterprises within international markets, the period spanning from 1952 to 1989 remains a conspicuous “black hole” in the annals of Romanian capital market history (Anghelache, Anghelache, Anghel, & Chiliment, 2018).

The Revolution of 1989 stands as a significant juncture in contemporary Romanian history, underscoring a subsequent reform program and the imperative need for the reconstruction of the capital market and its associated institutions. Mirroring the trajectory of other nations across Central and Eastern Europe, the foundational pillars of the Romanian capital market were laid upon the process of privatization, transitioning state-owned assets into private ownership (Anghelache, 2004). A preliminary stride towards establishing a comprehensive regulatory framework for the capital market materialized with the enactment of Law No. 52/1994 on securities and stock exchanges. The resurrection of the Bucharest Stock Exchanges was shortly decreed on April 1st by the National Securities Commission, June 23, 1995 marking its official inauguration. Concurrently, the establishment of the RASDAQ over-the-counter market facilitated transparent trading for approximately 5,700 privatized enterprises (Anghel, 2011), highlighting the collaborative efforts between Romania and the United States, aimed at steering capital market institutions towards the private sector (Anghelache, 2004).

Key milestones in the evolution of the Bucharest Stock Exchange include the launch of the first BET index in 1997, followed by BET-C in 1998. Moreover, the implementation of the new HORIZON trading system by 1999 positioned BSE for global alignment, while facilitating strategic cooperation agreements with prestigious counterparts (Anghelache, 2004). The introduction of sectoral indices, notably BET-FI in 2000, as well the inclusion of shares from two prominent entities, Banca Română pentru Dezvoltare - Groupe Societe Generale and Societatea Națională a Petrolului Petrom, led to spectacular increases in market capitalization and trading activity. Unprecedented peaks were achieved by 2002, when BSE outpaced the growth of the leading 57 stock exchanges globally (Georgescu & Dudian, 2008).

Another significant milestone was achieved through the merger between RASDAQ Electronic Exchange and BSE, enabling investors to trade rights attached to newly issued shares during subsequent increases in share capital (Anghel & Nicola, 2013). Following the accession to the European Union in 2007, the Romanian stock market witnessed a notable influx of foreign investors amplifying their stake in the total market turnover (Anghelache, Anghelache, Anghel, & Chiliment, 2018). Capitalizing on such favorable economic context, the Bucharest Stock Exchange enriched its spectrum of financial instruments, culminating in the launch of the futures market by the end of September. Nevertheless, 2008 posed considerable challenges, with a significant decrease in market capitalization, and transaction volumes. As a response to the turbulent market dynamics, BET-XT and BET-NG indices were introduced. The downward trend persisted until 2011, mirroring the evolution of other European and international counterparts (Anghel, 2011).

In present, the Bucharest Stock Exchange (BVB) is leading the development of a highly competitive market in Central and Eastern Europe, attracting significant capital flows from institutional and retail investors both domestically and internationally. Accommodating an impressive cohort of no less than 86 publicly listed companies, BSE has facilitated over

720,978 transactions worth over 7,291,298,789 lei across all administered markets (Bucharest Stock Exchange, 2023).

Despite its spectral historical trajectory, considering the advanced stage of academic research in the field of credit risk management, BSE still exhibits characteristics of an emerging institutional framework, entailing a series of systemic constraints. Specifically, the limited number of listed companies may falter in capturing the intricate nuances of credit risk, as well as in accommodating the latest models endorsed by reputable credit rating agencies. Furthermore, it is imperative to acknowledge that since many firms have entered the stock market quite recently, data homogeneity can only be achieved through a deliberate narrowing of the considered time horizon. In this context, the structural composition and the current developmental stage of the Romanian capital market emerge as the principal impediments to the effective implementation of the Merton methodology, purportedly diminishing its explanatory power and statistical robustness. The theoretical limitations are further exacerbated by informational deficiencies, notably the absence of reliable and comprehensive institutional default databases requisite for the perpetual and precise evaluation of financial phenomena.

III. METHODOLOGY

1. Suggested methodology and key aspects regarding sample selection and data collection

The methodology employed in this study involves constructing a sample dataset using existing financial data sourced from the BSE Database. Both daily and yearly trading reports will be gathered for publicly listed companies across various industries, with the aim of capturing a comprehensive representation of the market. Due to the limited availability of a solid financial database and the emergent nature of the Romanian financial market, the sample will only cover a relatively short timeframe of 7 years. Moreover, the research acknowledges the constraint posed by the restricted number of publicly traded companies on the Bucharest Stock Exchange, exacerbated by a significant influx of newly registered firms in recent years. Despite these limitations, the study endeavors to yield credible and compelling findings that reflect the current state of the Romanian financial market.

While the research aims at replicating the methodology proposed by Merton (1974) and subsequently refined by Kealhofer, McQuown, and Vasicek in their development of the Moody's KMV Model, the theoretical approach will be adapted to suit the unique characteristics of the BSE framework. Specifically, the study seeks to estimate probabilities of default (PD) for the selected public companies by calculating the number of standard deviations to default, also known as the distance-to-default as delineated by Merton. Given that equity volatility is typically unobservable directly, the research also aims to estimate it using methodologies recommended in existing literature.

Leveraging upon the seamless implementation of the Zeta model given the widespread availability of annual financial statements, the Merton's structural approach will be complemented by a parallel accounting-based credit risk assessment. Notably, the Z-score formula published by Edward I. Altman in 1968 will serve as a secondary tool for assessing the probability of default, adeptly accommodating the constraints inherent in the Romanian operational landscape. In this context, Altman's methodology will not only serve as a proxy for the homogeneous array of domestically produced accounting-based credit-scoring systems, but also underscore the paramount importance of evaluating fundamental financial ratios within the Romanian sphere of credit risk management. Upon deriving the Z-score for the scrutinized companies, a qualitative analysis will be performed, wherein the results will be compared against the thresholds suggested by Altman in his seminal paper.

In pursuit of achieving the primary research objectives, a sample comprising 62 publicly traded Romanian companies will be meticulously constructed, leveraging annual financial data spanning a seven-year period 2016 to 2022. The selection encompasses both standard and premium entities, contributing a total of 434 units for credit risk indices across both the Merton model and the Altman Z-score framework. Despite the constrained scope of the sample, the volume of scrutinized data is anticipated to yield empirically robust and pertinent insights, offering enhanced clarity on the current stage of the Romanian financial market. Ultimately, the methodological approach resonates closely with the theoretical assumptions and conclusions of the research endeavor, thereby fortifying the scholarly discourse on the subject.

In accordance with Admission Guidelines for the equity listing on the Regulated Market of the Bucharest Stock Exchange, companies must collectively satisfy the ensuring criteria concerning size, operational history, and free-float magnitude, further defined as the number of issued shares, existing in circulation and readily available for trading (Bucharest Stock Exchange, 2015):

- embody the legal form of a joint-stock company (*S.A. – societate pe acțiuni*);
- possess a proven operational track record spanning a minimum of 3 financial years, accompanied by annual financial statements crafted with utmost transparency and precision;
- amass total equity or anticipated market capitalization exceeding EUR 1 million;
- retain a free float of capital amounting to no less than 25%, subsequent to the public offering.

Furthermore, within the regulated market of the Bucharest Stock Exchange, two fundamental typologies of securities are distinguishable and present as follows:

- Standard stocks – indicative of companies that collectively fulfill the aforementioned minimum prerequisites;
- Premium stocks – indicative of companies boasting a free-float valued at a minimum of EUR 40 million, alongside a prior agreement established with a certified market-maker, aimed at enhancing the liquidity of issued shares.

The typological segregation of companies into the previously delineated categories will exert considerable influence in constructing and organizing the reference sample, thereby facilitating the dissemination of comparative insights. More precisely, the descriptive statistics tables computed for the present empirical investigation seek to conduct a parallel analysis of information pertaining to the mean, standard deviation, minimum and maximum values recorded by both standard and premium entities, with findings being articulated annually and cumulatively across the entire scrutiny interval.

2. Calculation of the Merton model

Proposed by Robert Merton in 1974, the eponymous model aims at evaluating the credit risk of a company by conceptualzing its equity value as a European call option on its assets. Considered pioneering work in credit risk modeling, the original methodology developed by Merton quintessencially resembles a structural credit risk model, serving as an indispensible tool in estimating the risk-neutral probability of default. This probability, commonly referred to as the "distance-to-default", is derived by assuming the existence of a predetermined amount of zero-coupon debt maturing at a future time, denoted as T. From this perspective, the Merton model can be perceived as introspective, as it develops an internal economic default mechanism, whereby a firm defaults if the aggregate value of its assets falls below the total outstanding debt due upon maturity (Hull, Nelken, & White, Merton's Model, Credit Risk and Volatility Skews, 2005). The theoretical framework of the Merton model rests upon five key assumptions, which can be summarized as follows:

- The debt instrument takes the form of a zero-coupon bond with maturity at time T and a nominal value of K;
- The firm cannot issue additional debt or equity until time T;
- The liquidation of the firm occurs at time T;
- At time T, the firm either defaults or remains solvent;
- Default occurs if and only if $V < K$.

This esentially entails that if at time T the firm's asset value surpasses the contractual payment obligation, denoted as D, creditors are reimbursed the full pledged amount, while shareholders are entitled to the residual asset value. Conversely, in case asset value falls below the promised payment, the firm inevitably defaults, resulting in the lenders receiving a payment equivalent to the asset value, while shareholders are left without any compensation (Hull, Nelken, & White, Merton's Model, Credit Risk and Volatility Skews, 2005).

Merton's discernment lies in the equivalence between the 'payoff' attribuable to equity holders and the returns of a long call option issued on assets A with predetermined strike price K (Merton R. , 1974). Hence, by identifying a relationship between equity value, resembling the option, and the underlying value of assets, the option pricing model is prone to augmented predictive capacity, thereby facilitating the provision of nuanced insights into the likelihood of the default scenario, wherein $V < K$ (Hull J. , 2023). Within the Merton framework, the payment attribuable to shareholders at time T is defined as follows:

$$\boldsymbol{E_T = max[V - K, 0]} \qquad \textbf{(3.1.)}$$

Taking into account the structural properties inherent in his model, Merton embraced the methodology pioneered by Black and Scholes in 1972 for option pricing. This approach hinges upon the core assumption that the value of the underlying asset adheres to a stochastic process, commonly referred to as geometrical Brownian motion (GBM) (Black & Scholes, The valuation of option contracts and a test of market efficiency, 1972).

$$\boldsymbol{dV = \mu V dt + \sigma_V V dW} \qquad \textbf{(3.2.)}$$

Here, V denotes the aggregate worth of the firm's assets, μ the anticipated return on the firm's value, σ_V the volatility associated with the fluctuations in the firm's asset returns and dW a standard Weiner process.

A direct implication of the GBM assumption pertains to the logarithm of the underlying asset value, denoted by lnV at time T, conforming to a normal distribution:

$$\boldsymbol{lnV_T \sim \Phi\left(lnV_0 + \left(\sigma_V - \frac{\sigma_V^2}{2}\right)T, \sigma_V\sqrt{T}\right)} \qquad \textbf{(3.3.)}$$

By intricately combining the Merton model with the Black-Scholes formula, a concrete relationship between the firm's equity, total assets and liabilities becomes evident. Thus, the current price of equity can be defined as following:

$$\boldsymbol{E_0 = VN(d_1) - Ke^{-rT}N(d_2)} \qquad \textbf{(3.4.)}$$

Where:

$$d_1 = \frac{ln\frac{V}{K} + (r + \frac{\sigma_V}{2})^2 T}{\sigma_V \sqrt{T}} \qquad (3.5.)$$

$$d_2 = d_1 - \sigma_V \sqrt{T} \qquad (3.6.)$$

Here E_0 represents the present value of equity, V the market value of assets, K the face value of debt, r the default-free interest rate, σ_V the volatility of asset returns and T the time horizon until maturity. Additionally, $N(*)$ denotes the cumulative distribution function of the standard normal distribution.

