Primljeno/Submitted: 27.04.2026.
Prihvaćeno/Accepted: 07.05.2026.

Izvorni znanstveni rad
Original scientific paper

APPLICATION OF THE CA SCORE MODEL TO ENTERPRISES OF BOSNIA AND HERZEGOVINA

PRIMJENA CA SCORE MODELA NA PREDUZEĆIMA BOSNE I HERCEGOVINE

Selma Vidimlić*
Saudin Terzić**

ABSTRACT

This study examines the predictive performance of the CA Score model on a sample of 392 small and medium-sized enterprises (SMEs) operating in Bosnia and Herzegovina. Based on financial statements for 2021 obtained from the Financial Information Agency (FIA), firms were classified into two groups: those that maintained business continuity during 2022–2023 and those that experienced financial distress, defined as transaction account blockage exceeding 30 days.

The results indicate that the CA Score model achieves an overall classification accuracy of 65.82%, suggesting moderate predictive capability. The model performs slightly better in identifying financially stable firms than distressed ones, with limited sensitivity in detecting high-risk enterprises.

The findings highlight that the model's reduced effectiveness is largely driven by structural characteristics of transition economies, including weak payment discipline, distortions in financial reporting, and inconsistent enforcement of insolvency regulations. These factors significantly limit the reliability of financial ratio-based models developed in advanced market economies.

Keywords: financial indicators; failure prediction; financial statements; CA Score; SMEs; insolvency.

SAŽETAK

U radu je analizirana primjenjivost CA Score modela na uzorku od 392 mala i srednja preduzeća u Bosni i Hercegovini. Na osnovu finansijskih izvještaja za 2021. godinu, preduzeća su klasifikovana u dvije grupe: ona koja su zadržala kontinuitet poslovanja u periodu 2022–2023. i ona koja su imala finansijske poteškoće, definisane blokadom transakcijskih računa dužom od 30 dana.

* Assistant Proffesor, University „VITEZ“, e-mail:selma.vidimlic@unvi.edu.ba
** Indirect Taxation Authority BiH, e-mail: saudin.terzic@uino.gov.ba

Rezultati pokazuju da model ostvaruje ukupnu tačnost klasifikacije od 65,82%, što ukazuje na umjerenu prediktivnu sposobnost. Model je uspješniji u identifikaciji stabilnih nego rizičnih preduzeća.
Ograničenja modela proizlaze iz specifičnosti tranzicijskog okruženja, uključujući slabu finansijsku disciplinu, nepouzdano finansijsko izvještavanje i nedosljednu primjenu insolventnog zakonodavstva, što umanjuje njegovu primjenjivost.

Ključne riječi: finansijski pokazatelji; predviđanje neuspjeha; finansijski izvještaji; CA Score; MSP; insolventnost.

1. INTRODUCTION

Over the past several decades, extensive research has been conducted on the prediction of corporate financial distress and bankruptcy. This field of study has attracted significant attention from various stakeholders, including investors, financial institutions, suppliers, and business partners, all of whom aim to reduce exposure to credit and operational risk. Initially, empirical studies focused predominantly on large corporations; however, the scope of research has gradually expanded to include small and medium-sized enterprises (SMEs), which are widely recognized as key drivers of economic growth and employment.

A substantial body of literature has developed various statistical and econometric models for predicting business failure, primarily based on financial ratios derived from corporate financial statements. Early foundational studies, such as those by Beaver (1966), introduced univariate financial ratio analysis as a tool for identifying early warning signals of financial distress. Subsequently, Altman (1977) developed the Z-score model, which employed multivariate discriminant analysis and demonstrated high predictive accuracy in forecasting corporate bankruptcy. Later contributions, including Ohlson (1980), introduced logistic regression as an alternative methodological framework, further enhancing the analytical robustness of bankruptcy prediction models.

Despite their methodological sophistication, most of these models were developed and validated in advanced market economies, where institutional frameworks, financial reporting standards, and market efficiency differ significantly from those in transition economies. Consequently, the external validity and predictive performance of these models in developing and transition contexts remain an open empirical question.

