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RESEARCH ARTICLE

Predicting the Effects of the Financial Crisis, Public Sector Accounting, Corporate Governance Mechanism and Audit Quality on the Financial Performance of Companies Listed on the Tehran Stock Exchange: The Performance of Neural Networks and Machine Learning

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ABSTRACT

This research examines the impact of financial crisis, International Public Sector Accounting Standards (IPSAS), corporate governance mechanisms (CG) and audit quality (AQ) on the financial performance of listed banks in Tehran Stock Exchange. The statistical population includes 24 listed banks during two periods: 1390-1397 (pre-crisis) and 1398-1402 (post-crisis). The dependent variables are return on assets (ROA), return on equity (ROE) and net interest margin (NIM). The research methodology is based on a combined machine learning approach using Fuzzy Neural Network (FNN) and Convolutional Neural Network (CANN). The FNN model is used to model uncertainties, while CANN aims to improve the generalizability of the model. The Particle Swarm Optimization (PSO) algorithm is used for parameter optimization. Model validation is performed using a 5-fold cross-validation technique. The results indicate that the financial crisis had a significant impact on the factors affecting the financial performance of banks listed on the Tehran Stock Exchange. During the crisis period, the importance of IPSAS, AQ, and CG increased significantly, highlighting the need for financial transparency and enhanced supervision under crisis conditions. Variables such as board size, composition, CAP and FSIZE showed a stronger positive effect on financial performance, while the negative effect of LEV increased. The optimized ANN-GA model showed high predictive accuracy (95.3% for ROA, 94.1% for ROE and 94.8% for NIM). Sensitivity analysis showed that in the pre-crisis period, CG, FSIZE and IPSAS had the most significant influence, while in the crisis period, the model's sensitivity to LEV, BSIZE and AQ increased significantly. Cross-validation tests confirmed the stability and high predictive power of the model, with the Diebold-Mariano test showing the significant superiority of ANN-GA over linear and logistic regression models. These results highlight the high capability of the ANN-GA model in identifying and predicting changes in factors influencing bank financial performance before and after the financial crisis. By emphasizing the importance of flexibility in banks' managerial and financial strategies in changing economic conditions, the study highlights the need for special attention to CG, IPSAS and AQ to improve financial performance. In addition, this research demonstrates the effectiveness of a combined machine learning approach in analyzing and predicting bank financial performance as a basis for strategic decision making in the banking industry and the formulation of regulatory policies.

INTRODUCTION

In the current global environment, which is characterized by rapid and complex changes in economic systems, there is an urgent need to focus on corporate governance mechanisms, standardized auditing practices, and the efficiency of public sector accounting, all of which play a fundamental role as essential components in improving the financial performance of manufacturing companies (Khajavi & Ebrahimi, 2018). Evaluating firm performance has been an important issue for a long time, and many discussions in accounting and management have been devoted to firm performance. Investors are always seeking to increase their capital, and strive to invest in companies with higher stock returns and better financial performance. However, in some cases, the financial performance of a company can be affected by crises (Ghosi & Akbarpour, 2019). A financial or economic crisis refers to a wide range of situations in which certain financial resources lose a significant portion of their nominal value. The financial crisis of the past decade has had a significant impact on the financial markets, leading to a significant reduction in equity financing by companies and financial institutions. One of the consequences has been an increase in the proportion of debt in companies' capital structures. As a result, many firms are unable to repay their debt during crisis periods, exposing them to financial distress and opportunistic behavior (Kheirollahi et al., 2022). One of the most recent financial crises is the COVID-19 pandemic, which has affected different industries and companies with varying degrees of severity (Iqbal & Mamel, 2023). However, the COVID-19 crisis is unique in its complexity and scale, presenting a new set of unprecedented challenges to even the most resilient and adaptable companies. While COVID-19 affects an unusually large segment of firms worldwide, a growing number of recent studies indicate significant heterogeneity depending on specific firm and industry characteristics (Carletti et al., 2020; Alfaro et al., 2020; Ding et al., 2021; Fahlenbrach et al., 2020; Albuquerque et al., 2020). On the other hand, the relationship between corporate governance and financial crisis has been evaluated since 1980. To assess the validity of this relationship, several studies have examined the impact of corporate governance mechanisms on the survival of companies facing financial crisis (Wang & Ding, 2006). The corporate governance system, as a system that combines several scientific branches such as accounting, financial management, economics and law, while maintaining a balance between social and economic goals and individual and collective goals, promotes and strengthens the efficient and optimal use of resources and requires companies to be accountable to other stakeholders. In addition, the implementation of a corporate governance system can lead to optimal resource allocation, improved transparency of financial information disclosed to the market, and ultimately economic growth and development (Jensen, Meckling & W; 1976). Audit quality has been recognized as an important factor in enhancing investor confidence and reducing agency costs. On the other hand, audit quality is another key component that can provide assurance to investors and other stakeholders (Abdullah & Tursoy, 2023). Independent auditors and high-quality audits contribute to the credibility and reliability of financial information by providing accurate and impartial assessments of financial reports (Doz & Prahalad, 1984). This in turn leads to increased transparency and reduced investment risk (Zattoni, 2011).

With increasing competition in global trade, audit quality has become one of the key components in corporate governance strategies and financial decision-making (Adrian & Okwom, 2015). Independently and accurately prepared audit reports can provide valuable insights to managers to identify weaknesses and strengthen performance aspects, thereby helping to maintain and enhance the company's competitive position in the market (Jassim Saeed et al., 2023). Attention to audit quality as an effective social and regulatory tool plays an important role in controlling management behavior and improving financial transparency, which ultimately leads to increased investor confidence and reduced investment risk (Obeid, 2016).

Recently, the global financial crisis has prompted the financial media to seek answers as to whether auditors have properly performed their auditing duties. For example, the Public Company Accounting Oversight Board has accused auditors of failing to apply auditing standards in relation to income statements and balance sheet accounts that were significantly affected by the economic crisis (Du & Lai, 2018). Globalization has been associated with the development and dynamism of the market,

while increasing instability at the level of large corporations. In addition, recent financial scandals around the world have raised concerns about the reliability of financial statements. These scandals and their consequences are the main reason for the increased attention to the quality of financial statements. Furthermore, the pressure of financial crises on many countries in recent years has increased the demand for high quality audits (Zureigat, 2011). Therefore, the research question posed in this study revolves around assessing the impact that audit quality can have in facilitating the sustainable improvement of organization's financial performance. This critical assessment addresses the potential of audit quality to act as a central mechanism for guiding companies towards long-term growth and success, especially in highly competitive market environments. Moreover, public sector accounting plays a crucial role in establishing a comprehensive framework for assessing and presenting financial performance (Egbunike & Akabuogu, 2018). Similarly, the importance of public sector accounting in providing reliable and understandable financial statements for effective economic decision-making is even more pronounced (Jamshidi et al., 2023). Therefore, given the current global shift towards a combination of economic barriers and new financial changes, the importance of public sector accounting and its impact on the financial performance of organizations is paramount (Boukhroufa et al., 2021).

Public sector accounting not only plays a vital role in measuring the management of critical financial assets and their efficient distribution in accordance with the objectives of the economic environment, but also in ensuring accountability to various stakeholders (Mowlaverdi et al., 2022). Standard public sector accounting reports implemented and developed by organizations such as IFAC can serve as powerful tools for transparency and improving the quality of financial information (Gholami Malek et al., 2022). Therefore, it can be said that public sector accounting can have a direct impact on the financial performance of companies and organizations. Standards such as IPSAS not only improve the reporting and comparability of financial information, but also pave the way for modernizing government accounting policies and ultimately increasing accountability and efficiency in public management (Polzer et al., 2002). Given this context, the main question is how public sector accounting can influence the financial performance of firms.

Overall, the aim of the present study is to predict the effects of financial crisis, public sector accounting, corporate governance mechanisms and audit quality on the financial performance of companies listed in Tehran Stock Exchange. This paper is structured as follows: First, the research literature on financial crisis, public sector accounting, corporate governance quality and audit quality is presented and the related empirical background is reviewed. Then, the research methodology is explained, the statistical population is presented and the data are analyzed. Finally, the research findings are presented and discussed and, based on the conclusions, several practical recommendations are proposed.

2. LITERATURE REVIEW

A financial crisis is a condition in which a firm experiences a period of reduced financial capacity prior to bankruptcy (Handriani et al., 2021). When a firm's declining profitability increases the likelihood that it will be unable to pay its principal debts and financial expenses, the firm is experiencing a financial crisis (Gordon, 1971). Except for bankruptcies resulting from sudden and unexpected events such as natural disasters, financial crisis precedes bankruptcy (Platt & Platt, 2006). Although financial distress or crisis and bankruptcy are closely related, they are distinct. Various definitions of business failure have been put forward to classify economic problems. In summary, four terms - failure or distress, insolvency, default and bankruptcy - have been used in the financial crisis literature (Altman & Hotchkiss, 2006). Firms in financial distress are more likely to engage in earnings management and to report financial statements with low credibility (Mercer, 2004). Firms in financial distress have a strong incentive to increase earnings in order to reduce the perceived risk of the firm to creditors and thus reduce the cost of debt financing. While financially distressed companies have many incentives to manipulate earnings, the external auditor is seen as an external monitoring mechanism to reduce fraudulent behavior in financial reporting. Moreover, financially distressed firms tend to oppose auditors in order to hide their manipulative behavior (Choi et al., 2012; Vafaei Pour & Ghasemi, 2020).

Public sector accounting is a specialized area of accounting that focuses on accurately documenting, auditing, correcting and communicating the monetary transactions of government entities and various not-for-profit organizations related to government. This particular form of accounting plays a crucial role in meeting the requirements of public governance, legislative bodies, stakeholders, lenders, employees and the wider community through comprehensive financial assessment and validation, as well as effective management of financial resources and budget utilization. By participating in the systematic review and transparent reporting of financial data, public sector accounting plays a significant role in enhancing accountability, transparency and efficiency in the public sector, thereby strengthening the confidence of various stakeholders involved in the governance and operations of government-related organizations (Jassim Saeed et al; 2024). In a broader interpretation, public sector accounting refers to the processes by which government entities collect and manage financial resources, including activities such as budget development, allocation, monitoring and presentation of financial data to support management decisions, all of which are subject to public oversight (Kawas et al., 2021). Essentially, public sector accounting is one of the important branches in financial management systems and is responsible for recording, analyzing and reporting on government and public financial and economic affairs. This area requires special care and transparency due to the public interest and government resources involved. The first consideration in this regard is full compliance with laws and regulations to ensure legal governance and resilience. The accounting of government organizations must be carried out in accordance with the accounting guidelines and rules laid down by the legislator. In addition, tax administration, which includes matters such as the review and collection of taxes and their imposition on the relevant institutions, is carried out according to this legal framework (Kurdistani et al., 2016). The second component is corporate governance, which in the context of government organizations leads to increased accountability and protection of public interests. Accounting in the public sector not only ensures the transparency of financial processes, but also contributes significantly to improving strategic decision-making, which ultimately leads to increasing the effectiveness and efficiency of relevant organizations (Abdullah & Tursoy, 2023).

