Tomas Bata University in Zlín
Faculty of Management and Economics

Doctoral Thesis

Effect of The Fintech Industry on Bank Performance: A Case Study from Vietnam

Vliv Fintech průmyslu a výkonnosti bank: Případová studie z Vietnamu

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ABSTRACT

Fintech is an emerging technology that fundamentally changes the ways of finance. Based on that, a new industry was born: the fintech industry. Fintech companies, commercial banks, and other financial institutions using emerging technologies are the leading entities in the fintech industry. The link between fintech and banks has attracted many scholars. However, the effect of the fintech industry on bank performance has not yet been clarified by the existing publication; thus, I raise the concern "Whether the fintech industry affects bank performance."

Based on many reports, I explore that the Vietnamese fintech industry is an interesting case study for the reasons: (1) Vietnam is a developing country, where fintech plays a critical role in economic growth rather than others; (2) the growth rate of fintech in a number of companies, users, transactions, and infrastructure, and the rate of bank investing in technology innovation in Vietnam are higher than others, especially compared to other countries in Southeast Asia; (3) Vietnamese government has paid more attention and facilitated for the fintech industry development to toward the digital economy.

Through literature review, **three research objectives** are designed to clarify the research concern: *(1) to evaluate the effect of fintech company growth on four perspectives of bank performance by the Balanced Scorecard; (2) to estimate the effect of fintech popularity by Google search on bank stock return; and (3) to estimate the effect of bank investment in technology innovation on bank efficiency by Data Envelopment Analysis*.

The findings show that the fintech company growth is a pressure, which negatively links to bank financial indicators and bank customer loyalty. Bank investment in technology innovation enhances and upgrades the bank technology system seems to be ineffective, which is harmful to bank efficiency. However, fintech company growth promotes bank performance by enhancing bank internal processes and improving bank employees' knowledge and skills. Fintech popularity is a positive factor in bank stock return, and fintech company growth is positive with overall bank performance.

The thesis contributes (1) positive effect of fintech company growth on bank performance; (2) positive effect of fintech popularity on bank stock return; (3) negative effect of bank investment in technology on bank efficiency; and (4) meaningful for stakeholders in the finance and fintech industry.

Further research might extend the scope (e.g., Southeast Asia) and apply new methods (e.g., text mining approach) to measure the fintech variables and evaluate their effect on bank performance.

ABSTRAKT

Fintech je nově vznikající technologie, která zásadně mění způsoby financování. Na základě toho se zrodilo nové odvětví: fintech průmysl. Hlavními subjekty fintech průmyslu jsou fintech společnosti, komerční banky a další finanční instituce využívající nové technologie. Spojení mezi fintech a bankami přitahuje pozornost mnoha vědců. Vliv fintech odvětví na výkonnost bank však dosud nebyl v dosavadních publikacích objasněn; proto vznáším otázku "Zda fintech odvětví ovlivňuje výkonnost bank".

Na základě mnoha zpráv zkoumám, že vietnamský fintech průmysl je zajímavou případovou studií z těchto důvodů: (1) Vietnam je rozvojovou zemí, kde fintech hraje rozhodující roli v ekonomickém růstu spíše než v jiných zemích; (2) míra růstu fintech v počtu společností, uživatelů, transakcí a infrastruktury a míra investic bank do technologických inovací ve Vietnamu jsou vyšší než v jiných zemích, zejména ve srovnání s jinými zeměmi v jihovýchodní Asii; (3) vietnamská vláda věnovala větší pozornost a usnadnila rozvoj fintech průmyslu směrem k digitální ekonomice.

Prostřednictvím přehledu literatury jsou navrženy tři výzkumné cíle k objasnění výzkumného problému: (1) vyhodnotit vliv růstu fintech společností na čtyři perspektivy výkonnosti bank pomocí Balanced Scorecard; (2) odhadnout vliv popularity fintech společností pomocí vyhledávače Google na výnosnost akcií bank; a (3) odhadnout vliv investic bank do technologických inovací na efektivnost bank pomocí Data Envelopment Analysis.

Zjištění ukazují, že růst fintech společností je tlakem, který negativně souvisí s finančními ukazateli banky a loajalitou bankovních klientů. Investice bank do technologických inovací posiluje a modernizuje technologický systém banky se jeví jako neefektivní, což poškozuje efektivnost banky. Růst fintech společností však podporuje výkonnost banky tím, že zlepšuje interní procesy banky a zlepšuje znalosti a dovednosti zaměstnanců banky. Obliba fintech technologií je pozitivním faktorem návratnosti bankovních akcií, zatímco růst fintech společností pozitivně ovlivňuje celkovou výkonnost banky.

Práce přispívá k (1) pozitivnímu vlivu růstu fintech společností na výkonnost bank; (2) pozitivnímu vlivu popularity fintech na výnosnost akcií bank; (3) negativnímu vlivu investic bank do technologií na efektivitu bank; a (4) významu pro zainteresované strany ve finančním a fintech odvětví.

Další výzkum by mohl rozšířit rozsah (např. jihovýchodní Asie) a použít nové metody (např. přístup založený na vytěžování textů) k měření fintech proměnných a vyhodnocení jejich vlivu na výkonnost bank.

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LIST OF SYMBOLS, ACRONYMS, AND ABBREVIATIONS USED

AGSVI	:	Average Google Search Volume Index
AHP	:	Analytic Hierarchy Process
AIC	:	Akaike's information criterion
ASEAN	:	Association of Southeast Asian Nations
ATM	:	Automatic teller machine
BITI	:	Bank investment in technology innovation
BSC	:	Balanced Scorecard
DEA	:	Data Envelopment Analysis
DMU	:	decision-making unit
EBT	:	Earning before taxation
EFA	:	Exploratory factor analysis
FE	:	Fixed effect
FPE	:	Prediction error
GFC	:	Global financial crisis
GLS	:	Generalized Least Squares
GSVI	:	Google Search Volume Index
HQ	:	Hannan and Quinn information criterion
IT	:	Information technology
K-plot	:	Kendall-plot
M&A	:	Mergers and acquisitions
NFC	:	Near-field communication
OLS	:	Ordinary least squares
P2P	:	Peer-to-peer
QQ-plot	:	QQ-plot
QR	:	Quick Response
RE	:	Random effect
RFS	:	Review of Financial Studies
SC	:	Schwarz's Bayesian information criterion
SFA	:	Stochastic frontier analysis
SMEs	:	Small and Medium-sized Enterprises
SWIFT	:	Society of Worldwide Interbank Financial Telecommunications
VAR-Granger	:	Vector Autoregressive and Granger causality
VECM	:	Vector error-correction model
VIF	:	Variance inflation factor

1 INTRODUCTION

1.1 Motivation for the study

Since the global financial crisis (GFC) of 2008-2009, the concept of "fintech" has been attended by both scholars and practitioners. In recent years, the fintech research field has attracted many academics with huge articles (Goldstein et al., 2019; Liu et al., 2020; Milian et al., 2019). Fintech substantially impacts society and how to save, take loans, make payments, and send remittances (Milian et al., 2019). Daud et al. (2022) found that the term artificial intelligence, clouding, and data technologies regarding fintech promotes the financial stability of 63 nations from 2006 to 2017. Through the channel of information and resource allocation effect, fintech development promotes enterprise transformation in China from 2012 to 2018 (Luo et al., 2022).

On the one hand, fintech helps efficiency-enhancing in the finance sector, changes the traditional business model, and brings customers the best experience in banking transactions (Vives, 2017, 2019). In China, from 2003 to 2017, Lee et al. (2021) found a positive effect of fintech on bank performance, namely, fintech impros the cost efficiency and technology banks use. In Jordan, Alkhazaleh and Haddad (2021) showed a positive relationship between banks' customer satisfaction and fintech products. The customers highly appreciated the ease of use and performance, security, transaction cost, availability, and accessibility of fintech products. Wang et al. (2021b) found evidence of the positive effect of fintech on bank performance. In detail, fintech improves competitiveness, service efficiency, and risk capability and reduces operating costs.

On the other hand, Navaretti et al. (2018) and Vives (2019) showed that fintech is a new player in the banking sector; it is not an intermediate financial institution but a competitor of the commercial bank. The fintech company utilizes technology development (e.g., blockchain, robot advisor, clouding, etc.) to provide banking products that are more advanced than commercial banks (Milian et al., 2019). In Indonesia, from 1998 to 2017, Phan et al. (2020) found that the increase in fintech companies reduces bank performance. In China, from 2014 to 2019, Wu and Yuan (2021) found a negative impact of fintech on bank profitability.

Besides, the rise of fintech has created high pressure for the incumbents and challenges for regulators to remain stable in society and the finance industry (Philippon, 2016). Navaretti et al. (2018) gave that fintech could disrupt the existing structure of the banking industry by creating a new gateway for customers, which requires the bank to react and adopt a new strategy to survive. Elsaid (2021) indicated that fintech would get some market share from incumbents, playing the role of a substitute in the finance industry. However, the

fintech growth creates new opportunities for banks to digitalization transformation, which aims to enhance their performance. Besides, through a systematic review of fintech and its relation to banking, Thakor (2020) stated that the shape and form of the relationship between fintech and banks are unclear and need further research to clarify.

Based on that, it can be seen that there is an inconsistency among scholars about the effect of fintech on banks. Therefore, I argue that it is a contemporary debate in academia and needs more evidence to validate the relationship between fintech and banks in the digital era.

1.2 Fintech and research concern

The term "fintech" is a "buzzword" that is established by the fusion of "financial" and "technology." Fintech is commonly understood as technological innovation enabled by information technology in the finance industry. Fintech often indicates startup companies that provide alternative financial products and innovative financial solutions, although it also includes traditional financial institutions like banks (Puschmann, 2017). Vives (2017) defined "*Fintech may be understood as the use of innovative information and automation technology in financial services.*" New digital technologies will level up the latest financial products and cost-effective products. Dhar and Stein (2017) defined fintech as "*Financial sector innovations involving technology-enabled business models that can facilitate disintermediation; revolutionize how existing firms create and deliver products and services; address privacy, regulatory and law-enforcement challenges; provide new gateways for entrepreneurship; seed opportunities for inclusive growth,*" which is used for indicating the technologies applicable for delivering financial products. Fintech often means utilizing technologies outside the finance industry's traditional business models (Milian et al., 2019). Schindler (2017) provided that fintech is a technical innovation that significantly affects business models, applications, and products in the finance industry. Paulet and Mavoori (2019) stated that fintech is the digital revolution that changes the business environment in the financial service landscape. Fintech is a new sector born through the combination of information technologies and financial services (Almulla & Aljughaiman, 2021). Daud et al. (2022) stated that fintech is an advanced technology that fulfills the gaps among financial services, financial systems, and financial capability in the finance industry.

The Oxford Dictionary states, "*Fintech is a computer program or other technology used to provide banking and financial service.*" Investopedia says, "*Fintech is used to describe new tech that seeks to improve and automate the delivery and use of financial services.*" The Financial Stability Board defines "*FinTech as technologically enabled innovation in financial services 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." Forbes provides that fintech is a catch-all for technology used to augment, streamline, digitize, and disrupt conventional financial services.

Following these fintech definitions above, I propose that *fintech is an emerging technology that fundamentally changes the finance industry*. Gomber et al. (2017) provided that emerging technologies regarding fintech consist of blockchain, social networks, near-field communication (NFC), peer-to-peer (P2P) technology, and big data. Cheng and Qu (2020) gave that artificial intelligence (AI), blockchain, cloud computing, and big data are critical technologies disrupting the banking industry. Wang et al. (2021) revealed that emerging technologies encompass big data, data mining, cloud platform, blockchain, biometrics, face/voice recognition, and quick payment. Alt et al. (2018), Arner et al. (2015), Lee and Shin (2018), and Thakor (2020) agreed that the global financial crisis (GFC) of 2008-2009 is a milestone, which remarks the fintech development with the emerging technology adoption in the banking industry.

In the finance industry, the providers consist of commercial banks, brokerage companies, and other businesses (e.g., lending institutions, insurance companies, etc.) that offer a variety of financial products (e.g., payment, saving, investing, lending, etc.). While commercial banks are the primary providers, fintech startup companies are the new entrants, significantly impacting incumbents (Philippon, 2016). Lee and Shin (2018) provided that fintech company uses disruptive technologies to provide unique and niche financial products. A fintech company is a new kind of enterprise in the finance industry, which creates more challenges for regulators and governments (Arner et al., 2017; Van Loo, 2018). It requires that the regulators catch up with the development of the fintech companies and the adoption of emerging technologies of other providers in the finance industry.

Table 1.1 Two meanings of fintech

Emerging technology	+	Commercial banks	=	Bank fintech
	+	Fintech company Others (e.g., brokerage, insurance, etc.)	=	Fintech-outside

Source: The author

Based on the emerging technologies and providers in the finance industry, as mentioned above, I propose two meanings of the fintech definition, illustrated in **Table 1.1**. *First*, the latest emerging technologies utilized by commercial banks are called bank fintech, which mainly indicates bank technology innovation. *Second*, other financial institutions (e.g., a fintech company, brokerage, insurance, etc.) dominated by fintech companies used emerging technologies to provide financial products or services, called the fintech-outside. These are the essential factors of the fintech industry, an emerging digital industry that plays a critical role in the economy.

Following Arner et al. (2015), Frame et al. (2018), Lee and Shin (2018), and Puschman (2017), the providers utilize emerging technologies to provide advanced financial products to customers, which formulate the new industry, a fintech industry in the digital era. The bank fintech adoption regarding the bank investment in technology innovation and the fintech company growth are two critical factors of the fintech industry. Besides that, the customer directly experiencing the advanced-financial products plays an essential role in the fintech industry development.

The rise of the fintech industry has led to much research about the role of fintech in the relationship with commercial banks. Many studies indicate the relationship between fintech and commercial banks in the mobile payment market (Agarwal et al., 2020; Elsaid, 2020; Yudaruddin, 2022), in the retail credit market (de Roure et al., 2016; Jagtiani & Lemieux, 2017; Wan et al., 2016); and bank and fintech company cooperation (Hornuf et al., 2020; Navaretti et al., 2018; Thakor, 2020). Besides, Cheng and Qu (2020) found that new technologies application decreases credit risks; Chen et al. (2021b) explored the positive effect of fintech products on bank customer satisfaction; Wu and Yuan (2021) revealed technology innovation is a negative factor in state-owned banks' profitability. In the USA, Li et al. (2017) found a positive impact of fintech funding and deals on bank stock return. Buchak et al. (2018) stated that fintech lenders fill the gaps in capital requirements and mortgage mortgage-related regulations of traditional banks, and Tang (2019) indicated that fintech lending is a substitute for banks in terms of serving customers, and a complement in terms of small loans. In Europe, Haddad and Hornuf (2019) found that reinventing fintech promotes the finance market. Hornuf et al. (2020) provided that traditional banks ally with fintech firms improve bank performance. These studies provide the various dimensions of the effect of fintech on bank performance, but they have not yet indicated "*How is the effect of the fintech industry on commercial banks?*" especially regarding bank performance, which leads to raising a concern "*Whether the fintech industry affects bank performance?*".

1.3 Vietnamese fintech industry context

1.3.1 Fintech company growth

Vietnam is an emerging fintech market with an increasingly connected population, a critical factor in the fintech industry development. In detail, the number of internet users and smartphones in Vietnam is higher than in other countries in the Association of Southeast Asian Nations (ASEAN), and it is predicted to increase significantly in the next few years (Statista, 2021b). Vietnam has attracted many investors from both domestic and foreign to invest in the fintech industry; thus, a growing number of fintech companies have been established. Statista (2021a) states that operating fintech companies have doubled

from 2016 to 2020. In detail, in 2016, there were 78 operating firms; by 2020, the number was 141 firms.

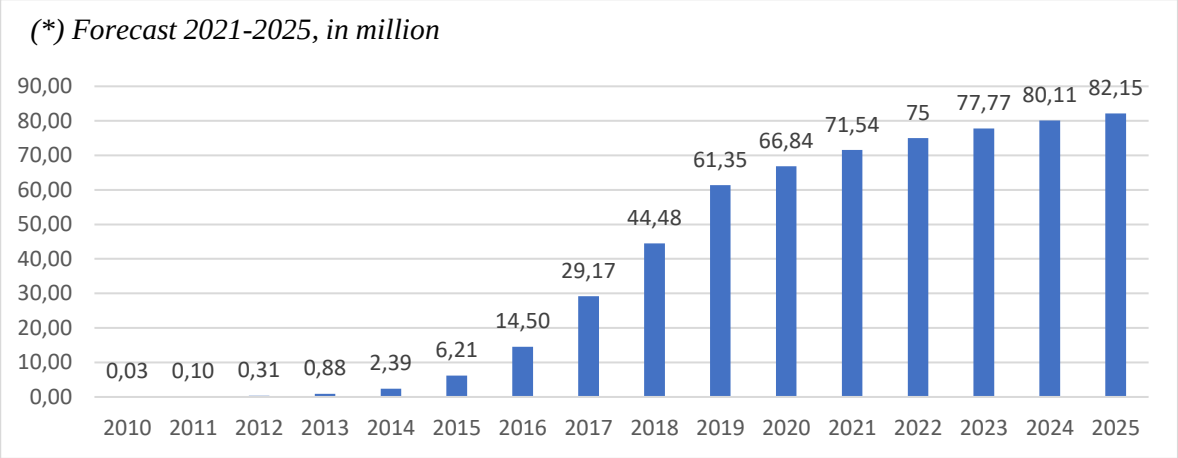


Figure 1.1 Number of mobile internet users in Vietnam

Source: Statista

Most fintech companies in Vietnam are startups, and payment is the biggest sector of the Vietnamese fintech industry (Le & Le, 2018; Lien et al., 2020; MBBank, 2021; Mittal, 2019; Solidiance, 2018). **Figure 1.3** shows the logo of the leading fintech startup companies in Vietnam. These companies and their products have become popular in Vietnamese life. Mobile payment attracts many fintech companies with big brand names, such as Momo, VnPay, Zalo Pay, and VinID, while Tima, DoctorDong, Vtien, etc., are famous brand names in the P2P lending segment.

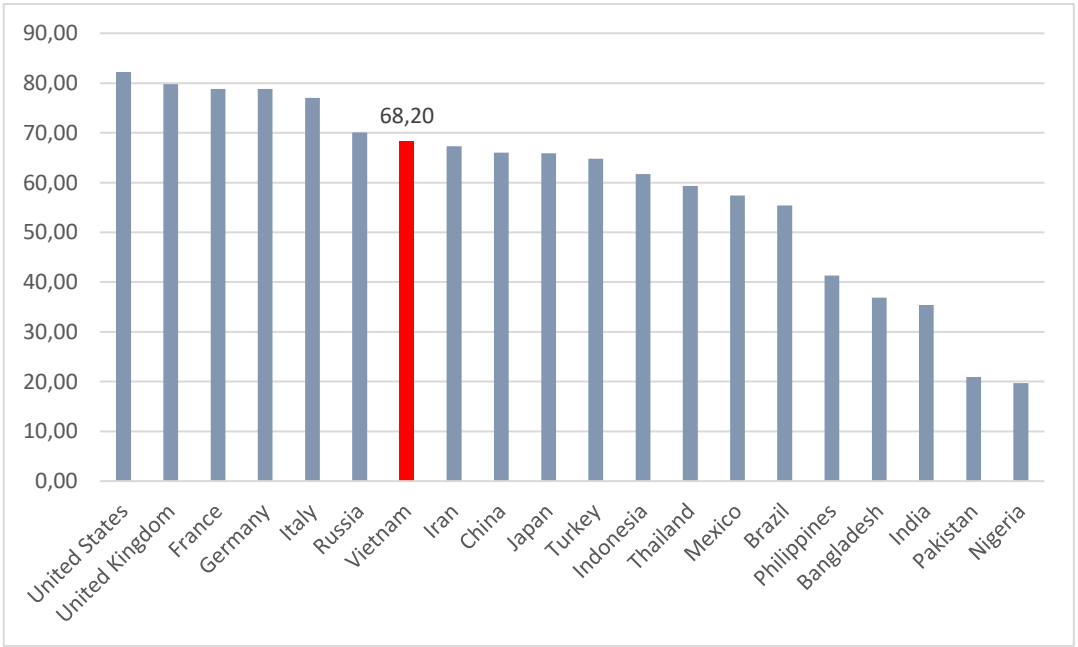


Figure 1.2 Penetration rate of smartphones in 2021 (% population)

Source: Statista

The rapid development of the Vietnamese fintech industry has attracted many investors, mainly investing in digital payment. According to (Statista, 2021a), in 2020, the transaction value of digital payments was 8.60 billion dollars, and the average share of internet users using mobile payments monthly was 26.2%. Besides, in 2019, the total funding value of deals for the digital payment category reaches 403 million dollars, while in 2016, it is just 28.8 million dollars. Momo is a successful case with the cumulation of funding raised from 2013 to 2021; it reached 433.8 million dollars.