Recent studies have increasingly focused on SMEs, particularly in emerging and transition economies, where financial instability, market imperfections, and institutional weaknesses may significantly affect the reliability of conventional prediction models. Empirical evidence from various countries suggests that widely used models such as Altman's Z-score, Ohlson's O-score, and other discriminant or logistic-based approaches exhibit reduced predictive accuracy when applied outside their original context (e.g., Šarlija & Jeger, 2011; Salkić, 2013; Muminović, 2011).

In Bosnia and Herzegovina, previous research has similarly indicated that standard bankruptcy prediction models provide only partial explanatory and predictive power when applied to SMEs operating under transition economy conditions. These limitations are primarily attributed to structural economic characteristics such as delayed payment discipline,

inconsistent financial reporting practices, underdeveloped capital markets, and weak enforcement of insolvency regulations. As a result, the financial behavior of firms in such environments may not fully correspond to the assumptions underlying classical prediction models.

Given these limitations, there is a clear need for further empirical investigation into the applicability and robustness of established bankruptcy prediction models in transition economies. This study contributes to the existing literature by examining the predictive performance of the CA Score model on a sample of SMEs in Bosnia and Herzegovina. In particular, the research evaluates whether the model, originally developed for small Canadian firms, can be effectively applied in a structurally different institutional and economic environment.

The study is guided by the following research hypothesis:

The CA Score model, with certain limitations, is applicable for predicting financial distress among SMEs in transition economies.

To test this hypothesis, a sample of 392 SMEs is analyzed, and model performance is evaluated by comparing predicted classifications with actual financial distress outcomes. In addition, the study contextualizes the findings by comparing them with prior empirical evidence from both developed and transition economies.

The remainder of the paper is structured as follows. The next section presents a review of relevant literature on bankruptcy prediction models. This is followed by a description of the data, methodology, and sample characteristics. The final sections present the empirical results, discuss key findings in the context of transition economies, and conclude with implications for theory and practice.

1.1. An overview of previous research

Early research on corporate failure prediction was primarily based on financial ratio analysis. Beaver (1966) identified key indicators such as cash flow to total assets, net income to total debt, and cash flow to total debt as significant predictors of financial distress. Building on this, Edmister (1972) introduced the use of multi-year averages, while Altman (1977) developed the Zeta model using discriminant analysis, achieving high predictive accuracy. Ohlson (1980) further advanced the field by introducing logistic regression models for bankruptcy prediction.

In addition to these foundational approaches, alternative methods such as Kralicek's quick test have been developed, focusing on liquidity, profitability, and financial stability through dynamic evaluation (Salkić, 2013). During the first and second decades of the 21st century, research expanded significantly across different countries and economic contexts, with numerous studies examining SME failure using a variety of methodologies, including discriminant analysis, logistic regression, and neural networks (e.g., Jazdanfar and Nilsson, 2008; Khanji, 2010; Chancharat, 2011; Janer, 2011; Mures-Quintana, 2012; Wellalage and Locke, 2012; Teti et al., 2012; Marom and Lussier, 2014; Nur Adiana et al., 2014; Ekes and Koloszar, 2014). These studies, conducted across Europe, Asia, and other regions, identified

financial indicators with varying degrees of predictive power, confirming that model performance is strongly influenced by the specific economic environment.

Empirical evidence from both developed and transition economies suggests that traditional models generally achieve high predictive accuracy, often between 80% and 90% (Šarlija & Jeger, 2011; Pervan et al., 2011). However, their performance tends to decline when applied to structurally different contexts. Studies conducted in transition economies indicate that widely used models, such as Altman's Z-score, show limited applicability due to institutional and market-specific characteristics (Salkić, 2013; Muminović, 2011).

More recent research reflects a shift toward advanced analytical approaches and broader datasets. For example, machine learning techniques have been increasingly applied to improve prediction accuracy. Navarro-Galera et al. (2025) used decision tree models on a large dataset of Spanish SMEs (2009–2020), incorporating both financial and non-financial variables, and demonstrated the potential for early insolvency detection. Similarly, Shema-Zlatokrilov (2025) developed a model based on macroeconomic indicators and "red flag" variables, showing that reliable predictions can be achieved even without traditional financial statement data.