As illustrated by Jones, Mason and Rosenfeld (1984), the implementation of Itô's lemma becomes feasible, in the context of asset value adhering to a geometric Brownian motion and equity value being contingent upon the asset value (Merton R. , 1974) (Jones, Mason, & Rosenfeld, 1984) (Hull, Nelken, & White, Merton's Model, Credit Risk and Volatility Skews, 2005). This subsequently facilitates the derivation of the instantenous volatility of equity at time zero from the asset volatility .

$$\boldsymbol{\sigma_E = N(d_1)\frac{V}{E}\sigma_V} \qquad \textbf{(3.7.)}$$

By combining both its short-term debt (STD) and long-term debt (LTD) in the presence of specific tuning parameters, represented by α and β, the company's default point, denoted as DPT, can be determined utilizing the following formula:

$$\boldsymbol{DPT = \alpha STD + \beta LTD} \qquad \textbf{(3.8.)}$$

Ultimately, the distance to default (DD) can be derived, factoring in the number of standard deviation to default. While enabling comparable cross-sectional analysis, the metric suggests that a greater distance underscores a reduced probability of experiencing a default event (Hull J. , 2023).

$$\boldsymbol{DD = \frac{ln\frac{V}{K} + (\mu_A - \frac{\sigma_V^2}{2})T}{\sigma_V \sqrt{T}}} \qquad \textbf{(3.9.)}$$

As evidenced by numerous empirical investigation, the asset value (μ_A) exhibits the tendency of increasing concomitantly with the default-free interest rate (r) (Hull J. , 2023). Therefore, it is noteworthy to acknowledge that the general assumption $\mu_A = r$ is also adopted throughout the present paper.

2.1. Equity value

In determining the total value of a company through the Black-Scholes option pricing formula, the traditional method involving the multiplication of outstanding shares by their current market price can be implemented (Merton R. , 1974).

As such, the ensuing formula is utilized to compute the equity value of the company:

$$\boldsymbol{E = N_T P_T} \qquad \textbf{(3.10.)}$$

Where: N_T denotes the number of tradable shares and P_T stands for the price of tradable shares. Additionally, it is noteworthy to mention that P_T corresponds to the market price per share, as observed on the final trading day of the fiscal year.

2.2. Equity value volatility

In accordance with the theoretical framework of the Merton model, its practical application is conditioned by a precise estimate of σ_E, a variable typically not directly observable (Hull J. , 2023). To address this challenge, scholars have advocated for a seemingly straightforward methodology which involves deriving volatility estimates by analyzing equity returns (Bharath & Shumway, 2008; Castagnolo & Ferro, 2014). Consequently, σ_E can be approximated as the standard deviation of equity returns, gleaned directly from market stock prices. In this pursuit, two distinct approaches emerge as viable alternatives, each offering nuanced insights and analytical paths for exploration.

The percentage price change method:

$$r_t = \frac{P_t - P_{t-1}}{P_t} \qquad (3.11.)$$

Where: r_t denotes the percentage return, P_{t-1} stands for the price from the preceding day (whether on a monthly or weekly basis), while P_t represents the price observed on the current day (also on a monthly or weekly basis).

The logarithmic price change method:

$$r_t = ln\frac{P_t}{P_{t-1}} \qquad (3.12.)$$

Where: r_t denotes the logarithmic return, P_{t-1} stands for the price from the preceding day (whether on a monthly or weekly basis), while P_t represents the price observed on the current day (also on a monthly or weekly basis).

In alignment with the foundational principles of the Merton framework, the assumption of continuous price changes, coupled with the adherence of the underlying asset value to a log-normal distribution assumes paramount significance in the practical application of the Merton model (Merton R. , 1974). In this context, the adoption of the logarithmic price change method becomes an obvious, yet imperative choice when calculating stock returns, inherently accomodating the notion of continuous price changes.

Consequently, the daily volatility of equity returns can be derived through the ensuing formula for the standard deviation:

$$\boldsymbol{\sigma_D = \sqrt{\frac{1}{n-1}\sum_{i-1}^{n}(r_t - \bar{r})^2}} \tag{3.13.}$$

Ultimately, the annualized volatility can be determined in the subsequent manner:

$$\boldsymbol{\sigma_Y = \sigma_D\sqrt{n}} \tag{3.14.}$$

Where: σ_D accounts for the daily volatility of equity and σ_Y for the yearly volatility. It is noteworthy to acknowledge the selection of $n = 254$ as the number of trading days within a single year. Moreover, r_t denotes the daily equity return, while $\bar{r}$ embodies the average of r_t.

2.3. Debt maturity

The current study considers a one-year debt maturity ($T = 1$). This assumption does not only streamline calculations and ensure consistency across analyses, but also aligns with the regulatory framework outlined in Article 28, paragraph (1) of the Accounting Law no. 82/1991, which mandates the disclosure of financial statements on a yearly basis. (Parlamentul României, 1991).

$$\boldsymbol{T = 1} \tag{3.15.}$$

2.4. Debt value and default point

Within the context of a one-year debt maturity, both the short-term (STD) and long-term debt (LTD) of a company can be retrieved directly from its annual balance sheet.

In finance, the default point refers to a critical threshold at which a borrower is considered to have defaulted on their financial obligations, typically in the context of loan repayment or bond issuance. Furthermore, it represents the point at which the borrower is unable or unwilling to fulfill their contractual commitments, often due to the asset value falling below the aggregate debt value. The determination of the default point may vary depending on the specific terms of the loan agreement or bond contract, as well as prevailing regulatory standards or industry practices. According to the KMV theoretical framework, the company's default point, denoted as DPT, can be described as a linear combination of its short-term (STD) and long-term debt (LTD), a formulation intricately influenced by specific tuning parameters, denoted as α and β.

$$\boldsymbol{DPT = \alpha STD + \beta LTD} \quad \textbf{(3.8.)}$$

As highlighted in various subsequent empirical studies, the assumptions inherent to the original Merton model continue to offer valuable into a company's default point. Consequently, the current quantitive analysis also also adheres to the widely accepted convention, wherein $\alpha = 1$ and $\beta = 0.5$ (Merton R. , 1974).

2.5. Risk-free rate

The common consensus for the risk-free rate in finance refers to the theoretical return on an investment devoid of any risk, typically represented by the yield on government securities, such as treasury bills or bonds, with negligible probability of default. The metric serves as a fundamental benchmark for evaluating the expected return on investments, providing a baseline against which the performance of other assets can be measured, adjusted for risk. The risk-free rate acts as a crucial parameter in various financial models, including asset pricing models such as the Capital Asset Pricing Model (CAPM) and option pricing models like the Black-Scholes model, facilitating the calculation of expected returns and the pricing of financial instruments.

Considering the atypical familiarity with the risk-free rate concept within the Romanian financial market, the imperative for a suitable proxy becomes evident. Building upon the assumptions articulated by by Codirlaşu in his 2006 research, the average interest rate for money market transactions emerges as a pertinent substitute for the risk-free rate. This information is readily accessible through the Interactive Database provided by the National Bank of Romania and summarized in the ensuing table:

Table 1: Average interest rate for money market transactions from 2014 to 2023 (%)

	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Interest rate	2.75	1.75	1.75	1.75	2.50	2.50	1.50	1.75	6.75	7.00

Source: National Bank of Romania

3. Calculation of the Altman Z-score model

Introduced by Edward I. Altman in 1968, the eponymous Z-score model stands as a seminal contribution to the domain of financial analysis and corporate credit risk assessment by integrating financial ratios into a comprehensive framework aimed at discerning the likelihood of corporate distress or bankruptcy. Altman notably underscored the potential of discriminant analysis in collectively utilizing selective indicators to predict bankruptcy and devised a bankruptcy index, which embodies a linear function derived from a set of ratios. Subsequently, the distribution of these distinct scores facilitates distinguishing between enterprises in good financial health and those experiencing difficulties (Munteanu, 2010). Leveraging upon balance sheet dynamics, income statement intricacies, and market indicators, the Altman Z-score remains a formidable toolset for gauging the fiscal soundness and solvency prospects of enterprises, standing as an emblematic figure among accounting-based credit-scoring systems.

The key accounting ratios suggested by Altman can be summarized as follows:

$$X_1 = \frac{Working\ capital}{Total\ assets} \tag{3.17.}$$

X_1 serves as a measure for the enterprise's flexibility, highlighting the proportion of working capital to total assets.

$$X_2 = \frac{Retained\ earnings}{Total\ assets} \tag{3.18.}$$

X_2 alludes to the enterprise's internal financing capacity.

$$X_3 = \frac{EBIT}{Total\ assets} \tag{3.19.}$$

X_3 pertains to the efficacy of asset deployment.

$$X_4 = \frac{Market\ capitalization}{Long\ term\ debt} \tag{3.20.}$$

X_4 characterizes the enterprise's indebtedness through the book value of non-current liabilities. Market capitalization can be described as the absolute value derived upon multiplicating the latest stock price at the end of the current fiscal period by the number of shares outstanding.

$$X_5 = \frac{Sales\ revenue}{Total\ assets} \tag{3.21.}$$

X_5 stands out as an efficiency indicator for assets, encapsulating the turnover of total assets in relation to sales revenue.

Ultimately, the bankruptcy index, commonly known as the Z-score, embodies the composite financial variable calculated as a weighted sum of the previously highlighted financial attributes (Altman E. , 1968).

$$\boldsymbol{Z = 1.2X_1 + 1.4X_2 + 3.3X_3 + 0.6X_4 + 1.0X_5} \tag{3.22.}$$

By integrating the numerical values of the specific financial characteristics, denoted as X, for each scrutinized company into the scoring function, three potential scenarios emerge:

- $Z < 1.81$ – corresponds to a distressed zone ('red zone'), indicating imminent default;
- $1.81 < Z < 2.99$ – corresponds to an inconclusive zone ('grey zone'), pertaining to an overall challenging financial situation, marked by visibly diminished performance;
- $Z > 2.99$ – corresponds to a safe zone ('green zone'), signaling the company's solvency and highly improbable default.

3.1. Earnings before tax and interest (EBIT)

Despite the widespread understanding of globally recognized profit margins among local authorities, the current legislative framework mandates the use of intermediary management balances for evaluating the financial performance of companies. As stipulated by the provisions of the Accounting Law no. 82/1991, expense and revenue accounts are temporarily closed by calculating the financial year's result, which includes current result, exceptional result, and corporate income tax (Parlamentul României, 1991). Consequently, given the standardized format prescribed by the National Agency for Fiscal Administration and the Ministry of Finance for the preparation of annual financial statements, adjustments become imperative in deriving the Altman Z-score to accurately reflect the peculiarities of the Romanian accounting and fiscal framework. To punctually address this issue, several scholars examining credit risk in Romania have proposed utilizing the current result as a proxy for earnings before interest and tax (EBIT) (Pahone, 2006) (Munteanu, 2010) (Pascaru, 2017). As such, the present study also adopts the assumption that EBIT is interchangeable with the current result.

The intermediary management balance termed as the "Current result" is primarily aimed at gauging the overall performance of the company in relation its entire spectrum of current operations. Furthermore, it articulates in a precise and clear manner the efficiency of the financial policy, meticulously considering the structure of financing mechanisms and the quality of the decision-making process. By correlating the operating profit with that related to financial activities, the current result leverages the gap between the firm's current revenues and expenses, also serving as the basis for the calculation of corporate income tax (Căruntu, Tănăsoiu, & Romanescu, 2007). In this context, the targeted indicator facilitates in-depth investigations into the dynamics of the performances recorded across successive financial years, remaining unaffected by exogenous factors or extraordinary events (De La Bruslerie, 2010).

On the contrary, EBIT is determined by deducting non-operational costs from the cumulative value of EBITDA, reflecting the excess generated from industrial and commercial activities (Vernimmen, Quiry, Dallocchi, Le Fur, & Salvi, 2005). In literal terms, it embodies the gross surplus prior to the fulfillment of financial commitments to creditors via interest payments and state remuneration through corporate income tax (Brodersen & Pysh, 2014). Therefore, considering the shared attributes of these two financial performance indicators, domestic scholarly discourse does not preclude the possibility of establishing a correlation between the internationally acknowledged profit margin and the current result used with prevalance in the Romanian fiscal practice. (Răducanu, 2022).

IV. EMPIRICAL FINDINGS

1. Descriptive statistics

1.1. The Merton Distance-to-Default (DD)

Given the unobservable nature of the two parameters V and σ_V, it becomes imperative to calculate first the equity value, also referred to as the market capitalization, and its corresponding volatility. This process unfolds through the assiduous collection of daily stock prices from the BSE Database, thereby facilitating the derivation of log returns and volatilities using Equations (3.12.) and (3.13.), respectively. In this context, it is noteworthy to acknowledge that since log returns are extracted on a daily basis, a transformation of daily volatilities into their annual counterparts is mandated.

In parallel, a thorough organization of yearly financial statements sourced from the Ministry of Finance database for each of the 62 analyzed companies was also conducted. Upon exploiting information pertaining to both the short-term and long-term debt structure, default points were calculated individually using Equation (3.8.). Ultimately, by utilizing the previously derived equity volatility and volatility, E and σ_E, the author solved for asset returns and volatility, thereby concluding the requisite inputs for the distance-to-default formula.

