FINTECH AND FINANCIAL SECTOR PERFORMANCE IN SAUDI ARABIA: AN EMPIRICAL STUDY

Ebrahim Mohammed Al-Matari [*], Mahfoudh Hussein Mgammal [**], Nabil Ahmed Mareai Senan [***], Hasnah Kamardin [****], Talal Fawzi Alruwaili [**]

* *Corresponding author*, Department of Accounting, College of Business, Jouf University, Kingdom of Saudi Arabia
Contact details: Department of Accounting, College of Business, Jouf University, Sakaka 72388, Kingdom of Saudi Arabia
** Department of Accounting, College of Business, Jouf University, Kingdom of Saudi Arabia
*** Department of Accounting, College of Business Administration, Prince Sattam bin Abdulaziz University, Al-Kharj, Kingdom of Saudi Arabia
**** School of Accountancy, College of Business, University Utara Malaysia, Kedah, Malaysia

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Abstract

Globally, the Fintech industry has grown in importance as a means of staying ahead of changes in the financial sector. This study aims to assess the influence of Fintech on Saudi Arabia's finan-cial corporate performance. The sample of the study is the financial service industry comprising banks and insurance companies. Data are gathered from the annual reports and DataStream for the years from 2014 to 2021. Banks and insurance companies make up the bulk of the financial ser-vices industry, which serves as a good representative sample. The associations between the in-dependent and dependent variables in five models are examined using ordinary least squares (OLS) and feasible generalized least squares (FGLS) regressions. The results reveal that Fintech has a positive impact on corporate performance. The results of additional tests are consistent with the main findings. We contributed to the literature and associated theories by shedding light on the impact of fintech on the financial sector. The findings have ramifications for a wide range of parties. Researchers can utilize the study and findings to learn more about Fintech in the context of Saudi Arabia, which stands for the Gulf region and the Arab World.

Keywords: Fintech, Fintech Score, Performance of Financial Sector, Saudi Arabia Country

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1. INTRODUCTION

Fintech comes from the combination of two words, "financial' and "technology", which is used to characterize the application of technology in the financial sector (Hu et al., 2019; Thakor, 2020). As a result, *fintech* is used to characterize the application of technology in the financial sector (Nguyen, 2020; Thakor, 2020). Fintech can be defined as the use of technological breakthroughs to provide financial services (Gomber et al., 2018), with the objective to improve the quality and efficiency of financial services through the application of information technology (Gai et al., 2018).

Throughout the decades since its inception, fintech has garnered worldwide attention. It was predicted then that the banking industry would be revolutionized by financial technology in the near future. In the twenty-first century, organizations are able to compete effectively if they have access to cutting-edge financial technologies. In this aspect, fintech has a substantial impact on the growth of the banking industry. The disruption brought by fintech has advantages for customers in terms of additional options for obtaining low-cost financial services (Al-Matari et al., 2022). Fintech, on the other hand, has a substantial impact on the growth of the banking industry. Customers now have additional options for obtaining low-cost financial services due to the disruption that fintech has brought about (Berger, 2003). In addition, fintech relies on the use of technology to provide financial services (Thakor, 2020). Fintech, according to Gai et al. (2018), aims to improve the quality and efficiency of financial services through the application of information technology. Fintech's worldwide marketplaces are raising in size and relevance, despite the differing economic growth rates in different nations, and this is a major problem for conventional financial institutions (Thakor, 2020; Vives, 2017). There were laws and regulations put in place by governments around the world to assist fintech development (Wonglimpiyarat, 2017). The government of Saudi Arabia has devoted close attention to this area because it is crucial to the country's financial stability.

In this context, there is an extensive body of literature that has focused on the understanding of Fintech with many variables. These include: antecedents of financial innovation perceived by the popular press; regulation and innovation; interpreting the forces of innovation; disruption, transformation in financial services; ecosystem; business models; investment decisions; regulatory arbitrage challenges; the rise of shadow banks; trends; security challenges; services; psychometrics; credit infrastructures; the limits of financialization; impacts of perceived value and perceived risk; the performance of investment firms; the impact of fintech firms on the banking industry; credit market competition; bank asset quality; peer-to-peer lending fintech corporation for sustainability performance and unearthing antecedents to financial inclusion through fintech innovations (Bernards, 2019; Elsaid, 2021; Gomber et al., 2018; Kang, 2018; Lee & Shin, 2018; Mutamimah & Robiyanto, 2021; Senyo & Osabutey, 2020; Tseng & Guo, 2021; Zavolokina et al., 2016). The existing literature related to fintech in the financial sector is still at an early stage (Huang et al., 2022; Li et al., 2020). Nonetheless, the current study focuses on examining the relationship between fintech and performance (marketing-based measurements and account-based measurements). As a result of the necessity of employing technology, this study is a basic study to directly analyze the link between factors in order to improve future studies.

Fintech is widely used in a wide range of countries, particularly those with a strong economic and information technology heritage such as the United Kingdom, China, South Korea, and India (Kim et al., 2016). On the other hand, fintech is still in its infancy in less developed countries such as Saudi Arabia and is expected to make significant progress in the near future. Policymakers, researchers, and financial authorities in Saudi Arabia are all taking an interest in fintech. Also, fintech is a hot topic in conferences and forums. Fintech and its uses in Saudi Arabia's financial sector have still to be empirically researched. As a result, this is an intriguing area of study in Saudi Arabia, where many questions remain unanswered. Fintech and its applications in the financial industry in Saudi Arabia are examined in this paper. In addition, the authors take into account the elements that influence a company's ability to adopt financial technology services. Policymakers, academics, and regulators in the financial industry will benefit greatly from the findings of this study.

We present a novel framework to examine Fintech with corporate performance proxies such as Tobin's Q (*TQ*), return on equity (*ROE*), Tobin's Q score (*TQSC*), return on equity score (*ROESC*) and corporate performance (*FPSC*) in the context of Saudi Arabian financial companies. In the end, the financial sector's grasp and adoption of fintech is vital to the to the stability of the economy. As a result, this is an intriguing subject for further study, and there are plenty of opportunities to be explored in Saudi Arabia. Research in the future should employ an accounting and market-based assessment of the firm's performance to accurately quantify it, according to (Al-Matari et al., 2014b). It is true that accounting-based measures can reflect the company's previous performance, while market-based indicators can help predict the company's future performance. As a result, the authors of the current research use these two metrics to assess overall performance.

Fintech is a term that refers to the proliferation of digital tools, platforms, and ecosystems that have made financial services or products more accessible, efficient, and affordable over the past eight years (Kou, 2019). As shown in Figure A.1 and Table A.3, fintech-related papers have been published in academic journals since 2016. We searched for "*fintech*" in both the Scopus and Web of Science (WOS) databases. WOS search engine's total search per year from 2016 to 2022 (May) is shown in Figure A.1 and Table A.3 (refer to Appendix), the percentages are 6 per cent, 13 per cent, 31 per cent, 21 per cent, 10 per cent, 6 per cent and 13 per cent; implying that 2018 is the year with the highest number of articles published. In 2022, we expect the overall number of papers to continue to grow. This indicates the rise in financial technology research from the WOS database website

during these years due to the importance of the topic at the present time, which is trying to provide information that helps researchers from around the world to show the determinants of this topic, which in turn helps decision makers to develop strategies in order to achieve the desires of customers.

Figure A.2 and Table A.4 (refer to Appendix) show the percentage of total research publications in the Scopus between 2016 and 2022 (May). The percentage of publications shows an increasing trend from 0 per cent in the year 2016 to 44% in the year 2021. In 2022, we expect the overall number of papers to continue to grow. Based on the above, it could be seen that there is a dearth of research in the fintech area, so this study will extend the literature review of fintech by examining the impact of fintech on performance. Furthermore, earlier research focused on partially financial sector firms such as banks, however, the current analysis includes all financial sector firms, including insurance and other financial firms. This suggests that there has been an increase in research on financial technology conducted from the Scopus source website over the course of these years due to the significance of the subject matter at the present time. This is because the researchers are attempting to provide information that assists researchers from all over the world in demonstrating the factors that determine the subject matter, which in turn assists decision-makers in developing strategies in order to satisfy the needs of customers. As a result, this number highlights the topic's relevance and the need for future research because of how crucial it is to the financial sector.

This study presented the following contribution. First, it has examined the association between fintech and financial sector performance in Saudi Arabia's market, a novelty for the Gulf Cooperation Council (GCC) countries. Whereas previous studies have focused on developed countries (Brandl & Hornuf, 2017; Laven & Bruggink, 2016).

Secondly, this study tried to highlight the role of fintech in the Saudi market because the Saudi market has become one of the most important investment interfaces from inside or outside the region because of the facilities provided by the state.