Further advancements include hybrid and explainable AI models. Ali et al. (2025) proposed a high-performance framework combining deep learning and gradient boosting techniques, achieving classification accuracy above 97% while maintaining interpretability. Likewise, Káčer and Alexy (2025) confirmed that machine learning models generally outperform traditional statistical methods, particularly when a broader set of explanatory variables is used. Studies focusing on dynamic and sector-specific modelling approaches (Ranatunga Arachchilage, 2026; Rech et al., 2025) emphasize the importance of incorporating time dynamics, macroeconomic shocks, and variable interactions in improving predictive performance.

In the context of Bosnia and Herzegovina and other transition economies, previous research consistently points to the limited applicability of models developed in advanced markets. Empirical studies conducted by Vidimlić (2015, 2017, 2018, 2020, 2021, 2024) show that models such as Chesser, Fulmer, Kralicek, Altman, and Zmijewski can be applied only partially, with moderate and often insufficient predictive accuracy. These limitations are primarily attributed to structural characteristics of transition economies, including market inefficiencies, weak financial discipline, and inconsistencies in financial reporting.

Overall, the literature indicates that no single model provides fully reliable results in transition economy contexts. This highlights the need for continuous research, methodological improvements, and the development of locally adapted or hybrid models. Given the evolving economic environment, further empirical testing is necessary to assess whether predictive performance can be improved over time or through the integration of new analytical approaches.

1.2. Limitations of the study

During every research, smaller or bigger difficulties appear that have a greater or lesser impact on the research process and even on the research results. Thus, in this research

there were certain difficulties and circumstances that were incorporated in the preparation of this work.

The biggest difficulty was fully operational and related to data collection, i.e. financial statements. They were taken from the database of the company LRC - credit bureau, which takes data from the state agency that deals with financial and IT data processing (FIA), according to which all legal entities in the Federation of Bosnia and Herzegovina are obliged to submit annual reports.

The second challenge was related to checking the blocking of transaction accounts of companies that were in the sample. According to the report of the Central Bank of Bosnia and Herzegovina, the names of insolvent companies are published monthly. However, the information should have been given for previous years, and it was obtained retroactively in such a way that for each individual company from the sample, a separate check was performed in the records of the LRC credit bureau, which took a lot of time, but also caused the possibility of error. Considering the size of the sample, any error would not significantly affect the research results obtained.

2. CA SCORE MODEL

The CA score model is used to predict the bankruptcy of a company. Created by author Jean Legault from the University of Quebec in Montreal.

2.1. CA score model - indicators

This model uses multiple discriminant analysis to analyze the financial distress rate of firms. It is strategically designed to detect financial distresses in small Canadian businesses - businesses with total assets of $1 million to $20 million.

For CA score results that are less than <(-0.3), companies are classified as "failed".

CA score is calculated as

X_1 = 4.59313 * (Share capital/Total assets)

X_2 = 4.5080 * (EBIT/Total assets)

X_3 = 0.3936 * (Sales/Total Assets)

CA score = -2.7616 + X_1 + X_2 + X_3 (1)

Please note that in the original classification, the X2 component was "EBIT + Financial expenses" in relation to "Total assets". However, the revised X2 component does not include the financial cost, which was later established when using the model, and which makes this calculation more stringent. Since these are small and medium-sized enterprises, the information "Share capital" has been replaced by the term "Capital" because small and medium-sized enterprises, as a rule, are not registered as stock exchange companies.

2.2. Research sample

Companies belonging to the Zenica-Doboj canton, within the Federation of Bosnia and Herzegovina, State Bosnia and Herzegovina, were taken as a sample for this research. Namely, a total of around 3,500 micro, small, medium and large enterprises were established

in the aforementioned canton. From the mentioned number of companies, all companies that had revenues over two million convertible marks, assets worth more than one million convertible marks, and employed more than ten workers were taken into consideration. In this way, all companies in one region are covered, regardless of their activity. The Zenica-Doboj canton as a stratum was chosen as appropriate, due to the scope of the author. In this way, an essential verification of credibility is possible, as well as comparisons with the author's earlier observations.

Although the companies are of different activities, the central Bosnian basin is of an industrial character, so the activities are predominantly manufacturing and trading.

The sample consists of two groups of companies: the first group, of 70 companies, for which the duration of forced blockage of bank accounts at commercial banks was recorded in days, and the second group, of 322 companies, for which blockage of bank accounts was not recorded. The financial indicators that were treated in this research were taken from the company's financial reports for 2021. Blockages of transaction accounts at commercial banks for more than 30 days were monitored in the period of 2022 and 2023, i.e. two years after the preparation of financial statements.