By meticulously combining the previously derived parameters with a suite of constants encapsulating the intracacies of the Romanian stock market and the overaching research goals – Equation (3.9.), the Merton Distance-to-Default was computed for each company on an annual basis, from 2016 to 2022. It is crucial to underscore that while Microsoft Excel sufficed for basic numeric manipulations, additional Python transformations were required for solving the system encompassing Equations (3.4.) and (3.7.), as well as for generating the visual plot. Presented below are the descriptive statistics tables for the Merton Distance-to-Default, offering comprehensive insights into both aggregate trends and yearly variations.

Table 2: Overall descriptive statistics of the Merton Distance-to-Default

	Standard	Premium
Obs	308	126
Mean	17.59	74.33
Std	58,13	223.08
Min	0.00	0.47
Max	606.21	1673.77

Table 3: Yearly descriptive statistics of the Merton Distance-to-Default

	2016	2017	2018	2019	2020	2021	2022
Standard obs	44	44	44	44	44	44	44
Standard mean	34.78	42.86	7.78	6.57	18.69	10.49	7.81
Standard std	74.37	111.85	20.28	9.16	67.55	30.93	20.99
Standard min	0.22	0.12	0.00	0.16	0.04	0.27	0.10
Standard max	376.35	606.21	129.28	52.92	426.42	194.2	126.63
Premium obs	18	18	18	18	18	18	18
Premium mean	100.54	26.13	162.69	134.82	37.89	22.71	26.74
Premium std	223.65	75.46	425.12	286.27	117.02	45.02	46.11

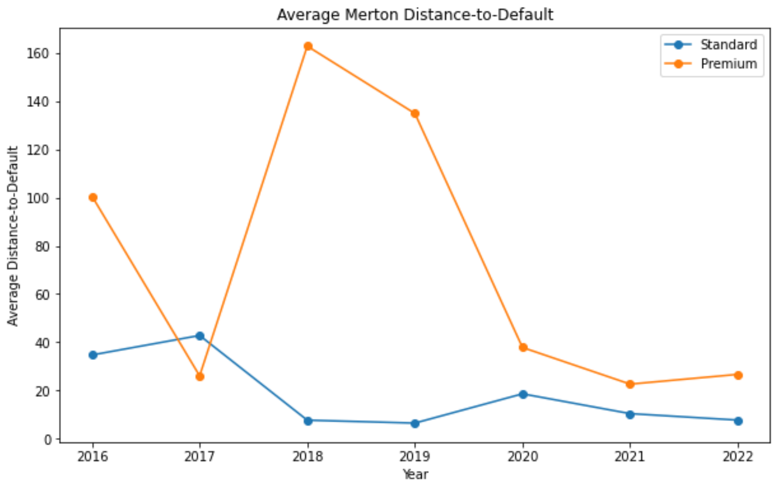
Premium min	1.92	1.22	1.25	1.32	0.47	0.77	0.65
Premium max	906.64	316.00	1673.77	1095.51	499.63	171.76	134.91
Overall obs	62	62	62	62	62	62	62
Overall mean	55.87	37.59	55.04	45.04	24.45	14.09	13.31
Overall std	141.68	101.38	241.73	164.88	84.83	35.71	31.28
Overall min	0.22	0.12	0.00	0.16	0.04	0.27	0.10
Overall max	906.64	606.21	1673.77	1095.51	499.63	194.20	134.91

Leveraging insights gleaned from Table 3, the mean Merton Distance-to-Default for premium shares presents a notable spectrum, fluctuating from 22.71 in 2021 to 134.82 in 2019. The standard deviation showcased dynamic oscillations, spanning from 45.02 in 2021 to 425.12 in 2017. The exceedingly pronounced volatility corresponds to a broader dispersion of values around the mean, thereby contributing to heightened uncertainty in projecting the trajectory of premium companies, based on stock market performance and financial statements analysis. The minimum and maximum Merton Distance-to-Default values for premium companies were 0.47 and 1673.77, respectively, underscoring the diverse risk profiles inherent within the analyzed sectors. While these statistics portray a semblance of resilience and adaptability to external shocks within the financial landscape, a discernible trend of gradual improvement unfolds during the initial phase of the observation period, alluding to the prolific nature of the stock market, as well the increased engagement on behalf of investors and abundant funding opportunities. Nevertheless, indicators of decay begin to manifest as of 2020 amidst the unprecedented challenges posed by the COVID-19 context. Notably, both corporate entities and regulatory authorities swiftly pivot on effectively preventing the contagion's spread, temporarily diverting attention from the stereotypical imperative of fostering sustained economic growth and stability through the perpetual refinement of capitalist mechanisms.

Shifting our focus towards standard companies, a narrower range characterizes the mean Merton Distance-to-Default, with values spanning from 6.57 in 2019 to 42.86 in 2017. In contrast to their premium counterparts, standard shares exhibited a smaller standard deviation, ranging from 9.16 in 2019 to 111.85 in 2017. While this arguably reduced volatility may suggest a higher level of consistency in financial attributes among the scrutinized entities, it becomes imperative to acknowledge that as the sample size increases, there is an equal probability of values clustering more closely around the mean, thereby furnishing stastically more robust insights. Within the standard category, minimum and maximum Merton Distance-to-Default values were documented at 0.00 and 606.21, relatively. Although numerous parallels can be drawn between the evolution of standard companies and their premium counterparts, the considerably diminished values suggest that economic fluctuations, irrespective of their nature, exert a comparatively limited impact on the trajectory of non-premium companies. Therefore, the extent to which between exogenous factors are correlated with the creditworthiness of standard obligors remains subject to debate.

Ultimately, upon a closer examination of the mean Merton Distance-to-Default values, it becomes strikingly evident that the standard group consistently lagged behind their premium counterparts throughout the analyzed period, thereby displaying a heightened risk of default. In this train of thoughts, the priviliged position of premium companies among both investors and credit institutions appears to be firmly anchored in a logical rationale, thereby fostering bold aspirations among standard entities to meet the additional prequisites imposed by the Bucharest Stock Exchange regulatory framework.

Figure 1: Average Merton Distance-to-Default by year



Following a thorough visual examination of the information depicted in Figure 2, discernible patterns emerge in the trajectories of standard and premium companies across the analyzed time span. Despite a significant discrepancy persisting between the two cohorts throughout the entire observation period, premium shares tend to outperform their standard counterparts, as suggested by their higher mean Merton Distance-to-Default values. In this context, it can be inferred that premium entities may capitalize on their reduced default probability to exploit more favorable debt conditions, whereas non-premium obligors are inherently more susceptible to credit risk, thereby struggling with proving their creditworthiness.

However, an intriguing phaenomenon surfaced in 2017, when the theoretically underperforming cohort embarked on an unforeseen positive trajectory, as their premium counterparts recorded the lowest figures throughout the entire scrutiny period. Nevertheless, both the disastrous decline and the increasing proximity to the perilous edge of bankruptcy propelled premium companies towards swift recovery and policy rectification, thereby serving as the premise for achieving landsliding peak performances in the subsequent year.

From another perspective, the pervasive uncertainty triggered by the COVID-19 has left an indelible mark on the more recent evolution of the Romanian financial market. While stock prices inherently plummeted, the national currency experienced heightened volatility and the average interest rate for money market transactions surged to historical highs. Against the backdrop of austerity measures enforced by both the central bank and the government, numerous economic sectors have been profoundly affected. Furthermore, a sentiment of exacerbarted reluctance permeated among investors, as funding options became either scarce or markedly unprofitable. In direct alignment with the current research endeavor, companies within the observed sample reacted poorly to the unprecedented challenges posed by the pandemic context, exhibiting low mean values for the Merton Distance-to-Default, regardless of their financial attributes or previous market performance. In essence, the findings underscore how extreme macroeconomic conditions render both standard and premium entities susceptible to default risk.

Ultimately, 2018 witnessed the largest discrepancy between the two analyzed groups, with premium companies benefiting the most throughout the expansionary phase of the macroeconomic cycle. Conversely, standard entities not only displayed minimal response to the various exogenous factors, but also recorded deteriorating performance due to allegedly inadequate decision-making processes and less favorable contractual terms when seeking external financing.

1.2. The Altman Z-score

Considering the credit-risk model class to which belongs, the Altman Z-score derivation process is characterized by a relative simplicity in comparison to the Merton distance-to-default, albeit demanding a thorough analysis of annual financial statements. Upon meticulously collecting and organizing yearly reports from the Ministry of Finance database for each of the 62 scrutinized companies, the key accounting ratios advocated by E.I. Altman were calculated, adhering to the assumptions tailored to harmonize with the pecularities of Romanian fiscal framework. By combining the identified financial attributes with specific tuning parameters into the Z-score model's weighted average formula – Equation (3.22.), the bankruptcy index was computed for each company on a yearly basis, from 2016 to 2022. It is noteworthy to mention that the numeric transformations were executed using Microsoft Excel, while Python played a pivotal role in generating the line plot. The descriptive statistics tables depicting both aggregate and yearly insights are provided for reference below:

Table 4: Overall descriptive statistics of the Altman Z-score

	Standard	**Premium**
Obs	308	126
Mean	6.29	12.88
Std	10,81	31.81
Min	-1.09	0.63
Max	108.55	231.38

Table 5: Yearly descriptive statistics of the Altman Z-score

	2016	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Standard obs	44	44	44	44	44	44	44
Standard mean	8.46	8.07	5.53	5.13	3.68	5.40	7.75
Standard std	13.48	12.29	9.06	7.07	3.63	5.67	17.43
Standard min	0.25	0.21	-1.09	0.37	0.19	-0.05	0.18
Standard max	56.33	53.63	54.71	40.47	19.36	23.36	108.55
Premium obs	18	18	18	18	18	18	18
Premium mean	14.28	8.93	18.32	23.76	11.03	6.65	7.16
Premium std	38.99	18.39	41.69	56.55	16.23	8.36	7.58
Premium min	1.47	0.90	1.29	0.88	0.81	0.63	1.11
Premium max	169.35	78.68	168.31	231.38	49.99	34.39	22.96
Overall obs	62	62	62	62	62	62	62
Overall mean	10.15	8.32	9.24	10.54	5.81	5.77	7.58
Overall std	23.64	14.17	24.01	31.61	9.69	6.52	15.18

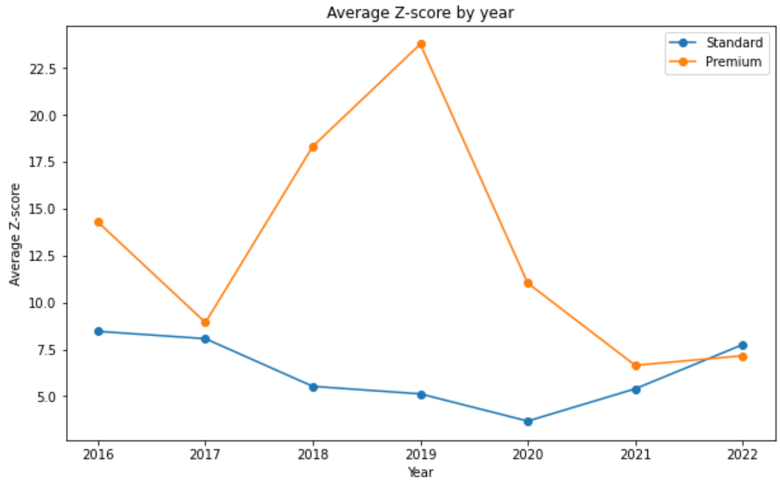
Overall min	0.25	0.21	-1.09	0.37	0.19	-0.05	0.18
Overall max	169.35	78.68	168.31	231.38	49.99	34.39	108.55

As depicted in Table 5, the mean Z-score for premium shares exhibited a discernible range, oscillating from 6.65 in 2021 to 23.76 in 2019. The standard deviation showcasted intriguing fluctuations, spanning from 7.58 in 2022 to 56.55 in 2019. The significantly high dispersion serves as an indicator of the heterogeneity inherent among companies, reflecting the impact of various factors such as size, industry classification and operational experience. The minimum and maximum Z-score values for premium companies were 0.63 and 231.38, respectively. These numerical reflections unveil a narrative of evolving financial health, hinting at a gradual improvement over time as an allusion to the expansionary phase of the economic cycle. Yet, signs of deterioration start to become visible as of 2020, given the global upheaval induced by the COVID-19 pandemic and its reverberating repercussions across multiple sectors worldwide.

