International Scientific Multidisciplinary Conference: AI for a Smarter Tomorrow - AI-SMART
DOI: https://doi.org/10.31410/AI.SMART.2025.33
Original scientific article

Audit Opinion Prediction Using the Decision Tree Algorithm

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Received: September 30, 2025
Accepted: November 30, 2025
Published: December 11, 2025

Keywords:
Audit opinion;
Decision tree;
Prediction

Abstract: *This paper presents a data mining approach for Audit opinion prediction in Government-owned enterprises within the Federation of Bosnia and Herzegovina using the Decision tree algorithm. A database was constructed from financial statements covering 2004-2019, incorporating indicators from balance sheets, income statements, and cash flow statements, alongside corresponding Audit opinions from the state audit body. The study evaluates three Decision tree algorithms (J48, RandomTree, REPTree) on data from 2020-2023, with REPTree achieving 73% classification accuracy through seven predictive rules. The findings demonstrate the potential of data mining techniques for pattern recognition in audit reports, contributing to transparency in financial reporting and supporting regulatory authorities in detecting irregularities within Government-owned enterprises.*

1. INTRODUCTION

Data mining enables the development of predictive models for assessing the accuracy of financial statements of government-owned enterprises. These predictive models represent forensic accounting tools that require continuous refinement and development, allowing state audit offices, financial data processing agencies, statistical bodies, tax authorities, banks, and ultimately the public to use them to assess the accuracy of financial statements. The development of these models is grounded in key financial indicators extracted from financial reports, which serve as input data, and the types of audit opinions provided on the respective financial statements, which constitute the output data. In this context, this study seeks to evaluate previously developed models for detecting audit opinions and inaccurate financial statements, using the most recent audited reports of publicly owned enterprises in the Federation of Bosnia and Herzegovina.

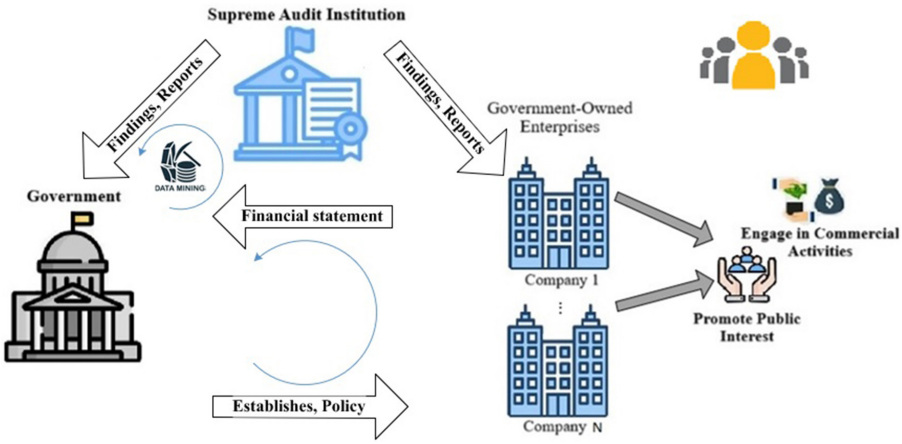

Figure 1. From Public Resources to Audit and Disclosure in Government-Owned Enterprises
Source: Own research

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The quality of state audit is of considerable importance for the oversight of the operations of government-owned enterprises. It is precisely this linkage between the published financial statements of government-owned enterprises and the auditors' opinions on those financial statements that provides a substantial amount of data to which data mining techniques can be applied (Figure 1).

The paper is presented in three parts. First, it provides an overview of earlier research; then, the research methodology is explained in detail; and finally, the research results and a discussion of the findings are given.

2. LITERATURE REVIEW

The application of data mining in the development of forensic accounting tools to assist in predicting auditors' opinions on financial statements has been explored by a large number of researchers (Pasiouras et al., 2007; Kirkos et al., 2007; Sánchez-Serrano et al., 2020). However, the development of the database used to train machine learning models is specific to each study, each country, and each type of enterprise for which the data are employed. Therefore, it is necessary to consider previous research that is exclusively related to Bosnia and Herzegovina. Gadžo et al. (2022) demonstrated that the data required from financial statements for developing models to detect inaccurate financial reporting can be based on the inputs used in the calculation of the Beneish M-Score model, which comprises eight partial indicators derived from key items in the balance sheet, income statement, and cash flow statement. In a continuation of this research, Gadžo et al. (2025) developed predictive models for detecting inaccurate financial statements of public enterprises in the Federation of Bosnia and Herzegovina (FBiH), based on corresponding audit reports issued by the Audit Office of Institutions in FBiH. This study developed four classification algorithms (J48, KNN, MLP, and BayesNet) to identify inaccurate financial reports. At that time, using the available dataset, the MLP algorithm yielded a prediction accuracy of 76%. No other authors had developed data mining models for predicting inaccurate financial statements specifically for Bosnia and Herzegovina's public enterprises. However, other forensic accounting tools have been tested for efficacy, such as the application of Benford's Law to detect fraudulent financial reporting (Isaković-Kaplan et al., 2021; Demirović & Proho, 2021), the use of the classical form of the Beneish M-Score model, which was not adapted to Bosnia-Herzegovina enterprises (Halilbegović et al., 2020), and more general research on the development and application of forensic accounting in Bosnia and Herzegovina (Pirnar & Grivec, 2025; Dupovac et al., 2025; Veledar et al., 2022, et al.). Furthermore, a significant portion of research addresses the identification of resource inefficiencies in the public sector of Bosnia and Herzegovina (Gadžo et al., 2024; Soko & Zorič, 2018) and the application of the DEA model for ranking public institutions (Bajrić et al., 2019).