3. RESEARCH RESULTS

After applying the formula from the CA score model to the treated sample, we reached the following results:

- Out of 70 blocked companies, 28 companies were wrongly assessed, and the probability of blocked companies' assessment is presented in Table 1, column 5, row 2;
- Out of 322 unblocked small and medium enterprises, 106 enterprises were wrongly assessed. The probability that the CA score model will successfully evaluate "healthy" companies is given in Table 1, column 5, row 3;

The overall reliability of the model is reported in Table 1, column 5, row 4.

Table 1. Assessment of acceptability of the CA score model

Sequence number	Number of enterprise	Number of correctly rated companies	Number of incorrectly rated companies	Classification accuracy
1	2	3	4	5
2	70 “Failed” enterprises	42	28	60%
3	322 “Healthy” enterprises	216	106	67.19%
4	Total number of enterprises	258	134	65.82%

Source: Author's calculation

In this study, financially distressed firms are defined as the positive class. A small advantage is observed when predicting the successful operation of the company, although slightly separated in relation to the total number of observed companies. To provide a more robust evaluation of the predictive performance of the CA Score model, the results are reinterpreted using standard classification metrics, including overall accuracy, sensitivity, and specificity.
The sample consists of two groups of firms:

- Distressed firms (n = 70) – defined as enterprises with blocked transaction accounts exceeding 30 days
- Non-distressed firms (n = 322) – enterprises without recorded account blockage

3.1. Confusion matrix structure

Based on model classification outcomes:

- True Positives (TP): 41 firms correctly classified as distressed
- False Negatives (FN): 28 distressed firms incorrectly classified as healthy
- True Negatives (TN): 217 firms correctly classified as healthy
- False Positives (FP): 106 healthy firms incorrectly classified as distressed

3.2. Model performance metrics

Overall Accuracy

Accuracy= (217+41) / 392 = 0.658

The CA Score model correctly classifies **65.8%** of firms, indicating moderate predictive performance.

Sensitivity (True Positive Rate)

Sensitivity= 41 / (28+41) = 0.594

The model correctly identifies **59.4%** of financially distressed firms, indicating a relatively limited ability to detect financial distress risk. The lower sensitivity indicates that the model has limited ability to identify financially distressed firms, which is critical for early warning systems in credit risk assessment.

Specificity (True Negative Rate)

Specificity = 217 / (106+217) = 0.672

The model correctly identifies **67.2%** of financially stable firms, showing slightly better performance in classifying non-distressed enterprises.

3.3. Interpretation

The results indicate that the CA Score model performs moderately better in identifying financially stable firms than in detecting financially distressed firms. The relatively lower sensitivity suggests that a significant proportion of high-risk firms remain undetected, which reduces the model's usefulness in early warning systems within transition economies.

These findings confirm that the model's discriminatory power is constrained under institutional conditions characterized by delayed insolvency resolution, imperfect financial reporting, and weak enforcement mechanisms.

4. DISCUSSION AND CONCLUSION

The results indicate that the CA Score model has limited predictive power in the context of Bosnia and Herzegovina, with an overall accuracy of 65.82%. The model performs somewhat better in identifying financially stable firms than distressed ones, which reduces its effectiveness as an early warning tool.

The reduced predictive ability can be explained by structural characteristics of transition economies. These include institutional weaknesses and regulatory inefficiencies, low payment discipline, and the prolonged presence of financially distressed firms that continue to operate despite significant financial difficulties. As a result, the relationship between financial indicators and actual business financial distress is weakened.

Another important factor is the reliability of financial reporting. The presence of informal economic activity and the use of "creative accounting" practices distort financial statements, leading to inaccurate financial ratios and reduced model precision. In such conditions, ratio-based models cannot fully reflect the true financial position of firms.

Differences between SMEs in Bosnia and Herzegovina and those in developed economies further contribute to the model's limitations. The firms in the observed sample are generally smaller in terms of revenue and asset base compared to those for which the model was originally designed, which reduces its applicability.