As for standard shares, a narrower range was observed for the mean Z-score, with values spanning from 3.68 in 2020 to 8.46 in 2026. The standard deviation exhibited variations from 3.63 in 2020 to 17.43 in 2022, visibly smaller in comparison to their premium counterparts. While this apparent homogeneity pervades the scrutinized entities, the reduced volatility may also be attributed to the notably higher number of standard companies included in the sample. Within this context, the minimum and maximum Z-score values for the standard category were documented at -1.09 and 108.55, relatively. Despite the numerical disparities, similar insights can be gleaned upon assessing the situation of standard companies. An initial phase of improvement is discernible at the onset of the time interval, with more recent years alluding to a turbulent financial landscape, as a result of diminished profitability throughout the lockdown and the subsequent post-pandemic recovery period.

Ultimately, it is imperative to underscore that the standard group persistently displayed a lower mean Z-score across the scrutinized period, indicating a discernibly elevated default risk in contrast to their premium counterparts. In this context, the segregation enforced within the Bucharest Stock Exchange regulatory framework seems to be grounded in a strategic rationale. The stringent criteria mandating a minimum free-float market capitalization, coupled with the prerequisite contractual arrangements with market-makers to bolster share liquidity, closely align with the theoretical aims of enhanced financial health and creditworthiness, respectively.

Figure 2: Average Z-score by year



Upon a close visual inspection of the data portrayed in Figure 2, discernible disparities emerge in the trajectories of standard and premium companies over the analyzed time interval. It becomes strikingly evident that a notable difference between the two cohorts persisted almost throughout the entirity of the 7-year period, with premium shares constantly exhibiting a commendably elevated performance, as suggested by their higher mean Z-score values. In this train of thoughts, one may conclude that premium companies indeed exhibit a lower probability of default, in comparison to their standard counterparts.

However, an intriguing reversal in this trend unfolds in the last financial year, with standard companies marginally surpassing their theoretically superior premium counterparts. Consequently, factors such as the minimal requirements for free-float market capitalization and the contractual obligations with market-makers aimed at enhancing share liquidity exhibited limited efficacy in absorbing the shocks inherent to financial crises, in this particular case the reverberations of the COVID-19 pandemic. In this context, companies appeared vulnerable to default irrespective of their size, industry classification or operational experience. Moreover, aspects such as heightened risk aversion among investors engendered by market uncertainty, rapidly growing double-digit inflation rates, escalating debt servicing costs, declining sales as a result of dwindling consumer expenditure power, as well as various operational and systemic constraints imposed by authorities to prevent the spread of disease seemingly reflected in the overall skewed trading activity.

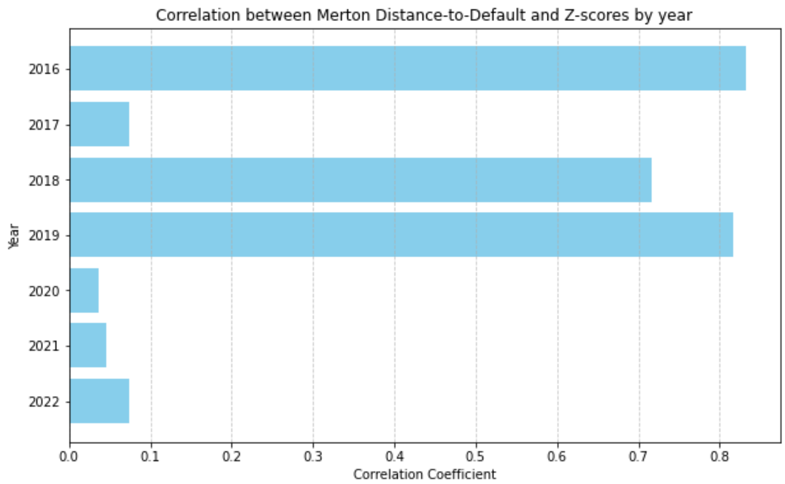
From another perspective, the peak discrepancy between the two scrutinized groups was recorded in 2019, highlighting the premium entities' adaptness at capitalizing on favorable market conditions, thereby outperforming their counterparts during periods of economic prosperity.

2. Correlation analysis

2.1. Correlations trends over time

To further assess the applicability and relevance of credit risk models within the Bucharest Stock Exchange framework, it becomes essential to identify and subsequently characterize the relationship interplay between values derived from the application of the two scrutinized credit-scoring models. The importance of correlation analysis resides in its capacity to validate several assumptions or hypotheses, while isolating the effect of specific variables. Moreover, considering both the theoretical limitations and the challenges inherent in data collection and sample formation when investigating credit risk in Romania, it is also pertinent to evaluate the potential interchangeability of structural and accounting-based models in producing similar outcomes. In this context, Pearson correlations between the Merton Distance-to-Default and the Altman Z-score were computed for all scrutinized companies across the designated time span. Ultimately, the results were interpreted with respect to various factors, including temporal dynamics and corporate status.

Figure 3: Pearson correlation coefficients between the Merton Distance-to-Default and Z-scores by year

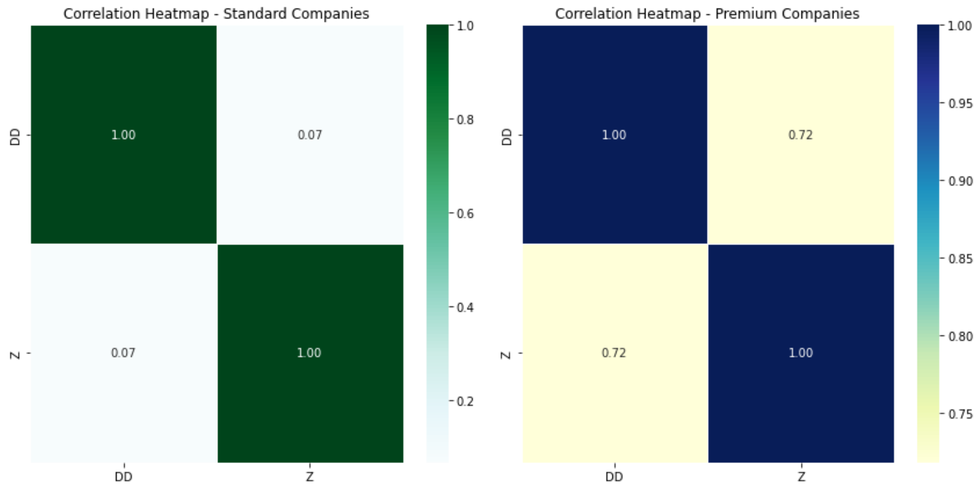


As depicted in Figure 3, a strong positive correlation emerges between the Merton Distance-to-Default and Altman Z-score values during the expansionary phase of the economic cycle. With variables moving in the same direction, pertinent conclusions regarding a company's credit risk exposure can be drawn, irrespective of the adopted methodological approach. Conversely, the low Pearson correlation coefficients observed in more recent years suggest that parallel financial statement and market activity analysis may furnish divergent insights concerning a firm's probability of default. This observations aligns closely with the broad spectrum of repercussions of the COVID-19 crisis, visible at both stock market and macroeconomic levels. In this context, it becomes apparent that amidst periods of extreme volatility structural and accounting-based models tend to react differently to various categories of factors, necessitating further investigations to achieve conclusive results. Nevertheless, it is noteworthy to acknowledge that no negative correlations were recorded, thus the probability of attaining high creditworthiness according to one theoretical model while simultaneously facing an inherent default risk according to the other remaining highly unlikely.

2.2. Correlations patterns across company profiles

Another factor potentially influencing the relationship between Merton Distance-to-Default and Altman Z-score values is the classification of sampled companies based on the Admission Guidelines for equity listing on the Regulated Market of the Bucharest Stock Exchange. Correlation heatmaps illustrating Pearson correlation coefficients for both standard and premium shares are presented are presented below:

Figure 4: Pearson correlation coefficients between the Merton Distance-to-Default and Z-scores by corporate status



Upon a through visual inspection of Figure 4, notable disparities emerge between Merton's structural approach and the Altman accounting-based credit-scoring model in assessing the creditworthiness of standard companies. While the exceedingly low correlation coefficient may partially be attributed to a larger data pool, the increased sample heterogeneity due to operation across diverse industries, vague liquidity prerequisites and conceivably lower market capitalization may also contribute to the inconclusive nature of results for the standard group.

On the contrary, premium shares demonstrated a stronger correlation, thus enhancing the feasibility of utilizing the Merton Distance-to-Default and the Altman Z-score interchangeably when predicting credit risk. This proves extremely useful considering the lacking nature of extensive default databases in Romania, allowing models to be chosen based on data accessibility without compromising subsequent statistical inference. Linking this observation to the findings from the previous section, premium companies encounter a diminished risk of default in comparison to their standard counterparts, with results remaining consistent to a large extent regardless of the methodological approach used.

2.3. Statistical significance of results

Prior to unequivocally accepting the previously derived Pearson coefficients and extrapolating their implications to the entire population, it is equally important to ascertain the statistical significance of the observed relationship between the Merton Distance-to-Default and the Altman Z-score. In this context, p-values will be computed for the observed correlations, factoring in both temporal fluctuations and the segregation of sampled companies into standard and premium categories.

Table 6: p-values for Pearson correlations by year

	p-value
2016	0.012
2017	0.048
2018	0.127
2019	0.064
2020	0.098
2021	0.081
2022	0.186

With p-values exceeding the customary significance threshold ($\alpha = 0.05$), we fail to reject the null hypothesis, thus lacking enough evidence to conclude a true correlation between the variables across the entire population. In this context, the possibility that annual correlations between the Merton Distance-to-Default and Altman Z-score could occur as a result of random variations cannot be excluded. Yet, the relatively high p-value does not inherently imply the absence of a relationship between variables, as factors such as reduced sample size may contribute to insufficient statistical power.

Table 7: p-values for Pearson correlations by corporate status

	p-value
Standard companies	0.289
Premium companies	0.000

With a p-value surpassing the conventional significance level ($p > 0.05$), there is insufficient evidence to reject the null hypothesis at a 95% confidence interval. Consequently, the previously articulated insights explanatory power, as the correlation observed between the Merton Distance-to-Default and Altman Z-score for standard companies may well be attributed to random shocks. The exact opposite can be argued for the premium cohort, considering the exceedingly low probability of encountering such a strong correlation solely by chance. Hence, both structural and account-based credit-scoring models exhibit ample efficacy in evaluating the creditworthiness of premium firms within the designated sample.

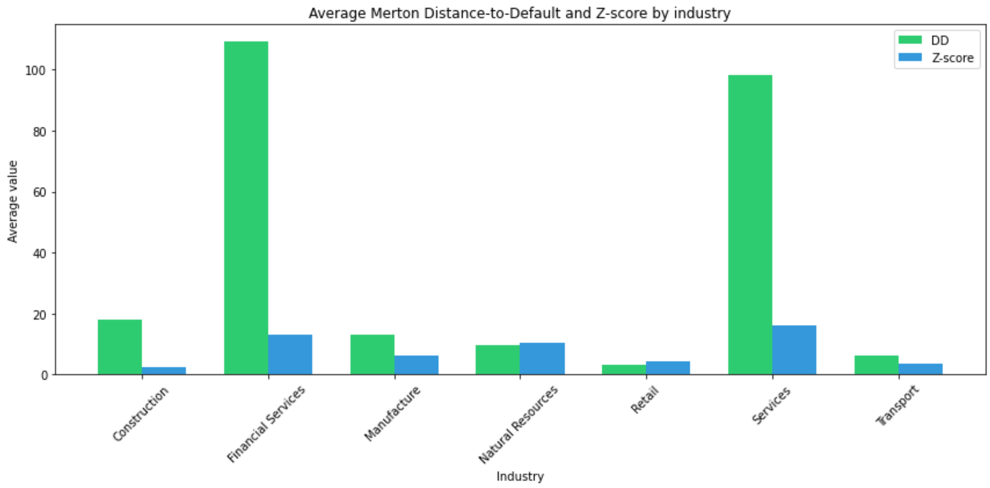
3. Comparative analysis

3.1. Industry classification

While further assessing the applicability of credit risk models within the Bucharest Stock Exchange framework, it becomes imperative to also consider the impact of several financial attributes or theoretical characterics on estimating the probability of default, as outlined by the two methodological approaches utilized throughout this study.