The purpose of this research is to examine the impact of fintech on Saudi Arabia's financial corporate performance. The study's sample includes banks and insurance businesses from the financial services industry. Data for the years 2014 to 2021 are taken from companies' annual reports and DataStream. Ordinary least squares (OLS) and feasible generalized least squares (FGLS) regressions are used to analyze the relationships between the independent and dependent variables in five models. According to the findings, fintech has a favourable impact on corporate performance. Additional tests show that the primary findings are correct.

The following sections will highlight financial technology in Arab countries, as provided in Section 2. Moreover, in Section 3, the literature review and hypotheses development will be highlighted, and the theoretical framework and methodology will be explained in Section 4. In addition, empirical results are provided in Section 5, and the discussion will be highlighted in Section 6. Finally, Sections 7 highlight the study's conclusion and limitations, as well as the study's implications and future recommendations.

2. FINANCIAL TECHNOLOGY IN THE ARAB COUNTRIES

2.1. Technology development in the Arab region

Fintech has been a new economic wealth since the global financial crisis (GFC), but it has been rising significantly since 2013. Indeed, some researchers believe that we will see a conflict between traditional banks, traditional financial institutions and these fintech emerging companies, which are able to compete with them. Despite the fact that many individuals and businesses are interested in it, fintech mergers and acquisitions have recently occurred, and even banks are beginning to employ this new technology. A report by Ernst & Young (2017) found that private sector investment in fintech has grown from less than $3 billion in 2012 to $19 billion in 2015. Technology that could transform the global financial system is being touted as the future of financial services.

Finally, Al-Matari et al. (2022) studied the interaction between corporate governance characteristics and fintech with companies' performance. They found that fintech has a significant association with companies' performance. They suggested that future researchers should study the direct relationship between fintech and companies' performance in the Saudi Arabian market. Moreover, fintech has a positive and significant link with performance among Chinese banks (Liu et al., 2021). The researchers recommended examining this relationship in different countries since using fintech technology improves the firms' performance. Based on that, the current paper examines this relationship in the Arab region such as Saudi Arabia's market.

2.2. Fintech in the Kingdom of Saudi Arabia

In Saudi Arabia, the fintech industry is expanding quickly. In fact, between 2017 and 2019, the value of transactions including financial technology climbed at a rate of more than 18% annually, reaching more than two-thirds of transactions that cost more than $20 dollars. About 98% of the total user base, followed by the personal finance sector, had transactions that amounted to more than 30 % of the value of fintech transactions. Additionally, payment transactions through repayment increased by an average of 27% in 2016 and by an annual average of 11% in 2019. The value of these transactions increased in the same period at a compound annual rate of 24%, reaching a value of 2 billion SAR (Saudi Arabian riyal), and 445 payments made via smartphones increased by 19.7% in the Kingdom to reach 4.4 million SAR in April 2019 (Harfoush, 2019). By 2023, it is expected that the transaction values in the financial technology market in the Kingdom will exceed $33 billion. It is likely that payments will continue in the acquisition of a large share of the market, followed by personal finance. With regard to sales of

insurance over the internet, these form a relatively small share of the market in Saudi Arabia. However, with the development and implementation of new regulations related to the electronic insurance brokerage business, the insurance technology sector in the Saudi Arabia will witness increasing growth (Harfoush, 2019).

In this environment, the Kingdom's financial technology sector is being developed by an active and efficient community of banks, colleges, firms, government organizations, and others interested in investing in the subject. The financial sector has benefited from the use of financial and technical services in the completion of many financial processes such as electronic portfolios and solutions, lending insurance, brokerage, and electronic investment. This resulted in increased use of financial and technical major benefits to the Kingdom of Saudi Arabia, particularly in the aftermath of the COVID-19 pandemic, when they arose. The Kingdom's *Vision 2030* scheme placed a strong emphasis on changes to boost financial digitization, calling for a society free of paper money through a project that aims to change the rules of the game in the sector under the guise of the *Financial Sector Development Program* (Vision 2030 Projects, 2017). One of the programs used to achieve the Kingdom's *Vision 2030* objectives as presented below (Al-Matari et al., 2022).

Moreover, through its crucial role in shaping upcoming financial services transactions, *fintech* is anticipated to help achieve financial stability (Thakor, 2020). The Kingdom of Saudi Arabia is making an effort to keep up with such advancements in financial technology by developing the industry appropriately and by fostering high investment returns. Financial technology companies have new tools that can help the financial sector increase operational effectiveness and efficiency. In order to support the financial technology system and ultimately strengthen the position of the Kingdom as a financial technology hub with prosperous and responsible systems for its banks, investors, companies, universities, and state institutions, the Saudi Arabian Monetary Agency (SAMA) introduced the website of the *Fintech Saudi* initiative in 2018 (https://fintechsaudi.com). Financial, insurance, and commercial services saw an 8% growth in the Kingdom of Saudi Arabia in 2019. It is noteworthy that the Kingdom's financial sector demanded powerful financial technology to aid in the search for a favourable investment environment and credit for investors after the financial crisis in 2008, which required the adoption of governance standards (local and international) (Al-Matari et al., 2022). The current study, which uses qualitative methods to investigate the influence of governance and financial technology, was motivated by this gap. According to the Kingdom's *Vision 2030* plan, the financial sector is one of the main pillars of the national transformation drive.

The results of this study are expected to provide a number of contributions to the fintech literature in light of its goals and objectives. The first contribution made by this study is that it studies the role of fintech in financial firms. Second, this study is novel because it is the first to the authors' knowledge to examine how fintech is influencing financial institutions in a developing economy like Saudi Arabia. Third, this study tries to examine this relationship with many performance proxies such as *TQ* and *ROE*. Fourth, this study tests this relationship with additional tests like the score of proxy performance. Figures A.1 and A.2 show that academic articles on fintech are on the rise, although the number of literature reviews on fintech is still low. In terms of fintech's technical features, these were covered by many authors (Bernards, 2019; Elsaid, 2021; Gomber et al., 2018; Lee & Shin, 2018; Mutamimah & Robiyanto, 2021; Senyo & Osabutey, 2020; Tseng & Guo, 2021; Zavolokina et al., 2016). The existing literature on fintech and the financial sector is still in its infancy (Li et al., 2020; Wu, 2021; Zhao et al., 2022). As previously stated, the majority of existing literature evaluations are primarily concerned with technical or regulatory elements of fintech.

The current paper takes a different approach, concentrating on corporate performance. Thus, this study is the first to focus on performance proxy among a developing country such as Saudi Arabia. The study helps stakeholders in the process of comprehending the economic justification for owning fintech by providing guidance to regulators, policymakers, businesses, and stakeholders.

3. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

3.1. Theory

Signalling theory asserts that in markets with information asymmetry, "signals" are issued by enterprises to communicate their identity and beliefs (Spence, 1973). These signals represent the process by which one group of people in the marketplace changes their beliefs about another group's unobserved action or both. To reduce information asymmetry and agency costs between companies and their associated parties, signalling information is vital. Companies' information disclosure policies, particularly those related to fintech, can range from complete nondisclosure to completely forthcoming, depending on the circumstances (Premuroso & Bhattacharya, 2007). We already know that these reasons have diverse consequences on the level of disclosure between organizations, sectors, and countries. This is based on a variety of considerations, including the price. The finance sector, in particular, makes use of this information to convey to potential investors that a company's business prospects and technological level are favourable (Bhattacharya & Ritter, 1983). Using these examples, it is easy to understand how organizations might utilize signalling theory to send signals to the people who use their data, such as in the case of financial statements.

Here, we present the definition of Fintech that was used in past studies. This summary will also serve as a guide for future research, allowing researchers to draw on these concepts and focus on developing a definition that is appropriate for the study population. Definitions that summarize prior definitions will also be used, and a nucleus will be constructed to support the addition of new definitions to the set.

Table 1. Fintech definition

Author, year	*Definition*
Kim et al. (2016)	"Fintech is a service sector, which uses mobile-centred IT-technology to enhance the efficiency of the financial system" (p. 1061).
Arner et al. (2017)	"Financial technology" or "FinTech" refers to "technology-enabled financial solutions. The term Fintech is not confined to specific sectors (e.g., financing) or business models (e.g., peer-to-peer (P2P) lending), but instead covers the entire scope of services and products traditionally provided by the financial services industry" (p. 412).
Gai et al. (2018)	"Describes the financial technology sectors in a wide range of operations for enterprises or organizations, which mainly addresses the improvement of the service quality by using information technology (IT) applications" (p. 266).
European Commission (2018)	"FinTech is a term used to describe technology-enabled innovation in financial services that could result in new business models, applications, processes or products and could have an associated material effect on financial markets and institutions and how financial services are provided" (p. 12).
McAuley (2015, as cited in Giglio, 2022)	"An economic industry composed of companies that use technology to make financial systems more efficient" (p. 82).
Investopedia (2016, as cited in Giglio, 2022)	"Fintech is a portmanteau of financial technology that describes an emerging financial services sector in the 21st century" (p. 82).
Ernst & Young (2016, as cited in Giglio, 2022)	"Organizations combining innovative business models and technology to enable enhance and disrupt financial services" (p. 82).
Hornuf et al. (2021)	"Technologically enabled financial innovation that could result in new business models, applications, processes, or products with an associated material effect on financial markets and institutions, and the provision of financial services" (p. 1513).

