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# The Artificial Intelligence and its Impact on the Performance of Jordanian Commercial Banks Listed on the Amman Stock Exchange by Using Balanced Score Card

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**Abstract: Objective:** The rise in technology has introduced artificial intelligence (AI) at the center of innovations and creation of competitive advantage in most sectors and banking is not an exception. Corresponding with the growing field of innovation and increased-efficiency, the present study looks at the role of artificial intelligence in its aspects of artificial neural networks, expert systems, natural language processing and machine learning towards the performance of Jordanian commercial banks listed in the Amman Stock Exchange. The Balanced Scorecard evaluates performance based on four perspectives of financial, customer, internal processes, and the learning/growth. The research question is as follows: Does AI in its aspects influence the performance of the Jordanian commercial banks according to the Balanced Scorecard? **Methodology:** In the year 2024, a survey was sent to twelve commercial banks, ten of them responded to the survey, and 153 valid questionnaires were successfully analyzed. A sample was composed of employees stationed in internal auditing function, the finance function, the support functional area, and the information security functional area. Both descriptive and inferential analysis were evaluated by the use of SPSS. **Key Results:** The study findings show that there is a strong significant positive relationship between with all AI dimensions and all perspectives, thereby indicating that AI can be a major strategy to support the performance of banks. **Conclusions and Recommendations:** The paper assumes that continuous and ethical assimilation of AI can be one of the ways of enhancing financial performance and customer satisfaction. Finally, the study recommends that Jordanian commercial banks allocate part of their profits to invest in artificial intelligence technologies, enabling sustainable and competitive banking in a rapidly changing global environment. **Conclusion:** Banks should adopt AI responsibly and in moderation, ensuring innovation is aligned with ethical and secure practices to enhance customer service, strengthen financial performance, and maintain competitiveness in the evolving financial sector.

**Keywords:** Artificial Intelligence, Bank Performance, Balanced Scorecard, Jordanian Commercial Banks.

# الذكاء الاصطناعي وأثره على أداء البنوك التجارية الأردنية المدرجة في بورصة عمان باستخدام بطاقة الأداء المتوازن

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**ملخص: الهدف:** أدى التطور المتسارع في التكنولوجيا إلى وضع الذكاء الاصطناعي في صميم الابتكار وتحقيق الميزة التنافسية في معظم القطاعات، ولم يكن القطاع المصرفي استثناءً من ذلك. وانسجامًا مع تنامي مجالات الابتكار وزيادة الكفاءة، تسعى هذه الدراسة إلى بحث دور الذكاء الاصطناعي بأبعاده المتمثلة في الشبكات العصبية الاصطناعية، والنظم الخبيرة، ومعالجة اللغات الطبيعية، والتعلّم الآلي، في تحسين أداء البنوك التجارية الأردنية المدرجة في بورصة عمّان. ويُقيَّم الأداء باستخدام بطاقة الأداء المتوازن من خلال أربعة أبعاد رئيسة هي: البعد المالي، وبعد العملاء، وبعد العمليات الداخلية، وبعد التعلّم والنمو. وتتمحور مشكلة الدراسة حول التساؤل الآتي: هل يؤثر الذكاء الاصطناعي بأبعاده المختلفة في أداء البنوك التجارية الأردنية وفقًا لأبعاد بطاقة الأداء المتوازن؟ **المنهجية:** في عام 2024، تم توزيع استبانة على اثني عشر بنكًا تجاريًا أردنيًا، استجاب منها عشرة بنوك، وتم تحليل (153) استبانة صالحة للتحليل الإحصائي. وتكوّنت عينة الدراسة من العاملين في دوائر التدقيق الداخلي، والشؤون المالية، والدعم والمساندة، وأمن المعلومات. وقد تم الاعتماد على الأسلوبين الوصفي والاستدلالي في تحليل البيانات باستخدام برنامج الحزمة الإحصائية للعلوم الاجتماعية.(SPSS). **النتائج الرئيسة:** أظهرت نتائج الدراسة وجود علاقة إيجابية قوية ذات دلالة إحصائية بين جميع أبعاد الذكاء الاصطناعي وجميع أبعاد بطاقة الأداء المتوازن، مما يشير إلى أن الذكاء الاصطناعي يمكن أن يُشكّل استراتيجية رئيسة داعمة لتحسين أداء البنوك التجارية الأردنية المدرجة في بورصة عمان. **الاستنتاجات والتوصيات:** تفترض الدراسة أن التبني المستمر والأخلاقي لتقنيات الذكاء الاصطناعي يُعدّ أحد السبل الفعّالة لتعزيز الأداء المالي ورفع مستوى رضا العملاء. كما توصي الدراسة بأن تخصص البنوك التجارية الأردنية جزءًا من أرباحها للاستثمار في تقنيات الذكاء الاصطناعي، بما يسهم في تحقيق الاستدامة والتنافسية في بيئة مصرفية عالمية سريعة التغير. **الخاتمة:** تؤكد الدراسة على ضرورة تبني تقنيات الذكاء الاصطناعي بصورة مسؤولة ومتوازنة، بما يضمن مواءمة الابتكار مع الممارسات الأخلاقية والآمنة، وتحسين جودة الخدمات المصرفية، وتعزيز الأداء المالي، والحفاظ على القدرة التنافسية في القطاع البنكي المتطور.

**الكلمات المفتاحية:** الذكاء الاصطناعي ، أداء البنوك ، بطاقة الأداء المتوازن ، البنوك التجارية الأردنية.

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## Introduction

Artificial Intelligence (AI) has become a fundamental technology that promotes the revolution of all sciences and industries in the world. We have already seen significant changes in the sphere of banking - an area that is expanding thanks to the progress concerning AI applications. Since banking is the foundation of the economic base, as well, with increased efficiency, such tools have been met with a response in the sector. Smart systems, digital assistants and intelligent chatbots have transformed how banks engage existing service users. Such systems may field questions from customers seeking information about their accounts, deliver advice that is tailored to a consumer's needs and assist the consumers in navigating financial products without much difficulty. This would mean that instead of time spent by employees in performing such tasks, could now be invested in solving difficult chores/tasks, to establish client relationships and improve on the quality of customer service (Jakesch *et al*., 2022) (Marques and Oliveira,2024).