It can be concluded that scientific research on the development of advanced models for predicting inaccurate financial statements or financial statement fraud in Bosnia and Herzegovina remains very limited. Therefore, this study contributes to the advancement of theory and practice in the detection of inaccurate financial reporting within the public sector of the Federation of Bosnia and Herzegovina.

3. METHODOLOGY

For the purpose of classifying audit reports, it was necessary to create a comprehensive database containing relevant attributes and parameters reflecting the key financial indicators of Government-Owned Enterprises (GOEs) in the Federation of Bosnia and Herzegovina (FBiH). This database was designed based on data collected from the financial statements of public enterprises and their corresponding audit reports, prepared by the Audit Office of the Institutions of FBiH.

The primary framework for building the database was grounded in the previous study entitled "Data Mining Approach in Detecting Inaccurate Financial Statements in Government-Owned Enterprises", covering a period of 16 years (2004-2019). A total of 200 financial statements, together with their corresponding audit reports, were collected and analyzed, as they were available at the time the research was conducted. The resulting models were subsequently tested on data gathered over four years (2020-2023).

3.1. Data Description

For each audit report, key indicators were included, such as: opening and closing balances of trade receivables (attribute codes: A3, A1); revenues from sales for the current and previous reporting periods (A4, A2); operating expenses for the current and previous reporting periods (A6, A5); opening and closing balances of current assets (A11, A7); opening and closing balances of property, plant and equipment (A12, A8); opening and closing balances of short-term financial investments (A13, A9); opening and closing balances of business assets (A14, A10); opening and closing balances of depreciation (A15, A16); administrative expenses for the current and previous reporting periods (A17, A18); opening and closing balances of short-term liabilities (A21, A19); opening and closing balances of long-term liabilities (A22, A20); operating profit/loss for the current and previous period (A23); and net cash flow from operating activities for the current accounting period (A24). Of the total number of indicators, 16 relate to the statement of financial position, 7 relate to the income statement, and 1 relates to the cash flow statement. These indicators were selected due to their frequent inclusion in auditors' observations in cases where modified opinions were issued. The irregularities particularly referred to non-compliance with standards such as IFRS 9, IFRS 15, IAS 2, IAS 16, IAS 36, IAS 37, and IAS 38, as well as issues related to cash flow statements and business performance disclosures.

The database contains 24 indicators for 200 financial statements. These indicators represent the variables used to train machine learning models with the aim of predicting audit opinions. The audit opinions were categorised into four groups. In addition to the unmodified (clean) audit opinion on financial statements, in accordance with International Standard on Auditing (ISA) 705 (paragraph 2), there are three types of modified audit opinions: Qualified opinion, Adverse opinion, and Disclaimer of opinion. The decision as to which type of modified opinion is appropriate depends on the nature of the issue leading to the modification-specifically, whether the financial statements are materially misstated or, in cases where sufficient appropriate audit evidence cannot be obtained, whether such misstatements could exist.

3.2. Proposed Model

A classification model was utilized to predict audit opinions based on accounting data extracted from the financial statements of public enterprises in the Federation of Bosnia and Herzegovina (FBiH), along with their corresponding audit reports. Classification represents a widely used technique in the analysis of large data sets. It is applied to predict the class or category of a known object based on previously learned classes from a training data set. In this study, various decision tree algorithms were employed, including J48, RandomTree, and REPTree. The selection of decision tree algorithms was motivated by their ability to generate clear and practically applicable decision tree graphics and associated rules, which can be effectively used on real-world data.

3.3. Preparation

Data mining algorithms were employed to analyze and extract useful insights from the dataset, and were implemented using the open-source software package WEKA. Originally, the dataset included

four distinct audit opinion categories (qualified, unqualified, adverse, and disclaimer of opinion), which were, for analytical purposes, consolidated into two categories: Negative (No) and Positive (Yes). Category NO represents adverse opinions and disclaimers of opinion. Category YES represents unqualified opinions and qualified opinions. Table 1 presents the structure of dataset classification.