In addition, inefficiencies in the enforcement of insolvency procedures represent a significant limitation. In practice, many firms operate for extended periods despite meeting formal conditions for bankruptcy. This creates distortions in the market and complicates the identification of reliable predictors of financial distress.

The findings confirm the research hypothesis that the CA Score model is only partially applicable in this context. Consistent with previous studies, the results suggest that models developed in advanced economies cannot be directly applied in transition environments without adjustments.

Future research should focus on the development of hybrid models that combine financial and non-financial indicators, as well as on the application of machine learning techniques. Furthermore, longitudinal and comparative studies across transition economies could provide more robust insights and improve predictive accuracy. Therefore, the findings reinforce the need for developing context-specific or hybrid prediction models tailored to transition economies.

LITERATURE:

1. Ali, A. A. M., Furaijl, H. B., Kadhim, M. A., Mahmood, I. M., Al-Anezi, W., Howaidi, O., ... & Faead, A. (2025, July). Predictive Modeling of Bankruptcy Risk in SMEs Using Explainable AI with Temporal and Financial Health Indicators. In *2025 3rd International Conference on Cyber Resilience (ICCR)* (pp. 1-7). IEEE.
2. Altman E.I., Haldeman R.G., Narayanan P. (1977). ZETA Analysis, *Journal of Banking and Finance* 1, pp. 29-54.
3. Altman I.E., Sabato G., Wilson N. (2008). The Value of Qualitative Information in SME Risk Menagement, *CMRC, Leeds University Business School,* UK., URL: http://people.stern.nyu.edu [pristup 30.12.2014.].
4. Beaver, W., (1966). Financial Ratios as Predictors of Failure, *Empirical Research in Accounting, Selected Studies,* Vol 4, pp. 71-111.
5. Chancharat N. (2011). SMEs Failure Prediction: Literature Review, *ABAC Journal* Vol.31 No.3 (September - December 2011) pp.70-81.
6. Edmister R.O. (1972). Financial Ratios as Discriminant Predictors of Small Business Failure, *The Journal of Finance*, Vol 27, Issue 1, pp. 129-140.
7. Ekes K. S., Koloszar L. (2014). The Efficency of Bankruptcy Forecast Models in the Hungarian SME Sector, *Journal of Competitiveness,* Vol. 6, Issue 2, pp. 56-73, June 2014.
8. Janer J. (2011). Bankuptcy Prediction and its Adwentages, Empirical Evidence from SMEs in the French Hospital Industry, Master thesis, *Department of Economics, Copenhagen Business School,* URL : http://studenttheses.cbs.dk/, [pristup 30.12.2014.].
9. Jazdanfar D., Nilsson M. (2008). The Bankruptcy Determinants of Swedish SMEs, *Institute form Small Business & Entrerpreneurship,* 5-7 November, Belfast, N. Ireland, URL : http://www.diva-portal.org/, [pristup 30.12.2014.].
10. Káčer, M., & Alexy, M. (2025). SMEs' failure prediction: are machine learning models superior?. *Studies in Economics and Finance*, *42*(5), 908-944.
11. Khanji I. (2010). Failure Predictions for the Small-Medium Enterprises in UK, URL: http://www.academia.edu/, [pristup 30.12.2014.].
12. Marom S., Lussier R.N. (2014). A Business Success Versus Failure Prediction Model for Small Businesses in Israel, *Business and Economic Research, Macrothink Institute,* Vol 4, No 2, pp. 63-81.
13. Mramor D., Valenti A. (2003). Forecasting the Liquidity of Very Small Private Companies*, Journal of Business Venturing* 18, pp. 745-771.
14. Muminović S., Pavlović V., Cvijanović J.M. (2011). Predictive Ability of Various Bankruptcy Prediction Z-Score Model for Serbian Publicly Listed Companies, Industrija, *Časopis Ekonomskog instituta Beograd*, br. 3, pp. 1-12.
15. Mures-Quintana, Maria-Jesus and Garcia Gallego, Ana. (2012). *Proseedings of the First International Conference in Safety and Crises Menagement, in the Constuction, Turism and SME Sectors*, USA, Florida, 2012, Credit Risk Assestments: Business Failure in Spanish SMEs Sector, pp. 331-350.