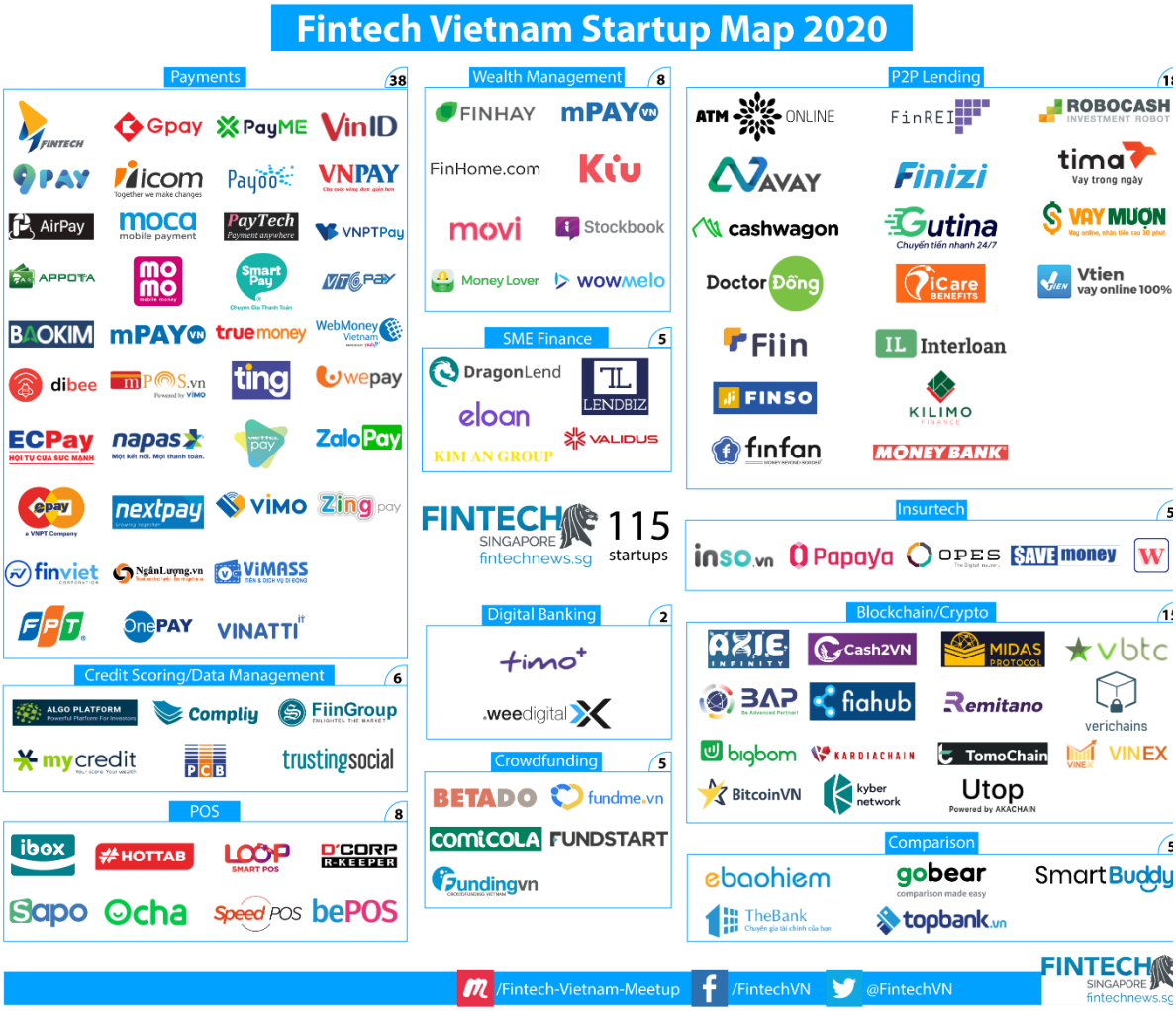


Figure 1.3 Leading Fintech startup companies in Vietnam

Source: Fintech Singapore

Along with the development of e-commerce, the Vietnamese fintech industry is assessed to have a bright prospect in the future (Ngo & Gim, 2014; Nguyen et al., 2015). Besides, according to Deloitte[1], Covid-19 is the chance for fintech companies. In the case of Vietnam, it might be explained by two reasons. First,

[1] *Accessed 2022 Apr 19: https://www2.deloitte.com/si/en/pages/financial-services/articles/gx-beyond-covid-19-new-opportunities-for-fintech-companies.html*

during the first and second waves of the Covid-19 pandemic in Vietnam, social distance and isolation were the main tactics of the "Zero-Covid" strategy. The citizens must stay in their houses; they are not allowed to free-move as before. At this time, the need for digital payment involving e-commerce had risen. Second, the income of firms and households is strongly negatively affected by social distance; thus, the demand for financial solutions has also increased. Therefore, I agree that Covid-19 might be a positive factor in the fintech industry growth.

Currently, the fintech industry gets attention from the State bank of Vietnam (SBV), but there are still some barriers to development, such as customers' financial literacy and legal framework governing. The government has issued a few official regulations for fintech development. In detail, Decree No. 87/2019/ND-CP amends and supplement several fintech products; Decree 116/2013/ND-CP guides the Law on money-laundering prevention and control; and circular No. 16/2020/TT-NHNN on providing guidelines for the opening and use of checking accounts at payment service providers. However, it seems insufficient; the community of fintech companies expects more space to develop fintech, such as cryptocurrencies, non-fungible tokens, etc. Furthermore, due to the rapid development of the fintech industry, the regulation of the fintech sandbox is also necessary to create an advanced environment for the fintech company development.

Table 1.2 Fintech companies in ASEAN-6

Country	2017		2018		2019		2020		2021	
	New	Tot. Oper.	New	Tot. Oper.	New	Tot. Oper.	New	Tot. Oper.	New	Tot. Oper.
Indonesia	100	440.00	142	583	108	691	67	758	27	785
Malaysia	68	346.00	72	418	57	475	48	523	26	549
Philippines	34	177.00	31	208	35	243	18	261	7	268
Singapore	208	770.00	266	1036	159	1195	120	1315	35	1350
Thailand	39	181.00	42	223	27	250	13	263	5	268
Vietnam	20	112.00	32	144	25	169	12	181	7	188

Source: https://www.uobgroup.com/techecosystem/news-insights-fintech-in-asean-2021.html

The UOB Group provides that data regarding fintech companies in six countries of ASEAN, which is illustrated in **Table 1.2**. The data show that Vietnam, a developing country is an interesting case of fintech development, where the fintech industry has sharply risen compared to other countries in ASEAN-6. In detail, in the period 2017-2021, the growth rate of total operating fintech companies in Vietnam is 67.86%, higher than Malaysia (58.67%), the Philippines (51.41%), and Thailand (48.07%) but lower than Indonesia (78.41%) and Singapore (75.33%), the two leading of fintech industry in ASEAN-6. Besides, the report of Statista (2021a) reveals the number of new fintech firms grew by 170% in the period 2017-2020, the transaction value of digital payment reached 8.6 billion US dollars, and the share of internet users using mobile payment monthly is 26.2%, and the biggest value of funding raised is 422.8

million US dollar belongs to Momo, one of the biggest e-wallet and mobile payment in Vietnam in 2020.

1.3.2 Bank investment in technology innovation

As I mentioned above about bank fintech definition, bank fintech regards commercial banks' use of emerging technologies, which directly indicates bank investment in technology innovation (BITI). Following the survey 2020 of the SBV, most Vietnamese commercial banks (93% of banks) are investing in technological innovation to enhance their performance. It shows that the banks are ready to compete with the fintech companies to provide advanced financial products to the customers.

In 2021, SBV approved the electronic know-your-customer (eKYC) for users to open bank accounts online through Decree 17/2021/TT-NNN. Following that, MBBank, Techcombank, VietinBank, TPBank, Vietcombank, OCB, and ACB implicated the services to their customers. It opens the door to providing advanced products to customers and brings more benefits for both banks and customers. The handling of customers' requirements is processed by advanced technologies such as artificial intelligence (AI) and machine learning. It helps to save operation costs for the banks and save spending time for the customers. Besides that, based on the electronic banking account, the bank could expand its list of banking products; it is like a potential market for penetration.

About ten years ago, in Vietnam, the race for mobile banking and internet banking development between commercial banks was interesting. However, these projects seem unsuccessful due to insufficient investments and a lack of experience in technology. However, in recent years, the effectiveness of mobile and internet banking has been improved by the collaboration between banks and fintech companies. The collaboration brings more benefits for both banks and fintech companies. Besides, it is also significantly meaningful for the finance industry and economy.

In the trend of disruptive technology development in the finance market to adapt to the rise of fintech, there are two flows of digital transformations of commercial banks. *First*, incumbents cooperate with the fintech companies to support rapid technology. A survey in 2019 of SBV shows that 72% of fintech companies collaborated with the banks, and 84% of bank managers wanted to cooperate with the fintech companies to deliver and launch new products. Besides, the efficiency of the credit rating and appraisal process is also a significant side of the collaboration between banks and fintech. VIB and Fintech Weezi, Techcombank and Fastacash, Vietcombank and M_Service, and VietinBank and Opportunity Network are the typical pairs between banks and fintech companies. *Second*, the banks must invest in improving the technology

system by bank-selves. However, the bank investment in technology innovation might be ineffective and highly risky caused of terms of IT experience and management skills.

SBV (2020)'s report showed that 95% of commercial banks have a digital transformation strategy. The technology involving robotics, AI, cloud computing, big data analysis, blockchain, and eKYC is applied in banking operations and product provision. Besides, building data storage that connects with public services, telecommunication, electricity, e-commerce etc., is being implicated by the commercial to increase the competition in the digital era. Software and technology involving payment infrastructure get special attention for investment to improve quality and promote bank efficiency; it meets the economy's need for non-cash payment. In 2020, QR code payments will be deployed by 20 banks. Integrating more features into the cards and mobile banking apps brings more benefits to the customers. Besides, synchronizing the interbank electronic payment system via the National Payment Corporation of Vietnam (Napas) promotes non-cash payment in quick, convenient, accurate, safe, and secure aspects.

The report of SBV (2020) gave that there is sustainability in Vietnamese commercial banks in terms of liquidity, risk management, and performance, but the Vietnamese banks are smaller in size and financial capability than other banks in Southeast Asia. Thus, banks are more vulnerable to shocks. Investment in disruptive technology is always accompanied by potential risks from cyberspace, especially involving data protection. It might be the possible shock, which is a high occurrence probability in the digital transformation of commercial banks. Therefore, commercial banks should be careful with the bank-self IT investment.

1.3.3 Attention of Government

The Vietnamese Government has issued regulations that create a solid legal foundation for the fintech industry development. For example, Decision No. 328/2017/QĐ-NHNN regardings the establishment of the Fintech Steering Committee of the State Bank of Vietnam, Decision No. 2655/2019/QĐ-NHNN regarding the development of information technology strategy in the banking industry, Decree No. 80/2016/NĐ-CP regarding electronic payment and e-wallet, Circular No. 23/2019/TT-NHNN regarding intermediary payment service, and other legal documents, which have facilitated for the rise of the fintech industry in Vietnam.

1.3.4 Research about fintech in Vietnam

In line with the rise of fintech research around the globe, a few scholars also indicated the role of the fintech industry in the relationship with the Vietnamese

economy. The qualitative study surveying 40 bank managers showed that the banks must adapt to the rise of fintech (Nguyen et al., 2020). The bank faces human resources challenges, information technology (IT) infrastructure, and changing customer behavior. Besides, the bank also needs the support of regulations from the government. The individual's financial literacy and perception are the critical factors in using fintech products (Lien et al., 2020; Morgan & Trinh, 2020).

Furthermore, I found studies about the link between fintech and other enterprises in Vietnam. For example, Truong and Tram (2017) discussed the opportunities for small and medium-sized enterprises (SMEs) to access credit from fintech companies. Dang and Vu (2020) studied technology's role in distributing microfinance institutions' products, and Le and Le (2018) researched the opportunities for the fintech industry development.

Regarding the relationship between financial literacy and fintech product adoption, Morgan and Trinh (2020) found a strong positive relationship between the level of financial awareness and fintech adoption in Vietnam. Morgan and Trinh (2019) surveyed adults' financial literacy in Vietnam and Cambodia; the results show that Vietnamese financial literacy is better than Cambodians. However, compared with the survey of OECD/INFE (2015), Vietnam is still lower than developed countries. I argue that the low level of financial literacy remains a significant challenge for the Vietnamese fintech industry development. Besides, Morgan and Trinh (2020) indicated that financial literacy scores vary depending on respondents' demographics and the kind of fintech products. The respondents are young, male, high income, used mobile payments have higher financial scores than others. It is an advantage for the Vietnamese fintech industry to grow in the future.

Following these studies, I recognize that the effect of the fintech industry on bank performance has not yet been clarified in Vietnam; thus, I argue that it needs more research to provide a holistic view of its effect.

1.4 Role of research in the developing country

First, the fintech industry plays a critical role in providing banking products in developing countries, including Vietnam, where most people do not have a bank account to use traditional banking products Demirgüç-Kunt et al. (2018), Demirgüç-Kunt and Klapper (2013), and Ozili (2018). The study by Le (2021) showed that fintech credit in 24 developing countries from 2013 to 2018 complemented bank credit and alternative financing sources for retail customers. Besides, fintech credit improves financial inclusion in developing countries. Mobile payment is a bridge to connect non-banking users to primary financial products in the developing world. Wenner et al. (2018) indicated that mobile

payment apps encourage saving habits, reduce transaction costs, and improve accessibility to alternative financing resources with a reasonable fee. In Vietnam, a developing country, Morgan and Trinh (2020) indicated that fintech brings new banking products and experiences for the customer, which might be a pressure and threat for a commercial bank in the finance market. Besides, MBBank (2021) gives both positive and negative evaluations of the fintech prospect in the Vietnamese finance market. Therefore, I argue that exploring the effect of the fintech industry on banks, especially regarding bank performance in Vietnam, is an interesting topic.

Second, most quantitative studies on the relationship between fintech and bank performance have focused on developed countries, lacking studies in developing countries like Vietnam. The review of relevant studies has confirmed this statement. Dranev et al. (2019) collected data from Zephyr (Bureau Van Dijk database) from January 2010 to February 2018 to investigate the impact of fintech mergers and acquisitions (M&A) on stock returns in the USA, Canada, China, India, and Europe. The findings revealed that in the short term, fintech M&A increases average abnormal return, but in the long term, its effect is negative. Li et al. (2020b) investigated the risk spillovers between traditional financial institutions and fintech companies in the USA from January 2011 to June 2018. The results showed that when risk spillover is higher, the association between two entities is stronger in the case downtrend, and there is a positive correlation between risk spillover from fintech companies to traditional financial institutions.

There are many studies about the relationship between fintech and banks in China. For example, from 2016 to 2019, Zhang and Zhuang (2020) indicated that the release of fintech events increases bank stock returns. Between 2008 and 2017, Cheng and Qu (2020) found that bank fintech reduces credit risk. Using data from 2009 to 2018, Wang et al. (2021b) explored that fintech decreases bank operational costs and increases service efficiency and risk control capabilities.

Few studies are in developing countries. In Indonesia, from 1998 to 2017, Phan et al. (2020) found that fintech growth by the number of fintech companies negatively affect bank performance. However, between 2016 and 2018, Asmarani and Wijaya (2020) explored that fintech funding does not affect bank stock returns in Indonesia. Based on data from 2012 to 2017, Mustapha (2018) studied that electronic payment technologies increase the performance of Nigerian banks. In Jordan, from 2012 to 2018, Bashayreh and Wadi (2021) showed that fintech positively affects bank performance.

Following these studies and to my best knowledge, I state that investigating the effect of the fintech industry on bank performance in Vietnam, a developing country, will be meaningful, filling the gap about its impact in developing

countries. The thesis outcome will provide scientific evidence to stakeholders in developing countries like Vietnam.

1.5 Research aim

The thesis regarding the effect of the fintech industry on bank performance in Vietnam is conducted for these reasons:

- *On the global, further research is encouraged due to the debate on the relationship between fintech and banks.*
- *The concern of whether the effect of the fintech industry on bank performance.*
- *Vietnam is an interesting case study due to (1) the fast growing of fintech company, (2) the fundamental change in bank investment in technology innovation, (3) Government pays more attention but lack scientific proof, and (4) the role of the fintech industry in developing countries like Vietnam*.

This thesis aims to ***evaluate the effect of the fintech industry on bank performance in the case study of Vietnam***. Besides, the thesis aims to provide comprehensive knowledge regarding the effect of the fintech industry on bank performance from various perspectives. In detail, qualitative and quantitative studies are employed to conduct the thesis. The time-series and panel approaches are applied to formulate the estimation research models. The Data Envelopment Analysis (DEA), Balanced Scorecard (BSC), and bank stock index are used to evaluate bank performance.

Furthermore, through the thesis, I aim to provide scientific proof which will be meaningful for stakeholders in the Vietnamese fintech industry. The findings will help stakeholders to make the proper decisions that promote the sustainable development of the Vietnamese finance market.

1.6 Dissertation structure

This dissertation is structured as follows:

Section 1: Introduction. This section presents the motivation for the thesis, the fintech and research concern, the Vietnamese fintech industry context, the role of research in the developing country, the research aim, and the dissertation structure.

Section 2: Literature review. This section presents the fintech history, bank performance measurement, the literature about the link between fintech and

banks, the literature about the effect of fintech on bank performance, the research gap, and relevant theories.

Section 3: Research design. This section presents the research problems, the research goals, the research questions, the research objectives, the research hypotheses, the research methodology, and the data collection.

Section 4: Results and discussion. This section reports and discusses the research outcomes of the effect of fintech company growth, fintech popularity, and bank investment in technology innovation on bank performance and the research result aggregation.

Section 5: Conclusion. The critical points of the thesis are briefly summarized in this section. Both theoretical and practical contributions are also provided in this section. Based on the findings, some implications are recommended. Besides, the limitations and directions for further research are also presented in this section.

2 LITERATURE REVIEW

This section consists of six parts. *Firstly*, the fintech history is presented to provide significant milestones of the fintech history and confirms two meanings of the fintech concept. *Secondly*, the bank performance measurement is presented. *Thirdly*, reviewing the existing publications indicates five strands of the relationship between fintech and banks. *Fourthly*, the strand of the effect of fintech on bank performance is preferred to be deeply reviewed. *Fifthly*, following the fourth sub-section, the gap regarding the effect of the fintech industry on bank performance is revealed. *Finally*, based on the existing publications, three theories of consumer, innovation disruptive, and productivity paradox are presented to explain the effect of the fintech industry on bank performance.

2.1 Fintech history

Following Kutler (1993), the term "fintech" was most probably initially used by John Reed, a chairman of Citigroup, in the early 1990s at the Smart Card Forum. He revealed the Citicorp project called fintech, which researched keeping in touch with the market preferences. After that, the term "fintech" has been popular and widely used in academia and practice (Puschmann, 2017). Regarding the fintech history research, the work by Arner et al. (2015) seems to be the first study that mentioned the fintech development line in the global scope. There are three stages of fintech history.

Fintech 1.0 (1866-1967) regards transatlantic cables and devices to verify signatures by banks, which was the fundamental infrastructure for financial globalization. The network linkages between banks worldwide were connected to facilitate international commerce development. Furthermore, in 1950, the Diners' Club Card, founded by Frank McNamara, was introduced as the initial charge card, which was convenient for payment cashless to restaurants. It is considered a remarkable technological enable in the finance industry, which is in the early stage of fintech history.

Fintech 2.0 (1967-2008) began in 1967 when Barclays Bank initially launched the automatic teller machine (ATM). It enables customers to perform financial transactions (e.g., cash withdrawals, deposits, balance inquiries, etc.) at any time without directly interacting with bank tellers. In 1973, the establishment of the Society of Worldwide Interbank Financial Telecommunications (SWIFT) supported the growing interconnect payment between banks, including across borders. In the USA, the physical trading of securities was replaced by electronic securities trading in 1971, and online banking was initially introduced in 1983, which remarked the change in utilizing disruptive technologies for improving the performance of relevant entities. The increase in electronic transactions led to increased risk concerns regarding inter-transactions and interlinked through

technology, which the regulators paid more attention to have the new regulations. Since the late 1980s, governments have issued directives and rules for electronic transactions between participants in the EU and USA. They were the framework for interconnection between entities in the market. By the early 2000s, under the support of complex computerized risk management, several million customers online often used the online financial products provided by the banks in the UK and USA. Furthermore, in this stage, the bank's internal processes and customer interaction without physical branches had been digitized by the effect of IT investment factors.