After addressing a variety of definitions of financial technology, as shown in Table 1, the previous definitions concentrated on one idea: *financial technology* (*fintech*) is the use of contemporary applications by the financial sector that aid the sector in streamlining operations, achieving total customer satisfaction, and enhancing the financial position of this sector. This is the definition that the current study adopts.

3.2. Fintech and corporate performance

The relationship between financial services and information technology has been studied for decades, but interest in fintech is still high. According to Balyuk et al. (2022), information technology (IT) can have an impact on banking productivity and consumer welfare. The consolidation of financial services was explained a few years ago by Thakor (2020), who stated that ongoing consolidation is more likely to lead to specialization-induced fragmentation of financial services in the related industry. It is expected that IT would lead to specialized players entering the market and increasing product adaptations based on customers' preferences, which has become a reality today (Thakor, 2020). There are consequences for the development of fintech from developments in technology, according to (Frame et al., 2019). Among the innovative new financial services enabled by modern technology are peer-to-peer lending without a middleman, cryptocurrencies, and smart contracts, to name just a few. The extent to which the advances involve non-intermediated transactions is unprecedented. As a result, this research aims to identify the substantial value that may be added to the literature and provide empirical evidence to comprehend fintech. To aid future researchers in assessing the fintech sector, we adopted the fintech Index as mentioned by Al-Matari et al. (2022). This index will be useful in future studies. In addition, the cost of intermediation is reduced and the availability of financial support is raised when it comes to fintech businesses (Vives, 2017). As a result of fintech's involvement in improving efficiency, the core of the banking industry was able to overcome and correct information asymmetries, all the while avoiding old technology and a culture of efficient operational design. As a result, fintech companies have a greater capacity for innovation than traditional businesses do (Vives, 2016). Lending, payment systems, financial advice, and insurance are just a few of the fintech innovations that have recently emerged in the banking and capital markets sectors (Vives, 2017).

Most people believe that technology in financial services plays an important role in today's world. However, practical studies are unsuccessful in discourse the factor's importance and its impact on performance in a straightforward way. This study therefore purposes to determine the impact of the fruitful technology role in banking, particularly in promoting financial services digitization and encouraging society to adopt paperless money. The measurement of fintech can be based on several methods, such as questionnaires (Hu et al., 2019; Ryu, 2018; Szopiński, 2016; Wonglimpiyarat, 2017). Fintech adoption is also measured by the revised Global Financial Technology Adoption Index (GFTAI) 2019 (Ernst & Young, 2019). As a result of the rules implemented in the Saudi financial industry, this study relied on a number of GFTAI items, particularly developments in the adoption of financial technology by consumers (Al-Matari et al., 2022).

This study utilizes an unweighted technique to assign the fintech elements a score. The impact of financial technologies on the efficiency of banks has been theoretically studied previously (Balyuk et al., 2022; Saiedi et al., 2018; Frame et al., 2019; Navaretti et al., 2017; Li et al., 2020; Thakor, 2020; Vives, 2016, 2017). Although previous studies did not empirically test the hypothesis widely (Al-Matari et al., 2022; Liu et al., 2021), this study explores the impact of fintech on the performance of Saudi Arabian financial sector companies, as an innovative approach. According to various theoretical studies, Fintech may improve financial services by enhancing service quality and company structures, making transactions more economical, more secure and more comfortable; and so, making financial services more accessible and more convenient (Begenau et al., 2018; Chen et al., 2019; Chiu & Koeppl, 2019; Fuster

et al., 2019; Meng et al., 2019; Vasiljeva & Lukanova, 2016). Fintech can also help commercial banks diversify their business models (Yao & Song, 2021). Besides, banks' stock returns are positively associated with the rise of Fintech activities (Li et al., 2017).

Alternatively, the rise of fintech may alter the banking system in accordance with the consumer hypothesis and the disruptive innovation hypothesis. If fintech firms can meet the same consumer needs as conventional financial institutions, fintech could replace conventional services (Aaker & Keller, 1990). New market entrants who use disruptive technology, lower prices and greater accessibility to their services face intense competition in the market (Christensen, 1997). As a result, some experts think that commercial banks may face difficulties given the rise of information technology (Brandl & Hornuf, 2017; Laven & Bruggink, 2016). This paper argues that fintech usage and acceptance might raise the sector's efficiency and competitiveness in Saudi Arabia. Effective fintech usage management may also improve sector performance and help it maintain its competitiveness. Balyuk et al. (2022), Buchak et al. (2018), Navaretti et al. (2017), Thakor (2020), Vives (2016, 2017) attempted to clarify the theoretical relationship between Fintech and bank performance. In addition, a few empirical researches that examined the connection between Fintech and performance discovered a strong correlation (Dwivedi et al., 2021; Nguyen et al., 2022). Thus, fintech companies can have a positive or negative impact on bank performance, as detailed in the preceding sections. Researchers, on the other hand, have rarely looked at the connection between a given Fintech activity and banking performance. As a result, our main hypothesis is stated as follows:

H1: Fintech has an impact on corporate performance.

In this case, sub-hypotheses can be formulated as follows:

H1a: Fintech has an impact on Tobin's Q (TQ) as a measure of corporate performance.

H1b: Fintech has an impact on return on equity (ROE) as a measure of corporate performance.

H1c: Fintech has an impact on Tobin's Q score (TQSC) as a measure of corporate performance.

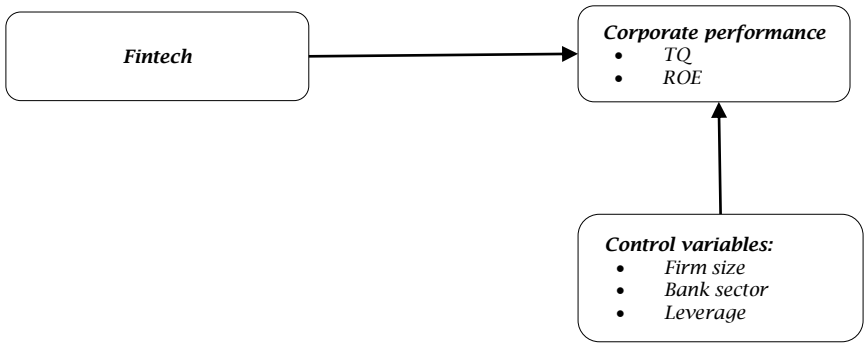
H1d: Fintech has an impact on return on equity score (ROESC) as a measure of corporate performance.

H1e: Fintech has an impact on the score of FP.

3.3. Theoretical framework

Figure 1 depicts the framework, which contains both exogenous (*fintech*) and native (other factors) variables (*corporate performance*). *Fintech* and *corporate performance* are the independent and dependent variables in this framework. The study's conceptual framework is supposed to be evaluated by these relationships, as depicted below.

Figure 1. Research framework



4. METHODOLOGY

4.1. Sample and data collection

The sample of the study is financial institutions, comprise of banks and insurance companies. There are 200 financial institutions listed on the Saudi market (Tadawul). A total of 153 financial institutions were left out because of a lack of compliance with laws and organizations, and delisted organizations with missing data. Thus, the sample of the study is 46 financial institutions for the period of 2014 to 2021. Sources of data come from the annual reports, DataStream, and company profiles. Data collected are related to the *fintech* and *corporate performance*.

4.2. Variables' measurements

4.2.1. Dependent variable

In order to meet the goals of our study, we use *TQ* (Al-Matari, 2019) and *ROE* to assess the dependent variable, corporate performance (*FP*). Accounting-based (*ROE*) and market-based (*TQ*) metrics are used to evaluate a company's performance (Al-Matari et al., 2014b). In line with previous research (DeFond et al., 2005; O'Sullivan et al., 2008; Srinidhi et al., 2014), this study used an aggregate measure of a *fintech* to determine its score. It is believed that employing a composite of structural variables lowers the error associated with individual structural variables (Srinidhi et al., 2014). According to O'Sullivan et al. (2008), aggregate measurements have a greater influence than individual measurements. In addition, we use the *TQ* and

ROESC to gauge the effectiveness. Finally, because this research relies on established performance measures (*ROE* and *TQ*), the final score was reached as presented below (Al-Matari et al., 2022).