One of the most important financial issues for companies today is the measurement of their performance. Many decisions made by a company's managers, investors and creditors are based on an assessment of the company's performance (Peterson, 1994). Financial ratios, which use data from a company's financial statements and specific market data, are often used to assess a company's financial performance (Mayer et al., 1997). Good corporate governance plays an important role in the performance of a company and the economy as a whole. Because of the systemic importance of companies in the economy, the stability and soundness of companies and the framework within which they operate are key elements in the stability of the financial system. Weak corporate governance structures can cause corporate problems to spill over into the wider economy. Ineffective corporate governance can lead to corporate failure. This was the case during the financial crisis that began in mid-2007. Weak corporate governance can also lead to a loss of market confidence in a company's ability to manage its assets and liabilities, which can ultimately lead to a liquidity crisis. On the other hand, companies are responsible not only to their shareholders but also to other stakeholders (Ng, 2022). Corporate governance has become a major focus of management research, particularly in the wake of the financial misconduct and scandals of recent decades. There is a clear need to improve the monitoring of management performance and the distinction between ownership and management in order to protect the rights of investors and other stakeholders. In fact, corporate governance is recognized as a set of requirements, including the internal relationships and controls of an organization, which ensures the establishment of these controls to prevent infringement of the rights of large and small shareholders and to implement the principles of general meetings. In the existing literature, several definitions of corporate governance have been proposed, generally falling into two categories: narrow definitions and broad definitions. Narrower views, such as the Cadbury Commission Report (1992) and Parkinson's Agency Theory (1994), focus on the relationship between owners and managers. In contrast, broader definitions, such as those discussed by Megginson (1994) and Robert Monks and Nell Minow (1995), take a broader approach and refer to the responsibilities of companies to the whole chain of stakeholders, including their social and environmental roles. Shareholders and other stakeholders need financial information for their decision-making, which is available in companies' annual reports. Companies' annual financial

reports during the COVID-19 crisis, as in previous years, provided shareholders and other stakeholders with various information on the quality of corporate governance, stock returns, financial performance and shareholder value. One of the objectives of presenting these reports is to reduce information asymmetry. Information asymmetry indicates that some insiders, such as managers, have more information about the company's financial situation, projects and future investments than outsiders (Pereira et al., 2020). Other stakeholders, such as the government, investors and creditors, use this information to assess the quality of the company. Therefore, presenting financial statements that contain information about the quality of the company's performance can be good news and affect the value of the company (Gumanti, 2011). Therefore, good organizational governance also has a significant impact on risk management in organizations. This impact is manifested through effective oversight of internal processes, risk assessment and the establishment of control policies. These mechanisms serve to hold managers to performance and regulatory standards and ensure compliance and accountability. In addition, such practices can help to prevent mismanagement of resources and minimize exposure to risk, thereby protecting the company in the face of non-fiat funding opportunities. Ultimately, this helps to improve the financial sustainability and long-term prospects of the company. Therefore, good corporate governance has a significant impact on capital structure, resource allocation and the provision of risk management strategies, playing a crucial role in the economic development of corporate finance. Consequently, these aspects are considered essential strategic elements to ensure the long-term success and prosperity of organizations in the competitive business landscape.

Audit quality refers to the extent to which auditors have been able to meet the expectations and needs of the users of financial reports. Audit quality is critical to the reliability and accuracy of financial reports, which in turn affects the decisions of the various users of this information. The community of individuals who rely on financial reports for decision making plays an important role in assessing the quality of audits performed. This assessment is based on a complex framework that considers various factors and criteria to determine the effectiveness and credibility of the audit process. The establishment of credible auditing standards and the identification of professional issues help to enhance audit quality and ensure that auditors adhere to best practice in their field. These standards and issues provide guidance to auditors, helping them to navigate the complexities of the audit process and to meet the evolving expectations of stakeholders in a changing business environment. In general, the pursuit of audit quality is an ongoing effort that requires collaboration among auditors, standard-setting bodies, and users of financial information to maintain the integrity and reliability of financial reporting (DeFond and Zhang, 2014). Conducting audits in accordance with standards is important; in other words, the auditor is obliged to fulfil its responsibilities by complying with auditing standards and laws, and to pay attention to issues such as accurate documentation of work and preservation of intellectual assets when providing audit services (Stephen Leloire et al., 2023). Despite the various definitions that exist, one of the most important and essential definitions to consider is that provided by DeAngelo (1981). This definition of audit quality revolves around market valuation, which can be divided into two distinct components. First, it emphasizes the auditor's ability to detect significant misstatements and, second, it emphasizes the importance of reporting these detected misstatements. The detection of such misstatements depends on the auditor's technical expertise, while the likelihood of detecting misreported statements is influenced by the auditor's resilience (Mohammadrezaei and Yaghoubnejad, 2018). Other definitions also suggest that audit quality is related to the accuracy and correctness of the information provided to the audience after the audit, implying that the audience should be able to use the linguistic and qualitative information reflected in the audit report to make financial decisions. This interpretation of audit quality emphasizes the direct relationship between the reliability of audited financial statements and audit quality (Titman and Trueman, 1986). It is important to note that it is essential to recognize the dynamic nature of the concept of audit quality, as audit quality evolves over time based on changes in the environmental context and the evolution of standards. This evolution allows auditors to provide more accurate financial reports, thereby improving the overall state of financial reporting. Finally, it is important to note that audit quality and financial reporting quality are two key factors in assessing the transparency and accuracy of financial reporting and have been increasingly studied in recent years (Gaynor et al., 2016). Thus, high-quality audits can lead to the consolidation of transparent financial reporting and increased accuracy in assessing the financial position of

companies, which in turn affects the quality of investors' financial decisions and increases the efficiency of financial markets.

Therefore, predicting the effects of financial crisis, public sector accounting, corporate governance mechanisms and audit quality on the financial performance of companies listed in Tehran Stock Exchange is a complex and multidimensional issue. Financial crisis, which is defined as a condition in which a company faces reduced financial capacity (Handriani et al., 2021), can lead to earnings management and reduced credibility of financial reports (Mercer, 2004). In such circumstances, the role of corporate governance and audit quality in monitoring management performance and protecting the rights of shareholders and stakeholders becomes more prominent (Ng, 2022). On the other hand, public sector accounting, with its emphasis on transparency and accountability (Jassim Saeed et al., 2024), can serve as a model for improving financial reporting in the private sector. The interrelationship between these factors and firms' financial performance is important because, in times of financial crisis, firms with strong corporate governance mechanisms are likely to be better able to manage risk (Ng, 2022). This strong governance leads to the selection of higher quality auditors, which in turn increases the credibility of financial reports (DeFond and Zhang, 2014). High-quality audits help reduce information asymmetry and increase investor confidence. Moreover, the principles of transparency and accountability in public sector accounting can serve as a model for improving financial reporting in the private sector (Jassim Saeed et al; 2024). During financial crises, the role of auditors in detecting and reporting misstatements becomes more critical (Choi et al., 2012). Ultimately, the interaction of these factors can have a significant impact on a firm's ability to manage financial challenges, maintain investor confidence, and improve financial performance. High audit quality can help reduce information asymmetry (DeFond and Zhang, 2014) and increase investor confidence. Effective corporate governance mechanisms can also contribute to improved risk management and strategic decision making (Abdullah & Tursoy, 2023). In times of financial crisis, companies with strong governance structures and high audit quality are likely to have a greater ability to overcome challenges and maintain financial performance. In addition, the principles of transparency and accountability in public sector accounting can serve as a model for improving financial reporting, thereby enhancing investor confidence and improving the financial performance of listed companies.

Regarding the effects of financial crisis, public sector accounting, corporate governance mechanism and audit quality on the financial performance of listed companies, several studies have been conducted. These studies have examined and predicted the effects of these factors on the financial performance of companies. In the following, some of the most important findings of this research are mentioned:

Raisi et al. (2016) conducted a study to evaluate decision trees in predicting the financial performance of companies listed on the Tehran Stock Exchange. The purpose of this study was to predict the performance of financial companies listed on the Tehran Stock Exchange using two dependent variables, return on equity and return on assets. The results indicate that between the two variables of return on assets and return on equity, return on equity has higher accuracy in terms of the scores obtained, and among the four decision trees, C5.0 had the best scoring characteristics.

In another study, Zolaghi and Firouzabadtappeh (2017) examined the impact of accounting estimates on predicting financial performance and liquidity of companies listed in Tehran Stock Exchange. The results show that accounting estimates have the ability to predict liquidity (quick and current ratios), but lack the ability to predict working capital. In addition, accounting estimates have the ability to predict financial performance (return on assets, return on sales).

Ližbetinová et al. (2019) conducted a study on predicting the financial performance of agricultural enterprises based on supply chain operations in seasonal decomposition. The main objective of the study was to predict the financial performance and profit of agricultural units through forward-looking estimates of income and expenses of conventional activities, using a multiplicative trend-seasonal model. The results show that, despite seasonal variations, sales revenues increase and costs decrease due to uniform production and efficient use of fixed assets. Furthermore, the quality of the predicted estimates is confirmed and the practical use of the trend-seasonal model for predicting the financial performance of agricultural units is highlighted.

Foroughi Nasab et al. (2021) conducted a study to examine the dimensions of social responsibility and improve the financial and non-financial performance of companies. The research findings indicate that the legal and ethical dimensions of social responsibility do not have a significant effect on changes in Tobin's Q ratio, while the social dimension of social responsibility has a positive and significant effect on changes in Tobin's Q ratio. On the other hand, the social dimension of social responsibility has a positive and significant effect on changes in structural capital, while the ethical and legal dimensions of social responsibility do not have a significant effect on changes in structural capital.

Carlos Lassala et al. (20-21) conducted a study to examine the financial performance of listed companies in pursuit of the Sustainable Development Goals (SDGs), using fuzzy set qualitative comparative analysis (fsQCA) to identify configurations of conditions that lead to high or low financial performance (return on equity) in IBEX 35 sample companies. The results show that socially responsible companies, whose values are aligned with the UN SDGs, can create competitive advantage and achieve better financial performance. The study also emphasizes that companies should adopt sustainability-based business models to meet current needs while ensuring the future of future generations.

Karim et al. (20-22) investigated the impact of accounting reports and information on predicting firm financial performance, with the aim of examining the role of annual report sentiment in predicting financial performance. Evidence suggests a non-linear relationship between sentiment and financial performance. The results suggest that sentiment information is a critical determinant in predicting financial performance and can therefore be used to assist shareholders in their decision-making process.

In another study, Abgineh et al. (2023) presented a financial performance model based on the disclosure of environmental information in companies listed on the Tehran Stock Exchange. The results showed a significant relationship between environmental disclosure and financial performance. Industrial pollution also affected this relationship. Attention to environmental information disclosure, especially in polluting industries, will create value and sustainable development for companies.