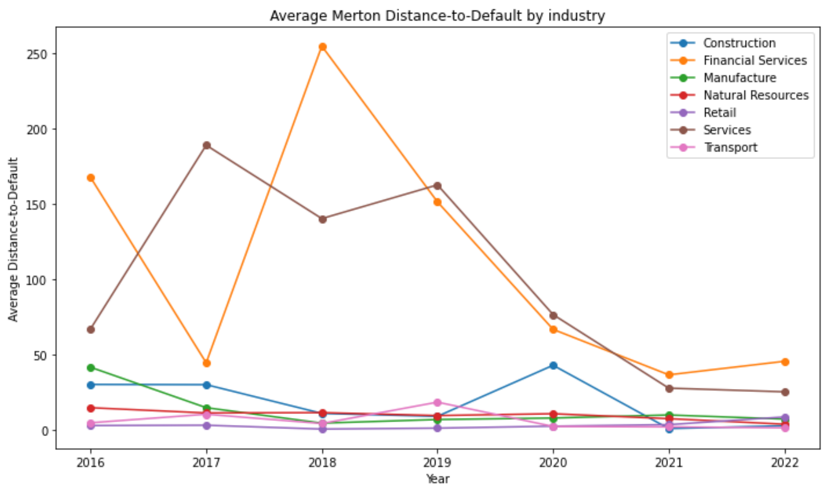
In the initial stage, valuable insights can be gleaned upon segregating companies based on their respective industries. It is noteworthy to acknowledge that the ensuing analysis only accounts for a broad industry classification, with more accurate description provided in Appendix I.

Figure 5: Average Merton Distance-to-Default and Z-score by industry



In alignment with the information presented in Figure 3, companies operating within the service industry exhibit the lowest probability of default, as suggested by their elevated cumulative average values in both the Merton Distance-to-Default and the Altman Z-score. Conversely, the retail sector appears as the most vulnerable to credit risk, beset by constantly evolving consumer preferences, seasonal demand patterns, slender profit margins due to fierce competition, as well as considerable operatonal costs. Furthermore, discernibly reduced values in both indicators were observed within the manufacture, transport and construction sectors. This can largely be attributed to recent shifts in energy pricing, volatility in commodity markets and other additional regulatory compliance costs.

Figure 6: Average Merton Distance-to-Default yearly by industry

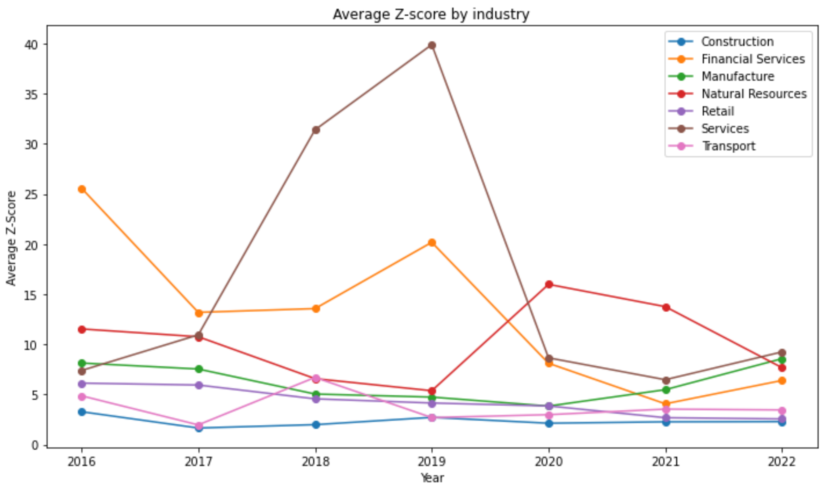


Drawing upon yearly data pertaining to the average Merton Distance-to-Default, distinct patterns emerge in the performance of companies spanning various industries. Remarkably high mean values consistently underscore the service sector’s enduring resilience to default risk, with peak discrepancies from rival cohorts evident in 2017 among entities providing general services and in 2018 within the financial industry.

Upon further investigations, the impact of the COVID-19 pandemic has seemingly reflected in the skewed performance exhibited by companies in more recent years, regardless of their industry classification. Nevertheless, it is noteworthy to acknowledge that the construction, retail and transport sectors borne the heaviest burdens, as they struggled with supply chain disruptions, income declines due to store closures and reduced foot traffic, as well as with mobility restrictions and dwindling consumer confidence in travel safety due to health concerns.

The service sector was not immune to these challenges either, as lockdown measures and social distanticing protocols precipitated substantial revenue losses and widespread layoffs within hospitality businesses. Concurrently, other firms grappled with scarce sponsorship deals, limited access to financing opportunities, along with extreme investor risk aversion due to market unpredictability.

Figure 7: Average Z-score yearly by industry



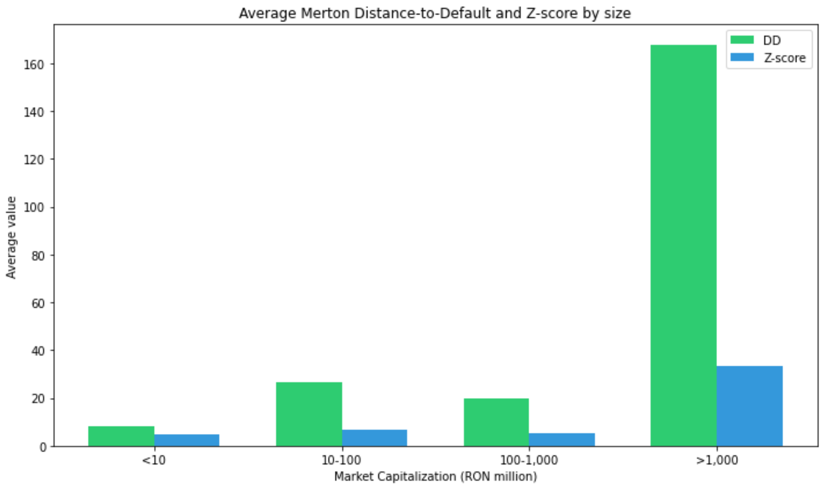
Similar insights can be gleaned upon a thorough visual inspecting of Figure 5, depicting the average Z-score values recorded by companies across various industries. In alignment to the previous observations, the service industry emerged as a cornerstone of stability within the Romanian financial market, exhibiting notably lower susceptibility to bankruptcy.

Nevertheless, in contrast to the structural approach endorsed by Merton, the Altman Z-score underscores an interesting phenomenon – the rapid surge of companies engaged in natural resources extraction, generation and distribution activities during the lockdown. At a second look, the results seem to be rooted in a logical rationale, with energy and utilities experiencing increased demand, due to individuals spending more time indoors. Moreover, the substantial government stimulus measures aimed at infrastructure projects during the COVID-19 era furnished additional opportunities for these companies to secure profitable contracts. Ultimately, amidst prevailing economic uncertainty, natural resources were perceived as hedge investments, thereby infusing dynamism into an ostensibly stagnant stock market.

3.2. Size classification

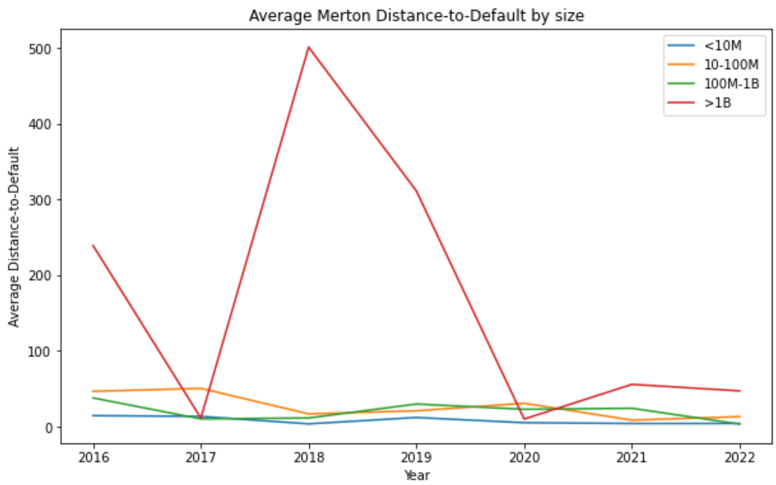
Another factor that could potentially influence credit risk pertains to the the size of the sampled companies. As the Bucharest Stock Exchange Database does not suggest a specific metric for a firm's size, the market capitalization determined as their number of shares outstanding multiplied by their corresponding price on the final trading day emerges as a pertinent proxy for assessing the magnitude of the subject entities.

Figure 8: Average Merton Distance-to-Default and Z-score by market capitalization



Upon a close examination of Figure 6, divergent insights can be argued regarding the influence of market capitalization on determining the probability of default. Specifically, firms amassing substantial total equity deviate significantly from the brink of bankruptcy, showcasing remarkably high cumulative means in both the Merton and Altman Z-score models. On the contrary, no linear relationship between market worth and likelihood of default can be identified for entities falling within the lower and median ranges, rendering largely inconclusive results. In this context, it becomes imperative to consider additional financial attributes or exogenous factors when assessing the creditworthiness for these latter categories.

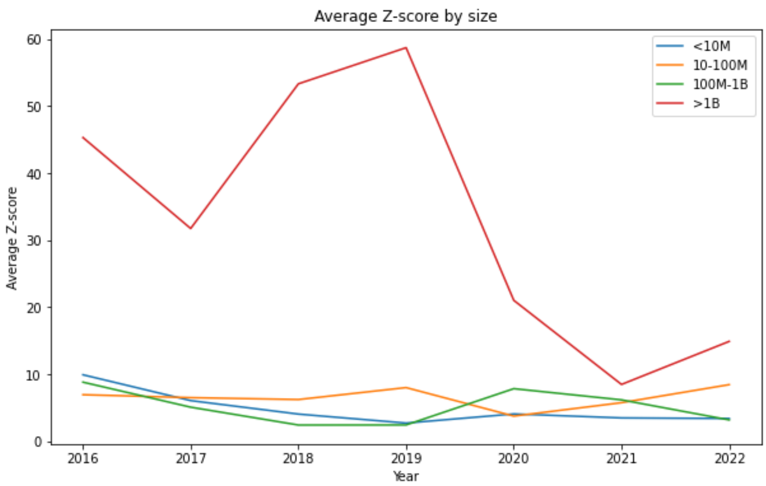
Figure 9: Average Merton Distance-to-Default yearly by market capitalization



When analyzing the annual performance of companies across different market capitalization ranges using the Merton (1974) approach, it becomes evident that extreme equity values act as a safeguard against the threat of bankruptcy, especially during periods of economic prosperity. In this context, the largest gap between firms accumulating total equity exceeding 1 billion RON and their smaller counterparts was observed in 2018.

Conversely, amidst more turbulent financial circumstances, companies collectively exhibited heightened susceptibility to credit risk, irrespective of their market capitalization. This is evidenced by the arguably lower average values for the Merton Distance-to-Default throughout both the lockdown period and the subsequent post-pandemic recovery phase. Nevertheless, despite the inherent challenges posed by the COVID-19 crisis, industry giants persisted in exploiting their competitive advantage, thereby achieving notably superior performances and eclipsing other minor players.

Figure 10: Average Z-score yearly by market capitalization



Following the accounting-based credit-scoring approach, the consideration of size becomes essential when estimating the probability of default among obligors exhibiting exceedingly high market capitalization within the designated sample. While market capitalization is present in the weighted average formula of Altman Z-score, exerting thus direct influence on the bankruptcy index, the findings suggest a direct correlation between total equity value and creditworthiness in the particular case of large firms. Therefore, size may potentially facilitate preferential access to external financing, while instilling greater confidence among institutional investors due to enhanced market visibility and unblemished liquidity. Ultimately, it may grant companies greater flexibility in pursuing strategic initiatives or reacting to dynamic market conditions.

V. FINAL CONSIDERATIONS

1. Theoretical limitations

Beyond speculations concerning the effectiveness of the conducted empirical examinations due to the potentially inadequate sample size and restricted time interval, it also becomes crucial to recognize a spectrum of theoretical limitations and subjective biases that might exert a considerable influence on the relevance and quality of the study. In this train of thoughts, it is essential to approach the research conclusions with mindfulness toward the acknowledged deficiences, thus mitigating the risk of unwarranted overgeneralization.

Considering the theoretical framework of the Merton model, the underlying assumptions may falter in accurately reflecting actual financial phenomena, given the overly simplistic depiction of debt structure, characterized by a singular zero coupon bond, as well as the unrealistic perception of time, whereby default can only occur at time T. By assuming a normal distribution for a company's total assets, along with a fixed corporate debt structure, the model may demonstrate inflexibility in responding to dynamic market conditions. This is because in real-world scenarios, equity valuations do not occur randomly and corporate indebtness typically reflects the current phase of the economic cycle, as well as various endogenous and external factors. In this context, it becomes evident that the Merton model manifests a tendency to underestimate the true probability of default, despite its correct implementation and adequate ranking of scrutinized firms based on the distance-to-default metric. Ultimately, due to its exclusive reliance on stock market information, the methodology is obviously not applicable to non-public entities, regardless of their size and market influence.