4.2.2. Independent variables

We used an unweighted technique to measure *fintech* as an independent variable in order to meet the goals of our study. This strategy works well when no one user group is given priority (Akhtaruddin et al., 2009). A dichotomous-based scoring system is used for the information items. The unweighted fintech-disclosure approach assigns a firm a score of "1" if it discloses an item in its annual report, and "0" if it does not. In order to calculate the sum of fintech items in the scores, the sum disclosure score is divided by the highest possible disclosure of fintech items by the company. Each firm's fintech items are then expressed as a ratio (Mgammal et al., 2018; Tsalavoutas, 2011). When it comes to determining the extent to which a corporation has disclosed its fintech items, unweighted fintech items are used as a guideline. According to annual reports, such as those for fintech companies, this is a common technique to classify the level of disclosure (Al-Matari et al., 2022; Mgammal, 2020).

According to the extant literature, fintech activities can be categorized into a number of distinct sub-topics. As an example, the GFTAI 2019 used a checklist of two primary categories to measure fintech acceptance (*consumer fintech services*: 19 fintech services across five categories; and *small and medium-sized enterprises* (*SME) fintech services*: four categories with 12 items). For the current study, we adopt only *consumer fintech services* by the GFTAI 2019. The *SME fintech services* are not adopted because of the differences in the banking sector's operations. As the current study aims to experimentally investigate the link between fintech and bank performance, thus, we also consider the possibility of studying the link between local and global issues of fintech and the performance of the financial sector. Finally, this study makes use of *FintechSC* standardized indicators for each of the variables examined (Al-Matari et al., 2022; Kou, 2019; Thakor, 2020; Varga, 2017; Vives, 2017). However, our current study aims to experimentally investigate the link between fintech and bank performance. Thus, we open our minds to the possibility of studying the link between local and global issues. Finally, this research makes use of *FintechSC* standardized indicators for each of the variables examined (Grice & Harris, 1998). Adopting the *FintechSC* standardized indicators allows our results to be easier to understand when they are compared to other studies (Alali et al., 2012; Al-Matari et al., 2022).

4.2.3. Control variables

To avoid model misspecification and reduce the likelihood of bias in our results, we have included numerous theoretically related control variables in our regression model alongside the explanatory variables. Because organizations with a high leverage ratio (*LEVGE*) are seen as riskier, we take this into account. The ratio of total debt to total assets was used as a leverage measure. We can reasonably assume that large firms (*FIMSILOG*) have the resources necessary to participate in fintech activity (Al-Matari et al., 2014a, 2014c; Andrew et al., 1989; Hatum & Pettigrew, 2006). The natural logarithm of a company's total assets is used to determine its size. For the final control variable, we utilized *BankSECTOR* as a dummy variable to control some macroeconomic events (Al-Matari & Alosaimi, 2022; Al-Matari & Mgammal, 2020).

4.3. Model specification

The regression equations are estimated using the methods for developing hypotheses. They are as follows:

$$TQ = \beta_0 + \beta_1\, Fintech\ + \beta_2\, FIMSILOG\ + \beta_3\, BankSECTOR\ + \beta_4\, LEVGE + \varepsilon_i \quad (1)$$

$$ROE = \beta_0 + \beta_1\, Fintech\ + \beta_2\, FIMSILOG\ + \beta_3\, BankSECTOR\ + \beta_4\, LEVGE + \varepsilon_i \quad (2)$$

5. EMPIRICAL RESULTS

5.1. Descriptive statistics

Descriptive statistics are shown in Table 2, which includes the maximum and the mean values of each statistic. This study's findings show that there is a wide range of diversity among the sample. With an average of 0.699 and a standard deviation of 0.875, it is demonstrated that the *TQ* ranges from 3.572 to 6.767. The average value of *ROE* is 0.235, ranging from -0.778 to 1.914. For *Fintech*, the average value is 0.399 and the value ranges from 0.000 to 1.000, meaning that some samples do not disclose consumer services elements while some disclose all the elements in the annual reports. For example, the *FIMSILOG* ranges from 5.090 to 8.778 with an average of 6.571 and a standard deviation of 0.952, whereas *BankSECTOR* ranges from 0.000 to 1.000 with 0.298 and 0.45. In addition, the *LEVGE* ranges from 0.090 to 0.959, with an average of 0.686 and a standard deviation of 0.158. It was proposed that data can be regarded as normal if the Skewness is in the range of -2 to +2 and Kurtosis are in the range of -7 to +7 (Hair et al., 2010). Further tests for normalcy included the Skewness and Kurtosis indices as shown in Table 3. Suggesting that the divergence of the data from normalcy was not substantial, the results showed that the value of Skewness was below 3 and the Kurtosis index was below 8 (Kline, 2011). The data are normal, as shown by the argument presented above.

Table 2. Descriptive statistics

Variable	*Obs.*	*Mean*	*Std. dev.*	*Min*	*Max*
TQ	329	0.699	0.875	-3.572	6.767
ROE	329	0.235	0.191	-0.778	1.914
Fintech	329	0.399	0.327	0.000	1.000
FIMSILOG	329	6.571	0.952	5.090	8.778
BankSECTOR	329	0.298	0.458	0.000	1.000
LEVGE	329	0.686	0.158	0.090	0.959

Note: TQ = Tobin's Q, ROE = return on equity, Fintech = financial technology, FIMSILOG = firm size, BankSECTOR = bank sector, and LEVGE = leverage.

Table 3. Normality test

Variable	*Skewness*	*Kurtosis*
TQ	0.675	6.280
ROE	0.909	6.485
Fintech	0.667	1.833
FIMSILOG	0.916	2.399
BankSECTOR	0.884	1.781
LEVGE	-0.849	3.616

Note: TQ = Tobin's Q, ROE = return on equity, Fintech = financial technology, FIMSILOG = firm size, BankSECTOR = bank sector, and LEVGE = leverage.

5.2. Multivariate regression analysis

Multicollinearity is indicated by variance inflation factor (VIF) values of more than 10 in Table 4 (Hair et al., 2010). No such problem was found, as evidenced by VIF values of 1.22 to 2.61.

Table 4. VIF and tolerance results

Variable	*VIF*	*1/VIF*
FIMSILOG	2.61	0.382747
Fintech	2.57	0.389516
BankSECTOR	1.26	0.795659
LEVGE	1.22	0.818213
Mean VIF	1.91	

Note: FIMSILOG = firm size, Fintech = financial technology, BankSECTOR = bank sector, LEVGE = leverage.

Here, we'll compare the OLS model to the random effect (RE) model by running the Breusch-Pagan Lagrange multiplier (LM) test. The difference between the two models may be boiled down to how they handle individual impacts. The LM test is suitable for making this kind of decision. If the LM test produces a chi-square statistic with a significance level of less than 0.05, then the null hypothesis is rejected and the pooled estimates are not suitable. This is why we recommend the random effects approach over the pooled OLS. Furthermore, the main difference between fixed effects and random effects is whether or not the error term is associated with independent variables, and thus, the choice between the fixed effects method and the random effects method of panel data regression involves the determination of the correlation via the Hausman specification test. As a result, while testing the null hypothesis, random effects are presumed, and when testing the alternative, fixed effects are used.

Based on the results shown in Table 5, the LM test is used to determine whether we have to use pooled estimate or a random effects model. The result of *Prob > chibar2* is less than 0.05 as shown in Table 5, Model 3 and other, such as Model 1, 2 or 4, which show *Prob > chibar2* is more than 0, then the pooled OLS model is used (Breusch & Pagan, 1980; Gujarati & Porter, 2013). In the meantime, the Hausman test is used to determine whether to use fixed or random effects in Model 3 as shown in Table 6 (Hausman, 1978). The Hausman test is used to determine if the explanatory variables and the error term are linked (Baltagi, 2013). The null hypothesis is rejected if the p-value is found, and the suitable model is the fixed effects one. In other words, the Hausman test has now taken place. Based on the results of the test, the fixed effect data model was the best Model 3 (refer to Table 6). Lastly, this model is performed using cross-sectional time-series FGLS regression to address and resolve the issue of heteroscedasticity in the data. A number of prior researchers, such as Baltagi (2013), Bel and Esteve (2018), Gruskin et al. (2019), Liu et al. (2019), Que and Hiep (2018), Sonora (2019), Van Dan and Binh (2019), used FGLS to evaluate the link between independent and dependent variables. FGLS was found to be appropriate because the nature of the data necessitates concentrating on just one subset of the financial sector.