The banking sector plays an important role in Jordan's economy. According to the Jordanian Banks Association (2023), this sector contributes around 8% to the national GDP. It also has a strong multiplier effect on disposable income. For every Jordanian dinar spent in the banking sector, another dinar is generated in other areas of the economy. Because of this economic impact, it is important for researchers and professionals to understand how artificial intelligence (AI) affects the performance of banks in Jordan. Thus, this study focuses on commercial banks listed on the Amman Stock Exchange. It examines how the use of AI technologies can improve their performance. Performance will be evaluated using the four perspectives of the Balanced Scorecard: the financial results, customer satisfaction, internal processes, and learning and growth within the organization. The main research question of this study is: Do different types of AI technologies, such as neural networks, expert systems, natural language processing, and machine learning, have a significant impact on these performance indicators in Jordanian banks?

It is from these questions that the rest of this research attempts to answer the sub-questions:

1. What is the impact of AI on the financial performance of Jordanian commercial banks?
2. Is there an impact of AI on both customer satisfaction and experience in these banks?
3. What effects did AI have on the internal processes within these banks?
4. The impact of artificial intelligence on learning, innovation and growth in these banks?

Therefore, the aim of this study is to verify, for the purpose of Jordanian commercial banks listed in Amman Stock Exchange, how artificial intelligence through its main dimensions can affect the overall performance; The study will use the Balanced Scorecard.

This study has academic and practical implications. From a practical angle, the present study adds to the body of knowledge by presenting empirical evidence on the impact of AI systems on bank performance in Jordan. It also contributes to the literature within the region, given that few have explored this relationship with a more complete performance model as that of balanced scorecard. Moreover, and from a practical point of view, the results of this research will assist bank operators and policy makers in banking sector to understand how AI techniques can be implemented for enhancing efficiency and competitiveness. It will also offer evidence that can assist in

strategic decision, performance assessment, and financial and operational process initiation in Jordanian banking.

The paper has five sections. The topic and research problem, objectives, and significance are presented in section one. Literature Review in the second section reviews the literature on artificial intelligence and bank performance. The third section discusses the methodology used, which includes data collection and analysis procedures. The fourth section provides the discussion of the results. The final section concludes the research and suggests practical implications as well as future research.

## Literature Review

### Artificial Intelligence

AI was coined in the 50s by John McCarthy and Marvin Minsky as a term that refers to this field, AI researchers predict human capabilities that will be reached by machines (reasoning, learning etc.) But the philosophical basis of AI could be said to have originated with Alan Turing, when he asked this question, "Can machines think?" This question set the stage for subsequent attempts to develop systems that could not only process data, but also exhibit intelligent behavior. About AI It looks as if the interpretation of AI has come a long way from mere simulation of human thought to designing machines which actually behave intelligently in real-world applications (Khailtash *et al*., 2022) (Ness *et al*.,2024).

Bermejo & Juiz (2023) state that AI constitutes a scientific discipline whose objective is to make machines perform tasks that usually require human intelligence. In this manner, it can fast-track work thereby saving on time and money. Similar to the (Raval *et al*.,2022), who emphasize that AI systems are increasingly gaining their own share of autonomy in their reasoning, the domain of decision making can be considered one of the algorithmic-based reasoning' (Lezaun 2017:203) The concept of AI has thus been transformed into a merely theoretical concept into a daily-life technology that is working to change the world around people, forcing May ways to adjust to it. From this point of view AI is a general domain of science, based around the modeling of mathematical/computational techniques which aim to approximate human perception, reasoning and problem solving.

Artificial Neural Networks (ANNs) are broadly categorized as one of prominent tools among the various AI paradigms. The ANNs are computational architectures inspired by the brain of humans with interconnected "neurons" that receive and transmit information, as presented in (Kalakonas and Silva,2024). Likewise, (Bennett *et al*.,2022) and (Nica *et al*.,2024) define neural networks as parallel processors that acquire knowledge through learning from experience and make use of knowledge to implement decision-making capacity. The common pitch is that neural networks should be thought of as a tool to help refine patterns and make better predictions, both critical aspects to modeling the behavior of humans in finance.

Another important field is Expert Systems (ES). (Daugirdas and Paliliūnas,2024) state that expert system is a computer program that acts as an expert in a particular field. Expert systems help to solve problems, and interpret data in a manner that uses an expert level of knowledge. In the same vein, (Yang and Zhu,2024) describe that expert systems are implemented based on a knowledge base for imitating human cognitive reasoning of an expert in consultation with historical experience. But both agree that one of the primary goals of an expert system is to aid decision making, especially in domains where the task itself is complex or knowledge-intensive in nature (say banking or finance).

A third area of importance is the use of Natural Language Processing (NLP). (Sonbol *et al*.,2022) refer to NLP as the aspect of AI that allows computers to comprehend or parse human language. When using NLP there are, in fact, levels of NLP functioning that are linguistic, grammatical, and semantic, and during real time usage, intent can be parsed and scope of the text or voice data can be managed in chunks to understand context. In banking, NLP allows and gives banks, or service providers, the ability to use chatbots or virtual assistants to orchestrate automated, customer communication to engage with customers and provide efficacious service.

Now, the last point is machine learning (ML), at present one of the fastest-growing sectors of AI. (Çelebi,2021) and (Christou,2023) explains that ML allows computers to learn from data and make predictions without being programmed. ML adopts both deterministic algorithms as well as statistical models; with these tools it solves pattern recognition problems through statistical learning theory techniques-such autonoMy is commonly pursued in AI named bayesian Networks, and it's also the zen core of DJI's Phantom UAV. In contrast to traditional programming, the result of following a set of instructions, ML learns in real-time from repeated exposure to data-so that over a period of time it gets better at its outputs. In brief, this stage brings its own in itself the benefits of an earlier one while laying the groundwork for future achievements.

However, in regular terms these stories are broadly in agreement; AI may indeed lay overall se much larger an egg of economics and rational decision making than merely one person. Nevertheless, at the same time, while some authors (Raval *et al*. 2022, Kalakonas and Silva 2024) stress its computerization compared to technology others (Daugirdas and Paliliunas or Yang and Zhu) focus more on what it delivers. These works together demonstrate that what we call AI is not just one technology it is a whole set of methods capable of remaking whole industries such as the Banking industry. (Cromwell,2023) from modern research, AI will be a natural, everyday part of bank operations. Customer Relationship Management to cost management, performance improvement and competition positioning are all areas that its application affects for those who use it. But these findings do in fact prove the limitations of traditional systems vis-à-vis the use for DVRAUD raised earlier: strictly speaking as far back as 1999 and also later by considering appropriate figures, (Doumpos *et al*.,2023) confirm that with AI we can improve quality and trustworthiness of our sent to an industry's users. Thus, taken together these results imply how those banks which adopt AI theoretically achieve greater operational efficiency and better service and then under traditional systems.