As concerning the Altman Z-score model, the weighted average formula may prove inadequate in elucidating certain industry-specific and macroeconomic intricacies. This is primarily due to the fact that, within real-world contexts, the relationship between financial variables cannot be resumed to a linear pattern. Moreover, since financial ratios are assessed at discrete intervals, accounting-based models may be deemed as exceedingly retrospective and intermittent, thereby lacking the flexibility to respond to subtle market dynamics. In this context, the emergence of more sophisticated credit-scoring systems designed to mitigate such theoretical deficiences was not incidental. Eventually, given the considerable weight attributed to the asset turnover, denoted as X_5, the bankruptcy index formula proposed by E. I. Altman may exhibit a potential bias towards manufacturing businesses. As such, companies with lower or zero sales revenue, attributable to their structural composition and presumed economic activity, inherently face elevated default risk.

From another perspective, it is important to acknowledge that both methological approaches were tailored to accommodate the particularities and limitations intrinsic to the Romanian operational framework. While these adjustments encompass common assumptions within domestic scholarly discourse, they do not follow a theoretically established consensus. In this train of thoughts, the utilization of the average interest rate for money market transactions as a substitute for the risk-free rate, along with the equivalence drawn between EBIT and the current result prevalent in Romanian accounting practices, may have contributed to the imprecise application of the considered models. Additionally, in determining the individual default point for each company, the study adheres to a convention wherein $\alpha = 1$ and $\beta = 0.5$. However, this approach overlooks the nuanced intricacies of financial environments and regulatory frameworks across different countries, as well as the disparities present among various industries. Since employing other combinations of tuning parameters for short-term and long-term debt would inevitably yield divergent outcomes, the optimal default point for companies listed on the Bucharest Stock Exchange remains a topic for future reflection.

Ultimately, it is important to underscore a series of issues beyond the author's control that could collectively compromise the integrity of the study. As highlighted throughout the paper, the Romanian financial landscape faces the looming threat of information distortion due to a vaguely ambiguous legislative framework and inadequate supervision on behalf of authorities. In this context, common practices such data manipulation to serve managerial interests, replication of figures from previous years and interpolation of missing values using questionable methods, inevitably result in skewed inputs for both the Merton and Altman Z-score models. Additional inconsistencies may arise during the integration of physically stored databases into institutional platforms, reflecting broad negligence or deficient digital proficiency.

2. Conclusions

Amid contemporary academic discourse, a discernible surge in interest has been noted towards the establishment of increasingly sophisticated credit-scoring systems capable of delivering elevated discriminatory power and precision. In this regard, perspectives confronting the theoretical limitations of existing methodological approaches may be lauded as innovative and forward-looking, whereas inquiries exploring their applicability and relevance in the presence of specific systemic barriers receive comparatively less scholarly attention. Notably, actuarial methods leverage the fulfillment of a broad spectrum of prerequisites, with subsequent empirical investigations mainly focusing on mature financial markets characterized by minimal exogenous constraints.

Within the specific context of Romania, researchers have continuously strived to develop local renditions of internationally acclaimed methodologies, thus providing both academics and industry professionals with a solid conceptual arsenal. Nonetheless, there remains a significant gap in domestic literature when it comes to the implementation of modern credit-scoring systems within the Romanian operational framework. In addition, previous empirical testing attempts seem to have been motivated by personal intrigue, rather than being grounded in objective selection criteria based on comparative performance.

The current paper aims to provide valuable insights by concurrently examining the applicability of both the Merton and Altman Z-score models, underscoring the advantages of a structural approach in contrast to the conventional accounting-based alternative. While serving as a comprehensive guide for stakeholders navigating the intricacies of an emergent financial landscape, the endeavor is also believed to enhance the quality of decision-making processes and the overall perception of risk within the Romanian sphere.

The selection criteria for the two mentioned credit-scoring systems can be attributed to the theoretically superior performance of structural models, the aspiration to evaluate a relevant account-based model amidst the wide range of formulas observed in practice, as well as the availability of numerical inputs, given the public access to both stock market data and annual financial statements. The study examines a sample of 62 companies publicly listed on the Bucharest Stock Exchange over a period of 7 years. While the considered firms vary in terms of size, industry classification and operational experience, they are further segregated into standard and premium categories according to the BSE Admission Guidelines for equity listing. Upon adjusting the original Merton and Altman Z-score theoretical frameworks to accommodate both the particularities and limitations of the Romanian financial market, the distance-to-default and bankruptcy index were computed for the examined dataset.

At first glance, empirical findings suggest a striking congruence in the depiction of reality across both models. Notably, companies within each group become increasingly susceptible to default during economic downturns, while premium stocks consistently display superior performance throughout the observation period. Although the Altman Z-score model is easier to implement due to its exclusive reliance on information retrievable from annual financial reports, its sporadic nature limits its ability to fully capture real-world market dynamics and industry-specific nuances. Conversely, the Merton model delivers a more precise assessment of credit risk, despite entailing a more intricate derivation process and capitalizing on harder to obtain data. Nonetheless, the research serves as evidence for the effective implementation of structural models even within the boundaries of the BSE operational framework. Additionally, extension to other financial markets sharing similar characteristics becomes feasible through subtle modifications in the underlying assumptions.

From another perspective, both models demonstrate considerable predictive power in assessing the premium cohort, with results aligning closely across methodological approaches. On the contrary, findings for standard companies remain to a certain extent inconclusive due to a larger data pool and overall sample heterogeneity. In this context, it can be inferred that the segregation criteria stipulated by the BSE regulatory framework play a crucial role in ascertaining an obligor's creditworthiness.

As concerning the extensive array of exogenous limitations identified throughout the paper – namely the lack of comprehensive default databases, the imperfect and inaccessible nature of information and the tendency for financial documents manipulation or replication due to inadequate regulatory oversight – certain aspects demand unequivocal prioritization by decision-makers. These include the advancement of legislative frameworks to establish institutional databases documenting historical corporate defaults, the implementation of reforms aimed at the systematization and standardization of public interest financial information, as well as the enhancement of oversight mechanisms for local rating agencies. Moreover, it becomes crucial to incentivize these organizations to adopt actuarial approaches that are in alignment with the standards upheld by their internationally recognized counterparts.

While the study holds significant importance, serving as a catalyst for both regulatory bodies and the academic community to adopt clear directives aimed at the perpetual refinement of credit risk assessment processes, the future unveils promising prospects for the extensive implementation of structural models within the Romanian operational landscape. Nevertheless, the realization of this potential hinges on embracing the previously outlined suggestions, thereby facilitating the eventual replacement of traditional accounting-based models. Ultimately, prudence remains a key factor in forging long-term financial stability, complementing the theoretical merits of any credit-scoring system and underpinning success across diverse fields of activity.

References

[1] Acharya, V., Huang, J., Subrahmanyam, M., & Sundaram, R. (2006). When does strategic debt-service matter? *Economic Theory*(29), 363-378. Available at: https://www.jstor.org/stable/25054353. [Accessed 9 March 2024]

[2] Altman, E. (1968). Financial ratios discriminant analysis and the prediction of corporate bankruptcy. *Journal of Finance*, 589-609. Available at: https://www.jstor.org/stable/resrep18592.9. [Accessed 9 March 2024]

[3] Altman, E., & Saunders, A. (1998). Credit risk measurement: Developments over the last 20 years. *Journal of Banking & Finance*(21), 1721-1742. Available at: https://doi.org/10.1016/S0378-4266(97)00036-8. [Accessed 8 March 2024]

[4] Altman, E., Haldeman, R., & Narayanan, P. (1977). Zeta analysis: A new model to identify bankruptcy risk of corporations. *Journal of Banking and Finance*, 29-54. Available at: https://doi.org/10.1016/0378-4266(77)90017-6. [Accessed 26 March 2024]

[5] Anderson, R., & Carverhill, A. (2007). *Liquidity and capital structure*. Center for Economic Policy Research. https://ssrn.com/abstract=997024. [Accessed 9 March 2024]

[6] Anderson, R., & Sundaresan, S. (1996). Design and valuation of debt contracts. *Review of Financial Studies*(9), 37-68. Available at: https://www.jstor.org/stable/ 2962365. [Accessed 9 March 2024]

[7] Anderson, R., & Sundaresan, S. (1996). Design and valuation of debt contracts. *Review of Financial Studies*, 9, 37-68. Available at: https://www.jstor.org/stable/ 2962365. [Accessed 9 March 2024]

[8] Anghel, M. (2011). The Analysis on the Evolution of Capital Market basically in Romania during 1995 - November 2011. *International Journal of Academic Research in Accounting, Finance and Management Sciences*, 1(2), 1-8. Available at: http://dx.doi.org/10.6007/IJARAFMS/v1-i2/9818. [Accessed 23 April 2024]

[9] Anghel, M., & Nicola, Z. (2013). SWOT analysis model of the capital market in Romania. *Romanian Statistical Review*, 1, 203-206. Available at: https://www.revistadestatistica.ro/suplimente/2013/1_2013/srrs1_2013a27.pdf. [Accessed 23 April 2024]

[10] Anghel, M., Popescu, A., Sfetcu, M., & Mirea, M. (2018). Credit risk management and analysis model. *Romanian Statistical Review*(8), 20-28. Available at: https://www.revistadestatistica.ro/supliment/wp-content/uploads/2018/08/rrss_08_ 2018_ -a2_ro.pdf. [Accessed 27 March 2024]

[11] Anghelache, G. (2004). *Capital market. Characteristics. Evolutions. Transactions.* Bucureşti: Editura Economica. [Accessed 23 April 2024]

[12] Anghelache, G., Anghelache, C., Anghel, M., & Chiliment, M. (2018). The evolution of the Romanian capital market. *Romanian Statistical Review*(4), 144-154. Available at: https://www.revistadestatistica.ro/supliment/wp-content/uploads/2018/04/rrss_4 _2018_ A06_ro.pdf.[Accessed 23 April 2024]

[13] Arora, N., Bohn, J., & Zhu, F. (2005). Reduced Form vs. Structural Models of Credit Risk: A Case Study of Three Models. *Journal of Investment Management*, 3(4), 1-41. Available at: https://doi.org/10.1002/9781119201892.ch7. [Accessed 9 March 2024]

[14] Asvanunt, A., Broadie, M., & Sundaresan, S. (2007). *Managing corporate liquidity: Welfare and pricing implications.* Columbia University. Available at: https://doi.org/10.1142/S0219024911006589. [Accessed 9 March 2024]

[15] Benzschawel, T. (2012). *Credit Risk Modeling: Facts, Theory and Applications.* London: Risk Books. [Accessed 8 March 2024]

[16] Bharath, S., & Shumway, T. (2008). Forecasting Default with the Merton Distance to Default Model. *Review of Financial Studies*, 1339-1369. Available at: https://www.jstor.org/stable/40056852. [Accessed 1 May 2024]

[17] Black, F., & Cox, J. (1976). Valuing corporate securities: Some effects of bond indenture provisions. *The Journal of Finance*, 31(2), 351-367. Available at: https://doi.org/10.1111/j.1540-6261.1976.tb01891.x. [Accessed 9 March 2024]

[18] Black, F., & Scholes, M. (1972). The valuation of option contracts and a test of market efficiency. The Journal of Finance, 27(2), 399-417. [Accessed 4 April 2024]

[19] Black, F., & Scholes, M. (1973). The pricing of options and corporate liabilities. *The Journal of Political Economy*, 637-654. Available at: https://www.jstor.org/stable/1831029. [Accessed 8 March 2024]

[20] Brennan, M., & Schwartz, E. (1978). Corporate Income Taxes, Valuation, and the Problem of Optimal Capital Structure. *The Journal of Business*, 51(1), 103-14. Available at: http://dx.doi.org/10.1086/295987. [Accessed 9 March 2024]

[21] Briys, E., & de Varenne, F. (1997). Valuing risky fixed debt: An extension. *Journal of Financial and Quantitative Analysis*(32), 239-248. Available at: https://doi.org/10.2307/2331175. [Accessed 9 March 2024]

[22] Brodersen, S., & Pysh, P. (2014). *Warren Buffett Accounting Book. Reading Financial Statements for Value Investing.* Saxonburg, Pennsylvania, United States: Pylon Publishing LLC. [Accessed 5 May 2024]

[23] Bucharest Stock Exchange. (2023). *General statistics.* Bucharest Stock Exchange. [Accessed 24 April 2024]

[24] Căruntu, G., Tănăsoiu, G., & Romanescu, G. (2007). *Financial Management.* Târgu Jiu, Romania: Editura Academica Brîncuși. [Accessed 5 May 2024]

[25] Castagnolo, F., & Ferro, G. (2014). Models for predicting defaults: Towards efficient forecasts. *Journal of Risk Finance*, 15(1), 52-70. Available at: https://doi.org/10.1108/JRF-08-2013-0057. [Accessed 1 May 2024]