Table 1. Two classes, based on the output variable "audit opinion"

Class	Assessment	Sample number	Percentage
1	No	73	36.50%
2	Yes	127	63.50%
	SUM	200	100,00%

Source: Own research

Table 2. Represents the structure of the database in the software where machine learning was applied to the given dataset.

Table 2. Actual DATASET

No.	1: A1 Numeric	2: A2 Numeric	3: A3 Numeric	4: A4 Numeric	5: A5 Numeric	6: A6 Numeric	7: A7 Numeric	8: A8 Numeric	9: A9 Numeric	10: A10 Numeric	11: A11 Numeric	12: A12 Numeric	13: A13 Numeric	14: A14 Numeric	15: A15 Numeric	16: A16 Numeric	17: A17 Numeric	18: A18 Numeric	19: A19 Numeric	20: A20 Numeric	21: A21 Numeric	22: A22 Numeric	23: A23 Numeric	24: A24 Numeric	25: MR02 Nominal
1	15699...	3.4564...	26163...	3.6116...	4.5061...	4.3346...	1.3818...	9.5776...	0.0	3.2707...	1.5185...	9.9081...	0.0	3.2928...	41723...	39400...	2.9718...	3.1568...	2.2590...	0.0	2.1569...	0.0	-2.289...	-1.370...	No
2	17373...	9.8336...	74694...	1.0456...	1.1551...	1.1884...	2.9156...	2.8289...	11533.0	5.8560...	2.5435...	2.8776...	13832.0	5.7674...	1.1975...	1.1592...	6.3494...	6.5316...	2.3169...	5.0518...	2.1590...	5.1300...	-2.538...	-2.208...	No
3	29689...	6.7346...	30827...	8.0447...	7.7801...	7.9173...	97095...	1.6650...	0.0	1.8040...	87531...	1.7137...	0.0	3.7338...	88783...	1.0983...	4.6690...	4.7987...	1.0871...	1.0029...	1.0377...	1.0018...	-1.371...	81372...	No
4	12265...	1.2202...	11317...	1.2645...	1.3914...	1.4072...	32612...	3.7858...	0.0	6.4556...	25734...	3.4868...	0.0	6.1498...	10518...	15751...	95136...	95089...	3.9090...	471429.0	3.4384...	550000.0	-17857...	37296...	No
5	721617.0	20642...	719155.0	22948...	22915...	21190...	15361...	19915...	0.0	36079...	15106...	18873...	0.0	34752...	150179.0	143955.0	10989...	11011...	10949...	0.0	815974.0	0.0	5098.0	354760.0	Yes
6	11158...	72006...	811865.0	60756...	64071...	74386...	18058...	57823...	0.0	97030...	15509...	58043...	0.0	94644...	373707.0	386491.0	23868...	22906...	32629...	99118.0	26866...	168583.0	1523.0	10796...	No
7	578070.0	30192...	701201.0	25884...	27211...	30963...	659437.0	835585.0	0.0	14950...	808314.0	745875.0	0.0	15541...	141990.0	156216.0	18133...	17256...	12190...	7500.0	10250...	22500.0	-21953...	258929.0	Yes
8	913693.0	16746...	828847.0	16059...	15009...	18399...	20209...	98931...	0.0	1.2170...	16130...	1.0750...	0.0	1.2364...	616060.0	861429.0	743510.0	701268.0	878994.0	60754...	10245...	61810...	439001.0	95633.0	Yes
9	47468...	59733...	40037...	58641...	61463...	62064...	50752...	39082...	0.0	1.1719...	43706...	40952...	0.0	1.1255...	207418.0	233251.0	34130...	33033...	58436...	14012...	47068...	20225...	3051.0	-2644.0	No
10	43207.0	2.0135...	1705.0	1.3207...	6.1494...	6.1366...	1.1055...	1.8062...	0.0	1.9688...	1.7860...	1.7164...	0.0	1.7932...	3.3066...	3.3225...	1.5785...	1.4632...	1.0506...	9.0431...	1.3498...	8.1562...	1.1749...	-2.483...	Yes
11	132720.0	3.2699...	179057.0	3.0332...	2.9270...	3.1668...	82651...	92891...	0.0	4.5342...	97100...	90305...	0.0	4.7203...	14163...	16675...	1.4145...	1.3369...	86972...	0.0	1.0136...	0.0	950150.0	14086...	Yes
12	128702.0	1.1817...	125618.0	1.1700...	1.1750...	1.2149...	743570.0	59176...	0.0	1.6274...	10309...	61664...	0.0	1.6406...	637047.0	581198.0	94247...	89366...	1.3912...	0.0	1.3767...	0.0	-40757...	523950.0	No