Artificial neural networks enhance the performance of a system by analyzing complex patterns to make accurate predictions (Bennett *et al*.,2022). This enhances the speed and accuracy in the forecasting of financial and non-financial events. Expert systems improve performance through the emulation of human expertise by applying logical rules and domain-specific knowledge to aid decision-making and enhance dependability and efficiency in the system. (Daugirdas and Paliliūnas,2024).

NLP makes it possible for correct and flexible user-system interactions because the system understands unstructured text. The above feature makes textual data transformation easier into something useful, therefore helping improve the performance of systems in general (Chen, X., *et al*.,2022). Such performance keeps getting better as machine learning continuously learns from experience and data. Models that adapt become increasingly accurate in terms of prediction and

classification. This fosters increased sustainability and efficiency in the system.(Sonbol *et al*., 2022)

**Artificial Intelligence and Financial Performance**

For a bank to stay safe and sound, financial success is a crucial requirement. This concept continues to be valid even today. At least, it is in this manner that a bank can earn a profit and ensure its liquidity, according to (Dinda *et al*.,2024). In the meantime, it can also establish good customer relationships. This is elaborated by (Oko and Elimi,2023) and (Al-Nsour *et al*., 2025), who had earlier defined the financial performance of banks to be akin to a full picture: assets, liabilities, earnings and profitability. (Sumarlan *et al*.,2024) and (Al-Koni *et al*.,2025) find that the financial performance of the banking industry can be measured using measures like return on assets (ROA), which provides a total account of a bank's profitability and efficiency within any given period. Taken collectively, these definitions are broad: not just is banking financial performance defined as a measure of profitability, but it is also motivational and an inquiry into operation viability over the long term.

Financial institutions have tended to develop more use of AI to improve efficiency and to gather information from customers. Based on (Doumpos *et al*.,2022), AI-powered applications enable financial institutions to provide smart and personalized service on the one hand; automate customer relationships on the other hand. This argument also appeals to (Kharoub and Nour,2024), who explains that AI can be reasonably evaluated by a BSC because it determines performance based on financial, customer, internal process and learning dimensions.

(Kurni *et al*.,2022) also propose that AI-based tools have both rendered the activities of funds very automated, even the screening and reporting activities being performed by machine learning algorithms; and introduced data analytics in combination with blockchain integration. Banks use AI for online banking via mobile, ATMs online banking etc., to make the operations more convenient and precise. (Hwang and Kim,2021) also add the point that strongly capitalized successful banks have access to more money than others to invest in AI, and obtain better people to implement AI projects. And the motivation to stay ahead with technological revolution is greater.

In addition, this is supported by most studies conducted on AI and financial performance. For example, (Isan *et al*.,2024) Recently empirically confirmed that the implementation of AI enhances the performance of workers, customer satisfaction, and the efficiency of risk management. (Schyab *et al*.,2023) and (Tanbour *et al*.,2025) Further provide empirical support that banks using AI techniques have higher ROA and ROE, and decreased other expenses. Equally, Rahman *et al*. (2023) and Lin Li (2023)) concur with this opinion by asserting that AI brings costs savings, improved efficiency and enhanced decision making. Even with such an accord, there are warnings from some researchers on how to use AI responsibly. Technology is advancing too rapidly for man and machine to be balanced. Ethical use, privacy, and economic resilience remain obligatory (Tang and Tian, 2020). (Schyab *et al*.,2023) assert that the positive economic advantages of AI are most sustainable if institutions also emphasize transparency, responsibility, and governance.

Overall, the discussed studies refer to a general conclusion that AI contributes to better financial results through increased efficiency of operations, risk management, and customer engagement. They differ in their priority, though: while some focus on technological development and profitability (e.g., Isan *et al*.,

2024; Schyab *et al*., 2023), others refer to ethical and strategic balance (e.g., Tang and Tian, 2020). Taken together, these studies suggest that successful application of AI to banking is a matter of technological expertise along with sound managerial discretion.

## Method, Data, and Analysis

The rapid trend of Jordanian commercial banks toward digital transformation revolution motivated the researchers to conduct this study. A questionnaire was designed to measure the extent of using four artificial intelligence applications (neural networks, expert systems, natural language processing, and machine learning) on bank performance through the Balanced Scorecard's four financial and non-financial dimensions. The level of use was taken as an indicator for each dimension, from which the overall usage index was derived using descriptive and inferential statistical measures, as well as the Beta coefficient, in line with the findings of several studies, such as the (e.g., Isan *et al*., 2024; Schyab *et al*., 2023) study.

To help meet the research objectives, an online questionnaire was developed and dispatched to twelve Jordanian commercial banks. Ten banks responded, forming 83.3% of the desired population. Employees within internal control, auditing, finance affairs, support, and information security departments were chosen as the sample population. By official reports from the participating banks ' human resources departments, 220 were supposed to be available to participate. The data reveal that in the survey there were nearly 225 male and female employees. A simple random sampling method was adopted to ensure that selection within the study population was unbiased by any bias on behalf of the selector. There were 153 valid responses that met the conditions for statistical analyses, which was more than enough according to Sekaran and Bougie (2020) representative of the Academy of Management Journal article's sample population. The study was based on two important procedures in social science research that are commonly employed: inferential statistics and descriptive statistics. Descriptive statistics were used to describe and summarize the sample characteristics. Inferential statistics, on the other hand, were used to test hypotheses and to describe the relationships among study variables.

## Results and Discussion

The primary method used to gather data was a questionnaire. It consists of two sections: The first section focused on the respondents' demographic characteristics (i.e., gender, age, years of experience, and educational level) (Figure 1).