Table 5. Test of Breusch-Pagan Lagrange multiplier (LM) and Breusch-Pagan/Cook-Weisberg test for heteroskedasticity

	Breusch-Pagan Lagrange multiplier (LM) test					*Breusch-Pagan/Cook-Weisberg test for heteroskedasticity*				
	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 5*	*Model 1*	*Model 2*	*Model 3*	*Model 4*	*Model 5*
chibar2(01)	0.00	0.00	4.88	0.83	16.13	271.65	15.42	143.67	6.14	35.02
Prob > chibar2	1.000	1.000	0.014	0.182	0.000	0.000	0.000	0.000	0.013	0.000

Table 6. Selected between random and fixed regression

Hausman test		
	Model 3	*Model 5*
chibar2(3)	2.00	3.78
Prob > chi2	0.5718	0.2861

Table 7. Multiple regression results using the pooled OLS — Model 1 and 2

OLS regression (Model 1)			*OLS regression (Model 2)*		
Variable	***Coeficient***	***t***	***ROE***	***Coeficient***	***t***
Fintech	0.434	2.720***	*Fintech*	0.006	0.150
FIMSILOG	0.083	1.100	*FIMSILOG*	-0.006	-0.350
BankSECTOR	-0.412	-6.200***	*BankSECTOR*	0.007	0.270
LEVGE	-1.427	-2.900***	*LEVGE*	-0.413	-4.670***
_cons	1.085	2.950***	_cons	0.552	4.700***
Number of obs.	329	-	Number of obs.	329	-
Years	Include		Include		
Prob > F	0.000	-	Prob > F	0.000	-
R-squared	0.199	-	R-squared	0.113	-
Root MSE	0.788	-	Root MSE	0.184	-

Note: Fintech = financial technology, FIMSILOG = firm size, BankSECTOR = bank sector, LEVGE = leverage. MSE stands for mean-square deviation. Significant levels: (*) p < 0.10; (**) p < 0.05 and (***) p < 0.01 respectively.

Fintech has a positive and substantial correlation with corporate governance (*TQ*) (β = 0.434; p < 0.05) in Model 1, according to the results in Table 7. Furthermore, the findings demonstrated that company size has a positive, but a not statistically significant, link with *TQ* (β = 0.083; p > 0.01). Finally, there is a negative relationship between the bank sector and leverage (β = -0.412; p < 0.01). (β = -1.427; p < 0.01) respectively. Furthermore, a second analysis of *ROE* performance revealed that fintech, business size, and bank sector had no effect on *ROE* (β = 0.006; p > 0.01) (β = -0.006; p > 0.01) (β = 0.007; p > 0.01), respectively. Finally, leverage (β = -0.413; p < 0.05) has a negative relationship with *ROE*.

5.3. Robustness test

Panel data fixed effects regression, shown in Table 8 was used to mitigate the negative impact of endogeneity by controlling for unobservable firm heterogeneity and partially eliminating its occurrence (Wooldridge, 2010). This is evident from Table 8, which shows that endogeneity was partially eliminated. The generalized method of moments (FGLS) estimator was run on dynamic panel data in order to account for the various causes of the endogeneity problem and provide robust results as a model developed (Baltagi, 2013; Bel & Esteve, 2018; Gruskin et al., 2019; Liu et al., 2019; Que & Hiep, 2018; Sonora, 2019; van Dan & Binh, 2019). The following formulae can be used to represent models in this context:

$$TQSC = \beta_0 + \beta_1\ Fintech\ + \beta_2\ FIMSILOG\ + \beta_3\ BankSECTOR\ + \beta_4\ LEVGE + \varepsilon_i \quad (3)$$

$$ROESC = \beta_0 + \beta_1\ Fintech\ + \beta_2\ FIMSILOG\ + \beta_3\ BankSECTOR\ + \beta_4\ LEVGE + \varepsilon_i \quad (4)$$

$$FPSC = \beta_0 + \beta_1\ Fintech\ + \beta_2\ FIMSILOG\ + \beta_3\ BankSECTOR\ + \beta_4\ LEVGE + \varepsilon_i \quad (5)$$

Table 8. Multiple regression results using the FGLS models — Model 3

Variable	***Fixed-effects (within) regression***		***Random-effects FGLS regression***		***Cross-sectional time-series FGLS regression***	
	Coeficient	***t***	***Coeficient***	***z***	***Coeficient***	***z***
FintechSC	-0.092	-0.23	0.216	1.02	0.245	2.380**
FIMSILOG	0.001	0.03	0.003	0.05	-0.039	-1.510
BankSECTOR	(omitted)	-	-1.052	-2.25**	-0.969	-4.360***
LEVGE	-1.321	-1.83*	-1.752	-4.45***	-2.287	-9.530***
_cons	0.897	1.56	1.499	3.50***	2.070	8.720***
sigma_u	0.471		0.260	-	-	-
sigma_e	0.838		0.838	-	-	-
rho	0.240		0.088	-	-	-
Number of obs.	329		329	-	329	-
Years	Include		Include		Include	
Time periods	-		-	-	7	-
R-sq: overall	0.208		0.232	-	-	-
Prob > F	0.0028		0.0000	-	-	-
Wald chi2(4)	-		64.44	-	395.98	-
Prob > chi2	0.5718 = fixed will select				0.000	-
Coefficients	-				generalized least squares	
Panels	-				heteroskedastic	
Correlation	-				no autocorrelation	

Note: TQ = Tobin's Q score, Fintech = financial technology, FIMSILOG = firm size, BankSECTOR = bank sector, and LEVGE = leverage. Significant levels: (*) p < 0.10; (**) p < 0.05, and (***) p < 0.01 respectively.

According to the results shown in Table 8 in Model 3, we found that the *FintechSC* has a positive and significant association with corporate governance (*TQSC*) ($\beta = 0.245$; $p < 0.05$). When we looked at the results of other studies, we couldn't find one that looked at the relationship between fintech and performance in the financial sector. This would have made the results of this study more similar to those of other studies. The results of this study show that using fintech to meet customer needs improves performance, which makes it important to use this technology in the future. Moreover, the results revealed that firm size has a negative but no significant relationship with the *TQSC* ($\beta = -0.039$; $p > 0.01$). Finally, bank sector and leverage have a negatively significant association with *TQSC* ($\beta = -0.969$; $p < 0.01$) and ($\beta = -2.287$; $p < 0.01$) respectively.

According to the results shown in Table 9 in Model 4, we found that *FintechSC*, firm size (*FIMSILOG*) and bank sector (*BankSECTOR*) have no effect on *ROESC* ($\beta = -0.203$; $p > 0.01$), ($\beta = 0.011$; $p > 0.01$) and ($\beta = 0.332$; $p > 0.01$) respectively. We were unable to locate a study that examined the link between fintech and performance in the financial industry in order to increase the congruence between the results of this study and those of prior research. The result of this study indicates that the use of fintech has a non-significant effect on accounting performance, and this result is a possibility associated with the short-term accounting variable, indicating that the effect depends on the duration of use of this technology in order to meet customer needs and increase customer loyalty over the long term. Finally, leverage (*LEVGE*) has a negatively significant association with *ROESC* ($\beta = -2.505$; $p < 0.01$).

Table 9. Linear regression results using the pooled OLS — Model 4

Variable	*Coeficient*	*t*
FintechSC	-0.203	-1.08
FIMSILOG	0.011	0.21
BankSECTOR	0.332	0.8
LEVGE	-2.505	-7.14***
_cons	1.548	3.59***
Number of obs.	-	329
Years	Include	
Prob > F	-	0.000
R-squared	-	0.1745
Adj R-squared	-	0.1643
Root MSE	-	0.906

Note: Fintech = financial technology; FIMSILOG = firm size; BankSECTOR = bank sector and LEVGE = leverage. Significant: (***) p < 0.01. MSE stands for mean-square deviation.

According to the results shown in Table 10 that tested Model 5, we found that the *FintechSC* and bank sector (*BankSECTOR*) have no association with *corporate performance score* ($\beta = -0.022$; $p > 0.01$) and ($\beta = -0.500$; $p > 0.01$) respectively. When we looked at the results of other studies, we couldn't find one that looked at the relationship between fintech and performance in the financial sector. This would have made the results of this study more similar to the results of other studies. The results of this study show that the use of fintech has a big effect on accounting and administrative performance. This could be because the short-term accounting variable didn't have much of an effect, which shows that the relationship between short-term and long-term has a negative effect on the relationship between fintech and performance in general. Firm size and leverage have a negative significant association with corporate performance score ($\beta = -0.106$; $p < 0.1$) and ($\beta = -5.362$; $p < 0.01$) respectively.