[26] Chen, R., & Fu, H. (2023). *Application of the Merton Model and the Altman Z-score Model in Credit Risk Assessment - an Empirical Study on Chinese Listed Companies.* Lund, Sweden: Lund University, Department of Economics. Available at: https://lup.lub.lu.se/luur/download?func=downloadFile&recordOId=9118955&fileOId=9118972. [Accessed 8 March 2024]

[27] Ciurlău, L. (2007). Credit risk quantifying models. *Finanțe - Provocările viitorului*(6), 234-240. Available at: https://feaa.ucv.ro/finance/fisiere/revista/165901816636_CIURLAU_RO.pdf. [Accessed 27 March 2024]

[28] Codirlaşu, A. (2007). *Financial and currency risk management.* Bucureşti: Academia de Studii Economice Bucureşti - Facultatea de Finanţe, Asigurări, Bănci şi Burse de Valori. [Accessed 27 March 2024]

[29] Codirlașu, A. (2007). *Modelling and measuring credit risk.* Bucharest, Romania: Academia de Studii Economice București, Facultatea de Finanțe, Asigurări, Bănci și Burse de Valori. Available at: http://www.dofin.ase.ro/acodirlasu/lect/riskmgdofin/crriskmod.pdf. [Accessed 8 March 2024]

[30] Crouhy, M., Galai, D., & Mark, R. (2000). A comparative analysis of current credit risk models. *Journal of Banking & Finance*(24), 59-117. Available at: https://doi.org/10.1016/S0378-4266(99)00053-9. [Accessed 8 March 2024]

[31] Dardac, N., & Moinescu, B. (2006). Credit risk quantitative evaluation in the Basel II perspective. *Economie teoretică și aplicată*, 41-46. Available at: http://store.ectap.ro/articole/93.pdf. [Accessed 27 March 2024]

[32] De La Bruslerie, H. (2010). *Analyse financière: Information financière, diagnostic et évaluation.* Paris, France: Dunod. [Accessed 5 May 2024]

[33] Duffee, G. (1999). Estimating the Price of Default Risk. *Review of Financial Studies*, 12(1), 1997-2026. [Accessed 9 March 2024]

[34] Duffie, D., & Singleton, K. (1999). Modeling term structures of defaultable bonds. *Review of Financial Studies*, 12(4), 687-720. Available at: https://www.jstor.org/ stable/2645962. [Accessed 9 March 2024]

[35] Duran, C. (2007). *Aspects regarding the evaluation of risk as a source of decision-making at the firm level.* Timișoara: Editura Politehnica. Available at: https://dspace.upt.ro/jspui/bitstream/123456789/4017/3/BUPT_TD_Duran%20Dan.pdf. [Accessed 27 March 2024]

[36] El Mallouki, L., & Fekkak, F. (2014). *Analyse financière.* Fes, Morocco: Université Sidi Mohamed ben Abdellah. [Accessed 5 May 2024]

[37] Fons, J. (1994, September-October). Using Default Rates to Model the Term Structure of Credit Risk. *Financial Analysts Journal*, pp. 25-32. Available at: https://doi.org/10.2469/faj.v50.n5.25. [Accessed 10 March 2024]

[38] Georgescu, A., & Dudian, M. (2008). Romanian capital market - PEST and SWOT analyses. *The annals of the University of Oradea - Economic sciences series*, 32. [Accessed 23 April 2024]

[39] Hart, O., & Moore, J. (1994). A theory of debt based on inalienability of human capital. *Quarterly Journal of Economics*(109), 841-879. Available at: https://doi.org/10.2307/2118350. [Accessed 9 March 2024]

[40] Hart, O., & Moore, J. (1998). Default and renegotiation: A dynamic model of debt. *Quarterly Journal of Economics*(113), 1-41. Available at: https://doi.org/10.1162/003355398555496. [Accessed 9 March 2024]

[41] Hull, J. (2023). *Risk Management and Financial Institutions.* Wiley Finance. [Accessed 4 April 2024]

[42] Hull, J., & White, A. (2000). *Valuing Credit Default Swaps I: No Counterparty Default Risk.* NYU Working Paper no. FIN-00-021. Available at: https://doi.org/10.3905/jod.2000.319115. [Accessed 9 March 2024]

[43] Hull, J., Nelken, I., & White, A. (2005). Merton's Model, Credit Risk and Volatility Skews. *The Journal of Credit Risk*, 1(1), 1-27. Available at: https://doi.org/10.21314/JCR.2005.004. [Accessed 4 April 2024]

[44] Ionescu, A. (2004). *Portfolio management*. București: Editura Era. [Accessed 19 April 2024]

[45] Jarrow, R. (2009). Credit Risk Models. *Annual Review of Financial Economics*, 1, 37-68. Available at: https://doi.org/10.1146/annurev.financial.050808.114300. [Accessed 8 March 2024]

[46] Jarrow, R., & Turnbull, S. (1995). Pricing derivatives on financial securities subject to credit risk. *Journal of Finance*, 50(1), 53-85. Available at: https://doi.org/ 10.1111/j.1540-6261.1995.tb05167.x. [Accessed 9 March 2024]

[47] Jones, E., Mason, S., & Rosenfeld, E. (1984). Contingent Claims Analysis of Corporate Capital Structures: An Empirical Investigation. *Journal of Finance*, 39(3), 611-25. Available at: https://doi.org/10.2307/2327919. [Accessed 9 March 2024]

[48] Kealhofer, S. (1995). Managing default risk in portfolios of derivatives. *Derivative Credit Risk, Ch. 4*, 49-66. [Accessed 9 March 2024]

[49] Khindanova, I., Knoch, M., Rachev, S., & Schwartz, E. (1999). Stable Models in Credit Risk. *8th Symposium on Finance, Banking, and Insurance* (pp. 1-9). Universität Karlsruhe (TH). Available at: https://doi.org/10.1016/S0895-7177(01)00129-7. [Accessed 9 March 2024]

[50] Kim, I., Ramaswamy, K., & Sundaresan, S. (1993). Does default risk in coupons affect the valuation of corporate bonds? A contingent claims model. *Financial Management*, 117-131. Available at: https://doi.org/10.2307/3665932. [Accessed 9 March 2024]

[51] Laajimi, S. (2012). Structural Credit Risk Models: A Review. *Assurances et gestion des risques / Insurance and Risk Management*, 80(1), 53-93. Available at: https://doi.org/ 10.7202/1091998ar. [Accessed 8 March 2024]

[52] Lawrence, E., Smith, S., & Rhoades, M. (1992). An analysis of default risk in mobile home credit. *Journal of Banking and Finance*, 299-312. Available at: https://doi.org/10.1016/ 0378-4266(92)90016-S. [Accessed 9 March 2024]

[53] Leland, H. (1994). Corporate debt value, bond covenants, and optimal capital structure. *Journal of Finance*, 49(4), 1213-1252. Available at: https://doi.org/10.2307/2329184. [Accessed 9 March 2024]

[54] Leland, H., & Toft, K. (1996). Optimal capital structure, endogenous bankruptcy, and the term structure of credit spreads. *Journal of Finance*, 51(3), 987-1019. Available at: https://ssrn.com/abstract=3372950. [Accessed 9 March 2024]

[55] Longstaff, F., & Schwartz, E. (1995). A simple approach to valuing risky fixed and floating rate debt. *The Journal of Finance*, 50(3), 789-819. Available at: https://ssrn.com/ abstract=5843. [Accessed 9 March 2024]

[56] Martin, D. (1977). Early warning of bank failure: A logit regression approach. *Journal of Banking and Finance*, 249-276. Available at: https://doi.org/10.1016/0378-4266(77) 90022-X. [Accessed 9 March 2024]

[57] McKinsey. (1993). Special report on "The new world of financial services". *The McKinsey Quarterly*(2). [Accessed 9 March 2024]

[58] Mella-Barral, P. (1999). The dynamics of default and debt reorganization. *Review of Financial Studies*(12), 535-578. Available at: https://www.jstor.org/stable/2646071. [Accessed 9 March 2024]

[59] Mella-Barral, P., & Perraudin, W. (1997). Strategic debt service. *Journal of Finance*(52), 531-556. Available at: https://doi.org/10.2307/2329489. [Accessed 9 March 2024]

[60] Merton, R. (1973). Theory of Rational Option Pricing. *Bell Journal of Economics and Management Science*, 4(1), 141-183. Available at: https://doi.org/10.2307/3003143. [Accessed 8 March 2024]

[61] Merton, R. (1974). On the Pricing of Corporate Debt: The Risk Structure of Interest Rates. *The Journal of Finance*, 29(2), 449-470. Available at: https://doi.org/10.1111/j.1540-6261.1974.tb03058.x.[Accessed 4 April 2024]

[62] Michalíková, K., Spuchľáková, E., & Cúg, J. (2014). A Comparative Anatomy of Credit Risk Models. *2014 2nd International Conference on Economics and Social Science* (pp. 69-74). Žilina: Department of Economics, Faculty of Operations and Economic of Transport and Communications, University of Žilina. Available at: https://www.researchgate.net/profile/Viktor-Dengov/publication/288373433_Credit_Risk_and_its_Evaluation/links/5ef618e5a6fdcc4ca431420d/Credit-Risk-and-itsEvaluation.pdf#page=82. [Accessed 9 March 2024]

[63] Ministry of Justice - National Office for Trade Registry. (2007). *Classification of Economic Activities - CAEN Rev. 2 - Explanatory Notes*. Bucharest: Ministry of Justice. [Accessed 4 May 2024]

[64] Munteanu, G. (2010). Methods of analyzing default risk. *Romanian Statistical Review* (12). Available at: https://www.revistadestatistica.ro/Articole/2010/A3_ro_12_2010.pdf. [Accessed 27 March 2024]

[65] Nagy, C., Ghica, E., & Tipărescu, C. (2023). Theoretical notions regarding default risk. *Drepturile persoanei în lumina jurisprudenței naționale : În honorem profesor Andrei Smochină*, 306-319. Available at: https://ibn.idsi.md/sites/default/files/imag_file/Volum_In_honorem_%2BAndrei_Smochina_2023_0.pdf. [Accessed 19 April 2024]

[66] National Bank of Romania. (2006). *Norm no. 9/2006 amending the National Bank of Romania's Norms no. 12/2003 regarding the supervision of solvency and large exposures of credit institutions*. Monitorul Oficial. [Accessed 19 April 2024]

[67] National Bank of Romania. (2013). *Regulation no. 3/2013 amending and supplementing Regulation of the National Bank of Romania no. 31/2011 regarding the reporting of statistical data and information to the National Bank of Romania*. Bucharest: Official Gazette of Romania. [Accessed 4 May 2024]

[68] Pahone, C. (2006). Bankruptcy Risk Estimation in Firm's Activity. *Iaşi University of Life Science Scientific Papers Journal - Horticulture Series*, 49, 247-252. Available at: https://www.uaiasi.ro/revista_horti/files/Nr_2006/vol_49_2006%20(45).pdf. [Accessed 5 May 2024]

[69] Parlamentul României. (1991). *Accounting Law no. 82/1991*. Bucharest: Official Gazette of Romania. [Accessed 13 March 2024]

[70] Parlamentul României. (2004). *Law no. 359/2004 regarding the simplification of formalities for registration in the trade registry of natural persons, family associations, and legal entities, their fiscal registration, as well as the authorization of legal entities' operation*. Bucharest: Official Gazette of Romania. [Accessed 4 May 2024]

[71] Parlamentul României. (2006). *Regulation no. 1/2006 concerning issuers and securities transactions*. Bucharest: Official Gazette of Romania. [Accessed 21 March 2024]

[72] Pascaru, S. (2017). Presentation of bankruptcy risk assessments models through the lens of anti-crisis management. *Meridian Ingineresc*(1), 89-92. Available at: 005.52: 005.334:658.14/.15. [Accessed 5 May 2024]

[73] Platt, H., & Platt, M. (1991). A note on the use of industry-relative ratios in bankruptcy prediction. *Journal of Banking and Finance*, 1183-1194. Available at: https://doi.org/10.1016/0378-4266(91)90057-S. [Accessed 9 March 2024]

[74] Radu, S. (2015). *Trends and perspectives in the capital market evolution*. Bucureşti: Editura Pro Universitaria. [Accessed 23 April 2024]

[75] Răducanu, F. (2022). Model of the diagnosis of profitability of the enterprise. *Romanian Statistical Review(Supplement no. 6)*, pp. 154-163. Available at: https://www.revistadestatistica.ro/supliment/wp-content/uploads/2022/07/rrss06_ 2022_08_en.pdf. [Accessed 5 May 2024]