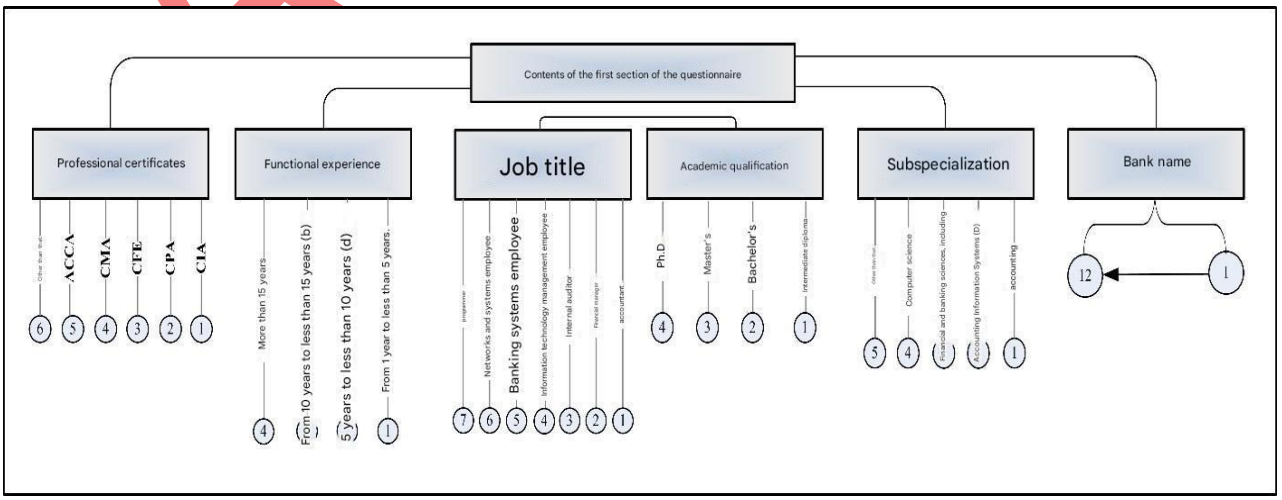


**Figure (1):** Contents of the first section of the questionnaire.

As shown in figure (1), two of the four scales used in this section were survey scales. Nominal scales are suitable for classifying individuals into categories on the basis of qualitative attributes. They permit us to group participants according to demographic characteristics among other things without any assumption about ranking or order.

The second section of the questionnaire involved two major parts. The first part contains 20 statements, incorporating 20 combinations designed to measure artificial intelligence, the independent variable, and its four dimensions: artificial neural networks, expert systems, natural language processing and machine learning. The second section of the questionnaire included another 20 items. These items were designed to assess the dependent variable, which represents the performance of Jordanian commercial banks. Performance was evaluated using the four Balanced Scorecard perspectives: financial performance, customer satisfaction, internal business processes, and learning and growth. In total, section two had 40 questions (figure 2).

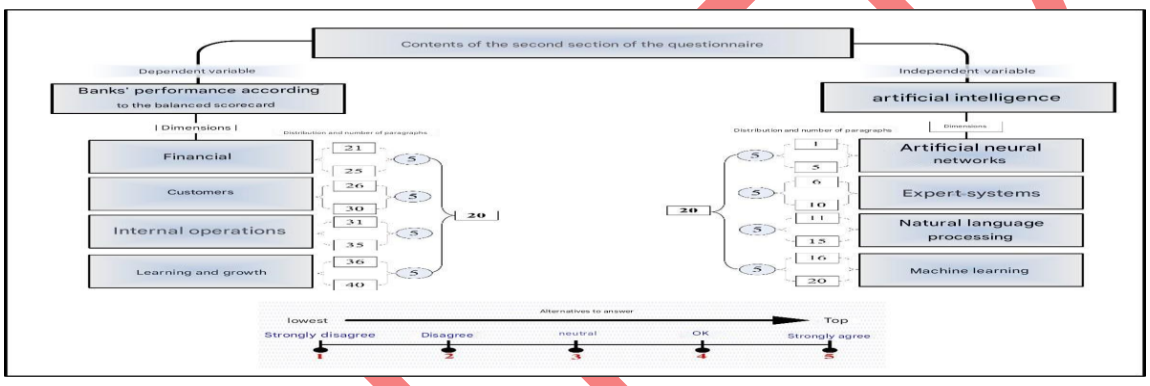


**Figure (2):** Contents of the second section of the questionnaire.

This section utilized ordinal scales to rank responses in a pre-defined order to assess the degree of agreement or disagreement. This was measured by the five-point Likert scale, where valid answers were available to five potential answers (strongly disagree to strongly agree) (Clark *et al*., 2021). The approach enables the evaluation of the level of attitude and perceptions of respondents towards the variables of the study.

To interpret the results, the class length was calculated using the following formula: C = (U.L – L.L) / 3 where:

- **C** represents the class width,
- **U.L** (Upper Limit) = 5,
- **L.L** (Lower Limit) = 1, and
- the number of levels (high, medium, low) = 3.

Thus, C = (5 – 1) / 3 = 1.33. Based on this calculation, the following intervals were used to classify the arithmetic mean scores (Bluman, 2017):

**Table (1):** Relative estimation according to corresponding arithmetic means.

| Arithmetic average | Relative estimate |
|---|---|
| From 1 to 2.33 | Low |
| From 2.34 to 3.66 | Middle |
| From 3.67 to 5 | High |

This classification was used in the course of the analysis to identify the overall degree of opinions of the respondents and his/her agreement to each statement. Both desertive and inferential analysis findings were subsequently discussed to point out the effect of the artificial intelligence dimensions on the overall performance of Jordanian commercial banks.

The findings related to the reliability and appropriateness of the statistical methods used are presented in the following section:

**Table (2):** Results of Testing the Quality and Suitability of Statistical Methods.

| Coefficient variable/dimension | | (SK) | (KU) |
|---|---|---|---|
| Independent | ANN | -0.454 | 0.514 |
| | ES | 0.508- | 0.156- |
| | NLP | 0.767- | 0.916 |
| | ML | 0.464- | 0.006 |
| | Artificial Intelligence (AI) | -0.399 | 0.167 |
| Dependent | financial perspective | 0.333- | 0.517- |
| | customer perspective | 0.404- | 0.473- |
| | internal processes perspective | 0.444- | 0.176- |
| | learning and growth perspective | 0.274- | 0.370- |
| | Bank performance (BSC) | 0.309- | 0.420- |
| Based on the results of the skewness (SK) and kurtosis (KU) values, it is evident that the data follow a normal distribution pattern. | | | |

| Independent Dimensions | (VIF) | (1/VIF) |
|---|---|---|
| ANN | 1.493 | 0.670 |
| ES | 1.508 | 0.663 |
| NLP | 1.292 | 0.774 |
| ML | 1.664 | 0.601 |

☜ The results indicate that there is no multi-collinearity problem, as evidenced by the tolerance value, which falls within the range of 0.2 to 1, and the Variance Inflation Factor (VIF) value, which did not exceed 5.

| AI | ANN | ES | NLP | ML |
|---|---|---|---|---|
| ANN | 1 | | | |
| ES | 0.430 | 1 | | |
| NLP | 0.423 | 0.312 | 1 | |
| ML | 0.490 | 0.547 | 0.388 | 1 |

It is evident that the explanatory or independent dimensions do not suffer from multicollinearity, as indicated by the absolute values of the correlation coefficients, which ranged from 31.2% to 54.7%, and did not exceed 80%.

| Hypothesis | Durbin Watson |
|---|---|
| Ho | 1.858 |
| Ho.1 | 1.889 |
| Ho.2 | 1.797 |
| Ho.3 | 1.899 |
| Ho.4 | 2.005 |

It is observed that there is no autocorrelation problem based on the test results for each hypothesis of the study, which ranged between 1.797 and 2.005.