Table 10. Multiple regression results using the FGLS model — Model 5

Variable	*Fixed-effects (within) regression*		*Random-effects FGLS regression*		*Cross-sectional time-series FGLS regression*	
	Coeficient	*t*	*Coef.*	*z*	*Coeficient*	*z*
FintechSC	0.316	0.380	0.059	0.120	-0.022	-0.090
FIMSILOG	0.090	0.860	0.057	0.550	-0.106	-1.700*
BankSECTOR	(omitted)		-1.090	-1.020	-0.500	-0.990
LEVGE	-5.643	-3.77***	-4.044	-4.5***	-5.362	-10.380***
_cons	3.282	2.75**	2.725	2.95**	4.530	7.750***
sigma_u	1.194	-	0.711	-	-	-
sigma_e	1.736	-	1.736	-	-	-
rho	0.321	-	0.144	-	-	-
Number of obs.	329	-	329	-	329	-
Years	Include		Include		Include	
Time periods	-	-	-	-	7	-
R-sq: overall	0.0773	-	0.1814	-	-	-
Prob > F	0.0020	-	0.0000	-	-	-
Wald chi2(4)	-	-	45.65	-	245.33	-
Prob > chi2	0.2861 = fixed will select				0.000	-
Coefficients:	-				generalized least squares	
Panels	-				heteroskedastic	
Correlation	-				no autocorrelation	

Note: TQ = Tobin's Q score, Fintech = financial technology, FIMSILOG = firm size, BankSECTOR = bank sector, and LEVGE = leverage. Significant levels are as follows: (*) p < 0 10; (**) p < 0.05, and (***) p < 0.01 respectively.

6. DISCUSSION

Organizations are always seeking and striving to reach the highest level of performance possible. Fintech must be implemented so that the organization can execute at its highest level. Fintech is believed to be one of the most important drivers in boosting overall performance, and the effects of both were explored in this study, with a variety of findings. *H1a* is supported because of the favourable and significant ($\beta = 0.434$; $p < 0.05$) impact of fintech on corporate performance (*TQ*). This outcome confirms that the company's method of enhancing its usage of financial technology aids

in improving performance by allowing clients to finish their work from any location (Al-Matari et al., 2022). In the same vein, it will instil client confidence in the organization, enhancing the importance of doing business with it in the long run. The analysis projected a positive link between *ROE* and *fintech*; however, this was not confirmed empirically ($\beta = 0.006$; $p > 0.01$). In the same path, Liu et al. (2021) proved that fintech has no significant link with performance. This result is the outcome of a process in which not all companies in the financial sector use fintech. This is evidenced by insurance companies, which did not spread the culture of promoting the use of fintech, hence negatively affecting the performance of the financial sector in general, as is the case with the percentage of insurance companies (it amounts to 76%). Because of the importance of this sector, all companies in the financial industry must undertake the process of establishing a culture of employing fintech.

This result supports the original result, which was shown in *H1b*. As a result, all organizations in the financial sector, without exception, must work continuously on the use of modern fintech, which in turn will work continuously to satisfy client's needs by providing services that assist them in implementing operations with much ease.

7. CONCLUSION

This study sought to examine the direct connection between fintech and the performance of listed Saudi financial firms in light of the efficiency improvements in financial technology. The sample was made up of financial companies that were listed on the stock exchange between 2014 and 2021. Non-financial companies were not included in the study since they are subject to different regulations and industry organizations. We eliminated delisted companies and those with insufficient data. Data were acquired from a variety of sources, including corporate profiles, annual reports, and DataStream. This study, one of the first of its kind, examines the impact of fintech on financial institutions in the setting of Saudi Arabia, a developing country. This study tested many models, the first model found a positive and significant association between *fintech* and corporate performance (*TQ*). On the contrary, the Model 2 found a positive and insignificant association between *fintech* and corporate performance (*ROE*). Moreover, the Model 3 found that *FintechSC* has a positive and significant association with corporate performance (*TQ*). The Model 4, on the contrary, found that *FintechSC* had a negative and insignificant association with corporate performance (*ROE*). In addition, the Model 5 found that *FintechSC* has a negative and insignificant association with *corporate performance scores*.

In light of the aforementioned findings, this study offers practical recommendations for various stakeholders on how fintech might help to improve corporate performance:

1. We observed from the annual reports that the majority of insurance companies do not disclose information about financial technology in their reports, so the regulators must require insurance companies or any company listed in the financial sector to comply with disclosure in order to increase the confidence of dealers due to its crucial role in supporting the economy.

2. By reviewing the literature about Fintech in the Kingdom of Saudi Arabia, we noticed through the collection of data that there are some companies in the financial sector that do not provide fintech data, which negatively affected the outcomes of the study with some variables. Therefore, companies must be obligated to adopt strict strategies by applying the fintech index, which in turn helps them achieve the ambitions of their dealers and enhances their competitive value in the market.

3. The other thing is that this study is the first that focuses on the financial sector in general, unlike previous studies that focused on a part of the financial sector such as banks. Only this study focused on the financial sector, which will contribute to laying a base for future studies and open the way for future researchers to conduct similar experiments in different countries. Accordingly, the management of the financial market must adopt a specific policy that obliges all companies listed in the financial sector to disclose fintech data, which in turn will help those interested and researchers to obtain data at the time required to conduct studies for analysis and evaluation. In view of the economic justification for having fintech, the research findings have consequences for regulators, policymakers, businesses, and their stakeholders.

4. Last but not least, the study's findings are anticipated to assist Saudi Arabia's authorities in developing corporate governance standards as well as fintech companies inside the financial industry. The findings also have significance for policymakers and practitioners in Saudi Arabia and other Middle Eastern countries, Asia, and developing countries with comparable cultures, socioeconomic institutions, or socioeconomic situations.

5. The study's findings were inconsistent, owing to the fintech index's limited deployment in the majority of insurance companies. The non-bank financial sector is critical to any country's economy, as it has the potential to accumulate savings and provide a variety of advanced financial tools. This enables countries to finance economic activities and then expand the establishment of investment projects, infrastructure projects, and major national projects, among others. It also creates job and employment opportunities in highly productive development projects. As a result, these businesses must be compelled to use fintech indicators that aid in performance improvement.

Finally, this study like any prior study has some limitations. Firstly, this study focuses only on one country of the GCC; so, it is recommended to do more studies including other GCC countries. Secondly, this study focuses on one country of the GCC; so, it is recommended to draw a comparison between Saudi Arabia and other GCC countries. Thirdly, this study examines the relationship between *fintech* and performance proxies like *TQ* and *ROE*, while we know that there are other measurements such as ROA, return on investment (ROI), return on sales (ROS), profit margin (PM), earning per share (EPS), market value added (MVA), market-to-book esteem (MTBV), and dividend yield (DY) (Al-Matari et al., 2014a). Therefore, the relationship between them was not

positive due to the lack of correlation between performance variables. This result also recommends that the financial sector must adopt a strict policy to compel all companies to apply financial technology, which in turn will help improve performance. So, we recommend future studies to extend performance proxies to include both accounting and market-based measures so as to accurately measure the corporate's performance. Fourthly, this study examined the link between fintech and performance; so, we suggest future examination to interact this variable with other characteristics of corporate governance such as the board of directors, audit committee characteristics, ownership structure, and internal audit characteristics. This study explored this relationship using performance as a dependent variable; we recommend that future research examine this relationship with other variables such as earning management, capital structure, and social responsibility. Finally, this study adopted part of the GFTAI 2019; so, future works should adopt all of the Global Fintech Adoption Index 2019.

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APPENDIX

Table A.1. Previous studies published in Web of Science (WOS) database (Part 1)