Supsomboon et al. (2023) conducted research to predict the financial performance of listed companies in Thailand during the transition period: A class-based approach using logistic regression and random forest algorithm. The study aimed to predict financial performance using logistic regression and random forest algorithm for companies listed on the Thai Stock Exchange. The results show that the determinants significantly affect the predicted financial performance in a given period. In addition, this study examines the impact of IPO funds on financial performance and finds that while there is no significant effect in the first year after listing, there is a subsequent positive correlation in the following two to three years, up to a certain threshold, with excess funds potentially leading to adverse effects. Overall, the predictive models provide valuable insights for companies, enabling them to priorities resources relative to important determinants in a given relative year, make informed decisions and increase their long-term success in the stock market. In another study, Lam et al. (2023) analyzed the decision making regarding the financial performance of companies using an integrated fuzzy entropy TOPSIS model. They presented a multi-criteria decision-making (MCDM) model, namely the fuzzy entropy TOPSIS model, to evaluate the financial performance of companies based on key financial ratios for portfolio investment. The fuzzy concept helps to reduce ambiguity and enhance meaningful information extracted from financial ratios. The results show that return on equity and debt-to-equity ratio are the most influential financial ratios for evaluating company performance. Companies with good financial performance, such as the best HD company, were identified based on the proposed portfolio selection model. A mean-variance (MV) model is used to validate the proposed model in portfolio investment. At the minimum risk level, the proposed model can generate a higher average return than the DJIA index. This study is significant as it helps to evaluate the financial performance of companies and select good performing companies using the proposed model for portfolio investment.

Moravveji et al (2024) conducted research to explain the optimal model for predicting financial performance based on the Q-Tobin’s ratio using data mining techniques. The results show that the

Firefly algorithm, genetic algorithm and evolutionary algorithms were effective in predicting the QTobins ratio and return on equity, with the Firefly search algorithm having the highest predictive power. These results emphasise the importance of using advanced algorithms in the analysis of financial data. In another study, Jasem Saeed et al. (2024) examined the impact of corporate governance, audit quality and public sector accounting on the financial performance of Iraqi companies and government organizations. The results indicate a significant impact of corporate governance, audit quality and public sector accounting on financial performance. The study shows that larger firms with stronger governance structures have better financial performance, and that focusing on the separation of management roles and strengthening effective management structures helps to improve firms' financial performance. In addition, neural network analysis reveals a significant impact of these factors on transparency and risk management. Therefore, this research re-emphasizes the importance of corporate governance and audit quality as key indicators for increasing operational efficiency and investor confidence.

The need to conduct research on predicting the effects of financial crisis, public sector accounting, corporate governance mechanisms and audit quality on the financial performance of companies listed on the Tehran Stock Exchange is noteworthy from several perspectives. Given the complex and variable economic conditions in Iran, examining the impact of financial crises on the performance of listed companies is of particular importance. Moreover, given the increasing importance of public sector accounting and corporate governance mechanisms in financial transparency and accountability, assessing the role of these factors in the financial performance of companies is essential. On the other hand, audit quality, as one of the main pillars of confidence building in the capital market, needs to be examined in more detail. This research can help policy makers, managers and investors to make more informed decisions and provide the basis for improving the financial performance of listed companies and enhancing the efficiency of the capital market. Therefore, based on the review of theoretical literature and research background, it is observed that in relation to the subject of the present study, there is little or no research that directly examines the impact of corporate governance, audit quality and public sector accounting on the financial performance of companies listed on the Iranian Stock Exchange. Most studies have used econometric methods, while this research uses neural networks and machine learning to address this research gap in this study.

3. Methodology

In terms of research classification based on the aim, the current research belongs to the type of applied research. In terms of research classification according to method, it is a type of descriptive research, and among the types of descriptive research methods, it is a type of post-event research. In order to test the research hypotheses, it is necessary to collect the factors affecting the dependent variable of financial performance of listed companies and express it based on a function such as F. This function is determined in a non-linear way, so artificial neural network and machine learning methods are used to predict financial performance. Basically, the financial performance of banks refers to the comprehensive assessment of the financial and operational status of banks listed on the Tehran Stock Exchange in a given period. This criterion includes a number of financial indicators that show the bank's efficiency and effectiveness in using financial resources, managing assets and liabilities, profitability and ability to create value for shareholders. Therefore, the machine learning techniques of reinforcement gradient and random forest were used to predict the financial performance of banks. To test the models, the neural network, fuzzy neural network and cerebellar neural network were used to determine the best models in predicting the financial performance of banks listed in Iran Stock Exchange and the results were analyzed. Then, the support vector machine of the optimal expectation algorithm was used to check the validity of the models. In this research, each of these machine learning models is compared with neural network models.

Machine learning models

Machine learning is a subset of data science that provides the ability to learn and improve experiences without being programmed. The beauty of machine learning solutions is that they learn from experience without being explicitly programmed. Simply put, you select models and feed them data. The model then automatically adjusts its parameters to improve results. Machine learning is a branch of artificial intelligence used to make predictions. Today, machine learning plays a

fundamental role in many stages of the finance and accounting ecosystem, from asset management to risk assessment and analysis of capital and financial market behaviors. In fact, companies that use machine learning technology have multiple advantages, both in terms of replacing old systems and developing enterprise or customized solutions (Rabiei, 2022). In short, machine learning is an important branch of artificial intelligence that aims to design algorithms that allow computers to develop their behavior based on experimental data. The most obvious feature of machine learning is knowledge discovery and automatic intelligent decision making. When big data is desired, it is necessary to use the scale of machine learning algorithms in the execution of the desired tests (Solis, 2019). In this research, a machine learning model was used to predict the financial performance of Iranian banks listed on the Tehran Stock Exchange, which explains some of these algorithms used in the research:

Gradient Boosting (XGBoost)

XG Boost is a performance-optimized distributed gradient boosting toolkit (Behera et al., 2023; Yan, Chen, Dong, Ju & Xu, 2022). It uses a recursive binary partitioning strategy to obtain the optimal model by selecting the best partition at each stage. The tree-based nature of gradient boosting makes it insensitive to outliers, and like many boosting methods, it is resistant to overfitting, which makes model selection much easier (Behera et al., 2023; Alabdallah, Iqbal, Zahid, Khan, Amin & Jalal, 2022; Pasayat, Mitra & Bhowmick, 2022). Equation (2) shows the regularized objective of the gradient boosting model at the t-th training stage, where l ($y_{\text{pred}}^{(t)}$, (, y_{truth}) represents the loss, which refers to the calculation of the difference between the simulated value $y_{\text{pred}}^{(t)}$ and the associated ground truth y_{truth} .

$L^{(t)} = \sum_i l(y_{\text{pred}}^{(t)}, y_{\text{truth}}) + \sum_k \Omega\ (f_k)$

Where $\Omega(f_k) = \gamma^T + \frac{1}{2} + \lambda\|w\|^2$represents the complexity of tree k, in which T denotes the number of leaves and $\|w\|^2$ specifies the $\ell 2$ norm of all leaf scores for the training samples. When searching for the tree, the parameters γ and λ adjust the degree of conservatism.

Random Forest (RF)

Random Forest is a nonparametric and nonlinear model first introduced by Ho (1995). This model avoids the problem of overfitting because it always converges (Breiman, 2001). Given the advantages of Random Forest, it is often used for stock forecasting (Ballings et al., 2015; Booth et al., 2014; Coyne, 2014). The determination of the prediction depends on the type of problem. In the case of classification, the decision trees in the RF-induced prediction model are arranged in a group and the result is determined by the predictions made by each tree, such as using majority voting (Tang, Henderson & Gardner, 2021). Meanwhile, the average of the trees' predictions forms the final prediction in the regression. That is, when RF receives an input vector (x) containing the values of many observable features examined for a particular training domain, it generates m regression trees and then averages the results. The RF prediction equation after m trees is $\{T(x)\}_1^M$ (Behera et al., 2023).

$f_{\text{rf}}^M(x) = \frac{1}{M}\sum_{m=1}^M T(x)$

3.2 Neural network

Artificial neural networks are a computational model inspired by the biological nervous system of the human brain. These networks consist of interconnected layers containing artificial neurons (or nodes). Each connection, like synapses in the biological nervous system, transmits signals from one neuron to another. Neural networks are capable of learning and recognizing patterns in data and can be used to perform various tasks such as classification, prediction, pattern recognition and optimization. They are widely used in various areas of artificial intelligence, including image processing, speech recognition and deep learning. One of the key advantages of neural networks is their ability to learn from data and improve their performance over time, making them very suitable for solving complex and non-linear problems.

Fuzzy neural network

A fuzzy neural network or fuzzy neural system is a learning machine that finds the parameters of a fuzzy system (i.e. fuzzy sets, fuzzy rules) using approximation techniques from neural networks. Both neural networks and fuzzy systems have similarities. Fuzzy logic allows clear decisions to be made based on uncertain or ambiguous information, while artificial neural networks attempt to solve problems without mathematical modelling by emulating the human thought process. Although both methods can be used to solve non-linear and ill-defined problems, each has its own drawbacks. The designer can only achieve relative satisfaction after extensive experience and practice with the complexity of the desired network, the learning algorithm to be used, and the degree of accuracy acceptable in this application. On the other hand, the design of fuzzy systems requires a deep understanding of fuzzy variables and membership functions, input-output relationships, and proper discrimination in the selection of fuzzy rules. By incorporating fuzzy logic operations into neural networks and the learning process, the shortcomings of neural networks and fuzzy systems can be addressed. The result of this work will be an artificial fuzzy neural network (Lee et al., 2010). Professor Jang introduced the Adaptive Neuro-Fuzzy Inference System (ANFIS) in 1993, which uses the Takagi-Sugano fuzzy system in the neural network structure for implementation to create a non-linear mapping between input and output spaces. This system works as follows: In each training round, during the forward movement, the outputs of the neurons are calculated normally up to the last layer, and then the resulting parameters are calculated using the least squares error method. Then, after calculating the error in the backward return, the error ratio of the antecedent parameters is distributed and their values are corrected using the gradient descent method (Zamani et al., 2014).

Cerebellar neural network (CMAC)

The Cerebellar Model Articulation Controller (CMAC) is a type of artificial neural network based on the structure and function of the cerebellum in the human brain. This network was introduced by James Albus in 1975 and is used to control robots and complex non-linear systems. The cerebellar network uses a memory to store and retrieve information, which is very similar to how the cerebellum works and controls movement. The network consists of several layers, each of which contains memory cells. Each input to the network activates a cell in each layer and the final output is the weighted sum of these cells. The basic formula for the CMAC output is as follows

$y = \Sigma (wi * ai)$

where: y: network output, Wi: weight corresponding to cell, i ai: activation of cell i (0 or 1). The learning process in CMAC involves adjusting the weights of the activated cells to reduce the error between the actual output and the desired output. This is usually done using the delta learning rule:

$\Delta wi = \beta * (y_{desired} - y_{actual}) * ai$

where: Δwi: change in weight of cell, i β: learning rate, $y_{desired}$: desired output, y_{actual}: actual output ai: activation of cell i. And to measure the performance of CMAC, the following criteria are usually used:

Mean Square Error (MSE): $MSE = (1/n) * \Sigma (y_{desired} - y_{actual})^2$

Root Mean Square Error (RMSE): RMSE = sqrt (MSE)

Mean absolute error (MAE): $MAE = (1/n) * \Sigma |y_{desired} - y_{actual}|$

In these formulae, n is the number of test samples. CAMC has advantages such as high learning speed, good generalization ability and noise immunity. However, this network can have difficulty in dealing with high-dimensional input spaces (high-dimensional problem). Various methods have been proposed to overcome this problem, such as quantizing the inputs and using radial basis functions. Compared to traditional neural networks, CMAC usually has a faster learning speed and is more suitable for applications that require fast response and real-time control.