Using SPSS will help to answer the questions raised by the study, measure the models developed, and achieve its one or more goals. Using the software means that through drawing on the software's capabilities one is also drawing on procedures and assumptions that could yield information related to statements and/or conclusions that are descriptive or inferential in nature. The study will demonstrate this below:

Descriptive Statistics: Measures such as means, standard deviations, and percentages were used to summarize the demographic characteristics of the study sample. These statistics also helped in understanding participants' views and perceptions regarding the study variables and their related dimensions.

**Table (3):** Descriptive Statistics for Independent Variables Dimensions (Artificial Intelligence).

| Dimensions | # | Paragraph | Arithmetic Mean | Standard Deviation | % | Degree of Usage | Rank |
|---|---|---|---|---|---|---|---|
| ANN | 1 | The implementation of artificial neural network techniques assists the bank's management in monitoring task performance, ensuring the achievement of defined objectives, overseeing operations, and guaranteeing the efficient execution of tasks. | 4.21 | .6850 | 84.2 | HIGH | 2 |
| | 2 | The employment of artificial neural network techniques assists the bank's management in strategic planning. | 4.19 | .6360 | 83.8 | HIGH | 4 |
| | 3 | The results of artificial neural network analysis play a crucial role in detecting fraudulent activities in the bank's financial data. | 4.20 | .6820 | 84 | HIGH | 3 |
| | 4 | The bank has a well-qualified and well-trained team to employ artificial neural network technology. | 4.16 | .6600 | 83.2 | HIGH | 5 |
| | 5 | The use of artificial neural network techniques enhances decision-making processes in the bank by improving the quality of accounting information. | 4.28 | .6830 | 85.6 | HIGH | 1 |
| General Index of ANN | | | 4.21 | 0.513 | 84.2 | HIGH | 2 |
| ES | 6 | The bank has the appropriate hardware and equipment to operate expert systems efficiently and effectively. | 4.25 | .7480 | 85 | HIGH | 2 |
| | 7 | The bank collaborates with specialized companies to train and develop the necessary skills of employees for working with expert systems. | 4.24 | .7350 | 84.8 | HIGH | 3 |
| | 8 | Expert systems contribute creative and innovative solutions to various problems faced by the bank, such as accounting events and operations, and enhance innovative thinking. | 4.19 | .6360 | 83.8 | HIGH | 4 |
| | 9 | Expert systems are used to enhance decision-making in the bank by utilizing the available information in databases and effectively contributing to the reduction of potential risks | 4.16 | .7650 | 83.2 | HIGH | 5 |
| | 10 | The use of expert systems enhances the understanding of customer needs with precision and improves the level of service provided to them. | 4.26 | .6960 | 85.2 | HIGH | 1 |
| General Index of ES | | | 4.22 | 0.541 | 84.4 | HIGH | 1 |
| NLP | 11 | The bank provides smart applications with the capability to process natural language to facilitate and regulate authorized access from both inside and outside, enhancing internal control systems. | 4.16 | .7210 | 83.2 | HIGH | 2 |

| Dimensions | # | Paragraph | Arithmetic Mean | Standard Deviation | % | Degree of Usage | Rank |
|---|---|---|---|---|---|---|---|
| | 12 | Smart applications with natural language processing capabilities contribute to improving the quality of banking services perceived by customers, and increase their satisfaction levels. | 4.19 | .6860 | 83.8 | HIGH | 1 |
| | 13 | AI applications with natural language processing capabilities, such as chatbots and voice interfaces, facilitate customer interaction and make it more seamless. | 4.12 | .7190 | 82.4 | HIGH | 4 |
| | 14 | Smart applications with natural language processing capabilities provide the ability to verify customer fingerprints and signatures, ensuring secure access to the network. | 4.10 | .6960 | 82 | HIGH | 5 |
| | 15 | Banking systems supported by natural language processing capabilities enable handling a wide range of languages and customers smoothly and quickly, enhancing the overall user experience. | 4.13 | .7230 | 82.6 | HIGH | 3 |
| General Index of NLP | | | 4.14 | 0.530 | 82.8 | HIGH | 4 |
| ML | 16 | The bank has the necessary systems, technological capabilities, and data to enhance its ability for machine learning and automatically detect cases of manipulation. | 4.19 | .6950 | 83.8 | HIGH | 1 |
| | 17 | Smart technologies driven by machine learning contribute to developing solutions for routine daily problems faced by the bank's operations. | 4.12 | .7250 | 82.4 | HIGH | 4 |
| | 18 | Smart applications employing machine learning provide standardized models for credit scoring of customers and accurately assess investment risks. | 4.18 | .7730 | 83.6 | HIGH | 2 |
| | 19 | The systems within the bank are updated regularly, ensuring continuous effective performance and the accumulation of previous experiences over time. | 4.11 | .6940 | 82.2 | HIGH | 5 |
| | 20 | The bank's systems are integrated effectively and seamlessly, enhancing their interaction and the smoothness of operations. | 4.17 | .6960 | 83.4 | HIGH | 3 |
| General Index of ML | | | 4.15 | 0.544 | 83 | HIGH | 3 |
| Overall AI Index | | | 4.18 | 0.403 | 83.6 | HIGH | |

**Table (4):** Descriptive Statistics Analysis Results for Dependent Variable Dimensions (Bank Performance According to BSC).