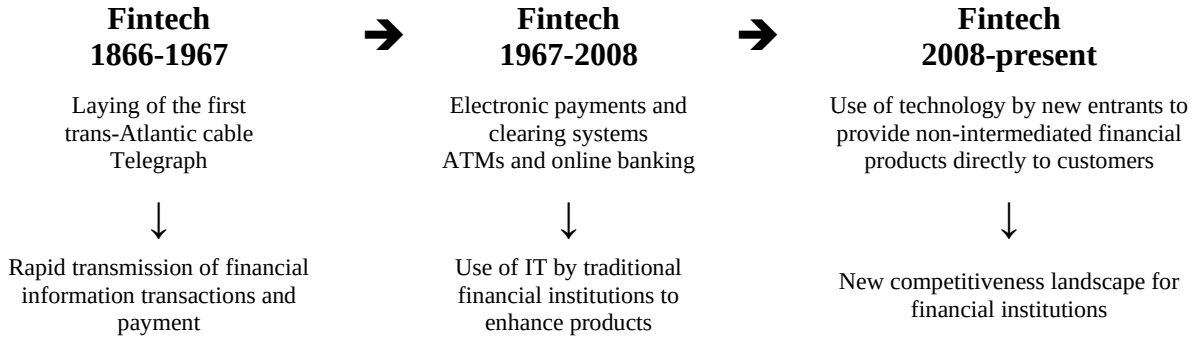


Figure 2.1 The three phrases of fintech

Source: Bates (2017)

Fintech 3.0 (2008-present) regards the democratizing of digital financial products. The global financial crisis (GFC) 2008-2009 most probably affected the mindset shift from the personalization banking products perspective. On the one hand, since 2008, due to the GFC, most general public distrusted the traditional financial system, and many employees who were professional financial knowledge lost their jobs, which were critical factors in facilitating the emergence of innovative players in the finance market. The new players had applied disruptive technologies to deliver alternative financial products, focusing on more retail customers than others. On the other hand, the political demand required the restructuring banking system in the post-GFC context. The policies of promoting market stability and enhancing risk management promoted the development of peer-to-peer platforms regarding lending and payments, which created startup companies to provide alternative financial products. Based on that, a new segment in the finance industry has been formulated, and it has been becoming the latest industry to compete with traditional financial institutions. Besides, in this stage, the concept of fintech often links to the development of disruptive technologies such as blockchain, artificial intelligence, big data, machine learning, etc. These technologies promote enhancing the performance of participants in the market.

Furthermore, although fintech has been formulated in the West, it plays a critical role in promoting economic development in developing countries like

Asia and Africa rather than in others; hence, Arner et al. (2015) called fintech 3.5 to indicate the fintech development in emerging markets. In developing countries, fintech is accelerated by promoting factors such as follows: the high rate of the young population having mobile devices, the fast-growing middle class, the inefficient financial market, many people without bank accounts, and the inconvenience of traditional banking products. Therefore, mobile-based fintech products that meet customers' demands are more attractive.

Table 2.1 The digitalization of the finance industry

	Stage 1: Before 1960	Stage 2: 1960-1980	Stage 3: 1980-2010	Stage 4: 2010-2020	Stage 5: After 2020
Strategy focus	Single customer channel	Two customer channels	Multi customer channels	Cross customer channels	Hybrid customer channels
Organization focus	Support processes	Back-office processes	Front-office processes	Provider processes	Customer processes
System focus	No systems integration	Partial internal systems integration	Internal systems integration	External financial products provider systems integration	External non-financial products provider systems integration

Source: Alt and Puschmann (2016)

Consistent with Arner et al. (2015), Bates (2017) and Thakor (2020) agreed that 1967 and 2008 are the significant milestones of the fintech development history, which is illustrated in **Figure 2.1**.

Alt and Puschmann (2016) and Puschmann (2017) provided that fintech has highly lied with the finance industry's IT investment. Following the work by Arner et al. (2015), Alt and Puschmann (2016) and Puschmann (2017) agreed that the launch of ATM by Barclays Bank in 1967, electronic trading by NASDAQ in 1971, internet banking by Stanford Credit Union in 1994, mobile banking by Norwegian Fokus Bank in 1999 are the critical remarkable of fintech history. Categorized by IT investment strategy in the finance industry, Alt and Puschmann (2016) and Puschmann (2017) proposed five stages of fintech development, illustrated in **Table 2.1**.

From stage 1 to stage 3, the IT investment strategy aimed at internal process digitalization, which focused on enhancing banking product quality and internal bank processes efficiency. The fourth stage regarded integrating providers and specialists in innovative technological solutions. The internal processes and application functions were standardized by outsourcing activities, which focused on back-office areas such as payment, appraisal, and investment to reduce in-house production costs. The fifth stage focuses on customer-oriented digitalization through fintech applications. Customer processes and journeys are central to fintech application design, financial products, and tools to collect, store, and analyze customer data. Hence, the new products must meet the requirements of multi-channel processes. The integration system between financial and non-financial providers is necessary to adopt the new era.

Alt et al. (2018) gave that fintech history links to four phases of financial technology development, as illustrated in **Figure 2.2**. First, based on physical media, the documents were transferred by physical modes of transportation, which is limited by the regional scope. Second, analog technologies enabled to transmit the documents faster and longer distances, which helped to enhance the performance of the industry and economy. Third, since the 1960s, the inception of digital technologies has supported electronic transactions between participants in the finance market, such as financial institutions, markets, and customers worldwide. Besides relying on digital technologies, the banks have paid more attention to IT investment to enhance their performance from the perspectives of customers, channels, financial products, and internal processes. Fourth, since 2008 (post-GFC), the strategy of reducing in-house production has been implicated by increasing outsourcing activities, facilitating the growing numbers of newly established non-financial companies called fintech companies. The new entrants in the finance industry have applied disruptive technologies to provide innovative solutions to fill the market gap. The occurrence of fintech companies not only brings more benefits for stakeholders but also creates challenges for incumbents in the digital era.

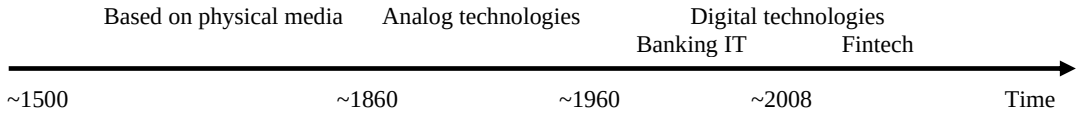


Figure 2.2 Evolution of financial technologies

Source: Alt et al. (2018)

Besides, many other studies mentioned the fintech history timeline, such as Ashta and Biot-Paquerot (2018), Lee and Shin (2018), Saksonova and Kuzmina-Merlino (2017), Teiglan et al. (2019), etc. Although there is a heterogeneous between specific fintech stages, all agree the GFC (2008-2009) is a critical milestone in fintech history. Based on that, and as I mentioned above, on a global scale, there are two parts of fintech development, namely pre-GFC and post-GFC. In the period of pre-GFC, fintech mainly indicates the traditional financial institutions' IT investment to enhance the performance in various perspectives such as customer, internal processes, delivering channels, etc. In the post-GFC, there are two strands of fintech development: bank fintech and fintech-outside. First, the banks continue to maintain the IT investment strategy to enhance their performance, but they tend to promote outsourcing activities to reduce in-house production. It means bank fintech, as I defined above. Second, fintech-outside is understood by emerging technologies used by non-banks, mainly fintech companies, which apply emerging technologies to provide innovative solutions to fill the finance market's gap. Two strands are still going on, and scholars and practitioners in the industry have paid their effect on the performance of incumbents more attention. It also provides significant background about fintech

measurement to conduct the study, investigating the relationship between fintech and bank performance.

2.2 Bank performance measurement

To my knowledge, the concept of bank performance is hard to define perfectly and accept. On the side of commercial banks, bank performance is the quantitative metric of financial ratios, such as profitability and market indicators, calculated by relying on financial statements and stock price movement. From the empirical research perspective, bank performance is measured in various ways. For example, Phan et al. (2020) used the ratio of net interest income to total assets, net income to total assets, net income to total equities, and the yield on earning assets for proxying bank performance. Asmarani and Wijaya (2020) and Li et al. (2017) calculated bank stock return to proxy bank performance. Singh et al. (2021) used bank profitability (return on assets and return on equity) to proxy bank performance. The common points of these measures are to use secondary data for calculating. Besides these studies, secondary data is also used for calculating the bank performance variables by Appiahene et al. (2019), Batten and Vo (2019), Chen and Lu (2021), Li et al. (2017), etc.

The primary data from the survey is also significant in research, which enriches the view about bank performance measurement. For example, based on a study of 317 respondents, Chai et al. (2016) stated that service factors improve bank performance. The collected data from 235 bank managers revealed that the practice of big data analytics applications enhances the performance of Jordani banks (Al-Dmour et al., 2021). Other studies by Al-Fakeh et al. (2020), Kebede and Tegegne (2018), and Rawashdeh (2018) designed the questionnaire to survey and measure bank performance.

Based on the bank-level data collection capability, in this thesis, I mainly use secondary data to measure bank performance; thus, the bank efficiency and stock price are selected to proxy the bank performance. Following Alber et al. (2019) and Chaity and Islam (2021), bank efficiency is defined as the effectiveness of inputs to produce an output. There are many ways to measure bank efficiency (Mester, 1997). For example, Stochastic Frontier Analysis (SFA) is a parametric approach, whereas Data Envelopment Analysis (DEA) is a non-parametric method. In this thesis, I refer to the use of the DEA approach to measure bank efficiency; its method is highly appreciated in the current context of Vietnam. Besides, following Pham et al. (2021b), the pure technical efficiency of Charnes et al. (1978) is applied for further analysis.

Besides the internal performance indicators (e.g., profitability, efficiency), bank performance is also presented by the external indicator, which relies on stock movement for calculation. The fintech factor might change investor behavior,

represented by the stock price movement. Therefore, the bank stock return is selected to proxy bank performance in this thesis.

Neely (2002) stated that the multi-dimensional approach is more holistic than the ratios approach in evaluating firm performance. According to Hasan and Chyi (2017) and Ratnaningrum et al. (2020), the BSC is highly appreciated for evaluating holistic firm performance. Following Al-Alawi (2018), Al-Dweikat and Nour (2018), Davis and Albright (2004), and Yaghoobi and Haddadi (2016), in this thesis, four perspectives of the BSC consist of financial, customer, internal process, and learning and growth perspectives are applied to evaluate the bank performance, which is affected by fintech.

2.3 Literature about the link between fintech and bank

Based on the history of fintech, fintech is formulated from the finance industry's inside, which is used to enhance the firm efficiency. Since 2008-2009, fintech has been considered a new segment, which is being by the commercial bank, the insurance company, and other traditional financial institutions (Arner et al., 2015; Goldstein et al., 2019). The rise of fintech has brought the debate about the effect of fintech on banks, a core segment of the finance industry. Based on that, I aim to understand the impact of fintech on banks. To find the gap in this field, I strategy to review the strands of the link between fintech and banks. Through literature review, I explore that most studies regarding the fintech field express the relationship between banks and fintech in various ways.

To enhance the review quality, I filter and choose the high-quality articles published by journals that belong to the Scopus/Web of Science database or with more than ten average citations per year (measured by the number of citations on Google Scholar divided into the number of publications years). The procedure for choosing high-quality fintech-related papers is as follows. First, combination keywords (e.g., fintech, financial technology, bank, commercial bank, retail bank, finance, finance industry, etc.) search articles on Google Scholar. Second, because fintech has rapidly grown in recent years, I choose the period of fintech 3.0 (2008-present) for the search scope. Since 2015 when the study by Arner et al. (2015) was published, a vast number of fintech-related papers have been released (Goldstein et al., 2019; Gomber et al., 2017; Milian et al., 2019); thus, I am toward collecting the published articles from 2015 to the present. Finally, the journal's name is queried on the Scopus or Web of Science; if it matches, the article is chosen for review or meets the number of citations.

Regarding the bank strategy for investment in the fintech company in Taiwan, Hung and Luo (2016) stated that banks have not been ready for fintech investment. However, there is encouragement from the Government. Bank managers discuss that the bank remains in a higher position than a fintech

company by size, profitability, market share, and especially the finance industry experiences. Thus, banks have not yet needed to invest in fintech companies. In contrast, Klus et al. (2019) conducted an in-depth interview with bank managers in Germany. The results showed that the bank's motives to cooperate with fintech are rapid innovation, enhancing competitive advantage, outsourcing, learning, and business model evolution.

Trust and credibility, resources and synergies, customer acquisition, and learning are the motives of fintech. In supplement to the strategy bank-fintech alliance issue, Hornuf et al. (2020) used the data of the 400 largest banks in Canada, France, Germany, and the United Kingdom from 2007 to 2017 to investigate the typical collaboration between banks and fintech and the preferred form of alliances. The results showed that the bank could ally with fintech because of the fintech pressure. The bank prefers to invest in a small fintech company and build product-related collaboration with a large fintech company. Besides that, the bank-fintech cooperation issue has been discussed by Navaretti et al. (2018), Thakor (2020), and Vives (2017, 2019). The cooperation is like a “win-win” for both parties, and the other will enhance and solve the pros and cons of each participant.

Table 2.2 Potential benefits and risks from bank-fintech cooperation

Benefits	Risks/Concerns
Enhance brand name reputation	Culture fit
Upgrade mobile apps functions	Cybersecurity issues
Reduce capital expenditure	Quality of human resource
Reduce operation costs	High risk in investment
Extend customers (younger, database, geographic)	Legal/regulation issues
	Technical complexity of integrating fintech functions

Source: Korn et al. (2016)

Collecting data from Chinese banks between 2014 and 2019, Fang et al. (2022) indicated that embracing bank-fintech strategic collaboration improves bank cost and interest income efficiency. Temelkov (2018) stated that depending on banks’ views, fintech companies might be a major threat and have bigger opportunities for bank development. Through the survey, Korn et al. (2016) gave some potential benefits and risks regarding bank-fintech cooperation, which are illustrated in **Table 2.2**. Through a practical literature review, Ruhland and Wiese (2022) indicated the motives of bank-fintech cooperation: customer satisfaction, financial return, knowledge transfer, competition, reputation & credibility, regulatory & synergies, product development, business model innovation, external innovation access, and strategic advantage. Another study by Drasch et al. (2018) provides four kinds of bank-fintech cooperations: acquisition, alliance, incubation, and joint venture. By the dimension of innovation type, the collaboration between banks and fintech toward enhancing the bank-to-customer and customer-to-customer process and developing advanced products. Following

that, the cooperation between banks and fintech will be “win–win–win” proposal for banks, fintech companies, and customers.

Mobile payment is the largest segment of fintech. It has risen since the fintech 2.0 stage. Today, mobile payment products are provided by both banks and fintech companies. Dahlberg et al. (2015) used 188 published articles to review mobile payments from 2007 to 2014 for analysis. The authors revealed that mobile payment was driven by two main factors: customer adoption and technology. Ease of use, perceived usefulness, trust, and risk are the most critical factors of customer acceptance. Simultaneously, the authors emphasized security-related technologies and connectivity to enhance the mobile payment market's competitiveness. Li et al. (2020a) and Jünger and Mietzner (2020) stated that customer behavior had changed from mobile payment products to fintech companies, especially significant changes in young customers with higher financial literacy. I argue that the rise of fintech (mobile payment companies) threatens incumbents. However, Dinh et al. (2018) gave that mobile payment adoption is promoted by the cooperation between a fintech company, a telecom company, and a bank in the emerging market. I argue that although the fintech company accounts for part of the payment market, the cooperation between banks and fintech will be better for customer needs.

Although mobile payments contribute to non-cash payments, there is no regulatory uniformity across transboundary countries, which challenges suppliers' development toward distributing products across countries. Miao and Jayakar (2016) compared mobile payment business models in China, South Korea, and Japan. The authors gave that national regulation is the critical factor in the mobile payment business model, and there is a difference in regulation between countries. In China, the Chinese mobile payment company is supported and facilitated for growth rather than foreign companies. In Japan and South Korea, the legal environment seems to be fair.

Using the data from 2004 to 2018 in Indonesia, Yudaruddin (2022) found that fintech payment and fintech lending negatively affect bank performance, but the interaction between fintech and bank variables positively influences bank performance. Mustapha (2018) found that electronic payment technologies increase bank performance in Nigeria. Besides, Agarwal et al. (2020) provided that mobile payment does not only affect commercial bank structure but also might reshape economic activities and stimulate business creation. Omarini (2018) assessed that mobile payment is the largest and most profitable segment, strongly competed by banks and fintech companies in retail banking. The mobile payment platform is creating a distinction in competitiveness capability between banks and fintech companies. The review study by Elsaid (2021) provided that the mobile payment segment plays the role of a pioneer, who takes the market share away from traditional financial institutions and might be a substitute bank

in the retail payment segment. However, in the development trend, cooperation between banks and fintech is essential, which brings more benefits for both parties. I argue that the collaboration will promote financial inclusion, especially meaningful in developing countries where conventional banks have not yet covered it.

Peer-to-peer (P2P) lending is the second largest segment of the fintech industry. P2P lending company provides the marketplace or market platform where the borrower and the lender transact the loans. The company charges the transaction fee, which is the company's income. The P2P platform creates a new channel for customers to save and borrow. Comparing the risk and interest rate between P2P platform suppliers and banks in Germany from 2007 to 2015, de Roure et al. (2016) revealed that the loans of P2P channels have a higher interest rate and higher risk than banks. However, when investigating the relationship between bank lending and P2P lending by controlling interest rates in different segments, the authors gave that the customers prefer the loans of the P2P platform to the bank. Jagtiani and Lemieux (2017) stated that in the niche market of the bank, P2P lending platforms are very active, which might play a role in reshaping the banking landscape. The P2P lending company collects, processes, and provides more relevant and better information than the bank's information through technology. However, because of the loans without collateral, thus the amount of loans is limited. Most loans of P2P loans are small. Additionally, Jagtiani and Lemieux (2017) revealed that the administration process's speed is also a strong point of the P2P lending company compared with the bank.

In China, collecting data from a survey with 474 online lenders, Wan et al. (2016) revealed that the willingness to lend is determined by initial trust and perceived benefit, while the fear of borrower opportunism is insignificant. Tang (2019) investigated the relationship between P2P platforms and banks in the USA. The findings gave that when the shock of bank credit is a chance for P2P lending to extend market shares. The low-quality bank borrowers tend to move from banks to P2P lending. Besides, in the retail credit segment, P2P lendings play the role of complementing banks. Sari (2020) stated that P2P lending companies provide the same banking product with simpler and more advanced than conventional banks; thus, it threatens banks. The empirical results in Indonesia from 2015 to 2019 gave that the growth of P2P lending companies reduces bank profitability. Kohardinata et al. (2020) stated that the products of P2P lending companies are substitutes for rural bank loans. Besides, the cooperation between banks and P2P lending companies creates complementary loans for customers in rural areas. Zhang et al. (2019) found a positive relationship between a small loan of P2P lending and domestic bank loans and a negative effect of the benchmark lending rate exerted on domestic bank loans.

Using the banking industry data of 28 EU countries from 1995 to 2015, del Gaudio et al. (2021) indicated that all forms of information and communication technology positively affect bank profitability. Advanced technology helps banks achieve economies of scale by reducing operation and transaction costs and increasing customer experience using banking products. Additionally, the authors emphasized that technology implementation in payment and risk management seems more efficient than others.

Text mining methods and the quantitative regression model were employed to investigate the "profitability paradox," or a negative effect of IT investment on bank performance. Kriebel and Debener (2020) validated the crucial role of technology in the banking sector. The estimation results show that the interaction between bank IT capability and infrastructure in US banks increases bank performance. In the survey of 102 banks in Germany, Switzerland, and Liechtenstein, Niemand et al. (2021) stated that although bank profitability was not affected by digitalization, banks are always proactive in utilizing technology for superior performance.

Based on the artificial intelligence technology index, blockchain technology index, cloud computing technology index, big data technology index, and internet technology index, Cheng and Qu (2020) constructed the fintech variables, then collected data from 60 commercial banks from 2008 to 2017 in China for investigation the effect of fintech on credit risk. The results showed that fintech reduces credit risk, which is relatively weak among large, state, and listed banks.