Title	*Author/s/year*	*Source title*	*Publication year*	*Total citations*
"Analyzing China's fintech industry from the perspective of actor-network theory"	Shim and Shin (2016)	"Telecommunications Policy"	2016	59
"From fintech to finlife: The case of fintech development in China"	Chen (2016)	"China Economic Journal"	2016	36
"The fintech phenomenon: antecedents of financial innovation perceived by the popular press"	Zavolokina et al. (2016)	"Financial Innovation"	2016	31
"Entry of fintech firms and competition in the retail payments market"	Jun and Yeo (2016)	"Asia-Pacific Journal of Financial Studies"	2016	19
"The digital revolution in financial inclusion: International development in the fintech era"	Gabor and Brooks (2017)	"New Political Economy"	2017	126
"Fintech, regtech, and the reconceptualization of financial regulation"	Arner et al. (2017)	"Northwestern Journal of International Law & Business"	2017	81
"Nurturing a fintech ecosystem: The case of a youth microloan startup in China"	Leong et al. (2017)	"International Journal of Information Management"	2017	67
"Definition of fintech and description of the fintech industry"	Dorfleitner et al. (2017)	"Business & Information Systems Engineering"	2017	63
"Economic and business dimensions fintech platforms and strategy"	Dhar and Stein (2017)	"Communications of the ACM"	2017	23
"The fintech revolution and financial regulation: The case of online supply-chain financing"	Tsai and Peng (2017)	"Asian Journal of Law and Society"	2017	23
"FinTech banking industry: A systemic approach"	Wonglimpiyarat (2017)	"Foresight"	2017	19
"Fintech sandboxes: Achieving a balance between regulation and innovation"	Bromberg et al. (2017)	"Journal of Banking and Finance Law and Practice"	2017	18
"On the fintech revolution: Interpreting the forces of innovation, disruption, and transformation in financial services"	Gomber et al. (2018)	"Journal of Management Information Systems"	2018	154
"Fintech: Ecosystem, business models, investment decisions, and challenges"	Lee and Shin (2018)	"Business Horizons"	2018	137
"Fintech, regulatory arbitrage, and the rise of shadow banks"	Buchak et al. (2018)	"Journal of Financial Economics"	2018	95
"A survey on fintech"	Gai et al. (2018)	"Journal of Network and Computer Applications"	2018	90
"Disruption of financial intermediation by fintech: A review on crowdfunding and blockchain"	Cai (2018)	"Accounting and Finance"	2018	49
"Understanding fintech start-ups — A taxonomy of consumer-oriented service offerings"	Gimpel et al. (2018)	"Electronic Markets"	2018	48
"Fintech and regtech: Impact on regulators and banks"	Anagnostopoulos (2018)	"Journal of Economics and Business	2018	47
"Fintech and the transformation of the financial industry"	Alt et al. (2018)	"Electronic Markets"	2018	42
"The innovation mechanisms of fintech start-ups: Insights from SWIFT's innotribe competition"	Gozman et al. (2018)	"Journal Of Management Information Systems"	2018	41
"What makes users willing or hesitant to use fintech? The moderating effect of user type"	Ryu (2018)	"Industrial Management & Data Systems"	2018	40
"New methods of entrepreneurial firm financing: Fintech, crowdfunding and corporate governance implications"	Ahlstrom et al. (2018)	"Corporate Governance"	2018	39
"Do fintech lenders penetrate areas that are underserved by traditional banks?"	Jagtiani and Lemieux (2018)	"Journal of Economics and Business"	2018	38
"Making innovation more competitive: The case of fintech"	Van Loo (2018)	"Ucla Law Review"	2018	38
"Is mobile payment still relevant in the fintech era?"	Iman (2018)	"Electronic Commerce Research and Applications"	2018	36
"Regulating fintech"	Magnuson and Magnuson (2018)	"Vanderbilt Law Review"	2018	34
"Fintech evolution: Strategic value management issues in a fast-changing industry"	Ashta and Biot-Paquerot (2018)	Strategic Change"	2018	25
"Fintech venture capital"	Ahlstrom et al. (2018)	"Corporate Governance"	2018	23
"Mobile payment in fintech environment: Trends, security challenges, and services"	Kang (2018)	"Human-Centric Computing and Information Sciences"	2018	21
"Data security and consumer trust in fintech innovation in Germany"	Stewart and Jürjens (2018)	"Information and Computer Security"	2018	20

Table A.1. Previous studies published in Web of Science (WOS) database (Part 2)

Title	*Author/s/year*	*Source title*	*Publication year*	*Total citations*
"The emergence of the global fintech market: Economic and technological determinants"	Haddad and Hornuf (2019)	"Small Business Economics"	2019	80
"How valuable is fintech innovation?"	Chen et al. (2019)	"Review of Financial Studies"	2019	59
"Artificial intelligence in fintech: Understanding robo-advisors adoption among customers"	Belanche et al. (2019)	"Industrial Management & Data Systems"	2019	56
"To fintech and beyond"	Goldstein et al. (2019)	"Review of Financial Studies"	2019	49
"Affordances, experimentation and actualization of fintech: A blockchain implementation study"	Du et al. (2019)	"Journal of Strategic Information Systems"	2019	46
"Adoption intention of fintech services for bank users: An empirical examination with an extended technology acceptance model"	Hu et al. (2019)	"Symmetry-Basel"	2019	36
"Fintech and the innovation trilemma"	Brummer and Yadav (2019)	"Georgetown Law and Economics Research Paper No. 11–23"	2019	35
"An empirical study of the impacts of perceived security and knowledge on continuous intention to use mobile fintech payment services"	Lim et al. (2019)	"International Journal of Human-Computer Interaction"	2019	32
"Relationship banking and information technology: the role of artificial intelligence and fintech"	Jakšič and Marinč (2019)	"Risk Management"	2019	28
"Improving financial service innovation strategies for enhancing China's banking industry competitive advantage during the fintech revolution: A hybrid MCDM model"	Zhao et al. (2019)	"Sustainability"	2019	24
"The poverty of fintech? Psychometrics, credit infrastructures, and the limits of financialization"	Bernards (2019)	"Review of International Political Economy"	2019	22
"A machine learning-based fintech cyber threat attribution framework using high-level indicators of compromise"	Noor et al. (2019)	"Future Generation Computer Systems"	2019	21
"Digital marketplace and fintech to support agriculture sustainability"	Anshari et al. (2019)	"Energy Procedia"	2019	19
"Fintech and banking: What do we know?"	Thakor (2020)	"Journal of Financial Intermediation"	2020	55
"Bitcoin, blockchain and fintech: A systematic review and case studies in the supply chain"	Fosso Wamba et al. (2020)	"Production Planning & Control"	2020	50
"Understanding fintech continuance: Perspectives from self-efficacy and ECT-IS theories"	Shiau et al. (2020)	"Industrial Management & Data Systems"	2020	35
"Sustainability, fintech and financial inclusion"	Arner et al. (2020)	"European Business Organization Law Review"	2020	21
"Unearthing antecedents to financial inclusion through FinTech innovations"	Senyo and Osabutey (2020)	"Technovation"	2020	18
"What have we learnt from 10 years of fintech research? A scient metric analysis"	Liu et al. (2020)	"Technological Forecasting and Social Change"	2020	17
				2285

Table A.2. Previous studies published in Scopus database (Part 1)

Title	*Author/s/Year*	*Source title*	*Publication year*	*Cited by*
"Riding the fintech innovation wave: Fintech, patents and bank performance"	Zhao et al. (2022)	"Journal of International Money and Finance"	2022	0
"Fintech platforms: Lax or careful borrowers' screening?"	Gallo (2021)	"Financial Innovation"	2021	1
"Fintech investments in European banks: A hybrid IT2 fuzzy multidimensional decision-making approach"	Kou et al. (2021)	"Financial Innovation"	2021	14
"Fintech in Latvia: Status quo, current developments, and challenges ahead"	Rupeika-Apoga and Wendt (2021)	"Risks"	2021	0
"Mitigating psychic distance and enhancing internationalization of fintech SMEs from emerging markets: The role of board of directors"	Puthusserry et al. (2021)	"British Journal of Management"	2021	2
"The effect of the implementation of interim measures for the management of micro finance to solicit public opinions on the stock performance of fintech's"	Wu (2021)	"Conference Proceedings of the 9th International Symposium on Project Management"	2021	0
"Understanding fintech platform adoption: Impacts of perceived value and perceived risk"	Xie et al. (2021)	"Journal of Theoretical and Applied Electronic Commerce Research"	2021	1
"How does the fintech services delivery affect customer satisfaction: A scenario of Jordanian banking sector"	Alkhazaleh and Haddad (2021)	"Strategic Change"	2021	0
"Using machine learning to evaluate the influence of fintech patents: The case of Taiwan's financial industry"	Chen and Chang (2021)	"Journal of Computational and Applied Mathematics"	2021	1
"Fintech developmental trends: The role and influence of sustainable digital logistics"	Svirina et al. (2021)	"E3S Web of Conferences"	2021	0
"Fintech and commercial banks' performance in China: A leap forward or survival of the fittest?"	Chen et al. (2021)	"Technological Forecasting and Social Change"	2021	6
"Industry 4.0 and intellectual capital in the age of fintech"	Wang et al. (2021)	"Technological Forecasting and Social Change"	2021	4
"The relationship between corporate social responsibility and financial performance: A moderate role of fintech technology"	Liu et al. (2021)	"Environmental Science and Pollution Research"	2021	11
"Fintech in the small food business and its relation with open innovation"	Najib et al. (2021)	"Journal of Open Innovation: Technology, Market, and Complexity"	2021	2
"Follow the trail: Machine learning for fraud detection in fintech applications"	Stojanović et al. (2021)	"Sensors"	2021	0
"Fintech predictive modeling and performance of investment firms in Kenya"	Gitonga et al. (2021)	"Webology"	2021	0
"Artificial intelligence assisted Internet of things based financial crisis prediction in fintech environment"	Pustokhina et al. (2021)	"Annals of Operations Research"	2021	0
"Factors influencing the adoption intention of using mobile financial service during the COVID-19 pandemic: the role of FinTech"	Yan et al. (2021)	"Environmental Science and Pollution Research"	2021	0
"Fintech credit, bank regulations and bank performance: A cross-country analysis"	Nguyen et al. (2022)	"Asia-Pacific Journal of Business Administration"	2022	0
"More than words: How press releases predict the performance of start-ups: Evidence from the fintech sector"	Stuckenborg et al. (2021)	"International Journal of Entrepreneurial Venturing"	2021	0
"A review of literature directions regarding the impact of fintech firms on the banking industry"	Elsaid (2021)	"Qualitative Research in Financial Markets"	2021	0
"How financial technology (fintech) can improve the business performance of securities firms by using the dynamic data envelopment analysis modified model"	Lin et al. (2021)	"Managerial and Decision Economics"	2021	0
"Fintech, credit market competition, and bank asset quality"	Tseng and Guo (2021)	"Journal of Financial Services Research"	2021	1
"4.0 digital transition and human capital: Evidence from the Italian Fintech market"	Izzo et al. (2021)	"International Journal of Manpower"	2021	0
"Adversarial learning networks for fintech applications using heterogeneous data sources"	Khuwaja et al. (2021)	"IEEE Internet of Things Journal"	2021	0
"Performance of fintechs: Are founder characteristics important?*"	Koroleva et al. (2021)	"Journal of East European Management Studies"	2021	0
"Technology as a resource for fintech"	Reyes-Mercado (2021)	"Palgrave Studies in Democracy, Innovation and Entrepreneurship for Growth"	2021	0