| Dimensions | # | Paragraph | Arithmetic Mean | Standard Deviation | % | Degree of Usage | Rank |
|---|---|---|---|---|---|---|---|
| Financial | 21 | Working through budget estimates in the bank contributes to achieving planned profits and desired growth. | 4.28 | .7110 | 85.6 | HIGH | 2 |

| Dimensions | # | Paragraph | Arithmetic Mean | Standard Deviation | % | Degree of Usage | Rank |
|---|---|---|---|---|---|---|---|
| | 22 | The presence of a comprehensive financial plan for research and development in the bank contributes to enhancing its growth and innovations. | 4.25 | .7190 | 85 | HIGH | 3 |
| | 23 | The bank establishes clear standards for assessing financial performance, which helps in measuring the effectiveness of the actions taken. | 4.21 | .6940 | 84.2 | HIGH | 5 |
| | 24 | The bank relies on a precise financial control system to achieve clearer and more transparent financial results. | 4.31 | .6810 | 86.2 | HIGH | 1 |
| | 25 | Correct financial performance evaluation contributes to better determining the bank's financial needs. | 4.23 | .6930 | 84.6 | HIGH | 4 |
| Overall Index for the Financial Perspective | | | 4.25 | 0.533 | 85 | HIGH | 1 |
| Customer | 26 | The bank regularly measures customer satisfaction to ensure the provision of excellent services that meet their needs. | 4.08 | .7650 | 81.6 | HIGH | 5 |
| | 27 | The bank seeks to measure the volume of customer requests to better understand their needs and improve its offerings. | 4.14 | .7380 | 82.8 | HIGH | 3 |
| | 28 | The bank monitors customer loyalty and attachment, helping it to strengthen relationships with them and develop effective strategies to retain them. | 4.18 | .7080 | 83.6 | HIGH | 1 |
| | 29 | The departments and branches cooperate in a coordinated manner to carry out their assigned tasks, aiming to provide excellent services to customers. | 4.17 | .7850 | 83.4 | HIGH | 2 |
| | 30 | The bank prioritizes customer satisfaction with the services provided at the top of its priorities. | 4.14 | .7950 | 82.8 | HIGH | 4 |
| Overall Index for the Customer Perspective | | | 4.14 | 0.574 | 82.8 | HIGH | 4 |
| Internal Business Process | 31 | The bank has a clear and publicly announced organizational structure that outlines the roles and responsibilities of employees to ensure efficient and effective use of resources in all operations. | 4.23 | .7020 | 84.6 | HIGH | 3 |
| | 32 | The bank's reliance on a management style that is based on active participation with employees to enhance a spirit of collaboration. | 4.25 | .6740 | 85 | HIGH | 2 |
| | 33 | The bank regularly measures employee satisfaction, which helps improve the work | 4.16 | .7470 | 83.2 | HIGH | 5 |

| Dimensions | # | Paragraph | Arithmetic Mean | Standard Deviation | % | Degree of Usage | Rank |
|---|---|---|---|---|---|---|---|
| | | environment and enhance positive interactions among them. | | | | | |
| | 34 | To enhance its competitive advantage, the bank focuses on continuous development by offering services that exceed those of its competitors, through building unique administrative and organizational systems. | 4.18 | .7080 | 83.6 | HIGH | 4 |
| | 35 | The bank aims to achieve leadership in providing modern banking services as part of its long-term strategy. | 4.27 | .6790 | 85.4 | HIGH | 1 |
| Overall Index for the Internal Business Process Perspective | | | 4.22 | 0.533 | 84.4 | HIGH | 2 |
| Learning and Growth | 36 | The bank works on developing its internal system to ensure that its goals are achieved efficiently and effectively. | 4.25 | .7550 | 85 | HIGH | 1 |
| | 37 | The bank is committed to attracting, developing, and retaining talent to enhance its institutional performance. | 4.08 | .7390 | 81.6 | HIGH | 5 |
| | 38 | The bank relies on modern technologies to improve its performance and enhance the level of service provided. | 4.19 | .6860 | 83.8 | HIGH | 2 |
| | 39 | The bank provides an environment that enables employees to develop their capabilities and enhance their skills, while encouraging innovation and creativity. | 4.12 | .7550 | 82.4 | HIGH | 4 |
| | 40 | The bank is committed to offering advanced training programs that align with the actual requirements of its employees. | 4.15 | .7320 | 83 | HIGH | 3 |
| Overall Index for the Learning and Growth Perspective | | | 4.16 | 0.553 | 83.2 | HIGH | 3 |
| Overall Performance Index for Banks According to the (BSC) | | | 4.19 | 0.435 | 83.8 | HIGH | |



**Results of the Descriptive Statistics for the Study Variables and Dimensions**

The descriptive analysis of the study variables revealed that the adoption of artificial intelligence (AI) in the Jordanian commercial banks, listed on the Amman Stock Exchange, is deemed very important. The overall AI usage was at 83.6% based on the responses from employees participating in the study. Also, of the AI dimensions included in the study, artificial neural networks had the highest rating, at 84.2%. Respondents indicated that neural network technology supports management of their banks by tracking performance toward targets, and monitoring other operational activities; this technology also impacts the quality of accounting and financial information, and helps improve decision making. These findings correspond with Tibi and Moulay's (2023) report that artificial neural networks have an important role in enhancing performance indicators in commercial banking organizations.

Additionally, the results of the study suggest that according to the participants, as survivors, expert systems have achieved a considerable degree of efficacy-, at 84.4% in Jordanian commercial banks on the Amman Stock Exchange. Given that expert systems demonstrate precision in interpreting what customers are looking for, and increase service quality, as well as develop innovative new solutions to numerous issues faced by banks-(for instance, turnover events and accounting), it recommends the inquiring attitude. This study supports survey based data reported by Abu Al-Khair and Al-Sayegh (2024) that expert systems have generally received higher evaluations regarding their operational performance in commercial banking.

The study results suggested that as judged by the sample, natural language processing achieved a moderate degree of efficacy -, at 82.6% in Jordanian commercial banks on the Amman Stock Exchange. This is largely due to those artificial intelligence applications which process natural languages. They are able to handle customer contact situations and thereby facilitate accessibility. Also, natural language processing applications can streamline automatically the process for authorized logins, both at home and internationally. This is because they fall within Software Level controls: when a person signs off, their ID is automatically logged off. This finding is consistent with the conclusion of (Setiawan *et al*.,2021) which reports that natural language processing has levelled off as a substantive asset in the performance of commercial banks.