Regarding banking digitalization, Rodrigues et al. (2020) conducted an in-depth interview with six specialists in the Portuguese banking sector with more than 30 years of experience. The findings showed that banking digitalization is mandatory to reduce operation costs, enhance productivity, and change the digital era's business model. Besides that, the experts proposed that clients, socioeconomic, humans, technology, profitability, risk, and security are digital transformation factors that should be considered. In Nigeria, Agboola et al. (2019) used the data from 370 non-managerial employees in a commercial bank to estimate digitalization's effect on bank performance. The result showed a significant positive relationship between bank performance and digitalization. Forcadell et al. (2020) surveyed 110 global banks from 2003 to 2016 in 13 developed countries and estimated the effect of corporate sustainability and digitalization on bank performance. The results showed that bank performance and bank efficiency are enhanced by corporate sustainability and digitalization strategies. Based on these studies, I discuss that banking digitalization or internal fintech on the bank-on-bank performance is still unclear; it needs more research to clarify.

In Turkish, from 2005 to 2017, Yazici and Baloglu (2018) provided that banking digitalization in business models negatively affected bank performance. Rodrigues et al. (2020) applied fuzzy cognitive mapping and system dynamics to analyze banking digitalization in Portugal. The results showed that trust, agility, efficiency, innovation, cyber risk, clients, socioeconomic and human factors, profitability, and technologies are the significant factors affecting banking digitalization. In India, Meena and Parimalarani (2020) stated that automation in the finance industry is a cause of leaving bankers' jobs. Banks tend to apply disruptive technologies to handle transactions and risk management. In banking digitalization, current jobs will be replaced by technological applications. However, it also creates new jobs regarding technology, such as jobs in cyber risk, data analysis, etc. Thus, the banks require the latest workforce must update their unique skills and knowledge.

In recent years, many quantitative studies have been conducted on the effect of fintech on bank performance, which is heterogeneous. Fintech is conducive to reducing bank operation costs, improving productivity, and promoting banking digitalization. Others claim that fintech is a negative factor for banks; it brings challenges to banks.

Phan et al. (2020) used the number of established fintech firms in the year to investigate its effect on the performance of 41 Indonesian banks, which was measured by return on assets, return on equity, net interest income, and the yield on earning asset from 1998 to 2017. A two-step generalized method of moment (GMM) system dynamic panel estimator was used for estimating the effect of fintech on bank performance. The findings showed that fintech negatively influences four measures of bank performance. Besides, state-owned banks are a negative link with fintech compared with others, and the effect of fintech on bank performance is sensitive to the impact of the global financial crisis.

In China, Lee et al. (2021) self-constructed the set of fintech indicators from the 12,846 samples of fintech enterprise-level data, while the stochastic metafrontier approach measures bank efficiency. Then, they used the two-step GMM dynamic panel data technique to estimate the impact of fintech innovation on 86 banks' efficiency from 2003 to 2017. The results show a positive effect of fintech development on bank efficiency, but the state-owned banks operate under inferior technology, which leads to low efficiency.

Using the five-factor model of Fama and French (2015), Li et al. (2017) examined the effect of fintech funding value and deals on the stock price of 47 US banks from 2010 to 2016. The estimation showed a positive relationship between fintech and contemporaneous bank stock returns. Asmarani and Wijaya (2020) applied the same method as Li et al. (2017) to examine the effect of fintech on the stock return of 8 banks from 2016 to 2018 in Indonesia. However, the result

differs from Li et al. (2017); fintech funding frequency and value do not significantly affect bank stock price.

Based on that, it can be seen that the effect of fintech on bank performance varies. Besides these reviewed studies above, there are many other relevant studies. Reviewing existing publications about the impact of fintech on banking, Frame et al. (2018) indicated that over the past 30 years, fintech has dramatically changed traditional financial institutions' productivity, internal process, and business model. In detail, the technology platform accelerates the payment system and transforms consumer lending into automation. In China, using data from 113 commercial banks from 2009 to 2018, using self-calculation fintech development variables, Wang et al. (2021b) showed that fintech development increases bank profitability and improves bank risk management capability. Based on the findings, the bank's technological infrastructure (hardware and software) must be improved to adapt to fintech development. Required hardware consists of a network, cloud servers, storage, and high-performance computers, whereas software regards data mining, AI, machine learning, and blockchain technologies. Zhao et al. (2022) investigated the effect of fintech development on bank performance in various aspects, such as capital adequacy, asset quality, and profitability. The estimation results showed that fintech development decreases bank profitability and asset quality while it increases capital adequacy and management capability. The findings also show that banks' reactions to fintech development differ; some ignore it, while others panic and overreact. Besides, the authors stated that the banks do not easily catch up with the fintech developments in IT infrastructure and technological capability; thus, cooperation with fintech companies is considered a suitable fintech adaptation strategy in the digital era.

Using data from 73 countries between 2013 to 2018, Nguyen et al. (2021) investigated the relationship between fintech credit, bank regulation, and bank performance. The findings showed that fintech credit is a negative factor in bank profitability, but it helps to control bank risk-related performance. Besides, depending on banking regulations, fintech credit might increase bank stability. In China, from 2008 to 2017, Cheng and Qu (2020) self-constructed the bank fintech variable using a web crawler tool and word analysis and investigated its effect on bank credit risk. The findings revealed that bank fintech is negative with credit risk, and large, state-own, and listed banks are weakly affected by fintech development. In the USA, collecting the daily data between Jan 2011 to Jun 2018, Li et al. (2020b) examined the risk spillover between fintech and traditional financial institutions. The results showed that when risk spillover increases, the association between entities is stronger, and in systemic risk, the correlation between variables is significantly positive.

By reviewing these studies above, I explore the various relationships between fintech and banks. I categorize these links into five strands: bank–fintech

cooperation, banks and fintech in the mobile payment market, banks and fintech in the retail credit market, banking digitalization, and the effect of fintech on bank performance. Of the five strands, I prefer the fifth strand, which regards the impact of fintech on bank performance. *First*, its effect is a debate, and further research is encouraged. *Second*, there are many ways to measure the fintech variables, but using Google search and accounting financial statements for fintech measurement have not yet been mentioned in relevant publications. *Third*, using the BSC approach for evaluating the effect of fintech on bank performance seems rare. *Fourth*, the findings regarding the effect of fintech on bank performance will be meaningful for stakeholders, such as policymakers, bank managers, fintech managers, and investors, especially in developing countries like Vietnam, an interesting case study.

2.4 Literature about the effect of fintech on bank performance

From the side of the systematic review study, Elia et al. (2022) reviewed 377 articles belonging Scopus database from 2014 to 2021. The outcome of R and VOSviewer software gave the critical role of fintech in the banking industry and provided further direction in the field of the effect of fintech on bank performance. Anagnostopoulos (2018) conducted action research to explore the impact of fintech on banks and the financial services sector. The findings showed that the market penetration by fintech startups explains bank cost-cutting and re-designing business models. Besides, the study indicated that many banks are using outdated technologies.

Iman (2019) gathered two data sources (survey and secondary data) for investigating the effect of fintech on a regional bank in Indonesia. The results show that although fintech has a significant technical and managerial impact, the bank has a reasonable reaction to the rise of fintech. In UAE, Dwivedi et al. (2021) surveyed 76 bankers (banking professionals and executives) to investigate the effect of fintech on bank competitiveness and performance. The findings by Smart-PLS indicated that fintech is a positive factor in bank competitiveness and performance. In detail, fintech decreases financial transaction costs, improves product delivery quality and productivity, increases flexibility and profit, and promotes growth. In Germany, Jünger and Mietzner (2020) conducted an online survey of 323 households to evaluate the impact of fintech adoption on banking digitalization. Logit and binary regressions showed that trust, financial literacy, and transparency are significant factors in switching to advanced-banking products.

Based on a survey of 378 respondents in Latvia, Saksonova and Kuzmina-Merlino (2017) revealed that fintech products are more competitive in convenience, speed and safety, and customer satisfaction than traditional banking products. Fintech development brings both opportunities and advantages to the

financing market and customers. Following the Reserve Bank of India website, Shanmugam and Nigam (2020) collected data from 50 banks in six periods from 2011-2012 to 2016-2017 to analyze the impact of fintech on financial performance. The results of the Kmeans algorithm approach showed that most banks are using outdated technologies, and the impact of fintech on bank performance is heterogenous in various periods. For example, in 2011-2012, fintech had a positive impact on 3 banks, a negative impact on 5 banks, and others had an insignificant; in 2015-2016, 8 banks had a positive impact.

Based on China Fintech Enterprise Database, Zhao et al. (2022) built the fintech development index and investigated its and fintech patents' effect on the performance of joint-stock commercial banks, policy banks, city commercial banks, and state-owned commercial banks (measured by capital adequacy, asset quality, management efficiency, earning power, and liquidity ratio). The Generalized method of moments (GMM) estimation showed that fintech decreases bank profitability and assets quality but increases capital adequacy and management efficiency. Using news headline searching and factor analysis, Wang et al. (2021a) built the fintech index to measure fintech development in China. Besides, BVD's Bankfocus provided the bank-level data to calculate the bank risk-taking (proxied by Z-score) and control variables. Based on the obtained panel data, the various quantitative techniques confirm that fintech increases bank risk-taking. Besides, the heterogeneity analysis showed a U-shaped trend between fintech and bank risk-taking, and its relationship is more sensitive with city banks, foreign banks, and rural banks than state-owned banks and jointly owned banks.

Based on the capital asset pricing model by Fama and French (1997), Li et al. (2017) investigated the effect of fintech funding on the stock return of 47 retail banks from 2010 to 2016 in the USA (provided by CB Insight). The findings revealed that the growth in funding and deals positively affects bank stock return. In the USA, Jagtiani and Lemieux (2018) collected data from LendingClub, and Federal Reserve's Y-14M reports to examine the relationship between fintech and traditional banks. The findings showed that fintech lenders had penetrated underserved areas by conventional banks, especially enormously significant in fewer bank branches, and fintech is reshaping the financial and banking landscapes. In the USA, Li et al. (2020b) collected the daily stock return of fintech and traditional financial institutions for estimating the risk spillovers between two entities. The estimation results by the Granger causality test across quantiles showed that the linkages between variables are stronger in the case of contemporaneous downtrends, and there is a positive correlation in risk spillover between fintech and financial institutions.

Al-Matari et al. (2022) used Global Fintech Adoption Index for proxying the fintech variable and investigated its effect on the performance of 47 financial institutions in Saudi Arabia from 2014 to 2020. The study showed that fintech

positively affects firm performance but does not moderate the link between the board of directors and firm performance. In Malaysia, based on the data of 26 banks (Islamic and conventional banks) from 2003 to 2018, Safiullah and Paramati (2022) revealed that fintech companies positively influence bank stability by Z-Score measurement. Besides, the fintech impact on small and Islamic banks is stronger than others. In India, Varma and Nijjer (2022) used the volume of mobile banking transactions for proxying the bank fintech variables and investing its effect on bank efficiency. The data of 167 banks from 2011 to 2019 is obtained from Bureau van Dijk. The findings gave that there is a negative effect of fintech on bank efficiency. Olalere et al. (2021) compared the impact of fintech on the valuation of banks between Malaysia and Nigeria. Based on the data of 26 banks from 2009 to 2019, the estimation results by the two-step GMM approach gave that fintech is a negative factor in bank valuation in Nigeria but positive in Malaysia.

In Lithuania, Pu et al. (2021) conducted a qualitative study to assess the relationship between fintech and commercial banks. The findings by SWOT and PESTEL analysis gave that fintech has a better position in competition with the banks, but it could not disrupt the role of commercial banks in the finance market. Besides, the occurrence of fintech encourages commercial banks to reach higher efficiency. Another qualitative study by Zveryakov et al. (2019) gave that fintech is filling the market gap, which traditional financial institutions have not yet covered. Besides, fintech is accelerating the growth of the finance market and the incumbents.

Furthermore, Stulz (2019) stated that fintech competes with banks in the retail banking market, which might negatively influence bank profits. However, fintech accelerates the banks better due to the harder competitiveness capability. Based on a survey of 2,819 bank customers in Spain in 2016, Carbó-Valverde et al. (2020) found that the increase in bank fintech promotes bank customers undertaking transactions through digital channels.

Gathering the fintech database from Cornelli et al. (2020), Financial Development and Structure Dataset, and World Development Indicator, Nguyen et al. (2021) aggregated a dataset of 73 countries from 2013 to 2018. The findings revealed that fintech credit has a negative impact on bank profitability but a positive one on bank risk-related performance. Besides, this relationship is moderated by banking regulations, and the level of banking regulation promotes bank stability.

Based on the dataset of 40 listed banks from Gulf Cooperation Countries (United Arab Emirates, Saudi Arabia, and Bahrain) from 2014 to 2019, Almulla and Aljughaiman (2021) investigated the effect of fintech on bank profitability. The findings provided that fintech is a negative factor in bank profitability.

Further analysis showed that many fintech companies negatively affect the performance of conventional banks but have an insignificant impact on Islamic banks. In Nigeria, Mustapha (2018) used the Sortino index for proxying the bank performance and ATM, POS, Mobile Money Transfer, and internet services to proxy the fintech variables. The data of 14 listed banks from 2012 to 2017 is obtained from the Nigeria Inter-Bank Settlement System and Central Bank of Nigeria. The finding showed that fintech is a positive factor in bank performance.

In the five countries of the East African Community (including Burundi, Kenya, Rwanda, Tanzania, and Uganda), Ky et al. (2019) investigated the effect of fintech on bank profitability, efficiency, and stability. The dataset of 170 banks from 2009 to 2015 is obtained from the Bureau Van Djik, the Global Financial Development, and the World Bank; the authors found a positive relationship between fintech and bank performance. In Nigeria, Agboola et al. (2019) self-constructed the questionnaire to collect the view of bank employees about the effect of fintech on bank performance. The sample of 370 respondents showed that fintech positively influences bank performance from product innovation and internal process perspectives.

The existing publications about the effect of the fintech industry on bank performance are various from fintech measurement (e.g., fintech companies, mobile banking transactions, fintech index provided by a third party, self-constructed fintech index, etc.), bank performance measurement (e.g., profitability, stability, competitiveness, stock return, etc.), scope of the investigation (e.g., individual country, group of countries, developed and developing countries), and data analysis techniques (e.g., GMM, Granger causality, SWOT, etc.). According to my best knowledge, using Google search and accounting financial statements for measuring the fintech variables and using the Balanced Scorecard for evaluating bank performance by the relationship with the fintech industry have not yet been mentioned by relevant publications. I argue they are the gaps in the effect of the fintech industry on bank performance.

2.5 Research gap

The existing publications about the effect of the fintech industry on bank performance revealed various ways to measure the fintech variable. For example, Ky et al. (2019) measured the fintech variables of 170 banks from 2009 to 2015 by basing on the involvement of banks with mobile money via Mobile Network operators. In detail, the fintech variables consist of dummy variables (involving or not), the number of involving years, the number of users, and transaction values. The finding shows a strong positive relationship between fintech and bank performance. In United Arab Emirates, Saudi Arabia, and Bahrain from 2014 to 2019, Almulla and Aljughaiman (2021) formulated the bank fintech score from fintech services' existence in the bank and used the number of fintech firms for

measuring the fintech variables. The estimation results show that bank fintech is a negative factor in bank profitability, and the growth of fintech firms negatively affects conventional banks but is insignificant for Islamic banks. Cornelli et al. (2020) and Nguyen et al. (2021) used the ratio of fintech credit on GDP for proxying the fintech variables and investigated its impact on bank performance. Based on the dataset of 73 countries from 2013 to 2018, Nguyen et al. (2021) indicated that fintech credit is a negative factor in bank profitability, but with the moderating of regulation, fintech credit is positive for bank stability. Based on the database of the World Bank, Sadigov et al. (2020) used the indices regarding mobile phones to access a financial institution account and the internet to pay bills for proxying fintech development. The finding gave that fintech development is a positive factor in economic growth. Besides, Cheng and Qu (2020) used crawler technology and word frequency technique for measuring the fintech variable. Sheng (2021) used the fintech index to indicate the fintech development of 31 provinces in China from 2011 to 2018, which the Institute of Digital Finance provided. Phan et al. (2020) measured the fintech variable as the number of fintech startup companies, whereas Asmarani and Wijaya (2020) provided the fintech variables are fintech funding frequency and fintech funding value. Based on these studies above and my best knowledge, using Google search and accounting financial statements to measure the fintech variable seems rare, which is the research gap in the link between fintech and bank performance. Therefore, conducting the study will fill the gap and enrich knowledge regarding fintech measurement and its relationship with bank performance in the digital era.

Many existing publications focus on investigating the effect of the fintech industry on bank performance in developed countries. For example, in China, Cheng and Qu (2020) provided that bank fintech decreases credit risks; Wang et al. (2021a) found a U-shaped trend in the relationship between fintech and banks' risk-taking; Chen et al. (2021b) explored the positive effect of fintech products on bank customer satisfaction; Wu and Yuan (2021) revealed fintech is a negative factor in state-owned banks' profitability; and other studies such as Lee et al. (2021), Sheng (2021), Zhao et al. (2022), etc. In the USA, Li et al. (2017) found a positive impact of fintech funding and deals on bank stock return; Buchak et al. (2018) stated that fintech lenders fill the gaps in capital requirements and mortgage mortgage-related regulations of traditional banks, and Tang (2019) indicated that fintech lending is a substitute for banks in terms of serving customers, and a complement in terms of small loans. In Europe, Haddad and Hornuf (2019) found that fintech development promotes the finance market. By cross-countries, Daud et al. (2022) indicated that fintech and bank concentration promote financial stability; Hornuf et al. (2020) provided that traditional banks ally with fintech firms improve bank performance. Besides these studies above, other studies about the effect of fintech on bank performance were conducted by Jünger and Mietzner (2020) in Germany, Jun and Yeo (2016) in South Korea,

Bashayreh and Wadi (2021) in Jordan, Phan et al. (2020) in Indonesia, Almulla and Aljughaiman (2021) in United Arab Emirates, Saudi Arabia, and Bahrain, Shanmugam and Nigam (2020) in India, etc. However, I explored that investigation in Vietnam seems rare. Therefore, I argue that it is a gap that needs to be filled.

The relevant studies show that bank performance measurement is various. Most studies used profitability (Phan et al., 2020; Shanmugam & Nigam, 2020), competitiveness (Dwivedi et al., 2021), stock return (Asmarani & Wijaya, 2020; Li et al., 2017), risk-taking (Wang et al., 2021a), efficiency (Almulla & Aljughaiman, 2021; Varma & Nijjer, 2022), customer satisfaction (Saksonova & Kuzmina-Merlino, 2017), process (Iman, 2019), etc.; others provide the view about the effect of fintech on bank performance through systematic review (Anagnostopoulos, 2018; Elia et al., 2022), the result of qualitative research (Pu et al., 2021). However, using the Balanced Scorecard for evaluating the effect of fintech on four perspectives of bank performance has not yet been found in existing publications. Therefore, I argue that it is a gap that needs to be filled.

Consequently, through these studies above (as just mentioned), I found that (1) current publications have not yet investigated the effect of fintech popularity by Google search and bank investment in technology innovation on bank performance; (2) the effect of fintech company growth on four perspectives of bank performance, which are based on the BSC approach has not yet conducted by existing publications; and (3) the existing publications focus on the developed countries, while the developing countries like Vietnam are missed; thus, conducting the study in Vietnam is necessary. Therefore, this thesis is conducted to fill the gaps. This thesis will provide novel evidence in this interesting field.

2.6 Relevant theories

These theories might explain the effect of the fintech industry on bank performance. First, following the study by Almulla and Aljughaiman (2021), Elsaid (2021), Phan et al. (2020), and Yudaruddin (2022), the consumer theory by Aaker and Keller (1990), and the disruptive innovation theory by Christensen (1997) are applied to explain the effect of fintech popularity on bank performance. Second, the effect of bank investment in technological innovation on bank efficiency might be explained by the productivity paradox by Solow (1987).

2.6.1 Consumer theory

As I mentioned above, fintech regards disruptive technologies that are used to provide the advanced-products to customers in the finance industry. The decentralized peer-to-peer platforms (e.g., lending and payment), which can replace the products of traditional financial institutions, have been supporting

fintech development. Farther, the blockchain regarding cryptocurrency might replace banknotes, reducing the banks' role in the future. Based on that, I recognize that the consumer theory by Aaker and Keller (1990) is highly appreciated for explaining the effect of fintech popularity on bank performance.

The theory states that in the market, the new products play complementary products for the old products; the combination brings the best experience to customers, but when new products meet customers' requirements (the same needs), they might replace the old products. It means that in the case of complementary fintech products, incumbents will benefit from the rise of fintech. In contrast, fintech offers alternative products, which negatively affect traditional banks. In Vietnam, following the reports of MBBank (2021) and SBV (2020), in recent years, the number of fintech users and transaction values have dramatically risen, which means the rise of fintech changes customer behavior in using banking products. It can be seen that fintech is invading the market of conventional banks. However, these reports also reveal that fintech is simply too small in size, scale, capital, etc., compared with commercial banks. Therefore, I argue that despite a negative relationship between fintech and banks, its relationship might be slightly weak.