13	343039.0	3.1922...	152202.0	2.7420...	2.6651...	3.1921...	69043...	5.0732...	0.0	5.8424...	80397...	4.7082...	0.0	5.8208...	24386...	26584...	2.1880...	1.7343...	39071...	0.0	33700...	0.0	118553.0	984787.0	Yes
14	33913...	5.1315...	35338...	4.7894...	3.5098...	3.6576...	4.6016...	1.7450...	3.5225...	2.4415...	5.3959...	1.6820...	1.7609...	2.5138...	57112...	61858...	2.2195...	2.1591...	52448...	0.0	25475...	0.0	1.3983...	2.2293...	Yes
15	2.2216...	3.1060...	2.2189...	2.7075...	2.0088...	2.1200...	2.9388...	714309.0	0.0	1.7528...	2.5756...	427563.0	0.0	1.6949...	890881.0	12215...	1.0196...	1.0045...	2.2666...	0.0	1.9752...	0.0	92340.0	51963...	No
16	74765.0	24476...	510822.0	28971...	28615...	23909...	11098...	19043...	0.0	41061...	984412.0	19650...	0.0	40960...	50977.0	79090.0	11370...	10614...	645507.0	326873.0	428495.0	445648.0	9570.0	54889.0	No
17	14927...	27512...	15676...	28712...	25943...	25528...	24011...	924261.0	0.0	79776...	25906...	720675.0	612.0	67300...	120129.0	72856.0	16230...	15056...	745251.0	330709.0	475101.0	0.0	144667.0	710165.0	No
18	588627.0	22122...	595237.0	20467...	19631...	20054...	835054.0	16835...	0.0	25207...	871313.0	15978...	0.0	24726...	56178.0	45572.0	13223...	12950...	365871.0	474419.0	453164.0	432021.0	93316.0	86307.0	No
19	10022...	1.1109...	10408...	1.1190...	1.1861...	1.2046...	19715...	50593...	0.0	70605...	23059...	58076...	0.0	81682...	13180...	14165...	55925...	55826...	16737...	184986.0	16285...	440858.0	-89699...	351440.0	Yes
20	1.0566...	1.1159...	1.2412...	9.9787...	9.8998...	1.1391...	3.2698...	2.4440...	0.0	4.5029...	4.4259...	2.5445...	0.0	4.5065...	1.7201...	1.5091...	1.7272...	1.7612...	8.3787...	1.2132...	7.7279...	1.4039...	620382.0	1.4642...	Yes
21	4048.0	29964...	2862.0	27317...	26811...	28061...	566034.0	10502...	0.0	16167...	218970.0	904676.0	0.0	11242...	117442.0	111249.0	23532...	22237...	421053.0	0.0	423770.0	0.0	200177.0	92272.0	Yes
22	1.0468...	2.9248...	9.9688...	3.7958...	3.7568...	3.0260...	1.2192...	1.1198...	251144.0	1.6923...	1.3149...	1.0217...	178595.0	1.5281...	5.3206...	5.4714...	8.9619...	8.6649...	9.5973...	1.8485...	6.6009...	1.2210...	237441.0	-9.952...	Yes
23	2.7740...	1.1340...	3.0764...	1.0677...	1.3637...	1.1922...	7.2361...	1.4746...	0.0	1.5831...	7.3502...	1.4915...	0.0	1.5750...	3.5882...	2.4786...	7.2103...	7.6062...	3.0755...	4.6460...	2.7897...	5.0203...	-42301...	1.7095...	Yes
24	256255.0	1.6252...	598960.0	1.6339...	1.5957...	1.5651...	19771...	1.3951...	0.0	3.7400...	21989...	1.4981...	0.0	3.7529...	12395...	14466...	96506...	97338...	19212...	0.0	29001...	0.0	232918.0	14811...	Yes
25	1.2644...	1.4773...	1.4277...	1.5044...	1.3562...	1.3588...	6.7021...	1.1249...	1064.0	2.0353...	7.4568...	1.1466...	0.0	2.1720...	1.1643...	1.1427...	6.7385...	6.7962...	3.6389...	1.7049...	4.2681...	2.1319...	61907...	1.0434...	No
26	18474...	30286...	17101...	29938...	32599...	32973...	22431...	2.0887...	0.0	2.3130...	20468...	1.8389E7	0.0	2.0435...	931294.0	598851.0	17485...	16655...	13861...	1.6002...	21054...	1.2317...	7968.0	34328...	No
27	20545...	1.9615...	19471...	1.6806...	1.3880...	1.6757...	2.1332...	3.3178...	3118.0	5.8662...	1.7613...	3.4757...	4488.0	5.7299E7	16945...	17806...	68873...	70210...	22877...	0.0	33435...	2632.0	26667...	43659...	Yes