Expected Optimization Algorithm (EOA)

Expected Optimization Algorithm (EOA) is a stochastic optimization method that was introduced in 2013 by Iranian researchers, Dr. Mohammad Reza Bashiri and Dr. Farzad Toheidi. This algorithm is inspired by the concept of mathematical hope and is designed to solve complex and non-linear

optimization problems. EOA starts by generating an initial population of random solutions. It then generates several new samples for each member of the population. In the next step, the mathematical hope algorithm calculates the improvement of the objective function for each member. The members with the greatest hope of improvement are selected for the next generation. The position of these selected members is updated using information from the generated samples. This process is repeated until the stopping condition is reached, so the expectation optimization algorithm can be used to predict the effects of the financial crisis, public sector accounting, corporate governance mechanism and audit quality on the financial performance of companies listed on the Tehran Stock Exchange. Inspired by the concept of mathematical hope, this algorithm is designed to solve complex and non-linear optimization problems. In the intended application, EOA begins with the definition of input (influencing factors) and output (financial performance) variables. Then, using historical data of listed companies, it creates a predictive model. The algorithm starts by creating an initial population of random solutions and generates new samples for each member. The mathematical hope of improving the objective function is calculated for each member and the best members are selected. This process is repeated until the stopping condition is reached. The main EOA formulas in this application are:

Generation of samples: $X_{ij} = X_i + r * (X_{best} - X_i) + \varepsilon$

Calculate the mathematical expectation of improvement: $E[\Delta F_i] = (1/m) * \Sigma (\max (0, F(X_i) - F(X_{ij})))$

Update position: $X_{inew} = X_i + \alpha * (X_{bestsample} - X_i)$

Criteria such as MSE, RMSE and MAE are used to evaluate the performance of the model. This approach helps financial analysts, investors and company managers to better understand the impact of various factors on the financial performance of companies. The resulting model can be used to simulate different scenarios and predict financial performance under different economic and managerial conditions. The advantages of using EOA in this area include the ability to solve complex problems, high convergence speed and the ability to avoid local optima. However, the need to fine-tune the parameters can be challenging. By combining statistical and optimization concepts, EOA provides an innovative approach to analyzing and predicting the financial performance of listed companies under different conditions.

The financial performance of banks can be assessed using indicators such as return on assets (ROA), return on equity (ROE) and net interest margin (NIM). Comparing these indicators with the banking industry average and their changes over time also provides a more comprehensive picture of the bank's financial performance. So; financial performance is examined as a dependent variable in this research and based on the studies of Addo et al, (2024); Ashiro et al, (2023); Canisio Zingirai and Mofaro Zingirai, (2024) is evaluated as follows.

$$\text{ROA} = \frac{\text{Operating Profit}}{\text{Total Assets}}, \quad ROE = \frac{Net\ Income}{Shareholders'Equity}, \quad NIM = \frac{Net\ Interest\ Income}{Total\ Earning\ Assets}$$

where:

Return on assets (ROA): This ratio measures a bank's profitability in relation to its total assets. It shows how effectively the bank uses its assets to generate profit from its operations.

Return on equity (ROE): This ratio shows how much profit the bank makes on the money invested by shareholders. It measures the bank's profitability from the shareholders' perspective.

Net interest margin (NIM): This ratio measures the difference between the interest earned on the bank's earning assets and the interest paid on interest-bearing liabilities as a percentage of total earning assets. It shows the bank's profitability from its main activities of lending and borrowing.

In this research, the variables of financial crisis, public sector accounting, corporate governance mechanism and audit quality have been used to predict the financial performance of banks listed in Tehran Stock Exchange and the way they are measured is as follows:

Financial crisis

In this research, the Covid-19 epidemic can be interpreted as a financial crisis. This interpretation is based on numerous studies that show the deep and far-reaching effects of this phenomenon on the global financial and economic system. Yıldırım and Erdil (2024) describe Covid-19 as an unprecedented exogenous economic shock, even more pervasive than the 2008 global financial crisis. Matif et al. (2024) also emphasize the pervasive economic and financial nature of this phenomenon. Other studies, such as Marko (2021), Wang et al. (2020) and Koze et al. (2021), specifically point to the negative impact of this crisis on the financial and economic system, increasing the risk of bankruptcy and cash flow disruptions. In addition, the empirical studies of Yan et al. (2023) provide stronger evidence of the negative impact of Covid-19 on the global financial and economic system. Therefore, considering the nature, extent and depth of the economic and financial impact of Covid-19 documented in these studies, it can be argued that this epidemic can be classified as a financial crisis. Therefore, according to the interpretation of Covid-19 as a financial crisis, it can be predicted that this phenomenon will have a significant impact on the financial performance of companies listed on the Tehran Stock Exchange. However, the nature of these effects is still unclear.

In this research, the time frame of the financial crisis is the same as the time frame of Kovid-19. For this reason, the time frame of the research is divided into two parts before and after the covid-19: the time frame from 1390 to 2017 when there was no covid-19 as a financial crisis, and the time frame from 2018 to 2014 when the covid-19 There was a financial crisis in the world economy. Because the purpose of this research is to investigate and predict the effects of the financial crisis caused by Covid-19, public sector accounting, corporate governance mechanisms and audit quality on the financial performance of companies admitted to the Tehran Stock Exchange. Therefore, by analyzing the financial and economic data of these companies in the mentioned periods, we will try to get a comprehensive picture of the impact of these factors during the crisis and after.

Corporate governance mechanism (CG)

In the present study, in line with the studies of Danro and Kim, (2005); Brown and Keller, (2006); Yang et al., (2008); Addo et al., (2024) and Mela et al., (2019). First, a list related to corporate governance that is compatible with Iran's reporting context has been prepared, then in order to operationalize the quality index of corporate governance, coding and scoring methods have been used. Based on this method, a score of zero or one (according to their operational definition) is assigned to each of the components of corporate governance, and by summing these scores, a score corresponding to the score of corporate governance is calculated for each company in each year. be made So that a higher score for this index indicates a more efficient corporate governance and a lower score for this index indicates a weaker corporate governance. The components of corporate governance and their operational definition are as described in Table (2).

Table (2) operational definition and components of corporate governance

Component Name	**Operational Definition**
Non-executive Board Members	If the ratio of non-executive members to total members is more than the average ratio calculated for all companies, it's 0; otherwise, it's 1.
Separation of CEO and Chairman Roles	If the CEO and Chairman roles are not separated, it's 0; otherwise, it's 1.
CEO Stability	If the CEO has changed in the past two years, it's 0; otherwise, it's 1.
Use of Accounting and Financial Experts	If there is no use of accounting and financial experts on the board, it's 0; otherwise, it's 1.
Non-executive Chairman	If the Chairman is an executive, it's 0; otherwise, it's 1.
Audit Committee	If there is no audit committee comprised of non-executive board members, it's 0; otherwise, it's 1.

Number of Board Meetings	If the number of board meetings is not mentioned in the company's annual report, it's 0; otherwise, it's 1.
Presence of Controlling Shareholders	If there are no controlling shareholders, it's 0; otherwise, it's 1.
Ownership Concentration	If the percentage of free-floating shares is more than the average free float percentage, it's 0; otherwise, it's 1.
Ownership Structure	If the ownership structure is not mentioned in the annual report, it's 0; otherwise, it's 1.
Related Party Transactions	If the related party transactions ratio to sales is more than the average for all companies, it's 0; otherwise, it's 1.
Government Ownership	If the percentage of government ownership in the company is less than the average percentage, it's 0; otherwise, it's 1.
Presence of Website	If there is no website for the disclosure of company information, it's 0; otherwise, it's 1.
Information Timeliness	If the company's information dissemination score is less than 50, it's 0; otherwise, it's 1.
Reliability of Information	If the company has retrospective adjustments, it's 0; otherwise, it's 1.
Auditor's Opinion	If the company received a non-acceptable opinion from the auditor, it's 0; otherwise, it's 1.
Future Plans	If the company's future plans are not mentioned in the annual reports, it's 0; otherwise, it's 1.
Employment Report	If there is no mention of employment and staffing status, it's 0; otherwise, it's 1.

International Public Sector Accounting Standards (IPSAS):

IPSAS: It is the symbol of the use of international public sector accounting standards, which will be used in this study in line with the studies of Pourhosseini Hisar et al. (1400) of public sector accounting. Therefore, based on the level of implementation of these standards in each country, there are two codes: one indicating the use of International Public Sector Accounting Standards and zero indicating that International Public Sector Accounting Standards are not used. Each bank receives a score between 0 and 100 percent based on the number of items disclosed in its annual report.

Audit Quality (AQ)

To measure the audit quality index, audit institutions are divided into two groups: large institutions and small institutions. In this research, the large institution is the audit organization and the small institution is the private audit institution that is a member of the official accountancy society. In this way, if the auditor of the company is an auditing organization, it is considered as a large and high-quality auditing institution and the number 1 is assigned to this company, otherwise the number 0 is assigned to this company. The theoretical basis for the choice of this variable is that previous studies have shown that the size of audit firms is directly related to the quality of their work. This is because large audit firms have more experienced auditors and a better monitoring system, and they are not willing to lose their reputation for low audit quality. Therefore, according to this argument, the larger the audit firm, the higher the quality of information on the companies audited. This measurement method has been used in many internal studies such as Namazi et al.

In this research, the following control variables were used to predict the financial performance of banks listed in Tehran Stock Exchange in line with the study of Ado et al. (2024):

1. Bank Sustainability Reporting Framework (BSRF): If the bank has reported on sustainability in its annual report, this variable is assigned a value of 1. However, if the bank does not report on sustainability in its annual report, this variable is assigned a value of 0.

2. Board sustainability committee (BSCOM): If the bank's board of directors has a sustainability committee, this variable is assigned a value of 1, otherwise a value of 0.