This theory is highly appreciated for explaining the relationship between fintech popularity and bank stock return. It explains the consumer behavior change of customers when new products (advanced products) are launched in the market. Fintech products play the role of alternative conventional banking products; thus, bank customers will switch to using fintech products instead of keeping using banking products. The volume of searching fintech-related keywords reflects the trend of fintech popularity in cyberspace, which indicate the users’ attention on fintech and using fintech products. The increase in search volume shows that many customers have changed to using fintech products, which will negatively influence bank performance, especially regarding bank prospects and competitiveness in the market. Its effect is sensitive to bank stock movement.

2.6.2 Disruptive innovation theory

In the current context of the finance industry, the relationship between fintech popularity and bank stock return might be explained by the disruptive innovation theory proposed by Christensen (1997). This theory states that the new entrant applies disruptive technologies to provide the advance-products, which are easier to use and cost-effective and create high pressure of competition in the market against the incumbents. In the market, the gaps are filled by the new entrants' business-model innovation and product innovation. Besides, they might create different challenges affecting the incumbents in each sub-sector.

Focusing on the fintech business model, Gomber et al. (2018), Lee and Shin (2018), Mention (2019), and Milian et al. (2019) stated that fintech had redefined how people use financial products regarding business model innovation of payment, investment, and protecting wealth. Due to the disruptive technologies, these products are more competitive in fees of charge and convenience than the incumbents.

In Vietnam, mobile payment and P2P lendings are the successful business models of fintech companies. In terms of speed, convenience, and multi-channel connections, mobile payment technology solutions have been improving and enhancing customer experiences. The users are now easy to use the advanced-payment products free of charge through mobile payment apps (e.g., Apple Pay, Google Wallet, Samsung Pay, Momo, etc.), which are integrated with near-field communication (NFC), and Quick Response (QR) code technologies. P2P lending, which allows individuals and businesses to lend and borrow from each other through the P2P platform, is a big trend in the finance industry. Based on the technologies of crawling data on cyberspaces and big data analytics, P2P lending companies design rapid lending processes that meet the needs of lenders with borrowers, then match them together, and collect fees from users. The P2P lending business model is more advanced in operational cost than banks due to no branches and no need to meet the capital requirements. Furthermore, other segments of fintech are more advanced in technology and product quality than banks. Therefore, I argue that the popularity of fintech might negatively link to bank performance.

2.6.3 Productivity paradox

Although the primary aim of bank investment in technology innovation is to enhance bank efficiency and effectiveness, its relationship might be adverse. Solow (1987) initially found that in the computer age 1970s-1980s (technological innovation development), there was a significant correlation between an increase in IT investment and a decrease in productivity. Based on that, Beccalli (2007), Del Gaudio et al. (2021), dos Santos and Sussman (2000), Gupta et al. (2018), Harris (2001), and Shu and Strassmann (2005) confirmed the existence of the productivity paradox in the bank industry. In detail, they stated a negative relationship between investment in technology innovation and bank performance might be explained by these reasons: bad management and failure to overcome resistance to change (dos Santos & Sussman, 2000), the over-ambitious objective while lacking experience in IT operation (Harris, 2001), and the long-term lag effect of cost on benefit (many years) and mismanagement (Gupta et al., 2018). However, due to competitive reasons, the bank must join the race to increase investment in technology innovation for digital transformation (Elsaid, 2021; Glushchenko et al., 2019; Gupta et al., 2018; Paulet & Mavoori, 2019).

As mentioned in fintech history, disruptive technology plays the role of digital transformation in the banking industry. In the trend of fintech adoption in the finance industry, the banks must increase bank investment in technology innovation if they do not want to be behind others, especially compared with the fintech companies in the retail banking market and farther in the whole market. In Vietnam, according to Austrade (2020), Dang and Pham (2021), FintechSingapore (2020), and SBV (2019, 2020), the commercial banks have been investing in emerging technologies, but it seems to be not sufficient to enhance bank competitiveness and improve bank performance in the digital era. Based on that, it might be the existence of a productivity paradox in the Vietnamese banking industry.

3 RESEARCH DESIGN

Based on the literature review above, this section provides the research problems, goals, research questions, objectives, and hypotheses about the effect of the fintech industry and bank performance in Vietnam.

3.1 Research problems

Based on the literature review and the context of the Vietnamese fintech industry, I am concerned about the *"How does the fintech industry affect bank performance in Vietnam?"*. This problem can be detailed in three dimensions:

- *Whether the effect of fintech company growth on the financial, customer, internal process, and learning and growth perspectives of bank performance*
- *Whether the effect of fintech popularity on bank stock return*
- *Whether the effect of bank investment in technology innovation on bank efficiency*

3.1.1 Fintech company growth and bank performance

In performance measurement, the multi-dimensional approach is more highly appreciated than the conventional approach to financial performance. In the performance measurement field, some multi-dimension methods are famous. For example, Keegan et al. (1989) mentioned the balance between internal and external and financial and non-financial measures, Cross and Lynch (1989) focused on the pyramid model, Brignall et al. (1991) proposed the approach to determinant and result factors, Kaplan and Norton (2005) proposed the Balanced Scorecard, and Neely et al. (2002) suggested the performance prism. Based on the number of citations, the BSC of Kaplan & Norton has evaluated the best framework. The number of citations of these approaches is shown in **Table 3.1**.

Table 3.1 shows that the original publication involving the BSC reached over 28,000 citations, more often (over 12 times) than the performance prism, the second-highest citation. The third is the determinant & result with 1,594 citations; next is the balance between internal & external measures, financial & non-financial measures (1,121 citations), and the pyramid (87 citations). It is significant proof that the BSC is the best approach to performance measurement, applied widely in academics and practice.

The BSC was first introduced in 1992, which helped the manager evaluate all critical ingredients of firm performance, which allowed to promote the firm's

bright prospects. After the paper in 1992, a series of relevant publications were published to complete the BSC approach, namely Kaplan and Norton (1996, 2000, 2001, 2005). The BSC contributed a comprehensive view regarding four perspectives (financial, customer, internal process, and learning and growth) of firm performance for managers.

Table 3.1 Multi-dimensional approaches to performance measurement

No.	Authors	Article	Approach	Citations
1	Keegan et al. (1989)	Are your performance measures obsolete?	The balance between internal & external measures, financial & non – financial measures	1,121
2	Cross and Lynch (1989)	Accounting for competitive performance	The pyramid	87
3	Brignall et al. (1991)	Performance measurement in service business	The determinant & results	1,594
4	Kaplan and Norton (2005)	**The balanced scorecard – measures that drive performance**	**The Balanced Scorecard**	**28,108**
5	Neely et al. (2002)	The performance prism: The scorecard for measuring and managing business success	The performance prism	2,203

Source: Google Scholar, date 22 Nov 2021

Customer is the critical perspective discussed by most Kaplan and Norton publications. The customer perspective consists of these ingredients: time, quality, performance and service, and cost. Customer satisfaction is highly appreciated to measure the customer perspective. The speed from receiving orders to customers having products or services linked to the time ingredient. On-time delivery and product quality are associated with quality ingredients. The price of a product or service plays a critical role in the cost ingredient, which creates the customer's value.

The internal process perspective is established based on the customer perspective to meet customer needs. The internal process perspective includes cycle time, quality, and productivity, which significantly affect employee activities.

The firm’s value and survival probability depend on the learning and growth perspective. In the intense global competition, learning and growth abilities enhance firm performance through staff knowledge, skill, and satisfaction, which are significant factors in improving the product, launching new products, creating more value, invading new markets, etc.

The financial perspective is the brief performance of other perspectives (as mentioned above), consisting of conventional financial indicators, such as profitability, growth, and shareholder value. These indicators reflect the outcome of the backward-looking but do not mention the present and future value-creating actions. However, these are meaningful to control the operations typically.

Furthermore, I found that the BSC has been used for many studies in the finance field. Kim and Davidson (2004) applied the BSC to evaluate the performance of

Korean banks and investigated the effect of IT expenditure on bank performance. Davis and Albright (2004) studied US banks' BSC implementation and its impact on financial performance. Al-Dweikat and Nour (2018) determined the success factors of the BSC and its effect on Jordanian banks. Other applications of the BSC are found in studies by Al-Alawi (2018), Tuan (2020), Wu (2012), and Wu et al. (2009).

A few relevant studies find the BSC application in the relationship between fintech and financial institutions. First, Pérez et al. (2017) applied the integration Analytic Hierarchy Process and BSC to evaluate the performance of Spanish financial software factories facing challenges of fintech development. The results determined the critical factors which are valuable for evaluating firm performance. However, the research entity is entirely a software company (non-financial institutions) that provides financial technology solutions for financial institutions. Hence, the study does not reflect the effect of fintech on banks under the BSC approach. Second, Subanidja et al. (2022) partly applied the BSC to assess the role of fintech companies on sustainable bank performance in the competitive advantage in Indonesia. The findings show that fintech companies, directly and indirectly, influence bank performance in general, but they did not focus on the specific perspective of the BSC. Besides, the study by Subanidja et al. (2022) collected data through distribution by email. The findings show the technological role has been increasing, but it has also created many challenges for the incumbent, namely, adaptation capability and quality human resources. However, I argue that a survey by email is insufficient, especially collecting informants' expressions/opinions about the effect of fintech on banks. One of the critical challenges is a cybercrime in the banking industry.

Using the BSC, Akinbowale et al. (2020) took a literature survey to analyze the effect of cybercrime on bank performance. The findings provided that, in line with fintech development, cybercrime negatively influences bank performance, especially in the level of trust. The study mentioned the link between fintech and banks, but it was a pure review study, which did not reflect the bank managers' opinion about the effect of fintech on bank performance. Besides, it presented a small part of fintech (cyber-crime) on bank performance. I argue that an expert survey about the effect of fintech on four perspectives of bank performance will be sufficient. Another study by Al-Busaidi and Al-Muharrami (2021) investigated the impact of information and communication technology (ICT) investment on bank performance by the BSC approach in Oman. The findings showed that ICT investment positively affects the other three perspectives (customer, internal process, and learning & growth) of bank performance beyond the financial indicator.

Consequently, based on four perspectives (financial, customer, internal process, and learning and growth) of the Balanced Scorecard, I am concerned

about "*Whether the effect of fintech company growth on the financial, customer, internal process, and learning and growth perspectives of bank performance*."

3.1.2 Fintech popularity and bank performance

Based on the existing publications about fintech, I recognize that fintech measurement is diverse in the academic field. There are many ways to measure the fintech variable. For example, Cheng and Qu (2020) used the text mining method to measure the bank fintech variable in China. The Institute of Digital Finance collected relevant information about financial innovation and activities that relied on disruptive technology in 31 provinces in China from 2011 to 2018. The report included the fintech index, which was disclosed and used for academics and policymaking. The study by Sheng (2021) used the fintech index to investigate its effect on the bank credit provision of firms. Besides that, for exploring the relationship between fintech and bank performance, the fintech variable is measured by the number of the fintech company (Phan et al., 2020), the fintech funding frequency, and the fintech funding value (Asmarani & Wijaya, 2020).

Furthermore, another perspective of the fintech variable is also found. For example, Dranev et al. (2019) provide the fintech M&A variable, which expresses the merger and acquisition of related firms in the fintech sector. Li et al. (2020b) defined and categorized fintech firms and financial institutions on the US stock market, then the risk spillover between the two entities was investigated. According to Hornuf et al. (2020), the bank-fintech alliance variables encompass the number and kind of alliances.

There is a significant link between internet search data and socioeconomic issues (Mellon, 2013, 2014). Google is the most powerful search engine on the globe. Google search data is more advanced than survey data in terms of cost and data availability. Besides, the Google search data is continuously updated (hourly, daily, weekly, monthly, and yearly), sorted, and ranged by time and region. When querying specific keywords on Google Trend, the time series of the volume of searching keywords is shown, called the Google searching volume index (GSVI). The scale of GSVI is from 0 (zero) to 100, which indicates the frequency of capturing keywords from lowest to highest. Based on that, the socio-economic issue is often measured by GSVI, and it has been popular in academics. For example, Mellon (2014) provided that Google search is a valuable tool to measure the issue of fuel prices, the economy, immigration, and terrorism in the US. Besides, the power of Google search is valid (Burivalova et al., 2018; Nghiem et al., 2016; Troumbis & Iosifidis, 2020)016; Troumbis & Iosifidis, 2020) in the prediction of COVID-19 (Ayyoubzadeh et al., 2020; Husnayain et al., 2020; Lin et al., 2020), and other various fields including finance field.

Li et al. (2021), Zhang and Tang (2016), and Huang et al. (2020) agreed that the search engine is an interesting measure to reflect popularity issues regarding financial assets in finance research. It measures public attention popularity in cyberspace through search volume. Utilizing Google search to calculate investor attention and estimate the volatility of financial assets has attracted many scholars. There is a negative relationship between Google search volume and stock returns in the US market from 2008 to 2013 (Bijl et al., 2016) and in the Philippines, Thailand, and Vietnam markets from 2009 to 2016 (Nguyen et al., 2019). In contrast, in 2012-2017, Ekinci and Bulut (2021) and Swamy and Dharani (2019) found a positive impact of Google search on returns of BIST 100 stocks and the Indian market, respectively. However, in Norway, Kim et al. (2019) stated this relationship is insignificant for the sample of 28 firms from 2012 to 2017. Besides the stock returns side, other financial assets are also investigated in connection with Google searches, such as foreign currency (Smith, 2012), cryptocurrency (Kristoufek, 2013; Qadan & Nama, 2018), fossil energy (Qadan & Nama, 2018), and commodity market (Bahloul & Bouri, 2016).

Following the fintech industry development, the fintech products such as mobile payment, peer-to-peer lending, etc., have become popular financial products in the digital era. Based on the fintech platforms in cyberspace, the fintech products are provided to the customers without physical branches like the banks. All features of fintech products, as well as usage instructions, are available on the servers. Thus, customers or clients must search the internet to find information about fintech products. Based on that, I argue that the volume of searching “fintech” and other related-fintech keywords might express the fintech development or fintech popularity from the lens of cyberspace. Therefore, in this study, I define fintech popularity as the attention of internet users on the fintech issue, which is measured by Google search. Besides, to the best knowledge, using Google search to measure fintech popularity is rare in academics. Thus, in this study, I propose that the Google search of fintech-related keywords measures the fintech popularity variable.

On the global, many quantitative studies about the link between fintech and stock return are estimated in various ways. Using the event window approach, Dranev et al. (2019) investigated the relationship between fintech M&A and abnormal stock return of companies in the US, Canada, Europe, China, and India. The results showed that fintech is a positive factor in abnormal stock returns in the short term but is not a significant factor in the long term. Besides, the authors also found that the returns of companies in developed countries are higher than in developing countries. Apply the same method as Dranev et al. (2019) for the Chinese bank stock price; Zhang and Zhuang (2020) found the release of fintech events increases bank stock return in the short term. In the USA, the link between the fintech stock returns variable and financial institutions' stock return variable has been found by Li et al. (2020b) via the risk spillover approach of Granger

causality. The findings show that the risk spillovers between the two variables are various tails (left, right, and central tails). Still, in the downstairs period (left tail), the spillovers are stronger than other tails, and there is a positive effect of the fintech variable on financial institutions' stock prices. Next, regarding the spillovers between fintech and financial institutions, Li et al. (2020b) used the spillovers approach to indicate a more significant effect from return and volatility of banks to fintech than the opposite direction. Li et al. (2017) employed the capital asset pricing model of three and five factors for estimating the impact of fintech on incumbent retail bank stock return in the USA from 2010 to 2016. The results showed that the fintech variable is a positive factor in bank stock return, but the effect is light. Besides, the authors discussed that fintech is not a threat to incumbent banks in the sample period, but in the future, the position of fintech will be changed quickly. Following Li et al. (2017), Asmarani and Wijaya (2020) found that fintech does not influence retail bank stock return in the Indonesian market, an emerging country.

Furthermore, many quantitative studies confirmed the significant relationship between fintech and banks, especially bank performance, which might influence bank stock performance. I argue that it is also a substantial reference to the relationship between fintech and bank stock prices. In detail, the rise of fintech decreases bank profitability (Phan et al., 2020; Zhao et al., 2022). The credit supply to SMEs is increased by the fintech development (Sheng, 2021). U-shaped is the pattern of fintech and bank risk-taking (Wang et al., 2021a). Fintech increases customer satisfaction, employee work efficiency (Chen et al., 2021b), and other interesting studies.

Consequently, based on these arguments above, I am concerned about "*Whether the effect of fintech popularity on bank stock return*."

3.1.3 Bank investment in technology innovation and bank efficiency

The rise of fintech is the technological innovation in the finance sector (Beck et al., 2016). Technological innovation mainly regards the software which supports the bank to increase performance (Arthur, 2017; Campanella et al., 2017; Scott et al., 2017). Following the bank fintech definition, which was proposed by Cheng and Qu (2020), Pham et al. (2021b), and Thakor (2020), bank fintech regards the utilization of information technology of the traditional financial institution to optimize the performance. Now, bank fintech is a significant link to bank investment in technology innovation. Thus, I argue that measuring bank fintech by bank investment in technology innovation is an appreciated choice.

Many publications investigate the link between bank technology innovation and bank performance. Based on the data from 444 Ghanaian bank branches, Appiahene et al. (2019) evaluated that BITI levels up the bank performance, but

the effect of BITI on the performance of deposits is insignificant. Relying on the data from the opinion of 417 bank managers in Nigeria, Ringim et al. (2015) found a positive relationship between BITI and bank performance. Gathering data from 3,190 banks in 17 countries from 2008 to 2011, Campanella et al. (2017) provide that the bank software system significantly affects banks in various aspects. There is a negative link between technology innovation and financial leverage. However, the bank software regarding planning and credit management is a positive factor in enhancing bank performance in competition capability.

Furthermore, using the data of 6,848 banks in 29 countries in Europe and the Americas from 1977 to 2006, Scott et al. (2017) indicate that technology innovation is a positive driver of profitability in the long term. However, small banks utilize technology innovation to enhance profitability better than large banks. Investigating the influence of technology innovation on the performance of 737 European banks in 1995-2000, Beccalli (2007) showed a profitability paradox. The technology innovation solution from external providers is better for increasing profit and efficiency than the acquisition of technology solutions by the banks. Besides, the aspects of the relationship between BITI and performance in commercial banks are investigated by many scholars in various countries. For example, Mustapha (2018) showed that bank performance is better after adopting electronic payment technologies. In India, Arora and Arora (2013) found a positive effect of BITI on operating profit and profit per employee. Shu and Strassmann (2005) found that the BITI provides a higher profit with marginal products for the US banks. Also, in the USA, Pierri and Timmer (2022) indicated the critical role of technology in monitoring loans, which is the key factor in performance improvement. Overall, these studies are significant in providing comprehensive knowledge about the effect of technology innovation on bank performance. However, most studies focus on developed countries with advanced technology development; thus, I am concerned that this relationship in developing countries like Vietnam might be different. This thesis argues that it is the gap and must be investigated to fulfill the missing knowledge. Besides, according to my best knowledge, relevant studies in emerging countries like Vietnam seem to be rare. Therefore, conducting quantitative research to investigate the effect of BITI on bank performance in Vietnam is necessary.

Bank efficiency is one of the measures of bank performance. According to Gupta et al. (2018), there are two ways of measuring efficiency: parametric and non-parametric. Stochastic Frontier Analysis (SFA) represents the parametric approach, while the non-parametric is meant Data Envelopment Analysis (DEA). The debate about the best method between SFA and DEA is still ongoing in academics. I find many publications about using SFA and DEA for measuring bank efficiency. For example, DEA is used by Owusu Kwateng et al. (2019), Paradi and Zhu (2013), etc. whereas Luo et al. (2016), Beccalli (2007), Doan et al. (2018), etc. applied the SFA for measuring bank efficiency. The appropriate

functional form and the factors of function form are the critical requirements of the SFA method. According to my knowledge, there is a lack of studies about determinants of Vietnamese bank efficiency, leading to poor proxies for measuring efficiency by the SFA method. DEA was initially proposed by Charnes et al. (1978); it has become famous and applied in academic and practice fields. It uses mathematical programming to measure efficiency. Staub et al. (2010) stated that the DEA is an easy technique to deal with multiple factors and is the most used technique. Therefore, in this thesis, I aim to apply the DEA approach to measuring bank efficiency in Vietnam.

Consequently, I am concerned about "*Whether the effect of bank investment in technology innovation on bank efficiency*."