[76] Reinwald, R. (2021). Comparing reduced form vs. structural models in measuring and managing credit portfolio risks - a comprehensive meta–analysis. *Przedsiębiorstwo & Finanse*(1), 65-81. Available at: http://cejsh.icm.edu.pl/cejsh/element/bwmeta1.element.ojs-issn-2084-1361-year-2021-issue-1-article-a547c5a0-b9ba-347e-8db4-80d34f5e7fce. [Accessed 9 March 2024]

[77] Ross, S. (2005). Capital structure and the cost of capital. *Journal of Applied Finance*, 15(1), 5-23. Available at: https://ssrn.com/abstract=765584. [Accessed 9 March 2024]

[78] Sommerville, R., & Taffler, R. (1995). Banker judgement versus formal forecasting models: The case of country risk assessment. *Journal of Banking and Finance*, 281-297. Available at: https://doi.org/10.1016/0378-4266(94)00051-4. [Accessed 9 March 2024]

[79] Spuchľáková, E., Frajtová Michalíková, K., & Birtus, M. (2014). Credit Risk Measurement. *2014 2nd International Conference on Economics and Social Science* (pp. 75-79). Žilina: University of Žilina, Faculty of Operation and Economics of Transport and Communications, Department of Economics. Available at: https://www.researchgate.net/profile/Viktor-Dengov/publication/288373433_Credit_Risk_and_its_Evaluation/links/5ef618e5a6fdcc4ca431420d/Credit-Risk-and-its-Evaluation.pdf#page=82. [Accessed 8 March 2024]

[80] Sudacevschi, M. (2014). Credit risk management in Romanian banks. *Managementul Intercultural*, XVI(1), 248-253. Available at: https://seaopenresearch.eu/Journals/articles/MI_30_25.pdf. [Accessed 19 April 2024]

[81] Vernimmen, P., Quiry, P., Dallocchi, M., Le Fur, Y., & Salvi, A. (2005). *Corporate Finance. Theory and Practice*. Chichester, West Sussex, England: John Wiley & Sons Ltd. [Accessed 5 May 2024]

[82] Weigel, D., & Gemmill, G. (2006). What drives credit risk in emerging markets? The roles of country fundamentals and market co-movements. *Journal of International Money and Finance*(25), 476-502. Available at: https://doi.org/10.1016/j.jimonfin.2006.01.006. [Accessed 9 March 2024]

[83] West, R. (1985). A factor-analytic approach to bank condition. *Journal of Banking and Finance*, 253-266. Available at: https://doi.org/10.1016/0378-4266(85)90021-4. [Accessed 9 March 2024]

[84] Wilson, T. (1987, September). Portfolio credit risk I. *Risk*, 10(9). [Accessed 9 March 2024]

[85] Wilson, T. (1997, October). Portfolio credit risk II. *Risk*, 10(10). [Accessed 9 March 2024]

[86] Zamore, S., Djan, K., Alon, I., & Hobdari, B. (2018). Credit Risk Research: Review and Agenda. *Emerging Markets Finance and Trade*, 6-18. Available at: https://doi.org/10.1080/1540496X.2018.1433658. [Accessed 8 March 2024]

Appendix I

Table 8: Sample list. Premium companies

Symbol	ISIN[1]	Name	Fiscal Code (CUI[2])	CAEN[3]	Industry	Category
ATB	ROATBI ACNOR9	ANTIBIOTICE S.A.	1973096	2110	Pharmaceuticals Manufacture	Premium
BIO	ROBIOF ACNOR9	BIOFARM S.A.	341563	2120	Pharmaceuticals Manufacture	Premium
BRK	ROBRKO ACNOR0	SSIF BRK FINANCIAL GROUP S.A.	6738423	6612	Financial Services	Premium
BVB	ROBVBA ACNOR0	BURSA DE VALORI BUCURESTI S.A.	17777754	6611	Financial Services	Premium
COTE	ROCOTE ACNOR7	CONPET S.A.	1350020	4950	Pipeline Transport	Premium
EL	ROELEC ACNOR5	SOCIETATEA ENERGETICA ELECTRICA S.A.	13267221	7022	Management Consultancy Services	Premium
ELMA	ROELMA ACNOR2	ELECTRO-MAGNETICA S.A.	414118	2651	Navigation Instruments Manufacture	Premium
FP	ROFPTA ACNOR5	FONDUL PROPRIETATEA	18253260	6430	Trusts and Funds Financial Entities	Premium
IMP	ROIMPC ACNOR0	IMPACT DEVELOPER & CONTRACTOR S.A.	1553483	4110	Construction	Premium
INFINI TY	ROSIFEA CNOR4	INFINITY CAPITAL INVESTMENTS S.A.	4175676	6499	Other Financial Services	Premium
LION	ROSIFAA CNOR2	LION CAPITAL S.A.	2761040	6499	Other Financial Services	Premium
SIF4	ROSIFDA CNOR6	SIF MUNTENIA S.A.	3168735	6499	Other Financial Services	Premium
SNG	ROSNGN ACNOR3	S.N.G.N. ROMGAZ S.A.	14056826	620	Natural Gas Extraction	Premium
SNN	ROSNNE ACNOR8	S.N. NUCLEAR-ELECTRICA S.A.	10874881	3511	Electric Power Generation and Distribution	Premium

[1] As per the ISO 6166 definition, the International Securities Identification Number (ISIN) code represents the international identifier allocated to securities, composed of 12 alphanumeric characters, uniquely identifying a securities issue (National Bank of Romania, 2013).

[2] According to Article 8, paragraph 1 of Law no. 359/2004, upon the registration of a company, a registration certificate is issued, which includes the registration number in the trade registry and the unique fiscal registration code (CUI) assigned by the Ministry of Public Finance (Parlamentul României, 2004).

[3] For the purpose of organizing information related to economic and social activities, as well as completing official documents whenever specifying an activity is required, the names of classification entities - activity classes - provided for in Order no. 337/20.04.2007 issued by the President of the National Institute of Statistics regarding the updating of the Classification of Economic Activities - CAEN, published in the Official Gazette of Romania, Part I, no. 293 dated May 3, 2007, shall be utilized (Ministry of Justice - National Office for Trade Registry, 2007).

SNP	ROSNPP ACNOR9	OMV PETROM S.A.	1590082	610	Petroleum Extraction	Premium
TEL	ROTSEL ACNOR9	C.N.T.E.E. TRANS-ELECTRICA	13328043	3512	Electric Power Generation and Distribution	Premium
TGN	ROTGNT ACNOR8	S.N.T.G.N. TRANSGAZ S.A.	13068733	4950	Pipeline Transport	Premium
TRAN SI	ROSIFCA CNOR8	TRANSILVANIA INVESTMENTS ALLIANCE S.A.	3047687	6499	Other Financial Services	Premium

Table 9: Sample list. Standard companies

Symbol	ISIN	Name	Fiscal Code (CUI)	CAEN	Industry	Category
AAG	ROAAGE ACNOR7	S.C AAGES S.A.	1196550	2711	Electric Equipment Manufacture	Standard
ALT	ROALTC ACNOR1	ALTUR S.A.	1520249	2932	Vehicle Parts Manufacture	Standard
ARM	ROARM AACNOR 7	ARMATURA S.A.	199001	2814	General Purpose Machinery Manufacture	Standard
BCM	ROBUCM ACNOR5	CASA DE BUCOVINA-CLUB DE MUNTE	10376500	5510	Hotels and Accommodation	Standard
BNET	ROBNET ACNOR1	BITTNET SYSTEMS S.A.	21181848	6202	Computer Programming Consultancy	Standard
BRM	ROBEMA ACNOR3	BERMAS S.A.	723636	1105	Beverage Manufacture	Standard
CAOR	ROCAOR ACNOR9	SIF HOTELURI S.A.	56150	5630	Beverage Serving	Standard
CBC	ROCBCH ACNOR3	CARBOCHIM S.A.	201535	2391	Abrasive Products Manufacture	Standard
CEON	ROCEON ACNOR0	CEMACON S.A.	677858	2332	Building Materials Manufacture	Standard
CMCM	ROCMC MACNO R0	COMCM S.A. CONSTANTA	1868287	2363	Building Materials Manufacture	Standard
CMF	ROCMBF ACNOR6	COMELF S.A.	568656	2892	Other Special Purpose Machinery Manufacture	Standard
CMP	ROCMPS ACNOR9	COMPA S.A.	788767	2932	Vehicle Parts Manufacture	Standard
CNTE	ROCNTE ACNOR9	CONTED S.A.	622445	1413	Wearing Apparel Manufacture	Standard
COMI	ROCOMI ACNOR3	CONDMAG S.A.	1100008	4221	Utility Projects Construction	Standard
CRC	ROCHOB ACNOR8	CHIMCOMPLEX BORZESTI S.A. ONESTI	960322	2013	Chemicals Manufacture	Standard

ECT	ROELBO ACNOR6	GRUPUL INDUSTRIAL ELECTRO-CONTACT S.A.	607321	2712	Electric Equipment Manufacture	Standard
EFO	ROEFRIA CNOR6	TURISM, HOTELURI, RESTAURANTE MAREA NEAGRA S.A.	2980547	5510	Hotels and Accommodation	Standard
ELGS	ROELGS ACNOR6	ELECTRO-ARGES S.A. CURTEA DE ARGES	156027	2751	Domestic Appliances Manufacture	Standard
ELJ	ROELJB ACNOR6	ELECTRO-APARATAJ S.A.	51	2712	Electric Equipment Manufacture	Standard
IARV	ROIARV ACNOR1	IAR S.A. Brasov	1132930	3030	Air and Spacecraft Machinery Manufacture	Standard
M	ROMEDL ACNOR6	Med Life S.A.	8422035	8622	Medical and Dental Activities	Standard
MCAB	ROMCAB ACNOR7	ROMCAB S.A.	7947193	2731	Wiring and Wiring Devices Manufacture	Standard
MECE	ROMECE ACNOR3	MECANICA FINA S.A.	655	6420	Holding Companies Activities	Standard
MECF	ROMECF ACNOR0	MECANICA CEAHLAU	2045262	2830	Agricultural and Forestry Machinery Manufacture	Standard
OIL	ROOILT ACNOR9	OIL TERMINAL S.A.	2410163	5224	Support Activities for Transportation	Standard
PPL	ROPRLA ACNOR7	PROMATERIS S.A.	108	2229	Plastic Products Manufacture	Standard
PREH	ROPREH ACNOR7	PREFAB S.A.	1916198	2361	Building Materials Manufacture	Standard
PTR	ROPESA ACNOR0	ROMPETROL WELL SERVICES S.A.	1346607	910	Petroleum and Natural Gas Extraction	Standard
RMAH	RORMA HACNOR 2	FARMACEUTICA REMEDIA S.A.	2115198	4773	Pharmaceuticals Retail	Standard
ROCE	ROROCE ACNOR1	ROMCARBON S.A.	1158050	2222	Plastic Products Manufacture	Standard
RPH	ROIAFR ACNOR4	ROPHARMA S.A.	1962437	4773	Pharmaceuticals Retail	Standard
RRC	ROPTRM ACNOR5	ROMPETROL RAFINARE S.A.	1860712	1920	Refined Petroleum Products Manufacture	Standard
SCD	ROSCDB ACNOR8	ZENTIVA S.A.	336206	2120	Pharmaceuticals Manufacture	Standard

SNO	ROSAUV ACNOR4	SANTIERUL NAVAL ORSOVA S.A.	1614734	3011	Ships and Boats Manufacture	Standard
SOCP	ROSOCP ACNOR5	SOCEP S.A.	1870767	5224	Support Activities for Transportation	Standard
STZ	ROSTZO ACNOR8	SINTEZA S.A.	67329	2014	Chemicals Manufacture	Standard
TBM	ROTBMB ACNOR9	TURBO-MECANICA S.A.	3156315	3030	Air and Spacecraft Machinery Manufacture	Standard
TRP	ROTRPL ACNOR7	TERAPLAST S.A.	3094980	2221	Plastic Products Manufacture	Standard
TUFE	ROTUFE ACNOR7	TURISM FELIX S.A.	108526	5510	Hotels and Accommodation	Standard
UAM	ROUAMT ACNOR1	UAMT S.A.	54620	2932	Vehicle Parts Manufacture	Standard
UCM	RORESY ACNOR6	UCM RESITA S.A.	1056654	2811	General Purpose Machinery Manufacture	Standard
UZT	ROUZTE ACNOR5	UZTEL S.A.	1352846	2892	Other Special Purpose Machinery Manufacture	Standard
VESY	ROVESY ACNOR8	VES S.A.	1223604	2599	Other Metal Products Manufacture	Standard
VNC	ROVRJU ACNOR7	VRANCART S.A.	1454846	1721	Paper Articles Manufacture	Standard