3. Board size (BSIZE): The natural logarithm of the number of board members is calculated.

4. Company size (FSIZE): The natural logarithm of the bank's total assets is calculated.

5. Financial leverage (LEV): The ratio of total liabilities to total assets is calculated.

6. Capitalization (CAP): Equity divided by total assets is calculated.

Finally, the final research model is as follows:

$$ROA = f(CG_{itj} + IPSAS_{itj} + AQ_{itj} + BSRF_{itj} + BSCOM_{itj} + BSIZE_{itj} + FSIZE_{itj} + lev_{itj} + CAP_{itj})$$

$$ROE = f(CG_{itj} + IPSAS_{itj} + AQ_{itj} + BSRF_{itj} + BSCOM_{itj} + BSIZE_{itj} + FSIZE_{itj} + lev_{itj} + CAP_{itj})$$

$$NIM = f(CG_{itj} + IPSAS_{itj} + AQ_{itj} + BSRF_{itj} + BSCOM_{itj} + BSIZE_{itj} + FSIZE_{itj} + lev_{itj} + CAP_{itj})$$

where in:

ROA indicates the return on assets, ROE indicates the return on equity, and NIM indicates the net profit margin, and these 3 are used as dependent variables of the financial performance of Iranian banks admitted to the Tehran Stock Exchange. And CG indicates the mechanism of banking governance, IPSAS indicates public sector accounting and AQ indicates the audit quality variable, and these three variables are used as independent variables to predict the financial performance of banks admitted to the Tehran Stock Exchange. has been On the other hand, BSRF indicates the sustainability reporting framework of banks, BSCOM indicates the sustainability committee of the board of directors, BSIZE indicates the size of the board of directors, FSIZE indicates the size of the company, lev indicates the financial leverage and CAP indicates the investments in the bank, which is The variables have also been used as control variables to predict the financial performance of Iranian banks admitted to the Tehran Stock Exchange. Therefore, in the above relationships, I represent the bank, t represents the time before the financial crisis (1390 to 1397) and j after the financial crisis (1398 to 1402). The statistical population of this research is the data of the banks admitted to the Iran Stock Exchange for the period of 2010 to the end of 2012, and the data related to this research were extracted from Kodal, Fipa Iran, Tehran Stock Exchange, Economic and Financial Data Bank. has been the data was arranged using Excel software. In order to achieve a suitable and targeted statistical population, the sample selection method was used and the selected banks have the characteristic of being located in the studied time period. After collecting the information of 24 banks in the mentioned site, all the statistical population was used to implement the model, and they were investigated as the target population of the research. R&Rstudio software was also used for data analysis.

4. Data Analysis and Findings

4.1. Descriptive analysis

Prior to the final review of the research findings, the first stage of data preparation involved collecting information for the period 1390-1402. The data cleaning process then involved removing outliers, checking and correcting missing data, and identifying and correcting possible errors in data entry. To normalize the data, the Z-score normalization method was used to make the scale of the variables the same. In addition, some variables such as bank size were transformed using natural logarithms. In the next step, qualitative variables such as audit quality, corporate governance, public sector accounting, board sustainability committee and bank sustainability reporting framework were coded as virtual variables. The normality of the data distribution was also checked using the Jarque-Bera test. Therefore, in this research, the Jarek-Bera test was used to check the distribution of the data, the results of which are described in Table 1.

Table 1. Normality test of research data

Row	**variables**	**1st Qu**	**3rd Qu**	**Jarque Bera Test**	
				X-squared	**p-value**
1	ROA	0/000	13/008	54634	**0/0000**
2	ROE	0/000	13/938	1898/1	**0/0000**
3	NIM	0/000	20/610	97969	**0/0000**

4	CAP	1/0E+5	5/0E+6	55172	**0/0000**
5	LEV	13/94	75/30	283836	**0/0000**
6	AQ	0/000	1/000	33/735	**0/0000**
7	IPSAS	0/000	1/000	32/677	**0/0000**
8	CG	2/000	11/00	12/47	**0/0019**
9	BSRF	0/000	1/000	34/298	**0/0000**
10	BSCOM	0/000	1/000	39/172	**0/0000**
11	BSIZE	0/6990	0/6990	10593	**0/0000**
12	FSIZE	14/51	16/40	12/211	**0/0022**

Source: Research calculations

Based on the results of Table 1. According to the Jarek-Bera test, all the variables analyzed with a p-value below 0.05 do not follow a normal distribution. The variables ROA, ROE, NIM, CAP and LEV show a strong deviation from the normal distribution with very high X-squared values, while AQ, IPSAS, BSRF and BSCOM have lower X-squared values, but are still not normal. CG with the lowest X-squared (12.47) is also abnormal. BSIZE and FSIZE indicate a concentration of data in a certain range and CAP with high values in the quartiles indicates a high variability. These results emphasize the need to use non-parametric methods or data transformation before statistical analysis. Therefore, considering that non-parametric methods such as machine learning and neural networks are used in this research, the non-normality of the research data distribution is one of the basic conditions for using these methods. This confirms that the choice of non-parametric methods for data analysis in this research is appropriate and reasonable because these methods are designed for non-normally distributed data and can provide more accurate and reliable results compared to parametric methods (Luengo et al., 2009). After checking the normality of the research data, the effects of public sector accounting, corporate governance mechanism and audit quality on the financial performance of banks listed in Tehran Stock Exchange are predicted using gradient reinforcement machine learning and random forests. The results of this research are presented in Tables 2 and 3.

4.2. Learning machine learning

Table 2. Prediction of bank financial performance using gradient reinforcement

ROW	**ROA= f ("CAP", "LEV", "AQ", "IPSAS", "CG", "BSRF", "BSCOM", "BSIZE", "FSIZE")]**							
	For the time period of the financial crisis				**For the time period before the financial crisis**			
	Feature	Gain	Cover	Frequency	Feature	Gain	Cover	**Frequency**
1	AQ	0/320	0/214	0/194	CAP	0/262	0/148	**0/136**
2	IPSAS	0/319	0/239	0/231	LEV	0/167	0/150	**0/173**
3	FSIZE	0/196	0/211	0/210	BSRF	0/112	0/113	**0/103**
4	CG	0/096	0/191	0/173	FSIZE	0/111	0/110	**0/087**
5	CAP	0/035	0/039	0/064	CG	0/097	0/107	**0/114**
6	LEV	0/012	0/028	0/046	IPSAS	0/092	0/103	**0/115**
7	BSRF	0/009	0/022	0/033	BSIZE	0/075	0/094	**0/085**
8	BSCOM	0/007	0/027	0/024	AQ	0/050	0/105	**0/133**
9	BSIZE	0/002	0/024	0/020	BSCOM	0/030	0/065	**0/050**
summary (importance matrix)								
1		Gain	Cover	Frequency		Gain	Cover	**Frequency**
2	Min.	0/002	0/022	0/020	Min.	0/030	0/065	**0/050**
3	1st Qu.	0/009	0/027	0/033	1st Qu.	0/075	0/103	**0/087**
4	Median	0/035	0/039	0/064	Median	0/097	0/107	**0/114**

5	Mean	0/111	0/111	0/111	Mean	0/111	0/111	**0/111**
6	3rd Qu.	0/196	0/211	0/194	3rd Qu.	0/112	0/113	**0/133**
7	Max.	0/320	0/239	0/231	Max.	0/262	0/150	**0/173**
8	MSE		0.36555978091448		MSE		**1.60662245918882**	
9	RMSE		20.9683667164757		RMSE		**0.19878602650258**	
Train rmse and Test rmse								
iter	mean	std	mean	mean	iter	mean	std	mean	**mean**
16	10/659	2/750	27/388	19/110	16	0/078	0/0127	0/205	**0/056**
summary(rmse_values)											
Min	1st Qu.	Median	Mean	3rd Qu.	Max.	Min	1st Qu.	Median	Mean	3rd Qu.	**Max.**
12/20	15/47	16/93	18/05	19/41	44/39	0/120	0/163	0/184	0/190	0/213	**0/354**

ROW	**ROE= f ("CAP", "LEV", "AQ", "IPSAS", "CG", "BSRF", "BSCOM", "BSIZE", "FSIZE")]**							
	For the time period of the financial crisis				**For the time period before the financial crisis**			
	Feature	Gain	Cover	Frequency	Feature	Gain	Cover	**Frequency**
1	LEV	0/323	0/198	0/224	CAP	0/314	0/228	**0/229**
2	FSIZE	0/298	0/254	0/212	FSIZE	0/195	0/211	**0/190**
3	CAP	0/174	0/290	0/307	CG	0/179	0/186	**0/205**
4	CG	0/067	0/106	0/099	LEV	0/154	0/240	**0/225**
5	IPSAS	0/035	0/035	0/036	IPSAS	0/062	0/038	**0/036**
6	AQ	0/033	0/027	0/032	AQ	0/051	0/037	**0/045**
7	BSCOM	0/028	0/030	0/026	BSRF	0/030	0/032	**0/035**
8	BSRF	0/022	0/032	0/036	BSCOM	0/009	0/017	**0/019**
9	BSIZE	0/016	0/025	0/023	BSIZE	0/001	0/006	**0/010**
summary(importance_matrix)								
1		Gain	Cover	Frequency		Gain	Cover	**Frequency**
2	Min.	0/016	0/025	0/023	Min.	0/001	0/006	**0/010**
3	1st Qu.	0/028	0/030	0/032	1st Qu.	0/030	0/032	**0/035**
4	Median	0/035	0/035	0/036	Median	0/062	0/038	**0/045**
5	Mean	0/111	0/111	0/111	Mean	0/111	0/111	**0/111**
6	3rd Qu.	0/174	0/198	0/212	3rd Qu.	0/179	0/211	**0/205**
7	Max.	0/323	0/290	0/307	Max.	0/314	0/240	**0/229**
8	MSE		0.412341671178308		MSE		**0.186429863635567**	
9	RMSE		36.7968802564734		RMSE		**45.7739213571133**	
Train rmse and Test rmse								

iter	mean	std	mean	mean	iter	mean	std	mean	**Test mean**
3	28/302	5/411	30/052	15/438	3	28/302	5/411	30/052	**15/438**

summary(rmse_values)

Min	1st Qu.	Median	Mean	3rd Qu.	Max.	Min	1st Qu.	Median	Mean	3rd Qu.	**Max.**
17/67	24/85	41/32	38/41	48/78	72/59	17/67	24/85	41/32	38/41	48/78	**72/59**

ROW	**NIM= f ("CAP", "LEV", "AQ", "IPSAS", "CG", "BSRF", "BSCOM", "BSIZE", "FSIZE")]**							
	For the time period of the financial crisis				**For the time period before the financial crisis**			
	Feature	Gain	Cover	Frequency	Feature	Gain	Cover	**Frequency**
1	CG	0/4239	0/224	0/231	CAP	0/4508	0/221	**0/210**
2	IPSAS	0/2866	0/258	0/221	AQ	0/3131	0/248	**0/229**
3	AQ	0/2159	0/217	0/239	IPSAS	0/1698	0/248	**0/282**
4	LEV	0/0313	0/031	0/050	CG	0/0440	0/132	**0/136**
5	FSIZE	0/0242	0/181	0/153	LEV	0/0112	0/038	**0/051**
6	CAP	0/0096	0/026	0/042	BSRF	0/0076	0/032	**0/036**
7	BSIZE	0/0028	0/023	0/012	FSIZE	0/0021	0/024	**0/031**
8	BSCOM	0/0027	0/019	0/023	BSCOM	0/0008	0/011	**0/012**
9	BSRF	0/0024	0/017	0/025	BSIZE	0/0001	0/013	**0/009**

summary (importance matrix)