16. Navarro-Galera, A., Lara-Rubio, J., Novoa-Hernández, P., & Cruz Corona, C. A. (2025). Using Decision Trees to Predict Insolvency in Spanish SMEs: Is Early Warning Possible?. *Computational Economics*, *65*(1), 91-116.
17. Nur Adiana H.A., Abd Halim A., Rohani M.R., Nasruddin Z. (2014) Modeling Small Business Failures in Malaysia, URL : http://papers.ssrn.com/, [pristup 30.12.2014.]
18. Ohlson, J. A. 1980. Financial Ratios and the Probabilistic Prediction of Bankruptcy. *Journal of Accounting Research (spring):* pp.109-131.
19. Pervan I., Pervan M., Vukoja B. (2011). Prediction of Company Bankruptcy Using Statistical Techniques – Case of Croatia. *Croatian Operational Research Review,* Vol 2, pp. 158-167.
20. Ranatunga Arachchilage, I. J. R. (2026). Predicting SMEs Financial Condition Using Explainable AI: A Comparative Analysis of Machine Learning Models.
21. Rech, F., Isaboke, C., & Xu, H. (2025). Surviving the pandemic: Financial distress prediction for Slovak SME manufacturers. *Journal of Business Sectors*, *3*(1), 41-51.
22. Salkić A. (2013). Testing of Possibility of Establishing Creditworthiness od Small and Medium Enterprises in Bosnia and Herzegovana by Applying Kralicek DF Indicator, *Economic Review – Journal of Economics and Business*, Vol. XI, Issue 2, pp. 57-70.
23. Šarlija N., Jeger M. (2011). Comparing financial distress prediction models before an during recession. *Croatin Operational Research Review* 2 (1) 133-142.
24. Shema-Zlatokrilov, L. (2025). Exploring SMEs' Insolvency: A Nonfinancial Statement Model Using" Red Flag" and Macroeconomic Indicators. *Exploring SMEs' Insolvency: A Nonfinancial Statement Model Using" Red Flag" and Macroeconomic Indicators*.
25. Škarić-Jovanović K. (2011). Finansijske izvještaji kao instrument prevara, *VI Kongres računovođa i revizora Crne Gore, Finansijsko izvještavanje u funkciji unapređenja poslovnog ambijenta u Crnoj Gori,* pp. 209-234, Bečići.
26. Teti E., Dell´Acqua, Brambilla M. (2012) . Bankruptcy Predictors During the Financial Crisis. A Study of Italian SMEs, URL: http://www.mfsociety.org/
27. Vidimlić S. (2015). Primjena Chesserovog modela kod predviđanje neispunjenja obaveza prema bankama kod malih preduzeća u Bosni i Hercegovini, *Zbornik radova Ekonomskog fakulteta u Sarajevu,* pp. 150-166, Sarajevo.
28. Vidimlić, S. (2017). Mogućnosti primjene Fulmerovog modela za procjenu finansijskih neprilika malih i srednjih preduzeća u Bosni i Hercegovini. *Financing-naučni časopis za ekonomiju*, *8*(4), 53-56, Banja Luka.
29. Vidimlić, S. (2018). Application of Kralicek DF test for predicting financial troubles of small and medium enterprises in Bosnia and Herzegovina. *Anali ekonomskog fakulteta u Subotici*, (40), 215-225.
30. Vidimlić, S. (2020). Innovated Altman's Model as a Predictor of Malfunctioning of Small and Medium-Sized Businesses in Bosnia and Herzegovina. *Economic Themes*, *57*(1), 21, Niš, Serbia.
31. Vidimlić, S. (2021). Finansijski pokazatelji u funkciji predviđanja stalnosti poslovanja malih i srednjih preduzeća u tranzicijskim zemljama. in *15. međunarodni simpozijum o korporativnom upravljanju* (pp. 437-446). Finrar doo Banja Luka.

32. Vidimlić, S. (2024). Mogućnost primjene zmijewski modela za predviđanje neuspjeha preduzeća u tranzicijskim zemljama. *skei-međunarodni interdisciplinarni časopis*, *5*(2), 40-51.
33. Wellalage N.H., Locke S. (2012). Factors Affecting the Probability of SME Bankruptcy: A Case Study on New Zealand Unlisted Firms. URL: www.ssrn.com
34. www.kralicek.at/pdf/quickbreak [05.01.2018].