Source: Own research

4. RESULTS AND ANALYSIS

The results presented in Table 3 facilitate a comparison of the performance of three decision tree algorithms, J48, RandomTree, and REPTree, employed for the classification of audit opinions on the financial statements of government-owned enterprises in the Federation of Bosnia and Herzegovina. Based on the evaluation criteria, it can be concluded that REPTree achieved the highest number of correctly classified financial statements (146) and the greatest prediction accuracy (73%), making it the most precise among the compared algorithms. J48 follows with an accuracy of 71%, while RandomTree exhibits the lowest accuracy at 69.5%. The Kappa statistic, which measures the agreement between the actual and predicted classifications excluding chance, further supports this finding. REPTree again demonstrates the strongest performance with a Kappa value of 0.3738, indicating the most reliable classifications, whereas J48 has the weakest result at 0.3316. Although REPTree exhibits a slightly higher mean absolute error (MAE) compared to J48 (0.3413 versus 0.3163), it attains the lowest root mean squared error (RMSE) of 0.4655, suggesting better model stability. Additionally, REPTree shows the lowest relative errors (RAE and RRSE), which further confirms its superiority.

The results presented in Table 4 illustrate the performance of the tested models on new financial data (new financial statements of government-owned enterprises in the Federation of Bosnia and

Herzegovina) for the period from 2020 to 2023. The models were evaluated separately for two subperiods: 2020-2021 and 2022-2023. This division was necessitated by changes in the financial reporting formats in the Federation of Bosnia and Herzegovina implemented in 2022. These changes involved reclassification of certain balance sheet items and enhanced balance control conducted by the Financial Informatics Agency of the FBiH, which is responsible for collecting electronic financial statement forms.

Table 3. The performances obtained by the Decision tree algorithms

EVALUATION CRITERIA	CLASSIFIERS		
	J48	RandomTree	REPTree
Timing to build model (in Sec)	0.01	0	0
Correctly classified instances	142	139	146
Incorrectly classified instances	58	61	54
Prediction accuracy	71	69.5	73
Kappa statistic	0.3316	0.3439	0.3738
F-Measure	0.6960	0.6950	0.7150
Mean absolute error (MAE)	0.3163	0.3050	0.3413
Root mean squared error (RMSE)	0.5021	0.5523	0.4655
Relative absolute error (RAE)	68.16%	65.72%	73.53%
Root relative squared error (RRSE)	104.29%	114.70%	96.67%

Source: Own research

It is notable that all three classifiers, J48, RandomTree, and REPTree, demonstrate a significant improvement in prediction accuracy in the later period (2022-2023) compared to the earlier one (2020-2021). J48 exhibits the most pronounced increase, from 47.5% to 86.2%, while REPTree consistently achieves high accuracy levels of 62.5% and 79.3%, respectively. The accuracy of the RandomTree algorithm remains moderate, showing some fluctuations between the two periods.

The Kappa statistic further corroborates these findings, as positive values in the 2022-2023 period indicate a moderate to substantial agreement between predicted and actual classifications, especially for J48 (0.5207) and REPTree (0.3872). Conversely, the negative Kappa value for J48 in the 2020-2021 period (–0.2139) suggests that classification performance during that earlier phase was poorer than or equivalent to random guessing. Similarly, the F-Measure values follow these trends, with significantly higher results in 2022–2023 across all classifiers, reflecting an improved balance between precision and recall. Overall, these results suggest that the predictive power of the models has improved over time, potentially due to better data quality, changes in financial reporting patterns, or model adjustments. In particular, REPTree and J48 show promising potential for practical application in classifying audit opinions based on current financial data.

Table 4. Results of model testing on new data for the period 2020–2023

EVALUATION CRITERIA	CLASSIFIERS					
	J48		RandomTree		REPTree	
	2020-21	2022-23	2020-21	2022-23	2020-21	2022-23
Correctly classified instances	19	25	23	16	25	23
Incorrectly classified instances	21	4	17	13	15	6
Prediction accuracy	47.5	86.2	57.5	55.2	62.5	79.3
Kappa statistic	-0.2139	0.5207	0.1099	0.0308	0.1329	0.3872
F-Measure	0.4580	0.8620	0.5830	0.6210	0.6130	0.8190