3.2 Research goals

The main goal is to "*evaluate the effect of the fintech industry on bank performance*" in Vietnam. The specific research goals are:

- *RG1: Evaluate the effect of fintech company growth on financial, customer, internal process, and learning and growth perspectives of bank performance*
- *RG2: Estimate the effect of fintech popularity on bank stock return*
- *RG3: Estimate the effect of bank investment in technology innovation on bank efficiency*

First, the four perspectives of the BSC approach are employed to evaluate the effect of fintech company growth on bank performance by conducting a qualitative study through semi-structured interviews. The fintech company is an essential part of the fintech industry in the digital era; thus, the growth of fintech companies through increasing the number of fintech companies, fintech transaction value, and fintech users significantly affects bank performance. I aim to conduct qualitative research to provide knowledge regarding this effect.

Second is the argument about using Google search to measure the internet user's attention to fintech, which proxy the fintech popularity variable. Following that, the investigation of the effect of fintech popularity on bank stock return is conducted. Due to the outcome of the Google search being time-series data, I formulated the time-series model, which is used to estimate the effect of fintech popularity on bank stock return.

Third, following the bank fintech definition and the argument above, the bank fintech is possibly measured by bank investment in technology innovation. Besides, the usefulness of the DEA approach in measuring bank efficiency in

developing countries like Vietnam has been confirmed; hence, the third specific goal is to estimate the effect of investment in technology innovation and bank efficiency.

The results of three specific goals will provide a comprehensive about the effect of the fintech industry on bank performance from some perspectives. *First*, qualitative and quantitative studies are employed to conduct the thesis. The first specific goal is to achieve a qualitative study, while the two other goals are quantitative studies. *Second*, characteristics of the fintech industry are measured and used to evaluate their effects on bank performance. *Third*, bank performance is measured in various ways, namely by the BSC and DEA approaches and bank stock returns, which differ from the conventional financial indicators approach. *Finally*, the time series and panel models are employed for the investigations.

3.3 Research questions

The main research question is "*How does the fintech industry affect bank performance?*". Following these mentions above, three specific research questions are proposed:

- *RQ1: How does fintech company growth affect financial, customer, internal process, and learning and growth perspectives of bank performance?*
- *RQ2: How does fintech popularity affect bank performance?*
- *RQ3: How does bank investment in technology innovation affect bank performance?*

3.3.1 Fintech company growth and bank performance

According to the BSC approach, there are four perspectives of firm performance: financial, customer, internal process, and learning and growth. The existing publications regarding the relationship between fintech companies and commercial banks' financial perspectives confirm that it is heterogeneous. *Firstly*, from a financial perspective, Phan et al. (2020) and Zhao et al. (2022) found a negative relationship between fintech and bank performance, while Frame et al. (2018), Lee et al. (2021), and Li et al. (2017) confirmed its relationship is positive, and Asmarani and Wijaya (2020) stated that fintech company growth did not influence bank performance.

Secondly, from a customer perspective, Addai et al. (2015), Alkhazaleh and Haddad (2021), and Pooya et al. (2020) stated that fintech has an optimistic effect on banks' customer satisfaction and loyalty and might increase bank service income. Siddiqui and Siddiqui (2020) and Siek and Sutanto (2019) stated that the

fintech companies provided high-quality products, which met the high customer demand in the digital era, while Baber (2020) gave that customer retention was not influenced by fintech.

Thirdly, the fintech company growth has created more opportunities and challenges for conventional banks in changing the internal process. Jagtiani and John (2018) stated that advantaged technologies create a new environment for banks in managing risk, especially regarding customer protection and maintaining financial stability. Alt et al. (2018), Puschmann (2017), and Vučinić (2020) provided that in the digital era, especially in the post-global financial crisis of 2008-2009, the fintech company is a critical factor that changed the internal processes regarding the system of risk management, appraisal, delivering products, evaluating customers and employees. However, how fintech company growth influences bank internal process is still an interesting topic in academics (Acar & Çıtak, 2019; Nicoletti, 2017; Zhuo et al., 2020).

Finally, from a learning and growth perspective, the high pressure of fintech companies requires bank employees must meet the new challenges of technological adaptation if they do not want to be sacked. Chen et al. (2021b) gave fintech enhances work efficiency, but it is high stress for bank employees in the new context of the technological innovation era. Besides adapting to the rise of fintech, Santoso et al. (2021) stated that human resource plays the most important role in the digitalization of banks. Besides employee satisfaction, training courses and workforce quality are the critical factors of the banking digitalization strategy.

Linking these arguments above with the context in Vietnam, I consider *"How does fintech company growth affect financial, customer, internal process, and learning and growth perspective of bank performance?"*.

3.3.2 Fintech popularity and bank performance

Based on the existing publications regarding the effect of the economic issue by Google search on stock price, the question of fintech and bank stock return is formulated. Nguyen et al. (2019) used the volume of Google search for stock tickers in the market of Vietnam, Thailand, Philippines, Malaysia, and Indonesia to measure the investor attention variable; then, its effect on stock return with basing on the asset pricing model of Fama and French is estimated. The findings show that the asset pricing model is not always effective, and a Google search might be a significant indicator to predict stock returns. In detail, Google search is a negative factor in stock return in Vietnam, the Philippines, and Thailand; investors are more sensitive to bad news than good news about the stocks.

Iyke and Ho (2021) examined the relationship between investor attention to Covid-19 by Google search and stock return in 14 African markets using the

EGARCH approach. The estimations gave that the rising global investor attention regarding Covid-19 is a predictive factor of stock return in the African markets. In detail, it decreases stock returns in Botswana, Nigeria, and Zambia, while it is a positive factor in stock returns in Ghana and Tanzania.

Regarding the political issue and stock market, de Area Leão Pereira et al. (2018) applied a Google search to measure Donald Trump's power indicator and its effect on stock markets. The findings provided the positive correlations between Trump's effect and the stock volatilities of Mexican, Japanese, Australian, and Brazilian markets are weak and moderate. The weak and moderate correlation between its impact and stock returns in the North American market is positive, and its effect in the Mexican market is negative.

Climate change is possibly computed by Google search volume on global warming, which significantly links to the stock price in the financial markets that the investors tend (Beatty & Shimshack, 2010; Choi et al., 2020). Furthermore, Smith (2012) found that Google search volume of keywords "economic crisis," "financial crisis," and "recession" might predict the volatility of foreign currency in the financial market.

Following these publications about the link between Google search and financial assets on the market, I formulate the question: *"How does fintech popularity affect bank stock return?"*.

3.3.3 Bank investment in technology innovation and bank efficiency

As I mentioned about fintech definition and fintech history, fintech is always to be in the bank, called bank fintech. Bank fintech might be understood as banking digitalization, which regards the bank investment in technology innovation. In recent years, especially post-GFC 2008-2009, the fintech start-up companies have dramatically grown, creating high pressure on banks in adaptation capability. Because of competition reasons, besides the strand of collaboration with the fintech companies, technology investment by the bank-self has been maintained as an influential strand in the adaptation strategy.

On the one hand, in the computer age, while most people believe that technology investment increases bank performance, Solow (1987) found a significant correlation between an increase in technology investment and a decrease in productivity, called the productivity paradox theory. Beccalli (2007) found the heterogeneous effect of different kinds of BITI on bank performance, namely outsourcing activities increase bank profitability and efficiency, while the acquisition reduces bank performance. By using the data from Indian banks, Gupta et al. (2018) confirmed the presence of the profitability paradox, which is also consistent with the findings of Harris (2001) and Shu and Strassmann (2005).

On the other hand, BITI accelerated customer digitalization through online banking (Carbó-Valverde et al., 2020). Ringim et al. (2015) provided that bank technology innovation capability enhances bank performance by reducing operational costs and increasing customer service management and process efficiency. In Ghana, Appiahene et al. (2019) found that BITI plays a critical competitive tool in the finance market, which increases overall performance, but it seems to be not effective with deposits and loans. The investigation of bank technology innovation in 17 countries in European by Campanella et al. (2017) stated that technological innovation in the planning and credit risk management software is negative with the leverage, but it positively influences bank competencies, abilities, and organization system. Besides, technological innovation increases bank profitability. In EU-28, del Gaudio et al. (2021) found that disruptive technologies improve bank performance and financial stability.

Following these arguments above, I formulate "*How does bank investment in technology innovation affect bank performance?*".

3.4 Research objectives

To answer the research question and especially achieve the research's main aim, the research objectives are set as follows:

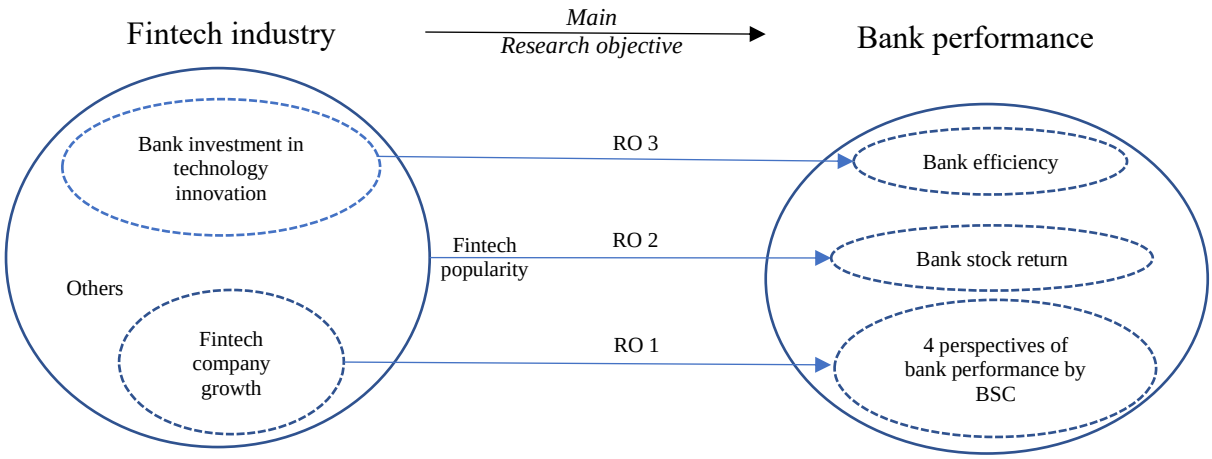


Figure 3.1 Research objectives

Source: The author

RO1: To evaluate the effect of fintech company growth on financial, customer, internal process, and learning and growth perspectives of bank performance

RO2: To estimate the effect of fintech popularity on bank stock return

RO3: To estimate the effect of bank investment in technology innovation on bank efficiency.

3.5 Research hypotheses

Depending on the protocol undertaken, there are three kinds of hypotheses (Toledo et al., 2011). First, based on the observation, the non-directional or inductive hypothesis is proposed, which does not show the exact direction between variables. Second, deriving from the existing theory, the directional or deductive hypothesis shows the expected direction between variables. Third, the null and alternative hypotheses are based on the statistical view.

The first research goal is conducted by qualitative study; thus, the relevant hypothesis is not formulated. However, I will present my observation to provide insight into the effect of fintech company growth on four perspectives of bank performance. The hypothesis involving the effect of fintech popularity on bank stock return is developed based on consumer and disruptive innovation theories. Based on existing publications and the obvious, the hypothesis regarding the effect of BITI on bank efficiency is developed.

3.5.1 Fintech company growth and bank performance

According to the reports by SBV (2019, 2020) and Statista (2021a, 2021b), in recent years, fintech has been dramatically growing in Vietnam. In detail, it is the sharp rise of fintech start-up companies, fintech users, fintech transactions, and fintech internet infrastructure. The products of fintech companies meet customers' demands, especially young citizens, who are always connected to the internet. However, the collaboration between banks and fintech is an inevitable trend. Most commercial banks are engaging with at least one of the fintech companies. For example, the cooperation between VIB and Fintech Weezi creates the MyVIB keyboard, a mobile application that provides the mobile transfer of money via social networks; Techcombank allies with Fintech Fastacash; VietinBank and Opportunity Network, etc. These collaborations bring more benefits to the banks in enhancing competitiveness and income.

According to my observations, in Vietnam, the collaboration between banks and fintech is being followed by the concept of Bömer (2020) and Hoang et al. (2021). It is presented in **Figure 3.2**.

Besides, **Table 3.2** shows that the earnings before taxation of 27 commercial banks in 2021 will increase by over 46,807 billion VND (an increase of 31%), especially regarding the dynamic banks such as Techcombank, MB, SeABank, and MSB. These banks are proactive in adapting to the rise of fintech. Based on that, I argue that when the rise of fintech is a positive factor in bank performance via the mechanism of collaboration between banks and fintech.

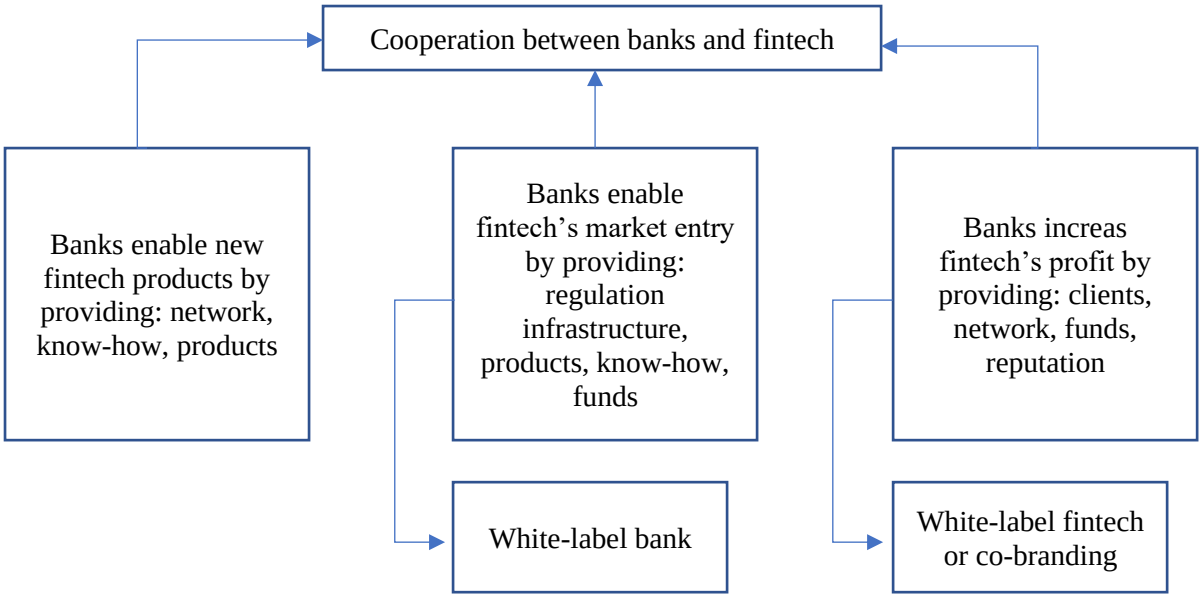


Figure 3.2 The collaboration between banks and fintech companies

Source: Bömer (2020)

According to my observation through reading fintech news on social media, in the short term, the fintech development is a fear for banks and investors that might negatively influence bank financial indicators, especially regarding market indicators. However, following the fintech history, as I mentioned, fintech was born to correct the fault of the financial institutions and make them more efficient; thus, in the long term, fintech is a positive factor for banks which might increase bank financial indicators. In this thesis, when the survey is conducted in Vietnam, I expect that the experts will feel the positive effect of fintech on bank financial performances, including internal financial and market indicators.

Table 3.2 Earning before taxation of banks in Vietnam

No.	Bank	EBT (Billion VND)		2021/2020		No.	Bank	EBT (Billion VND)		2021/2020	
		2021	2020	Value	%			2021	2020	Value	%
1	Vietcombank	27,238.7	23,049.6	4,189.1	18.17	15	Sacombank	4,400.0	3,339.3	1,060.7	31.76
2	Techcombank	23,238.4	15,800.3	7,438.1	47.08	16	LienVietPostBank	3,639.0	2,426.5	1,212.5	49.97
3	VietinBank	17,589.0	17,119.8	469.2	2.74	17	SeABank	3,268.5	1,407.9	1,860.6	132.15
4	MB	16,257.3	10,688.3	5,569.0	52.10	18	ABBank	1,958.8	1,403.2	555.6	39.60
5	VPBank	14,580.4	13,019.4	1,561.0	11.99	19	Nam A Bank	1,799.1	1,005.5	793.6	78.93
6	Agribank	14,000.0	13,202.0	798.0	6.04	20	Eximbank	1,205.1	1,339.5	-134.4	-10.03
7	BIDV	13,601.6	9,026.2	4,575.4	50.69	21	KienlongBank	1,010.0	153.4	856.6	558.41
8	ACB	11,998.1	9,595.9	2,402.2	25.03	22	Bac A Bank	908.4	734.8	173.6	23.63
9	HDBank	8,069.6	5,818.2	2,251.4	38.70	23	VietABank	844.1	407.5	436.6	107.14
10	VIB	8,011.1	5,803.0	2,208.1	38.05	24	PG Bank	329.3	212.2	117.1	55.18
11	SHB	6,224.2	3,268.0	2,956.2	90.46	25	BanVietBank	311.2	201.3	109.9	54.60
12	TPBank	6,038.3	4,388.5	1,649.8	37.59	26	SaigonBank	154.1	121.1	33.0	27.25
13	OCB	5,518.6	4,417.4	1,101.2	24.93	27	NCB	2.3	3.7	-1.4	-37.84
14	MSB	5,088.5	2,523.3	2,565.2	101.66		**Sum**	**197,283.7**	**150,475.8**	**46,807.9**	**31.11**

Note: EBT demotes Earning before taxation
Source: https://vietnambiz.vn/top-10-ngan-hang-co-loi-nhuan-cao-nhat-nam-2021-20220211073105986.htm (Accessed 27 June 2022)

Nowadays, fintech products are delivered via mobile devices (mainly smartphones), which meet customers' demands and might replace conventional

banking products. However, young customers are more proactive with fintech products, while older customers and staying rural face more challenges when using the advanced products of the fintech companies. Facing fintech development, commercial banks have changed how they deliver their products. According to my observation, many mobile banking applications have been launched and met the requirements of the new competitive environment. For example, the F@st Mobile, VCB Digital Bank, VietinBank iPay, etc., with free-of-charge service for all transactions, are accepted to use by the customers. Based on that, I believe that under the pressure of fintech development, bank customers are more satisfied with current banking products, especially those delivered through mobile banking applications.

Following the purpose of improving customer satisfaction and meeting new customer demands, the fintech development put the bank to new challenges of enhancing the bank's internal process procedure effectiveness. The fintech companies have applied disruptive technologies for risk management, operation system, credit appraisal, and productivity, which has attracted banks to participate in the digitalization race. I believe the race to upgrade and alternative the core-banking system will bring more benefits for banks than in previous versions.

Human resource quality is a key success factor in disruptive technology applications in banks. The bank staff must have new knowledge and skills to adapt to the new digital era of the finance market. In my observation, the training courses are often held by the bank's internal training center. Knowledge regarding disruptive technologies and its implication is always a priority in training programs. Hence, I believe that fintech brings new opportunities to learn new knowledge for bank employees. However, it also creates high pressure, which might negatively link to employee satisfaction regarding adaptation capability.

3.5.2 Fintech popularity and bank stock return.

I plan to measure the fintech popularity variables by employing Google search. Fintech-related keywords are extracted through Google Trend, a tool to record the search volume of Google. Besides, the magnitude of the keyword search index might show the aggregation variables' unique characteristics. Therefore, before formulating the hypotheses regarding fintech popularity and bank stock return, the fintech-related keywords family is proposed for extraction.

Based on 156 submitted proposals to the open call special issue on 15 Jan 2017 on Review of Financial Studies (RFS), Goldstein et al. (2019) provided the main topic areas among the emerging field of fintech in the digital era. They are big data, blockchain, crowdfunding, peer-to-peer lending, robot advisors, social media, and others. It can be seen that most topic areas link to emerging technologies, namely big data, blockchain, and robot advisor, while there are two

areas of the fintech business model that are less paid attention to by scholars. However, before 2017, peer-to-peer lending was the best highlighted in the fintech research. Besides, the word cloud from the abstracts gave that the term "fintech" is the highlighted keyword in this interesting field.