Table A.2. Previous studies published in Scopus database (Part 2)

Title	*Author/s/Year*	*Source title*	*Publication year*	*Cited by*
"Boosting sustainability in healthcare sector through fintech: Analyzing the moderating role of financial and ICT development"	Meiling et al. (2021)	"Inquiry (United States)"	2021	0
"Entrepreneurship and fintech development: Comparing reward and equity crowdfunding"	Troise et al. (2022)	"Measuring Business Excellence"	2022	0
"E-integrated corporate governance model at the peer to peer lending fintech corporation for sustainability performance"	Mutamimah and Robiyanto (2021)	"Kasetsart Journal of Social Sciences"	2021	0
"Intelligent fintech data mining by advanced deep learning approaches"	Huang et al. (2022)	"Computational Economics"	2022	2
"The effect of fintech on banks' performance: Jordan case"	Bashayreh and Wadi (2021)	"Lecture Notes in Networks and Systems"	2021	0
"Fraudulent transaction detection in fintech using machine learning algorithms"	Abdulsattar and Hammad (2020)	"Proceedings of the 2020 International Conference on Innovation and Intelligence for Informatics, Computing and Technologies"	2020	1
"Unearthing antecedents to financial inclusion through fintech innovations"	Senyo and Osabutey (2020)	"Technovation"	2020	26
"Determinants of fintech performance: Case of Russia"	Sukhinina and Koroleva (2020)	"PervasiveHealth: Pervasive Computing Technologies for Healthcare"	2020	0
"Multicriteria group decision making approach for evaluating the performance of fintech projects"	Wibowo et al. 2020)	"Proceedings of the 15th IEEE Conference on Industrial Electronics and Applications"	2020	0
"How does Islamic fintech promote the SDGs? Qualitative evidence from Indonesia	Hudaefi (2020)	Qualitative Research in Financial Markets"	2020	9
"Building a fintech ecosystem: Design and development of a fintech API gateway"	Ünsal et al. (2020)	"Proceedings of the International Symposium on Networks, Computers and Communications"	2020	0
"Conventional banks and fintechs: How digitization has transformed both models"	Paulet and Mavoori, (2020)	"Journal of Business Strategy"	2020	1
"Fintech platforms and competitiveness: Exploring role of mot as a differentiator for firms of indian origin (fios)"	Momaya et al. (2020)	"Proceedings of the 29th International Conference on Management of Technology"	2020	0
"Bank financial capability on MSME lending amid economic change and the growth of Fintech companies in Indonesia"	Wibowo and Aumeboonsuke (2020)	"Thailand and the World Economy"	2020	0
"Migrating from monolithic to serverless: A fintech case study"	Goli et al. (2020)	"Proceedings of the Companion of the ACM/SPEC International Conference on Performance Engineering"	2020	4
"Monitoring high-frequency data streams in fintech: FADO versus K-Means"	Pelckmans (2020)	"IEEE Intelligent Systems"	2020	1
"Economic ripple effect analysis of new converging industry: Focusing on inter-industrial analysis of fintech industry in South Korea, China and the United States"	Sawng et al. (2020)	"Journal of Scientific and Industrial Research"	2020	2
"Financial inclusion and fintech: A comparative study of countries following Islamic finance and conventional finance"	Baber (2020)	"Qualitative Research in Financial Markets"	2020	3
"The effect of marketing knowledge management on bank performance through fintech innovations: A survey study of jordanian commercial banks"	Al-Dmour et al. (2020)	"Interdisciplinary Journal of Information, Knowledge, and Management"	2020	1
"A machine learning approach to predict the success of crowdfunding fintech project"	Yeh and Chen (2020)	"Journal of Enterprise Information Management"	2020	14
"Banking and regulatory responses to fintech revisited: Building the sustainable financial service 'ecosystems' of tomorrow"	Fenwick and Vermeulen (2020)	"Lex Research Topics in Corporate Law & Economics Working Paper No. 2019-4"	2020	1
"Enhancing the security of FinTech applications with map-based graphical password authentication"	Meng et al. (2019)	"Future Generation Computer Systems"	2019	10

Table A.2. Previous studies published in Scopus database (Part 3)

Title	*Author/s/Year*	*Source title*	*Publication year*	*Cited by*
"Stock market sentiment classification from fintech news"	Sangsavate et al. (2019)	"International Conference on ICT and Knowledge Engineering"	2019	1
"Feasibility of the fintech industry as an innovation platform for sustainable economic growth in Korea"	Shin and Choi (2019)	"Sustainability (Switzerland)"	2019	12
"The impact of fintech on economic performance and financial stability in mena zone"	Kammoun et al. (2019)	"Impact of Financial Technology (FinTech) on Islamic Finance and Financial Stability"	2019	3
"Omni-script: Device independent user interface development for omni-channel fintech applications"	Ulusoy et al. (2019)	"Computer Standards and Interfaces"	2019	2
"The impact of fintech M&A on stock returns"	Dranev et al. (2019)	"Research in International Business and Finance"	2019	12
"Improving financial service innovation strategies for enhancing China's banking industry competitive advantage during the fintech revolution: A hybrid MCDM model"	Zhao et al. (2019)	"Sustainability"	2019	33
"The emerging fintech and financial slack on corporate financial performance"	Putri et al. (2019)	"Investment Management and Financial Innovations"	2019	1
"Fintech platforms in SME's financing: EU experience and ways of their application in Ukraine"	Sybirianska et al. (2018)	"Investment Management and Financial Innovations"	2018	7
"Data security and consumer trust in fintech innovation in Germany"	Stewart and Jürjens (2018)	"Information and Computer Security"	2018	28
"Emergence of Fintech and cybersecurity in a global financial centre: Strategic approach by a regulator"	Ng and Kwok (2017)	"Journal of Financial Regulation and Compliance"	2017	24
				241

Table A.3. Summary of publication in WOS database

Source	*Year*	*No. of publication*	*Per cent of publication*	*Total citations*
WOS	2016	4	6%	112
	2017	8	13%	420
	2018	19	31%	1017
	2019	13	21%	507
	2020	6	10%	196
	2021	4	6%	215
	2022/5	8	13%	235
	Total	**62**	**100**	**2702**

Figure A.1. Summary of publication in WOS source

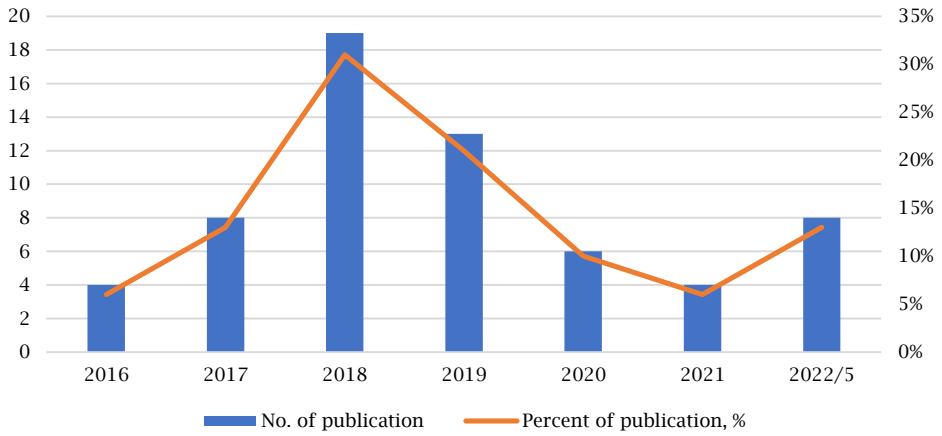

Table A.4. Summary of publication in Scopus source

Source	*Year*	*No. of publication*	*Per cent of publication*	*Total citations*
Scopus	2016	0	0%	0
	2017	1	1%	27
	2018	2	3%	35
	2019	8	11%	74
	2020	18	25%	68
	2021	32	44%	45
	2022/5	12	16%	35
	Total	**73**	**100**	**284**

Figure A.2. Summary of publication in Scopus source