Source: Own research

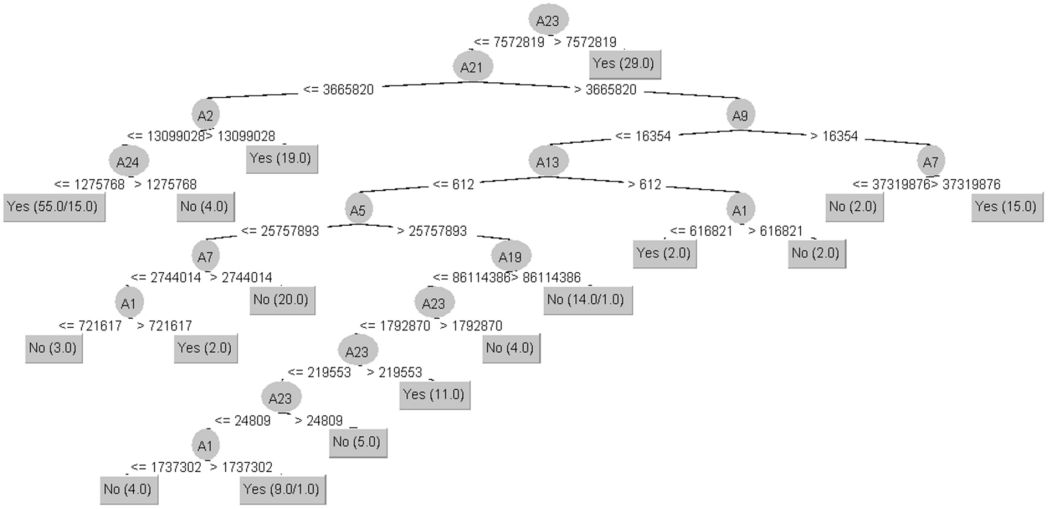

Figure 2. Obtained J48 - Decision tree mode

Source: Own research

Figure 2 illustrates the obtained J48 decision tree model developed for classifying audit opinions based on financial indicators of government-owned enterprises in the Federation of Bosnia and Herzegovina. Each node in the tree represents a test on a specific attribute (financial indicator), with branches indicating possible outcomes of the test. Following these decision rules, the model predicts whether the financial statements will receive an unmodified or a modified audit opinion.

The J48 algorithm was selected due to its ability to generate clear and interpretable decision rules, which is particularly important in the context of audit reports where understanding the rationale behind classifications is essential. The depth of the tree and the number of leaves reflect the complexity of the model, while the derived rules help identify key factors influencing the audit opinion.

This decision tree model can be easily applied in practice due to its simple and transparent structure. The clear rules derived from the tree enable auditors and managers to quickly understand the key factors influencing the classification of financial statements, thereby facilitating informed decision-making. Furthermore, the intuitive nature of this approach allows its use by individuals without deep technical knowledge of machine learning, increasing its practical applicability in everyday auditing and financial processes.

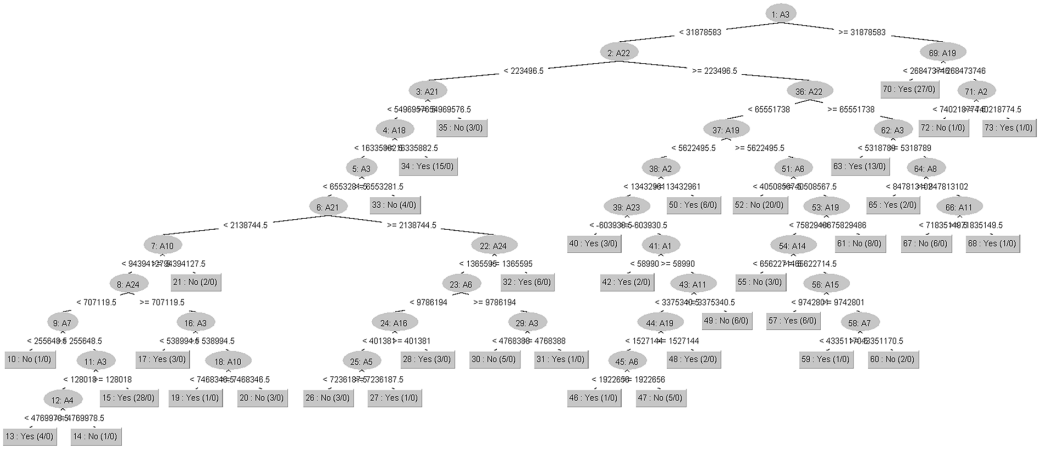

Figure 3. Obtained RandomTree - Decision tree model

Source: Own research

Figure 3 illustrates the RandomTree decision tree model obtained from the analysis. This model is characterized by a more complex tree structure compared to simpler decision trees, as it constructs multiple randomized splits to improve classification performance. The randomness introduced in the tree-building process helps in reducing overfitting and increasing the model's robustness when dealing with diverse financial data. However, the increased complexity can make interpretation less straightforward, which might limit its immediate practical use compared to simpler models like J48. Nonetheless, RandomTree can offer valuable insights in situations where higher model variability and generalization are required.

Table 5 presents a comparative overview of the complexity and structure of the three decision tree classifiers: J48, RandomTree, and REPTree. The size of the tree, which corresponds to the total number of nodes, is largest for RandomTree (73), indicating a more complex model with many decision points, while REPTree is the simplest with only 13 nodes. Similarly, RandomTree has the greatest depth (11), suggesting a deeper hierarchy of decisions, whereas REPTree's depth is the shallowest (6), implying a more concise model. The number of leaves, representing final decision outcomes, follows the same trend, with RandomTree having the highest count (37), J48 moderate (17), and REPTree the lowest (7). These metrics highlight a trade-off between model complexity and interpretability, where simpler trees like REPTree may be more practical for real-world applications due to their ease of understanding, while more complex trees like RandomTree might capture subtler patterns at the cost of reduced transparency.