Thus, as the research shows, the machine learning dimension attained an 83 % rating from subjects in Jordanian commercial bank institutions listed upon the Amman Stock Exchange. The reason for this is that banks equipped with the necessary systems, technical infrastructure, and data can use machine learning technologies to recognize manipulation independent of administrative commands. As found in (Setiawan *et al*.,2022), banks that have not implemented machine learning techniques expect a similar effect from their introduction. In tests on the performance of these banks, evidence convincingly confirms this prediction.

In addition, from the description of the study variables, it is discovered that the dependent variable, bank performance as measured by balanced scorecard, was highly rated among participants in the same category of commercial bank institutions with a score of 83.8%. Also, the financial dimension similarly achieved a rating of 85%, which can be considered as evidence to support financial control systems. These systems produce clearer financial results and a more precise assessment of financial requirements available. This result is congruent with the earlier understanding of (Shiyyab *et al*.,2023) and (Setiawan *et al*.,2021) (J) that the financial aspect is a significant factor influencing performance in banking as any factor from software level to top management is. Similarly, the customer dimension received a high rating of 82.8%. Based on the participants' feedback, I attribute this to the banks' effective monitoring of customer loyalty and affiliation, which enhances client relationships and supports strategic retention efforts. This is in agreement with (Kumar and Gupta,2023), who also identified the customer dimension as a key contributor to performance.

Consequently, in similar fashion, customer dimensions have showed high-ranking of 82%. This result can be referred to the bank effective monitoring of customer loyalty and affiliation that can boost the relationship between clients and support strategic retention efforts. In fact, this result goes in tandem with (Kumar and Gupta ,2023) and (Nour *et al*.,2022) who also found that customer dimension is a key contributor to organizational performance. In

addition, internal operation dimension was also rated highly at 84% these results indicate that banks are pursuing is service leadership and innovation in their strategic planning henceforth, the continuous improvement add development of a new administrative system can give these organizations the needed competitive edge. Our findings agree with those of who found that internal operation can significantly improve performance.

Finally, the learning and growth dimension achieved a score of 83.2%. This reflects the banks efforts to increase internal systems and provide intentional training that connects to the employee needs. These findings are consistent with (Aysan *et al*.,2024), which also suggested that the learning and growth dimension has a substantial influence on organizational effectiveness.

**Table (5):** Results of Testing the Main Hypothesis.

| Summary of the Model | | | Analysis of Variance | | | | |
|---|---|---|---|---|---|---|---|
| **R** | **R Square** | **Adjusted R Square** | **Df** | | **F** | **F Table** | **Sig** |
| 0.820 | 0.673 | 0.664 | 4<br>148 | | 75.991 | 2.37 | 0.000 |
| **D.V** | **I.V** | **B** | **Std. Error** | **Beta** | **Standardized Coefficients** | | |
| | | | | | **T** | **Sig** | |
| Performance of Commercial Banks Measured by the Dimensions of the Balanced Scorecard | Constant | 0.526 | 0.215 | | 2.448 | 0.016 | **table T = (1.960)** |
| | ANN | 0.220 | 0.049 | 0.259 | 4.504 | 0.000 | |
| | ES | 0.205 | 0.047 | 0.255 | 4.410 | 0.000 | |
| | NLP | 0.182 | 0.044 | 0.222 | 4.151 | 0.000 | |
| | ML | 0.270 | 0.049 | 0.337 | 5.550 | 0.000 | |

**Table (6):** Results of Testing the First Sub-Hypothesis.

| Summary of the Model | | | Analysis of Variance | | | | |
|---|---|---|---|---|---|---|---|
| **R** | **R Square** | **Adjusted R Square** | **Df** | **F** | **F Table** | **Sig** | |
| 0.645 | 0.417 | 0.401 | 4<br>148 | 26.425 | 2.37 | 0.000 | |
| **D.V** | **I.V** | **B** | **Std. Error** | **Beta** | **Standardized Coefficients** | | |
| | | | | | **t** | **Sig** | |
| Performance of Commercial Banks Measured by the Financial Dimension of the Balanced Scorecard | Constant | 0.688 | 0.351 | | 1.958 | 0.052 | T table = (1.960) |
| | ANN | 0.273 | 0.080 | 0.263 | 3.431 | 0.001 | |
| | ES | 0.199 | 0.076 | 0.202 | 2.624 | 0.010 | |
| | NLP | 0.189 | 0.072 | 0.187 | 2.627 | 0.010 | |
| | ML | 0.191 | 0.079 | 0.195 | 2.410 | 0.017 | |

**Table (7):** Results of Testing the Second Sub-Hypothesis

| Summary of the Model | | | Analysis of Variance | | | |
|---|---|---|---|---|---|---|
| **R** | **R Square** | **Adjusted R Square** | **Df** | **F** | **F Table** | **Sig** |
| 0.663 | 0.439 | 0.424 | 4<br>148 | 29.004 | 2.37 | 0.000 |
| **D.V** | **I.V** | **B** | **Std. Error** | **Beta** | **Standardized Coefficients** | |
| | | | | | **t** | **Sig** |
| Performance of Commercial Banks Measured by the Customer Dimension of the Balanced Scorecard | Constant | 0.320 | 0.371 | | 0.862 | 0.390 |
| | ANN | 0.185 | 0.084 | 0.164 | 2.194 | 0.030 |
| | ES | 0.175 | 0.080 | 0.163 | 2.179 | 0.031 |
| | NLP | 0.179 | 0.076 | 0.165 | 2.358 | 0.020 |
| | ML | 0.377 | 0.084 | 0.356 | 4.489 | 0.000 |

**Table (8):** Results of Testing the Third Sub-Hypothesis.

| Summary of the Model | | | Analysis of Variance | | | |
|---|---|---|---|---|---|---|
| **R** | **R Square** | **Adjusted R Square** | **Df** | **F** | **F Table** | **Sig** |
| 0.633 | 0.401 | 0.385 | 4 | 24.778 | 2.37 | 0.000 |

| | | | 148 | | | | |
|---|---|---|---|---|---|---|---|
| **D.V** | **I.V** | **B** | **Std. Error** | **Beta** | **Standardized Coefficients** | | |
| | | | | | **t** | **Sig** | |
| Performance of Commercial Banks Measured by the Internal Processes Dimension of the Balanced Scorecard | Constant | 0.752 | 0.356 | | 2.113 | 0.036 | T Table = (1.960) |
| | ANN | 0.206 | 0.081 | 0.198 | 2.545 | 0.012 | |
| | ES | 0.180 | 0.077 | 0.181 | 2.334 | 0.021 | |
| | NLP | 0.183 | 0.073 | 0.182 | 2.522 | 0.013 | |
| | ML | 0.261 | 0.080 | 0.266 | 3.242 | 0.001 | |