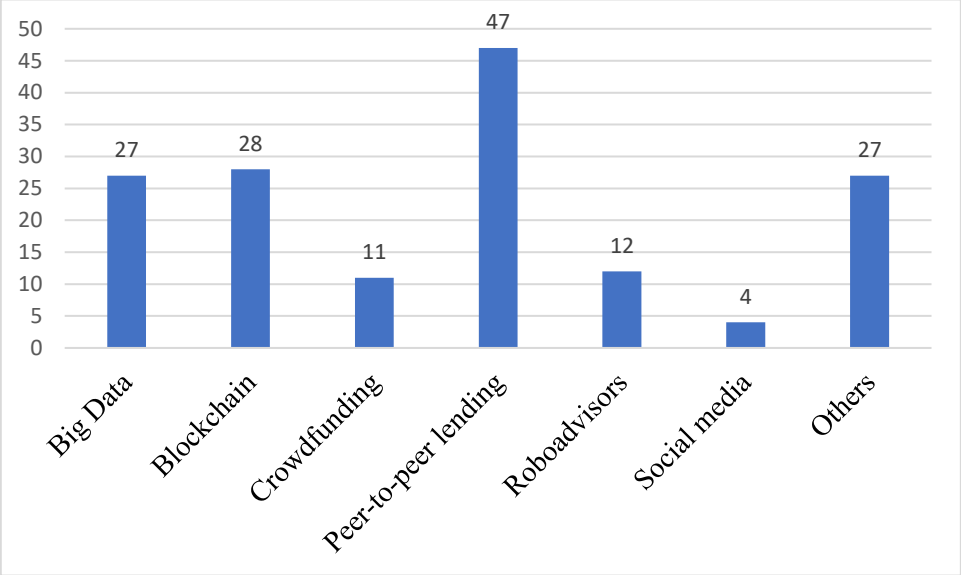


Figure 3.3 Main topics among the proposals for the RFS

Source: Goldstein et al. (2019)

Furthermore, the fintech-related keywords might be validated by the fintech categorization. Lee and Shin (2018) stated that fintech has redefined using conventional banking products for saving, lending, borrowing, and transferring money. The fintech startup companies are established and operated with different business models: payment, wealth management, crowd-funding, lending, capital market, and insurance. These terms are more common in social life when mentioned about fintech companies. Besides, Lee and Shin (2018) provided that the peer-to-peer platform, barcode (QR code), and near-field communication are the critical technologies for the sharp development of the payment business model.

Another study by Gomber et al. (2017) provided three dimensions of the digital finance cube: technologies, institutions, and business models (see more detail in **Figure 3.4**). Although digital technologies and institutions are also discussed and suggested for further research, the business models seem to be paid more attention to because they are the fintech industry's front face. Fintech business models stick with advanced products, which fix the gaps of conventional bank products and become familiar in social life. Besides, based on the study by Alt et al. (2018) and Puschmann (2017), although different dimensions might show fintech, it provides advanced products to customers. Hence, these keywords regarding the fintech business model and fintech products are regularly searched on the internet, a

significant channel to provide fintech knowledge to the customer in the digital era.

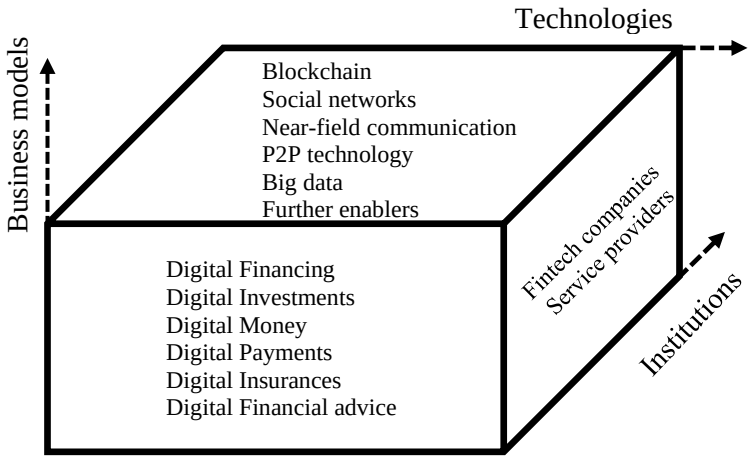


Figure 3.4 Three dimensions of the digital finance cube

Source: Gomber et al. (2017)

According to the reports by Statista (2021a, 2021b) and UOB (2020, 2022), payment and P2P lending are the two largest segments of the fintech industry, while others are not popular in Vietnam. It might be caused that Vietnam is a developing country; most people need primary banking products for payments and lending.

Following the arguments above, in this thesis, I selected the fintech-related keywords among the general fintech and the basis fintech products for extracting and formulating the fintech variables. In detail, three kinds of fintech popularity variables are established: fintech popularity in general, fintech popularity in payment, and fintech popularity in lending. Based on that, the hypotheses regarding the effect of fintech popularity on bank stock return are formulated.

As mentioned above, in Vietnam, I consider that the fintech industry development creates pressure for banks to improve bank performance, which might positively influence bank stock return. However, following Cheng and Qu (2020), Ruhland and Wiese (2022), Pham et al. (2021b), and Thakor (2020), the faster growing of fintech companies compared with conventional banks and the popularity of the fintech company products in cyberspace, I argue that the fintech popularity in cyberspace is contributed by highest weight of the fintech company development. Besides, fintech is very new in the digital era, while banking product is conventional; thus, through the behavior of search new information in cyberspace, internet users want to know how about term “fintech” and other fintech-related terms as well as how to use the fintech products (Pham et al., 2021b). Most related-fintech information mentions the fintech company and

fintech platforms. Based on that, I strategy to apply the consumer theory of Aaker and Keller (1990) and the disruptive innovation theory of Christensen (1997) for formulating the hypothesis regarding the effect of fintech popularity on bank stock return is developed based. These theories state that fintech companies apply disruptive technologies to provide innovative financial solutions. Fintech products play the role of alternative products in the finance industry and might change customer behavior, which is the reason for decreasing bank performance (Elsaid, 2021; Phan et al., 2020).

Besides, Almulla and Aljughaiman (2021), Beccalli (2007), Phan et al. (2020), and Thakor (2020) found a negative effect of the fintech industry on bank performance that leads to a decrease in bank stock return in the stock exchange market. Based on that, I propose the following:

H_1: There is a negative effect of fintech popularity on bank stock return.

Besides, the increase in the search volume of fintech payment and fintech lending keywords reflects fintech popularity in payment and lending, respectively. I argue that it decreases investors' optimism about bank stock prices. Therefore, I hypothesize that:

H_{1a}: There is a negative effect of fintech popularity in payment on bank stock return.

H_{1b}: There is a negative effect of fintech popularity in lending on bank stock return.

3.5.3 Bank investment in technology innovation and bank efficiency

As mentioned in the fintech history sub-section, BITI aims to enhance bank performance by reducing and monitoring costs and improving quality services. Technology innovation helps efficiency-enhancing in the finance sector, changes the traditional business model, and brings customers the best experience in banking transactions (Vives, 2017, 2019). Wang et al. (2021b) found evidence of the positive role of BITI in bank performance. In detail, utilized emerging technology improves competitiveness, service efficiency, and risk capability and reduces operating costs. Besides, Cheng and Qu (2020) revealed that bank technology innovation reduces credit risk, which supports improved bank performance. Banks apply disruptive technologies for collecting data and producing the scoring credit. Emerging technologies promote risk credit system management and increase bank diversification, which increases bank profits. Bank technology innovation improves banks' internal process management systems and business models (Demirguc-Kunt and Huizinga, 2010). Campanella et al. (2017) provided that banks can expand business models by adopting bank fintech, which increases bank performance. Dorfleitner et al. (2017) stated that

BITI helps banks to collect and analyze customer data regarding demographic and transaction history, which promotes bank effectiveness and reduces costs.

Besides that, following scanning most Vietnamese banks' annual reports and SBV's reports for 2019 and 2020, I explore that the main aim of bank investment in technology innovation is to enhance performance. Therefore, in this thesis, I propose that:

H_2: There is a positive effect of bank investment in technology innovation on bank efficiency.

3.6 Methodology

The methodology of the three studies is designed to explore the effect of fintech company growth, fintech popularity, and bank investment in technology innovation on bank performance.

The qualitative study is firstly designed to get insight into the effect of fintech company growth on bank performance by basing on the four perspectives of firm performance proposed by Kaplan and Norton (1996, 2000, 2001, 2005). Besides, following the argument above, I conduct two quantitative studies to provide experimental evidence. In detail, the second study aims to estimate the effect of fintech popularity on bank stock return, and the third study investigates the effect of BITI on bank efficiency. The main properties of the three studies are presented as follows:

3.6.1 Fintech company growth and bank performance

a. Application method

Following Marisova et al. (2021), the qualitative study highly appreciated the deeper and richer description, especially involving complicated and sensitive issues, such as evaluating the effect of new entrants' growth on the incumbents in the market. Besides, the qualitative approach is proper for collecting the data and opinions of hard-to-reach respondents, such as executives, directors, and governors. Qu and Dumay (2011) stated that an unstructured interview is an appreciated method when conducting a qualitative study regarding hard-to-reach respondents. Furthermore, El Ammar and Profiroiu (2020) provided that semi-structured interviews are valuable for collecting in-depth opinions of interviewees with experts and professional skills. Ryan et al. (2009) gave that semi-structured interviews allow to focus on open-ended queries instead of structured questionnaires. Based on these statements, to know how the effect of fintech company growth on the four perspectives of bank performance, the qualitative approach is employed by replying to the semi-structured interview. The platform for the semi-structured interview is designed as **Table 3.3**.

Table 3.3 Semi-structured interview platform

No.	Focus area	Questions and probes	Time
1.	Opening	*Introduce the interview and collect basic information about the interviewee*	
2.	Overview	1. In your opinion, what is a fintech company? 2. How is your evaluation of fintech company growth (regarding the number of companies, transactions, and users)? 3. What are the advantages and disadvantages of fintech company growth? 4. What is your opinion of the effect of fintech company growth on bank performance?	25-30 minutes
3.	Effect of fintech company growth on the financial perspective	1. What do you know about the financial perspective? 2. What are the ingredients of the financial perspective? 3. What is your opinion of the effect of fintech company growth on the ingredients of the financial perspective?	25-30 minutes
4.	Effect of fintech company growth on the customer perspective	1. What do you know about the customer perspective? 2. What are the ingredients of the customer perspective? 3. What is your opinion of the effect of fintech company growth on the ingredients of the customer perspective?	25-30 minutes
5.	Effect of fintech company growth on the internal process perspective	1. What do you know about the customer perspective? 2. What are the ingredients of the customer perspective? 3. What is your opinion of the effect of fintech company growth on the ingredients of the internal process perspective?	25-30 minutes
6.	Effect of fintech company growth on the learning and growth perspective	1. What do you know about the learning and growth perspective? 2. What are the ingredients of the learning and growth perspective? 3. What is your opinion of the effect of fintech company growth on the ingredients of the learning and growth perspective?	25-30 minutes
7.	Closing	*(friendly environment)*	

Note:
The consumed time is depended on the determined ingredients of the interviewee.
According to the determined ingredients, the interviewer will the responding questions

Source: The author

The semi-structured interview platform consists of seven parts. The first and final are the opening and closing parts, created in a friendly environment to promote a compelling and memorable interview. Part 2 is to go straight to the main topic of the interview, which relates to fintech literacy, evaluating fintech company growth (number of companies, transactions, and users), including its advantages and disadvantages, and its effect on bank performance. Part 3-6 link to the literacy and determinant factors of four perspectives of bank performance and evaluate the effect of fintech company growth on these factors.

The study focuses on the interviewees, who have in-depth knowledge of fintech and bank operations. *First*, bank managers have best practices and evidence-based practices in the banking industry and can provide valuable information about the effect of fintech company growth on bank performance. *Second*, lecturers

teaching finance and banking subjects often update their in-depth knowledge and experience in training and consultants. They understand the trend and relationship between fintech companies, bank operations, and performance. They are selected to interview because they have sufficient knowledge and experience in the banking industry, which is better than selecting interviewees randomly.

The purpose sampling is selected to interview to mitigate ambiguity and enhance confidentiality for the interviewees. The study chooses the interviewee who is suitable for the research and ready for the interview. All interviewees will be identified with the capital letter of the alphabet to boost their confidence and willingness to release in-depth information.

b. Manage the semi-structured interview

The semi-structured interview is conducted as follows. The orientation questionnaire is first designed. Then, to avoid rambling, causing a loss of time, and creating a readiness atmosphere for the interview, in January 2022, I phoned and emailed the potential interviewees to make an appointment. After a week, I received a reply from eight interviewees who agreed to arrange the time and place for a face-to-face interview. The semi-structured interview will be conducted in the interviewees' offices from February to April 2022. In each interview, the respondent and I discussed the fintech company and its effect on bank performance. Each interview takes about 2-3 hours. The detail regarding the interview is shown in **Table 3.4**.

Table 3.4 Information of interviewees

Res.	Job	Old	Gender	Exp.	Major	Date	Duration
A	Manager	34	Male	12	Finance and Law	12 - Feb	~150m
B	Manager	35	Male	10	Finance	20 - Feb	~170m
C	Lecturer	32	Male	9	Finance - Banking	27 - Feb	~140m
D	Manager	46	Female	22	Finance	5 - Mar	~130m
E	Manager	42	Female	20	Finance	12 - Mar	~150m
F	Manager	50	Male	25	Finance - Banking	19 - Mar	~160m
G	Lecturer	45	Female	18	Finance	26 - Mar	~160m
H	Manager	33	Male	10	Economic	3 - Apr	~120m

Managers work as directors and deputy directors of the bank branch.
Lecturers are researching and teaching finance-banking courses in universities.
Denote: Res. means the respondent; Exp. means experience.

Source: The author

Eight respondents consist of two lecturers (25%) and six bank managers (75%); the average age is 39.625 years old; the average experience is 16.75 years; and their major is regarding banking and economics, which indicates that the view of respondents is valuable and reliable. Regarding gender, 37.50% of females, while the male is 62.50%.

c. Orientation questionnaire

The pilot survey in January 2022 asked five bank managers about their fintech understanding by asking, *"In your opinion, what is fintech?"*. All respondents answered that fintech commonly regards fintech platforms, fintech apps, and fintech companies. Hence, designing the semi-structured interviews to evaluate the effect of fintech company growth on bank performance is highly appreciated. Following Arner et al. (2015), Lee and Shin (2018), Milian et al. (2019), Pham et al. (2021c), and Puschmann (2017) about fintech development, the growing number of fintech companies, fintech transactions value, and fintech users are selected to discuss in the interview.

Kaplan and Norton (1996, 2000, 2001, 2005) developed the Balanced Scorecard, which uses four perspectives of financial, internal process, customer, and learning and growth to evaluate firm performance. Following these perspectives, I designed the structured questionnaire to survey to save time and cost. This questionnaire is meant to help respondents (Min, 2016; Murry & Hammons, 1995). Besides, the survey's outcome is served for conducting the qualitative study; thus, the questionnaire criteria is designed as an open question, which helps the respondents feel confident to discuss and leave their opinions about the questionnaire items.

Following the existing publication of the BSC application for evaluating bank performance, the orientation questionnaire for conducting the survey is formulated. Kim and Davidson (2004) gave that the ingredients of the financial perspective aim to increase business performance and competitive advantage, namely enhancing revenues and improving cost, structure, and asset utilization. The ingredients of the customer perspective purpose to increase customer satisfaction and market share, namely increased customer loyalty, high customer retention & acquisition rate, low fees for using the bank's services, and no time limitation for using the bank's service. The increase of operational excellence and customer value consists of easy access to banking services, providing anytime, anywhere banking service, performing profitability analyses, innovative loan & deposit process, and effectiveness and efficiency in producing & delivering service, which are the targets of the internal process perspective. The improved employee efficiency and effectiveness target the learning and growth perspective, which includes providing customer information, broadening employee work skills, and providing more product information.

Yaghoobi and Haddadi (2016) used the traditional financial indicator regarding profitability to proxy the financial perspective, such as general profit, cash flow, return on investment, and economic value-added. Customer satisfaction, customer retention, new customer acquisition, market position, and market share are the targets of the customer perspective. The internal process perspective

relates to three main business processes' main internal chains: innovation, operation, and after-sale services. The learning and growth perspective criteria regarding human resource quality consist of employee satisfaction, continuity, training, and skills. Furthermore, following Al-Alawi (2018), Al-Dweikat and Nour (2018), Al-Najjar and Kalaf (2012), Davis and Albright (2004), Kim and Davidson (2004), Tuan (2020), and Yaghoobi and Haddadi (2016), the initial questionnaire with the critical ingredients of four perspectives is designed to discuss with the respondents. The orientation ingredients for the semi-structured interview are below:

- *Financial perspective: enhance revenues, improve cost structure and asset utilization, return on investment, economic value added, valuation, and service income.*

- *Customer perspective: increase customer loyalty, customer retention, new customer acquisition, low fees for using products, trust, reliability, and satisfaction.*

- *Internal process perspective: effective and efficient in producing and delivering products, internal value chain (innovation, operation, and after-sale service), and risk management.*

- *Learning and growth perspective: improve employee efficiency and effectiveness, training and skills courses, and IT knowledge.*

I believe the orientation questionnaire is highly appreciated, and it makes respondents pleased when conducting the interview. The answer and opinions of interviewees are used to determine the main ingredients of each perspective and then used for discussion about the effect of fintech company growth on bank performance.

d. Data processing

The notes are named, coded, and assigned based on the interview content. The data is then categorized based on the main parts (parts 2-6 in **Table 3.3**), which relate to evaluating fintech company growth, perspective literacy, and the effect of fintech company growth on ingredients of the corresponding perspectives. Then, the frequency analysis technique is employed to assess qualitative data. Besides, the effect of fintech company growth on ingredients is determined based on the case description. The ingredients are selected to discuss based on most interviewees' agreements (more than 50%).

3.6.2 Fintech popularity and bank stock return

a. Model and variable measurement

Based on the goal of using Google search to measure the fintech popularity variable to formulate the time-series variables, illustrate the fintech industry development within five years. Then, their effects are examined in the relationship with the bank stock return. The time-series model which demonstrates the effect of fintech popularity on bank stock return is formulated as below:

$$Return_t = f\left(fin_t^k\right) \quad (3.1)$$

Where, $Return_t$ is the bank stock return at time t; and fin_t^k is the kind of k of fintech popularity at time t.

Depending on the characteristic of variables, the specific models and suitable methods will be determined and applied for estimating the effect of fintech popularity on bank stock return. The estimation results will be used to validate the research hypothesis and discuss the effect of fintech popularity on bank stock return.

Fintech popularity variable

Before using Google Trend to extract the fintech popularity variables, I formulate the fintech-related keywords. The term "fintech" is the compound word of "finance" and "technology," which is very popular; thus, the keyword "fintech" and "finance technology" is compulsory. Besides, extending fintech-related keywords is also necessary; it will provide insight into the effect of fintech popularity on bank performance.

Table 3.5 Fintech-related keywords for extraction

Dimension	Keywords in English	Keywords in Vietnamese
Fintech in general	Fintech, financial technology	Công nghệ tài chính
Fintech payment	Mobile money, mobile payment, mobile wallet, e-money, e-wallet	Tiền điện tử, thanh toán di động, thanh toán online, ví điện tử
Fintech lending	Peer-to-peer lendings	Cho vay ngang hàng, cho vay online, cho vay đồng cấp

Source: The author

This study defines that the fintech-related keyword families relate to the fintech categorization. As I mentioned above, in the measurement fintech popularity variable and the context of fintech in Vietnam, the fintech-related keywords are selected by relying on the fintech industry and the two largest segments of the fintech industry. Depending to Goldstein et al. (2019), Lee and Shin (2018), Gomber et al. (2017), Anagnostopoulos (2018), Buchak et al. (2018), Milian et al. (2019), Alt et al. (2018), Wang et al. (2021a), Cheng and Qu (2020), Sangsavate et al. (2019), and Cao et al. (2021) and the opinion of three experts

about the Vietnamese finance industry (*three experts are the commercial bank manager, the fintech company chief, and the lecturer in the finance banking department of Can Tho University*), I determine 16 fintech-related keywords including both English and Vietnamese forms. English form consists of fintech, financial technology, peer-to-peer lending, mobile money, mobile payment, mobile wallet, e-money, and e-wallet. Vietnamese form encompasses công nghệ tài chính, cho vay ngang hàng, cho vay online, cho vay đồng cấp, tiền điện tử, thanh toán di động, thanh toán online, and ví điện tử, which are translated from the English form (see detail in **Table 3.5**).