Table 5. Measure the complexity and structure of a Decision Tree

EVALUATION CRITERIA	CLASSIFIERS		
	J48	RandomTree	REPTree
Size of the tree	33	73	13
Tree Depth	10	11	6
Number of Leaves	17	37	7

Source: Own research

Figure 4 illustrates the REPTree decision tree model obtained from the analysis. This model is characterized by its relatively simple and shallow structure compared to the other decision trees examined. The REPTree efficiently summarizes the decision rules with fewer nodes and leaves, which enhances its interpretability and practical usability.

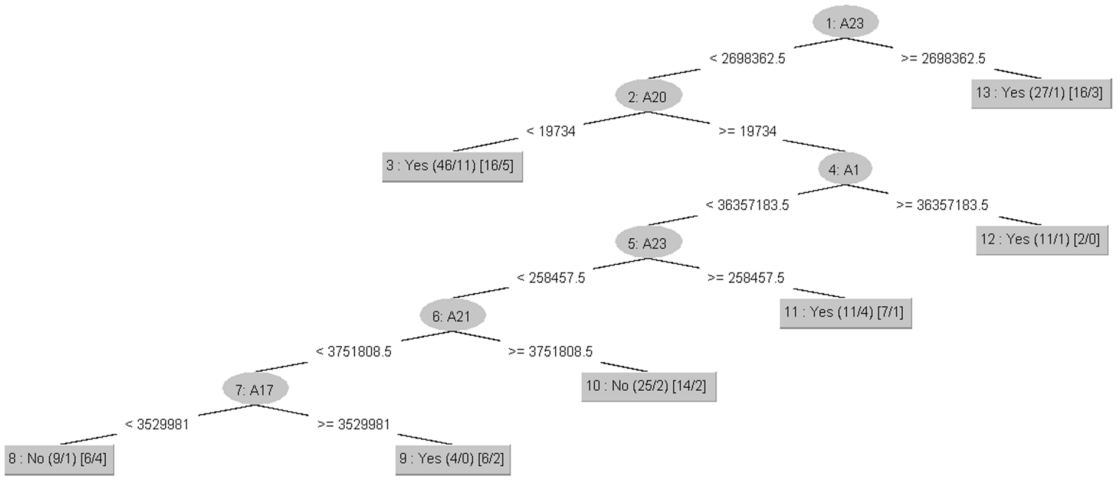

Figure 4. Obtained REPTree - Decision tree model

Source: Own research

Table 6 shows the decision rule obtained by the REPTree model. The rule is based on the values of financial indicators (denoted as A23, A20, A1, A21, A17) and leads to the classification of the decision as 'YES' (unqualified/positive or qualified opinion) or 'NO' (adverse opinion or disclaimer of opinion).

Table 6. Decision rule for the obtained Decision tree model

	Conditions (IF)	Results (THEN)
1	A23 >= 2698362.5;	'YES'
2	A23 < 2698362.5; A20 < 19734;	
3	A23 < 2698362.5; A20 >= 19734; A1 < 36357183.5; A23 < 258457.5; A21 < 3751808.5; A17 >= 3529981;	
4	A23 < 2698362.5; A20 >= 19734; A1 < 36357183.5; A23 >= 258457.5;	
5	A23 < 2698362.5; A20 >= 19734; A1 >= 36357183.5	
6	A23 < 2698362.5; A20 >= 19734; A1 < 36357183.5; A23 < 258457.5; A21 < 3751808.5; A17 < 3529981;	'NO'
7	A23 < 2698362.5; A20 >= 19734; A1 < 36357183.5; A23 < 258457.5; A21 >= 3751808.5;	

Source: Own research

The model (see Figure 4 and Table 6) is characterized by clarity and comprehensibility, making it suitable for practical application in predicting audit opinions based on data obtainable from financial statements. Its applicability can provide valuable insights to all relevant stakeholders interested in the performance of government-owned enterprises.