**Table (9):** Results of Testing the Fourth Sub-Hypothesis.

| **Summary of the Model** | | | **Analysis of Variance** | | | |
|---|---|---|---|---|---|---|
| **R** | **R Square** | **Adjusted R Square** | **df** | **F** | **F Table** | **Sig** |
| 0.671 | 0.451 | 0.436 | 4<br>148 | 30.357 | 2.37 | 0.000 |

| **D.V** | **I.V** | **B** | **Std. Error** | **Beta** | **Standardized Coefficients** | | |
|---|---|---|---|---|---|---|---|
| | | | | | **T** | **Sig** | |
| Performance of Commercial Banks Measured by the Learning and Growth Dimension of the Balanced Scorecard | Constant | 0.346 | 0.354 | | 0.979 | 0.329 | T Table = (1.960) |
| | ANN | 0.215 | 0.080 | 0.200 | 2.684 | 0.008 | |
| | ES | 0.267 | 0.076 | 0.261 | 3.486 | 0.001 | |
| | NLP | 0.179 | 0.072 | 0.171 | 2.474 | 0.014 | |
| | ML | 0.250 | 0.080 | 0.246 | 3.131 | 0.002 | |

The results indicated that artificial intelligence and its components—machine learning, artificial neural networks, expert systems, and natural language processing—have a statistically significant impact on the performance of commercial banks listed on the Amman Stock Exchange at the significance level ($\alpha \leq 0.05$). The assessment of bank performance utilized the four Balanced Scorecard perspectives: financial results, customer satisfaction, internal business processes, and learning and growth. The results are consistent with Taibi and Moulay (2023), who reported that AI significantly contributes to bank performance in various areas.

In addition, the results demonstrate a statistically significant effect ($\alpha \leq 0.05$) of artificial intelligence and its dimensions, artificial neural networks, expert systems, machine learning, and natural language processing, on the financial performance of commercial banks as measured by the financial dimension of the balanced scorecard. Based on these findings, the writer believes that artificial neural network techniques can not only help improve the quality of accounting information within banks but also enable more accurate budget forecasts. This instrument is capable of managing bank planned profits and growth targets. In a addition, this writer has observed that AI applications enhance financial control programs. This has a positive impact on financial performance (financial dimension). This result is consistent with the study results of (Shiyyab *et al.*,2023) and (Setiawan *et al.*,2021).

It can be seen clearly that results of the Second Sub-Hypothesis Test: At the level of ($\alpha \leq 0.05$) a statistically significant effect was observed for artificial intelligence and its dimensions (machine learning, natural language processing, artificial neural networks, expert systems) on the performance of the Amman Stock Exchange listed commercial banks, as measured by the customer dimension of balanced scorecards. The study indicates that AI applications equipped with natural language processing abilities, such as chatbots, enhance the bank's interaction with customers, which improves the quality of banking services and raises customer satisfaction. This result is similar to that of Kumar and Gupta (2023).

Also, findings for the Third Sub-Hypothesis Test: A statistically significant effect at the ($\alpha$

≤ 0.05) level was discovered for artificial intelligence and its dimensions (machine learning, artificial neural networks, natural language processing, expert systems) on the performance of the Amman Stock Exchange listed commercial banks, measured by the internal processes dimension of balanced scorecards. The author notes that smart technologies supported by machine learning techniques can generate solutions of routine problems raised within banking operations. The integration of different systems within the bank improves their interaction and operational smoothness, as Tang and Tien (2020) also acknowledge.

The results of the Fourth Sub-Hypothesis Test: A statistically significant effect at the (α ≤ 0.05) level was found for artificial intelligence and its dimensions (expert systems, machine learning, artificial neural networks, natural language processing) on the performance of the Amman Stock Exchange listed commercial banks, measured by the learning and growth dimension of balanced scorecards. The writer attributes this to banks' co-operation with specialized companies in training and developing the skills needed by their employees to handle the various AI systems, leading to an able and trained workforce adept at coping with modern technologies. This result is confirmed by the study of Aysan *et al*. (2024).

**Conclusion and Suggestion**

High Research Results Maintain: The study recommends maintaining the high level achieved by the research findings by focusing on the independent variables, which are (artificial neural networks, expert systems, machine learning, and natural language processing). These areas have a significant impact on the dependent variable, which includes (financial dimension, customer dimension, internal processes dimension, and learning and growth dimension), as evidenced by the study results. When they work out who to recognize a well-managed company and avoid any supervision or other regulation altogether, then he or she can outdo most other professional managers at actually managing corporations. Is the principal conclusion on his original work Ghford (1930: 179) shows is that general users of artificial intelligence must learn something about it first, or at least be suspicious of closing the computer window behind them in case something within it (whether smell or taste). The study advises that management in Jordanian commercial banks listed on the Amman Stock Exchange should pay greater attention to professional certifications and provide support and encouragement for employees to attend specialized accounting courses such as (CIA, CPA, CFE).

Invest in AI Technologies: The recommendation is to allocate some of the banks' profits for investment in artificial intelligence technologies, significantly facilitating sustainable banking activity in a rapidly changing global banking environment that directly supports the use of modern and renewable technologies to help banks have a leading position through an increasingly unpredictable field. Moreover, continuing AI Adoption: The recommendation applies to Jordanian commercial banks listed on the Amman Stock Exchange to continue the responsible acceptance of artificial intelligence technologies. All accept AI technologies in moderation, where innovation occurs in conjunction with ethical and secure practices, leading to banks better serving customer needs, improving financial performance, and a competitive environment that can evolve with rapidly changing technology in the banking and financial services sector.

## Future Research Suggestions

Incorporation of a Strategic Dimension: By virtue of the findings generated within this research, introducing a strategic dimension to the balanced scorecard as a new and revised dimension of research is an interesting area of future research direction.

Cross-Sector Application: The model and its variables could be extended to include additional sectors, beyond banking, to help determine the reliability of findings, provided from this study.

## Disclosure Statement

- **Ethical approval and consent to participate:** All procedures conducted in this study were carried out in accordance with institutional and ethical standards.
- **Availability of data and materials:** The data and materials used in this study are available from the corresponding author upon reasonable request.
- **Authors' contributions:** All authors contributed equally to all stages of this study.
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## Open Access



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