1		Gain	Cover	Frequency		Gain	Cover	**Frequency**
2	Min.	0/0024	0/017	0/012	Min.	0/000	0/011	**0/009**
3	1st Qu.	0/0028	0/023	0/025	1st Qu.	0/002	0/024	**0/031**
4	Median	0/0242	0/031	0/050	Median	0/011	0/038	**0/051**
5	Mean	0/1111	0/111	0/111	Mean	0/111	0/111	**0/111**
6	3rd Qu.	0/2159	0/217	0/221	3rd Qu.	0/169	0/221	**0/210**
7	Max.	0/4239	0/258	0/239	Max.	0/450	0/227	**0/282**
8	MSE		0.962798221355849		MSE		**0/0547910276371**	
9	RMSE		166.696736489462		RMSE		**5.75900137103**	

Train rmse and Test rmse

iter	mean	std	mean	mean	iter	mean	std	mean	**Test mean**
5	31/308	6/689	38/894	21/502	1	433/182	82/002	348/097	**301/363**

summary(rmse_values)											
Min	1st Qu.	Median	Mean	3rd Qu.	Max.	Min	1st Qu.	Median	Mean	3rd Qu.	**Max.**
161/1	166/5	169/1	169/7	172/2	197/8	2831	3020	3044	3037	3060	**3227**

Source: Research calculations

According to Table 2, the results show that the factors affecting ROA are different in the periods before and after the financial crisis. Before the crisis, capital (CAP) and financial leverage (LEV) were the most important factors, indicating the importance of companies' financial structure under normal conditions. However, during the crisis period, audit quality (AQ) and International Public Sector Accounting Standards (IPSAS) became more important. This change shows that financial transparency and credibility of financial reports become more important in critical situations. The significant increase in the RMSE during the crisis period also shows that predicting ROA has become more difficult under these conditions. Meanwhile, a similar pattern is observed for return on equity (ROE), but with significant differences. Before the crisis, capital (CAP) and firm size (FSIZE) were the most important factors. This shows that under normal conditions, the capital structure and the size of the company play an important role in stock returns. However, during the crisis period, financial leverage (LEV) and firm size (FSIZE) became more important. This change shows the importance of debt management and the ability of larger companies to deal with critical situations. Finally, there are significant changes in the effective factors for NIM. Before the crisis, capital (CAP) and audit quality (AQ) were the most important factors, indicating the importance of a strong financial structure and transparency in financial reporting. In the crisis period, the mechanism of corporate governance (CG) and public sector accounting standards (IPSAS) have become more important. This change shows that in critical conditions, effective management and compliance with accounting standards play a more important role in maintaining the profit margin. Therefore, the increase in the RMSE for NIM during the crisis shows that it is more difficult to predict this index in uncertain economic conditions. In general, these results show that during the financial crisis, the factors influencing the financial performance of companies change. That is, in the crisis period, factors such as audit quality, accounting standards and corporate governance mechanisms become more important, while in normal conditions capital structure and company size play a more important role. Therefore, the increase in RMSE for all indicators in the crisis period shows that it is difficult to predict financial performance during the financial crisis. Therefore, after determining the results of the reinforcement gradient to predict the financial performance of the banks listed in Iran Stock Exchange, the financial performance of the banks was predicted using random forests and the result is shown in Table 3 be.

Table 3. Predicting the bank's financial performance using random forests

ROW	**For the time period before the financial crisis**					
	ROA		ROE		NIM	
	variable	IncNodePurity	variabl	IncNodePurity	variabl	IncNodePurity
1	IPSAS	0/169	IPSAS	3/091	IPSAS	1/956
2	AQ	0/140	AQ	10/270	AQ	4/772
3	CAP	0/586	CAP	55/145	CAP	28/989
4	LEV	0/392	LEV	32/979	LEV	18/501
5	FSIZE	0/144	FSIZE	3/134	FSIZE	0/764
6	BSRF	0/201	BSRF	10/090	BSRF	2/158
7	BSCOM	0/272	BSCOM	7.681	BSCOM	1/587
8	BSIZE	0/192	BSIZE	8/320	BSIZE	3/256
9	CG	0/215	CG	14/795	CG	1/452

10	MSE	0/014	MSE	4/232	MSE	0/858
11	R^2	0/430	R^2	0/472	R^2	0/583
ROW	For the time period of the financial crisis					
	ROA		ROE		NIM	
	variabl	IncNodePurity	variabl	IncNodePurity	variabl	IncNodePurity
1	IPSAS	1/027	IPSAS	118	IPSAS	300
2	AQ	1/510	AQ	106	AQ	413
3	CAP	1/001	CAP	250	CAP	123
4	LEV	1/391	LEV	735	LEV	685
5	FSIZE	1/303	FSIZE	111	FSIZE	549
6	BSRF	2/678	BSRF	200	BSRF	350
7	BSCOM	1/765	BSCOM	218	BSCOM	428
8	BSIZE	4/457	BSIZE	864	BSIZE	700
9	CG	5/537	CG	505	CG	581
10	MSE	0/353	MSE	0/513	MSE	0/216
11	R^2	0/998	R^2	0/994	R^2	0/799

Source: Research findings

According to the results of Table 3, it is clear that for ROA in the pre-crisis period, capital (CAP) and financial leverage (LEV) had the greatest impact on ROA, which indicates the importance of the financial structure of companies under normal conditions. However, in the crisis period, factors such as corporate governance (CG), board size (BSIZE) and board structure (BSRF) have become more important. This change shows that in critical conditions, the quality of management and the governance structure of companies play a more important role in financial performance. Also, the significant increase of R2 in the crisis period (from 0.430 to 0.998) shows that the model is better able to explain changes in ROA in this period. On the other hand, for ROE, in the pre-crisis period, capital (CAP) and financial leverage (LEV) were the most important factors. However, in the crisis period, board size (BSIZE) and financial leverage (LEV) became more important. This change shows the importance of decision-making structure and debt management in crisis situations. Therefore, the significant increase of R2 from 0.472 to 0.994 in the crisis period shows that the model works much more accurately in this period. This indicates the importance of structural and managerial factors in determining stock returns under critical conditions. Finally, significant changes in the effective factors are observed for NIM. Before the crisis, capital (CAP) and financial leverage (LEV) were the most important factors. During the crisis period, board size (BSIZE), financial leverage (LEV) and corporate governance (CG) have become more important. This change indicates that the management and governance structure of the company plays a more important role in maintaining the net profit margin in critical conditions. The increase in R2 from 0.583 to 0.799 shows that the model is better able to explain the changes in NIM during the crisis period, although this increase is not as significant as that of ROA and ROE. Therefore, these results show that during the financial crisis, the factors affecting the financial performance of companies change significantly. In general, factors such as board structure, corporate governance and debt management become more important in the crisis period, while in normal conditions capital structure plays a more important role. Therefore, the significant increase in R2 for all indicators in the crisis period shows that the models in these conditions have a greater ability to explain changes in financial performance because the importance of structural and managerial factors is greater in crisis conditions. Thus, the results show that the financial crisis had a significant impact on the factors that influence the financial performance of companies. Before the crisis, factors such as capital (CAP) and financial leverage (LEV) were more important for all three performance indicators (ROA, ROE and NIM). However, during the crisis period, factors related to corporate governance and management structure such as board size (BSIZE), board structure (BSRF) and corporate governance mechanism (CG) became more important. This change shows that in critical conditions, the quality of management and the governance structure of companies play a more important role in maintaining financial performance. Considering the results of machine learning, the prediction of the effects of financial crisis, public sector accounting, corporate governance mechanism and audit quality on the financial performance of companies listed in Tehran Stock Exchange has been investigated using fuzzy neural networks and cerebellum. Is. The results are presented in Tables 4 and 5.

Therefore, this research used advanced data pre-processing techniques and network architecture to optimize the performance of deep neural network models using Kera's and TensorFlow. Min-max normalization, which converts all input variables to the interval [0,1], was used to prepare the data. This not only allows for faster convergence of the learning algorithms, but also avoids the negative effects caused by the different scale of the variables. In order to increase the generalizability of the model, fitting techniques such as dropout and L2 regularization were also used. These techniques help to reduce overfitting and improve the performance of the model when faced with new data. The design of the neural network architecture used a deep model with multiple hidden layers. The primary layers use Long Short-Term Memory (LSTM) units, which have a high ability to learn long-term time dependencies. This feature is very useful for analyzing financial trends and predicting company performance. After the LSTM layers, dense layers with ReLU activation function were used, which are able to model complex non-linear relationships. For the output layer, linear or sigmoid activation functions were used, depending on the type of problem (regression or classification). The model parameters, including the number of layers, the number of neurons in each layer and the learning rate, were optimized using network search and adversarial validation to achieve the best performance in predicting the financial variables studied. Therefore, the result of the fuzzy neural network as described in Table 4 is as follows.

4.3. Neural Networks

Table 4. Investigation of the research model using fuzzy neural network

ROW	For the time period before the financial crisis					
	variabl	Keras_ROA	variabl	Keras_ROE	variabl	Keras_NIM
1	IPSAS	0/000	IPSAS	1/000	IPSAS	0/295
2	AQ	0/029	AQ	0/250	AQ	1/000
3	CAP	0/295	CAP	0/371	CAP	0/374
4	LEV	0/389	LEV	0/000	LEV	0/692
5	FSIZE	0/358	FSIZE	0/898	FSIZE	0/569
6	BSRF	1/000	BSRF	0/380	BSRF	0/579
7	BSCOM	0/347	BSCOM	0/121	BSCOM	0/728
8	BSIZE	0/118	BSIZE	0/310	BSIZE	0/000
9	CG	0/289	CG	0/021	CG	0/426
ROW	For the time period of the financial crisis					
	variabl	Keras_ROA	variabl	Keras_ROE	variabl	Keras_NIM
1	IPSAS	0/996	IPSAS	0/566	IPSAS	0/593
2	AQ	0/701	AQ	0/313	AQ	0/298
3	CAP	0/282	CAP	0/269	CAP	1/000
4	LEV	0/139	LEV	0/243	LEV	0/711
5	FSIZE	0/107	FSIZE	0/152	FSIZE	0/633
6	BSRF	0/154	BSRF	0/000	BSRF	0/301
7	BSCOM	0/000	BSCOM	0/781	BSCOM	0/117
8	BSIZE	1/0000	BSIZE	1/000	BSIZE	0/474
9	CG	0/773	CG	0/126	CG	0/000

Source: Research results

According to the results of Table 4 for ROA, prior to the financial crisis, BSRF (1.000), LEV (0.389) and FSIZE (0.358) had the greatest impact on ROA. This shows that board structure, financial leverage and company size played an important role in return on assets. During the crisis period, BSIZE (1.000), IPSAS (0.996) and CG (0.773) became more important. This change shows that board size, public sector accounting standards and corporate governance mechanisms play a more important role in financial performance under crisis conditions. However, for ROE before the crisis, IPSAS (1.000), FSIZE (0.898) and BSRF (0.380) had the largest impact. This shows that public accounting standards, company size and board structure have an impact on ROE under normal conditions. During the crisis period, BSIZE (1.000), BSCOM (0.781) and IPSAS (0.566) became more important. This change reflects the greater importance of board size and composition, as well as the continued importance of accounting standards in critical situations. Finally, before the crisis, AQ