5. CONCLUSION

REPTree stood out as the most precise and reliable model in detecting inaccurate financial statements of government-owned enterprises, with notable improvements in the period after 2022. This makes it suitable for practical application in predicting audit opinions based on current financial data from balance sheets, income statements, and cash flow statements. The J48 algorithm also demonstrates significant potential for prediction, while RandomTree offers somewhat lower interpretability. The model can serve as a tool for early detection of issues with inaccurate financial reporting in government-owned enterprises, before auditors formally signal a risk to going concern. Additionally, founders of government-owned enterprises can use the model to assess the quality of financial statements. Ministries of Finance or governing bodies can use the model as an additional filter in supervising and allocating funds to government-owned enterprises. Banks can use the model as an extra quality control for financial statements of government-owned enterprises before processing their loan applications. Although the scope of application is broad, it may be most significant for commercial audit firms and state audit offices in BiH. These models can be a useful tool for public auditors in preparing the annual audit plan, since, due to limited resources, state auditors' sample only a few dozen government-owned enterprises for annual audits. These models can serve as red flags for both state and commercial auditors, given that in years when a government-owned enterprise is not covered by the state audit plan, commercial audit firms must be engaged. Accurate prediction of inaccurate financial statements can indicate irregularities, embezzlement, or data manipulation. Therefore, the recommendation for future research in this field is to explore the application of mathematical models for detecting inaccurate financial statements to facilitate their practical use.

Author Contributions

We would like to acknowledge that all authors contributed equally to the preparation of this work. The order of authors listed in the paper is purely formal and does not reflect differences in the level of contribution.

Acknowledgment

This research and the publication of this paper were financed by the Federal Ministry of Education and Science of the Federation of Bosnia and Herzegovina (FMON FBiH).

References

Bajrić, H., Kadrić, E., Pasic, M., & Vatreš, A. (2019). *Evaluation of the Efficiency and Ranking of Primary Schools in Canton Sarajevo Using DEA*. In B. Katalinić (Ed.), *Proceedings of the 30th DAAAM International Symposium* (pp. 115–122). DAAAM International. DOI: https://doi.org/10.2507/30th.daaam.proceedings.015

Dupovac, V. Ž., Isaković-Kaplan, Š., & Demirović, L. (2025). Forensic Accounting and Investigations in the Fight Against Money Laundering. *Journal of Forensic Accounting Profession*, 5(1), 83–108. https://doi.org/10.2478/jfap-2025-0005

Gadžo, A., Halilbegović, S., Đaković, A. O., & Hodžić, A. (2022). Predicting Auditor's Opinion on Financial Statements of Public Enterprises Based on Indicators of the Beneish M-score Model. *Journal of Forensic Accounting Profession*, 2(2), 1–13. https://doi.org/10.2478/jfap-2022-0006

Gadžo, A., Suljic, M., Jusufović, A., Filipović, S., & Suljić, E. (2025). Data mining approach in detecting inaccurate financial statements in government-owned enterprises. *Croatian Operational Research Review*, 16(1), 1–15. https://doi.org/10.17535/crorr.2025.0001

Gadžo, A., Veledar, B., & Osmanović Đaković, A. (2024). Data Envelopment Analysis for Assessing Efficiency in Public Utilities with a Focus on Water and Sewerage Services. *Interdisciplinary Description of Complex Systems,* 22(4), 497–509. https://doi.org/10.7906/indecs.22.4.8

Halilbegović, S., Ćelebić, N., Cero, E., Buljubašić, E., & Mekić, A. (2020). Application of Beneish M-score model on small and medium enterprises in Federation of Bosnia and Herzegovina. *Eastern Journal of European Studies*, 11(1), 146–163.

Isaković-Kaplan, Š., Demirović, L., & Proho, M. (2021). Benford's law in forensic analysis of income statements of economic entities in Bosnia and Herzegovina. *Croatian Economic Survey*, 23(1), 31–61. https://doi.org/10.15179/ces.23.1.2

Kirkos, E., Spathis, C., & Manolopoulos, Y. (2007). Data mining techniques for the detection of fraudulent financial statements. *Expert systems with applications*, 32(4), 995-1003.

Pasiouras, F., Gaganis, C., & Zopounidis, C. (2007). Multicriteria decision support methodologies for auditing decisions: The case of qualified audit reports in the UK. *European Journal of Operational Research*, 180(3), 1317–1330. https://doi.org/10.1016/j.ejor.2006.04.026

Pirnar, M., & Grivec, M. (2025). FORENZIČNO RAČUNOVODSTVO – KLJUČ ZA ODKRIVANJE PREVARA. [Forensic accounting – The key to fraud detection], ZBORNIK RADOVA, Računovodstvo i revizija u teoriji i praksi, str. 259-311. DOI 10.7251/ZBLC2501295P

Sánchez-Serrano, J. R., Alaminos, D., García-Lagos, F., & Callejón-Gil, A. M. (2020). Predicting audit opinion in consolidated financial statements with artificial neural networks. *Mathematics,8*(8), 1288.

Soko, A., & Zorič, J. (2018). Municipal efficiency and economies of scale in Bosnia and Herzegovina. *Lex Localis – Journal of Local Self-Government, 16*(4), 715–734. https://doi.org/10.4335/16.4.715-734

Veledar, B., Bašić, M., & Čolpa, A. (2022). State and perspectives of forensic accounting development in Bosnia and Herzegovina. *Journal of Forensic Accounting Profession, 2*(1), 1–18. https://doi.org/10.2478/jfap-2022-0001