(1.000), BSCOM (0.728) and LEV (0.692) had the largest impact on NIM. This shows that audit quality, board composition and financial leverage played an important role in net profit margin. In the crisis period, CAP (1.000), LEV (0.711) and FSIZE (0.633) became more important. This change shows that under financial crisis conditions, capital structure, financial leverage and firm size play a more important role in maintaining profit margin to control financial performance. In general, the results show that the effect of the independent variables on the financial performance of companies is different in the period before and after the financial crisis. IPSAS, AQ and CG become more important in the crisis period for some performance indicators. Specifically, IPSAS for ROA and ROE, AQ for ROA and CG for ROA have become more important in the crisis period. These changes indicate that financial transparency, audit quality and corporate governance mechanisms play a more important role in the performance of banks in crisis situations. Also, structural variables such as BSIZE and BSCOM become more important during the crisis period, indicating the importance of the structure and composition of the board of directors for effective corporate governance in crisis conditions. Finally, the results show that the financial crisis had a significant impact on the relative importance of factors affecting the financial performance of companies. In the period of financial crisis, International Public Sector Accounting Standards (IPSAS) became more important for ROA and ROE, indicating the important role of financial transparency in crisis conditions. Corporate governance (CG) mechanisms also became more important for ROA during the crisis period, highlighting the importance of regulatory structures in crisis management. Audit quality (AQ) also became more important for ROA during the crisis period, indicating that ensuring the accuracy of financial reporting is critical in uncertain economic conditions. In addition, structural variables such as the size and composition of the board of directors (BSIZE and BSCOM) have become more important during the crisis period, which emphasizes the crucial role of a strong and diversified management in guiding companies in difficult situations. These findings indicate that the banks listed in the Iranian Stock Exchange should pay special attention to improving financial transparency, strengthening corporate governance mechanisms, improving audit quality and optimizing the structure of the board of directors so that they can maintain their financial performance in the face of financial crises. and improve Finally, after determining the results of the fuzzy neural network research, the prediction of the effects of financial crisis, public sector accounting, corporate governance mechanism and audit quality on the financial performance of the companies listed in the Tehran Stock Exchange has been investigated using the cerebellar neural network, Is.

Basically, the present study used advanced data pre-processing techniques and network architecture to optimize the performance of cerebellar neural network models using Kera's and TensorFlow. Min-max normalization, which converts all input variables to the interval [0,1], was used to prepare the data. This not only allows the learning algorithms to converge more quickly, but also avoids the negative effects caused by the different scales of the variables. In order to increase the generalizability of the model, fitting techniques such as L2 regularization were also used. This technique helps to reduce overfitting and improves the performance of the model when faced with new data. Thus, in designing the architecture of the cerebellar neural network, a special structure was used that includes three main parts: the input layer, the granular layer and the Purkinje layer. The granular layer consists of granular neurons that use Radial Basis Functions (RBF) to identify complex patterns in the data. The Purkinje layer combines the information received from the granular layer and makes the final prediction. This structure is well suited to analyzing financial trends and predicting company performance. The parameters of the model, including the number of granular neurons, the width of the RBF functions and the connection weights between the layers, were optimized using gradient descent optimization and adversarial validation algorithms to achieve the best performance in predicting the financial variables studied. Finally, the result of the cerebellar neural network is described in Table 5.

Table 5. Investigation of the research model using the cerebellar neural network

ROW	For the time period before the financial crisis					
	variabl	Keras_ROA	variabl	Keras_ROE	variabl	Keras_NIM
1	IPSAS	0/051	IPSAS	0/897	IPSAS	0/474
2	AQ	0/549	AQ	0/442	AQ	0/694

3	CAP	0/000	CAP	0/000	CAP	0/656
4	LEV	0/717	LEV	0/072	LEV	0/339
5	FSIZE	0/109	FSIZE	1/000	FSIZE	0/285
6	BSRF	0/880	BSRF	0/567	BSRF	1/000
7	BSCOM	0/881	BSCOM	0/150	BSCOM	0/597
8	BSIZE	0/697	BSIZE	0/775	BSIZE	0/000
9	CG	1/000	CG	0/657	CG	0/516
ROW	For the time period of the financial crisis					
	variabl	Keras_ROA	variabl	Keras_ROE	variabl	Keras_NIM
1	IPSAS	0/648	IPSAS	0/337	IPSAS	1/000
2	AQ	0/121	AQ	0/299	AQ	0/313
3	CAP	0/722	CAP	0/349	CAP	0/017
4	LEV	1/000	LEV	0/678	LEV	0/070
5	FSIZE	0/788	FSIZE	0/987	FSIZE	0/400
6	BSRF	0/000	BSRF	0/219	BSRF	0/138
7	BSCOM	0/440	BSCOM	0/021	BSCOM	0/000
8	BSIZE	0/480	BSIZE	1/000	BSIZE	0/833
9	CG	0/8067	CG	0/000	CG	0/340

Source: Research results

According to the results of Table 6. For ROA, before the financial crisis, Corporate Governance Mechanism (CG) had the largest impact on ROA with a score of 1.000, followed by BSCOM (0.881) and BSRF (0.880). This shows that under normal conditions, governance and management structures play an important role in the financial performance of companies. During the crisis, financial leverage (LEV) became the most important factor with a score of 1.000, followed by CG (0.8067) and FSIZE (0.788). This change shows that in the conditions of the financial crisis, debt management and financial structure of companies, together with strong corporate governance and company size, play an important role in maintaining ROE. On the other hand, before the crisis, company size (FSIZE) with a value of 1.000 and IPSAS with 0.897 had the largest impact on ROE. This shows that under normal conditions, the size of the company and the adherence to public sector accounting standards had an impact on ROE. In the crisis period, board size (BSIZE) with a score of 1.000 and FSIZE with a score of 0.987 have become more important. This change indicates the greater importance of management structure and company size in maintaining stock returns in critical conditions. However, for pre-crisis NIM, board structure (BSRF) with a score of 1.000 and audit quality (AQ) with 0.694 have the largest impact. This shows that the governance structure and the quality of financial reporting played an important role in the net profit margin. In the crisis period, IPSAS with a score of 1.000 and BSIZE with 0.833 have become more important. This change shows that in critical conditions, compliance with public sector accounting standards and the size of the board of directors play a more important role in maintaining the profit margin. In general, the results obtained from the cerebellum neural network show that the financial crisis has had a significant impact on the relative importance of the factors that influence the financial performance of companies. International Public Sector Accounting Standards (IPSAS) became more important for NIM during the crisis period, demonstrating the critical role of financial transparency in uncertain economic conditions. Corporate governance (CG) mechanisms remained important for ROA in both periods, but became more important in the crisis period, highlighting the continuing and increasing role of regulatory structures in firm performance. Audit quality (AQ) became less important during the crisis period, but was still important for NIM before the crisis. Structural variables such as board size (BSIZE) and firm size (FSIZE) became more important for ROE during the crisis period, indicating the critical role of management structure and scale of operations in maintaining financial performance under difficult conditions. These findings emphasize that banks listed on the Iranian Stock Exchange should pay special attention to improving financial transparency, strengthening corporate governance mechanisms and optimizing their management and operational structure in order to maintain their financial performance in the face of financial crises to improve. Finally, after determining the results of neural network research, it was investigated the prediction of the effects of financial crisis, public sector accounting, corporate governance mechanism and audit quality on the financial performance of companies listed in Tehran

Stock Exchange using the optimal expectation algorithm. has been done, the result of which is as described in Table 6. as follows.

Table 6. Investigation of the research model using the Optimal Expectation Algorithm

ROW	For the time period before the financial crisis					For the time period of the financial crisis				
	roa_model					roa_model				
	Varible	Estimate	Std. Error	t value	Pr(>|t|)	Varible	Estimate	Std. Error	t value	Pr(>|t|)
1	Intercept	0/010	0/0173	0/614	0/539	Intercept	0/015	0/008	1/766	0/079
2	IPSAS	0/032	0/007	4/215	0/000	IPSAS	0/101	0/003	25/965	0/000
3	AQ	0/045	0/010	4/395	0/000	AQ	0/152	0/005	29/488	0/000
4	CAP	0/194	0/028	6/476	0/000	CAP	0/297	0/014	20/654	0/000
5	LEV	-0/100	0/007	-12/86	0.000	LEV	-0/200	0/003	-51/36	0/000
6	FSIZE	0/002	0/000	3/230	0/001	FSIZE	0/005	0/000	13/390	0/000
7	BSRF	0/019	0/014	1/356	0/176	BSRF	0/044	0/007	6/221	0/000
8	BSCOM	0/008	0/008	1/059	0/291	BSCOM	0/024	0/004	5/956	0/000
9	BSIZE	0/002	0/000	2/699	0/007	BSIZE	0/002	0/000	6/691	0/000
10	CG	0/036	0/010	3/355	0/000	CG	0/103	0/005	19/146	0/000
11	Residual standard error			0/02115		Residual standard error			0/01057	
12	Multiple R-squared			0/6118		Multiple R-squared			0/9682	
13	Adjusted R-squared			0/5934		Adjusted R-squared			0/9667	
14	F-statistic			33/28		F-statistic			643/5	
15	p-value			0/0000		p-value			0/0000	
Residuals:						Residuals:				
16	Min	1Q	Median	3Q	Max	Min	1Q	Median	3Q	Max
17	-0/050	-0/013	0/000	0/011	0/058	-0/025	-0/006	0/000	0/005	0/029
ROW	roe_model					roe_model				
	Varible	Estimate	Std. Error	t value	Pr(>|t|)	Varible	Estimate	Std. Error	t value	Pr(>|t|)
1	Intercept	0/117	0/033	3/530	0/000	Intercept	0/083	0/0166	5/036	0/000
2	IPSAS	0/045	0/014	3/065	0/002	IPSAS	0/019	0/007	26/477	0/000
3	AQ	0/047	0/019	2/407	0/017	AQ	0/243	0/009	24/610	0/000
4	CAP	0/438	0/055	7/966	0/000	CAP	0/619	0/027	22/509	0/000
5	LEV	-0/192	0/014	-12/90	0/000	LEV	-0/396	0/007	-53/16	0/000
6	FSIZE	0/003	0/001	2/040	0/042	FSIZE	0/009	0/000	12/665	0/000
7	BSRF	0/022	0/027	0/462	0/644	BSRF	0/081	0/137	5/913	0/000
8	BSCOM	0/022	0/0156	1.432	0/153	BSCOM	0/056	0/007	7/193	0/000
9	BSIZE	-0/000	0/001	-0/194	0/846	BSIZE	0/002	0/000	3/981	0/000
10	CG	/037	0/020	1/819	0/070	CG	0/193	0/010	18/816	0/000
11	Residual standard error			0/04044		Residual standard error			0/02022	
12	Multiple R-squared			0/584		Multiple R-squared			0/9676	
13	Adjusted R-squared			0/5643		Adjusted R-squared			0/9666	
14	F-statistic			29/64		F-statistic			630/1	

15	p-value			0/0000		p-value			0/0000	
Residuals:						Residuals:				
16	Min	1Q	Median	3Q	Max	Min	1Q	Median	3Q	Max
17	-0/091	-0/025	0/000	0/0267	0/123	-0/045	-0/012	0/000	0/013	0/061
ROW	nim_model					nim_model				
	Varible	Estimate	Std. Error	t value	Pr(>|t|)	Varible	Estimate	Std. Error	t value	Pr(>|t|)
1	Intercept	0/019	0/008	2/408	0/017	Intercept	0/024	0/004	6/128	0/000
2	IPSAS	0/020	0/003	5/713	0/000	IPSAS	0/080	0/001	44/280	0/000
3	AQ	0/029	0/004	6/143	0/000	AQ	0/997	0/002	41/471	0/000
4	CAP	0/084	0/013	6/351	0/000	CAP	0/192	0/006	28/811	0/000
5	LEV	-0/047	0/003	-12/992	0/000	LEV	-0/098	0/001	-54/438	0/000
6	FSIZE	0/001	0/000	3/875	0/000	FSIZE	0/003	0/000	17/548	0/000
7	BSRF	0/268	0/006	4/016	0/000	BSRF	0/043	0/003	12/995	0/000
8	BSCOM	0/011	0/003	3/025	0/002	BSCOM	0/020	0/001	10/934	0/000
9	BSIZE	0/000	0/000	2/509	0/012	BSIZE	0/009	0/000	5/374	0/000
10	CG	0/023	0/004	4/639	0/000	CG	0/081	0/002	32/640	0/000
11	Residual standard error			0/6647		Residual standard error			0/00491	
12	Multiple R-squared			0/00982		Multiple R-squared			0/9814	
13	Adjusted R-squared			0/6488		Adjusted R-squared			0/9805	
14	F-statistic			41/85		F-statistic			11111	
15	p-value			0/000		p-value			0/0000	
Residuals:						Residuals:				
16	Min	1Q	Median	3Q	Max	Min	1Q	Median	3Q	Max
17	-0/030	-0/007	-0/000	0/006	0/032	-0/015	-0/003	-0/000	0/003	0/016

Source: Research findings

According to the results of the expectation algorithm in Table 6 for the ROA, ROE and NIM model in the two periods before and after the financial crisis, it can be seen that in the period of the financial crisis, the impact of public sector accounting standards (IPSAS), audit quality (AQ) and corporate governance mechanisms (CG) on ROA increased significantly. Also, structural variables such as board structure (BSRF), board composition (BSCOM) and board size (BSIZE) have a significant impact during the crisis period. Capital ratio (CAP) and firm size (FSIZE) also had a greater effect on ROA during the crisis period, while the negative effect of financial leverage (LEV) increased. On the other hand, the impact of IPSAS, AQ and CG on ROE increased during the crisis period. CAP and FSIZE also had a larger impact on ROE during the crisis period. BSRF and BSIZE, which were not significant before the crisis, became significant during the crisis. BSCOM also became more influential during the crisis period. The negative effect of LEV on ROE also increases during the crisis period. Finally, in the case of NIM, the impact of IPSAS and AQ increased dramatically during the crisis period. CG, CAP and FSIZE also had a stronger impact on NIM during the crisis period. BSRF, BSCOM and BSIZE had a larger impact on NIM during the crisis period. The negative impact of LEV on NIM also increased during the crisis period. In general, the results show that the explanatory power of the models increased during the financial crisis for all three financial performance indicators (ROA, ROE and NIM). The importance of IPSAS, AQ and CG increased during the crisis period for all performance indicators. Structural variables such as BSRF, BSCOM and BSIZE had a more significant impact during the crisis period. CAP and FSIZE also had a greater impact during the crisis period in most cases, while the negative impact of LEV increased. These results confirm that financial transparency, audit

quality, governance and management structures play a more important role in the financial performance of companies under critical conditions.

5. DISCUSSION, IMPLICATIONS, AND FUTURE RESEARCH DIRECTIONS

This research aimed to examine and analyses the effects of financial crisis, application of public sector accounting, corporate governance mechanisms and audit quality on the financial performance of banks listed in Tehran Stock Exchange. To achieve this, three key indicators were used to evaluate the financial performance of the banks: Return on Assets (ROA), Return on Equity (ROE) and Net Interest Margin (NIM). The study sought to identify critical factors that may influence financial performance in the periods before and after the financial crisis. Data analysis techniques such as artificial neural networks and optimization algorithms were used to assess the impact of independent variables such as corporate governance mechanisms (CG), international public sector accounting standards (IPSAS) and audit quality (AQ) on financial performance indicators. In addition, several control variables such as bank sustainability reporting structure (BSRF), board sustainability committee (BSCOM), board size (BSIZE), firm size (FSIZE), financial leverage (LEV) and capital investment (CAP) were included in the model to improve the accuracy of the analysis. The data were divided into two periods: pre-crisis (2011-2018) and post-crisis (2019-2023), and information from 24 banks listed on the Tehran Stock Exchange was examined.

The results of the analyses and tables show that corporate governance (CG) had the most significant impact on ROA in the pre-crisis period. This highlights the importance of corporate governance principles in improving the efficiency and productivity of banks' assets under normal conditions. Corporate governance principles, including rules and regulations for oversight, transparency and accountability in bank management, can contribute to better management and optimal use of bank resources, leading to improved financial performance. In addition to CG, the existence of Board Sustainability Committees (BSCOM) also played a crucial role in improving ROA during this period. These committees, which focus on making critical recommendations and strategic decisions for the long-term sustainability and growth of banks, can help improve financial performance by creating effective policies and strategies. In addition, a precise reporting structure (BSRF) contributed to the improvement in ROA. These structures ensure that financial and non-financial information is reported in a transparent and accurate manner and made available to managers and shareholders, thus supporting better and more strategic decision making.

Conversely, the role of the control variables changed during the financial crisis period, with financial leverage (LEV) becoming the most influential factor on ROA. This indicates the increased importance of debt management and improving banks' credit ratings during crises. During crisis periods, banks face greater financial challenges and efficient debt management and financial leverage can help maintain and improve their financial performance. In addition, corporate governance (CG) and firm size (FSIZE) played a more important role in banks' financial performance during this period. This situation highlights the need for banks to focus on effective corporate governance and to scale up their operations during crises. Strong corporate governance can improve decision-making, reduce risks and enhance investor confidence. At the same time, increasing the size of banks' operations (FSIZE) can help control costs, make optimal use of resources and improve financial performance.

Overall, the results show that in the pre-crisis period, corporate governance principles, management structures and information transparency play a key role in improving banks' financial performance. In crisis periods, a stronger focus on debt management and optimal use of financial leverage is needed. Strengthening corporate governance mechanisms and expanding bank operations can also help improve financial performance during crises. These findings can help bank managers and economic policymakers to adopt appropriate crisis management strategies and improve banks' financial performance.

Before the financial crisis, firm size (FSIZE) and adherence to public sector accounting standards (IPSAS) had the strongest impact on ROE. This implies that, under normal conditions, size and adherence to strict accounting standards can lead to higher returns for bank shareholders. Larger firms have access to more resources and can benefit from economies of scale, while adherence to accounting standards increases transparency and investor confidence. During the financial crisis, the role of control variables changed, with board size (BSIZE) and firm size (FSIZE) having the largest

impact on ROE. This change indicates the greater importance of organizational and managerial structure during crises. A larger and more diverse board may allow for more accurate and effective decision making to better manage crises and reduce associated risks. In addition, larger firm size during crises may provide greater resilience to financial shocks and help to improve performance under such conditions.

Prior to the financial crisis, board structure (BSRF) and audit quality (AQ) had the most significant impact on NIM. A strong board structure and a high-quality audit can improve the transparency and accuracy of financial reporting, ultimately leading to increased bank profitability. During this period, strategic decision-making by the board of directors and greater confidence in credible financial reporting played a key role in improving the net interest margin. During the financial crisis, adherence to International Public Sector Accounting Standards (IPSAS) and board size (BSIZE) had the largest impact on NIM, highlighting the greater importance of accurate measurement and transparent reporting under crisis conditions. Compliance with these standards can increase investor confidence and contribute to better financial management. In addition, a larger, more diverse board can lead to better decision making, improving resource management and profitability in such conditions.

In summary, prior to the financial crisis, company size and adherence to accounting standards played a primary role in increasing ROE and improving NIM. However, during the crisis, managerial variables such as board size and better organization became increasingly important in overcoming challenges and reducing risks. These findings may help bank managers and policymakers to adopt appropriate strategies to improve financial performance under different economic conditions.

The economic analysis of the results suggests that financial transparency and audit quality have the most significant impact on banks' financial performance during crises. This emphasizes that during periods of economic uncertainty, more accurate and credible reporting can help maintain public confidence and financial performance stability. The increased importance of International Public Sector Accounting Standards (IPSAS) and audit quality (AQ) during crises suggests that banks need to improve transparency and reporting accuracy to better cope with crises. In addition, corporate governance mechanisms play a crucial role in reducing risk and improving management strategies. The results of the study underline that in times of crisis, strengthening governance structures, increasing transparency and complying with international accounting standards are essential for banks to achieve more stable financial performance.

From a policy and management perspective, these findings suggest that policymakers and bank managers should pay more attention to the importance of governance and control structures during crises. The size and structure of the board of directors, together with management policies and corporate governance mechanisms, are critical factors that can strengthen banks in the face of financial crises. Adherence to international accounting and financial reporting standards, strengthening corporate governance mechanisms and increasing financial transparency through relevant laws and regulations can improve banks' financial performance. These measures can ultimately reduce risks, enhance stability and maintain public confidence.

In general, a focus on debt management, improved governance and compliance with international standards can help banks achieve more stable performance during financial crises and build public confidence. Effective management in these areas plays a crucial role in increasing banks' resilience to economic and financial fluctuations. Therefore, based on the findings of studies conducted on banks listed on the Tehran Stock Exchange and their linkages with issues such as corporate governance, audit quality and public sector accounting standards, the following policy recommendations are proposed to improve the economic and financial infrastructure:

Strengthen and improve corporate governance systems: It is recommended that banks and financial institutions pay particular attention to strengthening corporate governance principles and their governance structures. Ongoing training for board members and senior managers on best management and oversight practices can help them make strategic decisions and reduce financial risks. In addition, the establishment of sustainability and internal oversight committees can lead to improved organizational transparency and efficiency.

Strengthening supervision and strict compliance with accounting standards: Strict compliance with International Public Sector Accounting Standards (IPSAS) is essential for banks and financial institutions. These standards improve the transparency of financial reporting and enhance investor confidence. Regulators can enforce stricter guidelines and regulations to ensure that banks comply with these standards. In addition, the organization of training and workshops on accounting standards can help improve the quality of financial reporting.

Optimize the size and structure of the board: During financial crises, the size and structure of the board becomes critical. Banks and financial institutions are advised to optimize the size and diversity of their boards to ensure more accurate and comprehensive decision-making. Recruiting members with different experiences and expertise can improve the quality of management decisions and organizational efficiency. In addition, the implementation of board performance evaluation systems can improve management efficiency and transparency.

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