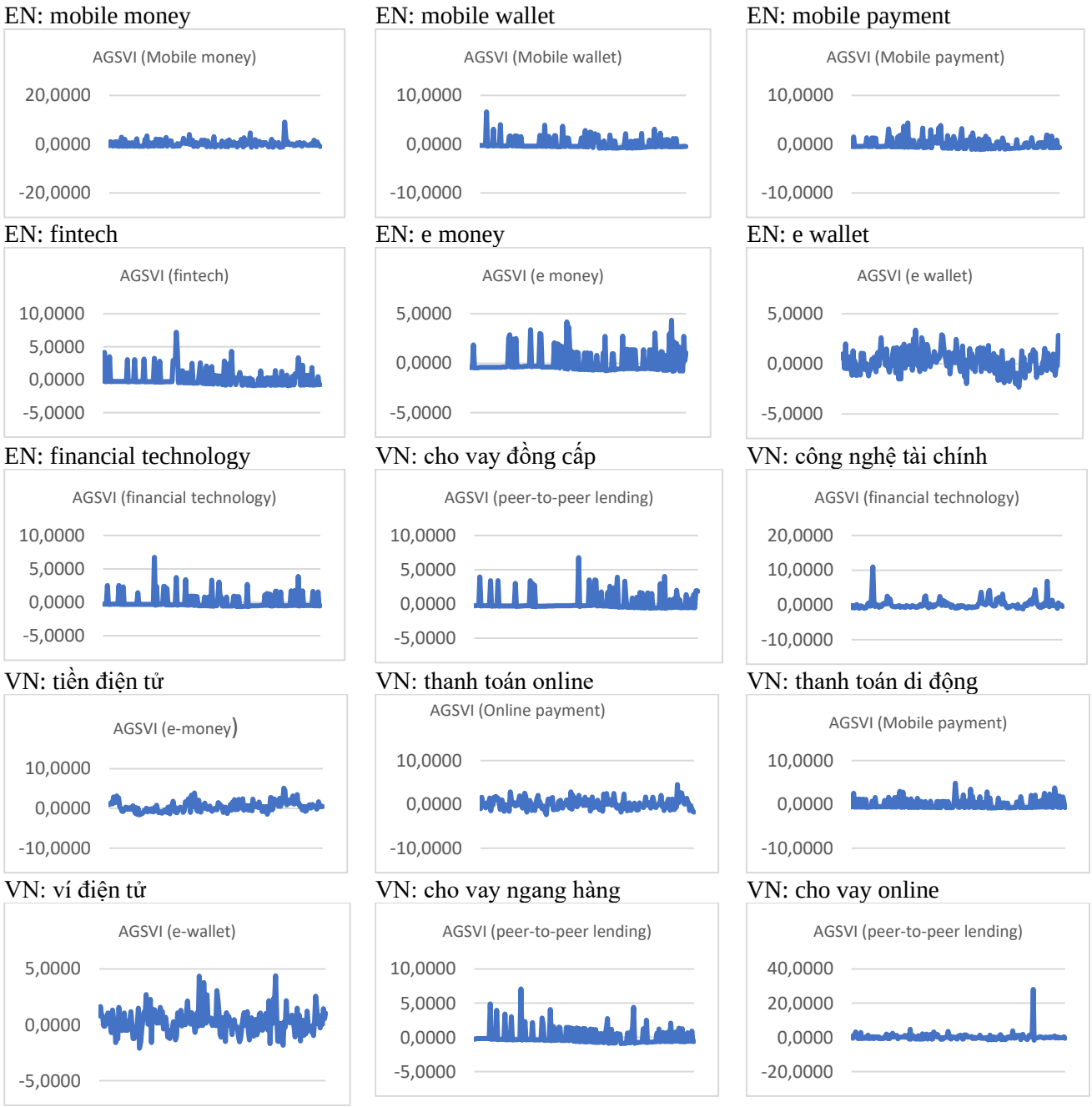
After that, the Google Search Volume Index (GSVI) of 16 keywords is collected from Google Trends from 2016w46 to 2021w46. The $GSVI^{peer-to-peer\ lendings}$ is near to none, which might be caused by the fact that the term peer-to-peer lendings are not favorite in Vietnam, or the term "peer-to-peer lending" does not popular; it is replaced by pure Vietnamese keywords, such as the term "cho vay ngang hàng," "cho vay online," and "cho vay đồng cấp." According to my observation, these Vietnamese keywords regarding P2P lending are often present in physical and virtual advertising campaigns, such as outside advertising and on social media networks. Thus, the $GSVI^{peer-to-peer\ lendings}$ is not considered for the next steps. The rest of the GSVI of the 15 keywords including the terms of "fintech", "financial technology", "mobile money", "mobile payment", "mobile wallet", "e-money", "e-wallet", "công nghệ tài chính", "cho vay ngang hàng", "cho vay online", "cho vay đồng cấp", "tiền điện tử", "thanh toán di động", "thanh toán online", and "ví điện tử" are valuable for the next steps.

Due to the value of GSVI depending on the period of downloaded data, the raw GSVI is not significant for analysis. Therefore, Bijl et al. (2016) and Kim et al. (2019) proposed the Average Google Search Volume Index (AGSVI) as an alternative. Motive from the survey by Bijl et al. (2016), Kim et al. (2019), and Huynh (2019), in this study, I apply $AGSVI_t^k$ equation of the GSVI at week t of keyword k with $\sigma_{GSVI_t^k}$ of the standard deviation of GSVI for the past 52 weeks for measuring the components of fintech popularity variables.

$$AGSVI_t^k = \frac{GSVI_t^k - \frac{1}{52}\sum_{i=1}^{52} GSVI_{t-i}^k}{\sigma_{GSVI_t^k}} \tag{3.2}$$

Next, motive from the study by Cheng and Qu (2020), the exploratory factor analysis (EFA) method is applied to reduce the number of fintech variables and confirm the significance of choosing keywords. The estimation result by EFA gives that (1) KMO = 0.501 > 0.5, Bartlett's Test = 128.619, and Sig. = 0.059 < 10% means the EFA is suitable for the data; (2) six eigenvalues are higher than one (eigenvalue closest and above is 1.092), and Cumulative = 0.522 indicates

that six significant factors might explain the change of 52.26% of 15 inputs ($AGSVI^{k}$). Due to this sample having 209 observations, we strategy to select the threshold of factor loading value absolute is 0.5 for determining the composition of the representative variables (Hair et al., 1998). The estimation shows that the $AGSVI^{mobile\ payment}$ does not meet the requirement; thus, it is not used for computing the representative variable value.



Note: EN = English; VN = Vietnamese

Figure 3.5 Movement of AGSVI fintech-related keywords

Source: The author

Based on 14 significant components, we determine that there are six kinds of AGSVI: $AGSVI^{wallet}$, $AGSVI^{money}$, $AGSVI^{fintech}$, $AGSVI^{product}$, $AGSVI^{lending}$, and $AGSVI^{product}$ with the respective components, as shown in **Table 3.6**. I argue that the classification matches the meaning of keywords and the current situation of the fintech industry in Vietnam.

Table 3.6 Factor loading value

Component	Represent variable or fintech popularity variable					
	fin^{wall}	fin^{mon}	$fin^{fintech}$	fin^{pro}	fin^{lend}	fin^{pay}
1 Mobile wallet	0.739					
2 E-wallet	0.582					
3 Mobile money		0.635				
4 Tiền điện tử* (mobile money)		-0.618				
5 Công nghệ tài chính* (financial technology)			-0.630			
6 Fintech			0.625			
7 Financial technology			0.590			
8 Thanh toán online* (online payment)				0.654		
9 E-money				0.619		
10 Cho vay ngang hàng* (peer-to-peer lending)				0.597		
11 Cho vay online* (peer-to-peer lending)					0.703	
12 Cho vay đồng cấp* (peer-to-peer lending)					0.680	
13 Ví điện tử* (e-wallet)						0.695
14 Thanh toán di động* (mobile payment)						0.549

GSVI of peer-to-peer lending is near zero, and AGSVI of mobile payment does not meet EFA requirements; thus, these are dropped.
** denotes Vietnamese form*
Source: The author

The value of representative variables is computed by the regression option on SPSS version 23. Besides, motive from the study by Cheng and Qu (2020), the value of the fintech popularity variables will be standardized from 0 (zero) to 1 (one) by the maximum-minimum processing, which consists of fin^{wall}, fin^{mon}, $fin^{fintech}$, fin^{pro}, fin^{lend}, and fin^{pay}. The characteristics of six fintech popularity variables are presented in **Table 4.2**.

Following six fintech variables (fin^{wall}, fin^{mon}, $fin^{fintech}$, fin^{pro}, fin^{lend}, and fin^{pay}), I argue that they are suitable for three hypotheses (H_1, H_{1a}, and H_{1b}) as formulated above. In detail, $fin^{fintech}$ and fin^{pro} are proxied for the fintech popularity with the suitable components (volume of searching keywords) of variables, namely $fin^{fintech}$ consists of the term "fintech," "financial

technology," and "công nghệ tài chính"; fin^{pro} encompasses the term "thanh toán online," "e-money," and "cho vay ngang hàng," which are the two biggest segments of the Vietnamese fintech industry. The fintech popularity in payment variables include fin^{pay} and fin^{wall}, which are formulated from the components of "ví điện tử," "thanh toán di động," "mobile wallet," and "e-wallet." The volume of searching the term "mobile money," "tiền điện tử," "cho vay ngang hàng," and "cho vay đồng cấp" contribute to the fintech popularity in lending variable. Based on that, it does not need to modify the hypotheses H_1, H_{1a}, and H_{1b} about the expectation of the effect of fintech popularity (including in payment and lending) on bank stock return.

Bank stock return variable

According to the State Bank of Vietnam, at the end of 2021, there were 31 commercial banks, including 19 listed banks in two official stock exchanges (HOSE and HNX), but there were 11 banks that had been listed after 2016. Thus, we select 8 listed banks (*trading code: ACB, BID, CTG, EIB, MBB, SHB, STB, and VCB*) for computing the bank stock return variable (denote: *BankReturn*). I selected these banks caused of matched the requirement of continuous trading in the sample period (match with data from Google search). Besides, these banks are also the top biggest in authorized capital and are well-known in the Vietnamese banking industry. The authorized capital of 8 selected banks occupies 46.99% of the total authorized capital of 31 commercial banks (230,839 billion VND in a total of 491,242 billion VND). According to the dataset of 19 listed banks from Vietstock, eight selected banks account for 68.90% of the total assets and 57.59% of total market capitalization at the end of 2021. Therefore, I believe these banks highly appreciate the sample selection. The raw data for calculating the bank stock return variable is provided by Vietstock, a trusted statistical organization in Vietnam. *BankReturn* is computed as follows:

Based on Kim et al. (2019), Kiymaz and Berument (2003), Truong et al. (2020), and Nguyen et al. (2019), *Return* at time t is calculated by the equation below:

$$Return_t = log(BankIndex_t) - log(BankIndex_{t-1}) \quad (3.3)$$

$$BankIndex = \frac{CMV}{BMV}\ x\ 100 \quad (3.4)$$

CMV is the current market value, and BMV is the base market value.

$$CMV = \sum_{i=1}^{n}(P_i x S_i x F_i x C_i) \quad (3.5)$$

Where n is the number of bank stocks in the basket; P_i is price of bank i; S_i is the shares outstanding of bank i; F_i is the free-float rate of bank stock i; and C_i is the limited coefficient of capitalization weight of bank stock i in the index basket at the calculation time.

At the weekend, GSVI is released; thus, the investors will have a rational reaction at the first trading date of the week (Bijl et al., 2016; Swamy & Dharani, 2019). Therefore, the first opening price is chosen to measure.

Following the collected variables, the time-series model above is modified as below:

$$Return_t = f\left(fin_t^{fintech}\right) \quad (3.6)$$

$$Return_t = f\left(fin_t^{pay}\right) \quad (3.7)$$

$$Return_t = f\left(fin_t^{lend}\right) \quad (3.8)$$

$$Return_t = f(fin_t^{mon}) \quad (3.9)$$

$$Return_t = f\left(fin_t^{wall}\right) \quad (3.10)$$

$$Return_t = f\left(fin_t^{pro}\right) \quad (3.11)$$

$$Return_t = f\left(fin_t^{fintech}, fin_t^{pay}, fin_t^{lend}, fin_t^{mon}, fin_t^{wall}, fin_t^{pro}\right) \quad (3.12)$$

These models are used for estimating in the next section.

b. Data collection

The data is obtained from two sources. *First*, Vietstock, a trusted statistical organization in the Vietnamese stock exchange market, provides the components (the open price, close price, trading volume, the number of shares outstanding, etc.) to compute the bank stock index and bank stock return variable. *Second*, Google Trend provides the volume of the searching index of each keyword.

According to MBBank (2021), MBSecurities (2018), and Morgan and Trinh (2020), since 2016, the fintech industry has dramatically risen, which is a milestone in fintech development in Vietnam. Therefore, I am considering 2016 to start collecting a series of data to investigate the effect of fintech popularity on stock return in a case study of Vietnam.

Following Swamy and Dharani (2019) and Bijl et al. (2016), the weekly data is highly appreciated for reflecting investor attention on changes in the stock movement in the market. Therefore, the weekly data from 2016w46 to 2021w46 is obtained for the study. However, due to the downloaded data period from Google Trend, the computed fintech variables are valued at less than 52 weeks compared to the raw data. Therefore, the sample for further analysis is from 2017w46 to 2021w47.

c. Data analysis

I apply a set of quantitative techniques for estimating the effect of fintech popularity on bank stock return: Granger causality and Vector autoregression (VAR-Granger) and Copula. VAR-Granger is referred to apply for examining the relationship between time-series variables with the reasons. *First*, VAR-Granger helps to understand and forecast the link between time-series variables. *Second*, the series might be affected by its and other series lags. *Third*, VAR-Granger is not only for bivariate analysis but also for multivariate time series analysis. In this study, fintech is the exogenous series of bank stock returns and otherwise. Besides, as proposed models above, I argue that the VAR-Granger is highly appreciated for analysis. The VAR-Granger estimation result will provide the bi-directional or uni-directional causality between pair variables, which helps to get insight into the effect of fintech popularity on bank stock returns.

Following Lütkepohl (2005), the VAR model with p lags is formed:

$$Y_t = \alpha Y_{t-1} + \beta X_t + u_t \tag{3.13}$$

- Y_t is the matrix with (K x 1) of endogenous variables
- α is a matrix with (K x K_p) of coefficients of the lagged value of Y_{t-1}
- β is a matrix with the coefficient of matrix X
- X_t is the matrix (M x 1) of exogenous variables, including intercept terms
- u_t is the matrix (K x 1) of white noise

The Granger model is formed:

$$\begin{cases} Y_t = \alpha Y_{t-1} + \beta X_t + u_t \\ X_t = \gamma X_{t-1} + \delta Y_t + \varepsilon_t \end{cases} \tag{3.14}$$

Based on the statistical value of β and δ, the Granger causality between two variables (X and Y) is validated. There are four types as below:

- $\beta \neq 0$ and significant and δ insignificant, X causes the change of Y (called uni-directional causality)
- β insignificant and $\delta \neq 0$ and significant, Y causes the change of X (called uni-directional causality)
- $\beta \neq 0$ and significant and $\delta \neq 0$ and significant, there is a causality between X and Y (called bi-directional causality)

- β insignificant and δ insignificant, there is no causality between X and Y (or there is no relationship between X and Y)

Besides, the Copula is an effective method to determine the joint distribution from the dependence structure of variables, and it has become popular in the finance domain (Aas, 2016; Patton, 2012; Rodriguez, 2007). However, according to my knowledge, there are no studies on the Copula application in the fintech research field, especially investigating the relationship between fintech and banks. Therefore, I argue that the Copula application for estimation is necessary. The results will provide new scientific evidence in this emerging field. Furthermore, I consider the Copula as the robustness check method of estimation results in this study.

The three famous families of Copula are Gumbel, Clayton, and Normal (Gaussian), which are influential in estimating the dependency structure between pair time series variables by the right-tail, left-tail, and normal distribution, respectively (Hofert et al., 2018; Huynh et al., 2020). The Gumbel approach will capture the right-tail (or upper-tail) dependency, which means pair variables might have positive changes simultaneously. In contrast, the Clayton approach will indicate the simultaneous negative changes of pair variables or the left-tail dependency (or lower-tail). The Normal approach reveals the no-tail dependency structure between pair variables. This study prefers three families to estimate the dependency structure between variables. Besides, the maximum pseudo-likelihood method is employed to estimate the parameters of Gumble, Clayton, and Normal. Furthermore, the Kendall-plot graphic provides the visual diagnosis, which is also used for assessing the dependency structure between pair variables (Hofert et al., 2018; Huynh et al., 2020).

Based on Sklar's theorem, the copulas are formulated. A multivariate distribution function in $[0, 1]^d$ is used for illustrating the n-dimensional copula $C(u_1, u_{2, \ldots,} u_d)$, which has the marginal distribution (u_i) following a uniform ranging [0, 1] interval. Following Sklar (1959), the link between the marginal distributions $F_1(x_1)$, …, $F_d(x_d)$ and any joint distribution $H(x_1, \ldots, x_d)$ can be related by an appropriate Copula C:

$$H(x_1, \ldots, x_d) = C(F_1(x_1), \ldots, F_d(x_d)) \quad (3.15)$$

The Copula density c can be obtained as below:

$$c(F_1(x_1), \ldots, F_d(x_d)) = c(u_1, \ldots, u_d) = \frac{\partial^d (u_1, \ldots, u_d)}{\partial u_1, \ldots, \partial u_d} \quad (3.16)$$

There is a one Copula if all x, y ϵ [-∞, +∞], which is F(x, y) = C(FX(x), FY(y)), with F(x, y) as a joint density function with margin function F(X) and F(Y).

The Copula is widely applied for various purposes, especially in statistical applications. In this thesis, it just is employed as the statistical approach for estimating the dependency structure between variables. Following the study by (Hofert et al., 2018; Huynh et al., 2020), I plan to employ the three famous families of Copula to estimate the relationship between fintech popularity and bank performance: Gumbel, Clayton, and Normal. Based on Jin (2018), the parameters and structure dependence are estimated in **Table 3.7**.

Table 3.7 Copula estimation of parameters and structure dependence

Name	Copula	Parameter	Structure dependence
Gaussian	$C_N(u,v,\rho) = \emptyset(\emptyset^{-1}(u), \emptyset^{-1}(v))$	ρ	No tail dependence: $\lambda_U = \lambda_L = 0$
Clayton	$C_C(u,v,\theta) = C_C(1-u, 1-v; \theta)$	θ	Asymmetric tail dependence: $\lambda_U = 0, \lambda_L = 2^{-1/\theta}$
Gumbel	$C_G(u,v,\delta) = \exp\left(-\left((-\log(u))^\delta + (-\log(v))^\delta\right)^{1/\delta}\right)$	$\delta \geq 1$	Asymmetric tail dependence: $\lambda_U = 2 - 2^{1/\delta}, \lambda_L = 0$

Source: Jin (2018)

Based on the parameters, the meaning of three Copulas is indicated below:

- The Gaussian Copula (or Normal Copula) does not capture the upper or lower tail.
- Clayton Copula captures the left-tail dependence between variables (or the lower tail dependence), which means two events might incur simultaneously in the negative change.
- Gumbel Copula regards right-tail dependence between variables (or the upper tail dependence), which means two events might incur simultaneously in the positive change.

Besides three famous families of Copula, the Kendall-plot (K-plot) graphic is also used for determining the dependence structure between variables. The data is ranged by Quantile-Quantile-plot (QQ-plot) for testing the normal features. The data (X_i, Y_i) is converted into (W_i: n, H(i)) with i=1, 2, …, n.

The value of H(i) is followed by:

$$W_i{:}\, n = \omega k_0(\omega)\{K_0(\omega)\}^{i-1}\{1 - K_0(\omega)\}^{n-i} d\omega \tag{3.17}$$

With the requirement H(i) < … < H(n), and W_i:n is the expected statistical value in ranking i from the random sample W = C(U,V) = H(X,Y) with n observations. The value of W_i:n is calculated below:

$$K_0(\omega) = P(UV) \leq \omega = P\left(U \leq \frac{\omega}{v}\right) dv = 1dv + \frac{\omega}{v} dv = \omega - \omega log\,(\omega) \tag{3.18}$$

And k_0 is the relative density.

Before using the VAR-Granger and Copula for estimating the relationship time-series variables, the Dickey-Fuller and Phillips–Perrons approaches are first used for checking the stationary of data series or unit root test (Dickey & Fuller, 1979; Phillips & Perron, 1988). If the data series are not stationary at level I(0), the first difference will be an alternative. Next, choosing the optimal lags of the variable is conducted (Lütkepohl, 2005). Then, the co-integration test is performed to check the short-run and long-run relationship between variables (Dolado et al., 1990; Pfaff, 2008).

3.6.3 Bank investment in technology innovation and bank efficiency

a. Model

Motive from the study by Anagnostopoulou (2008), Beccalli (2007), Ho and Mallick (2010), Lee et al. (2021), Pham et al. (2021b), and Phan et al. (2020), I formulate the panel model for investigating the effect of BITI on bank efficiency as below:

$$Bank_{it} = \propto + \beta Fintech_{it} + \gamma Char_{it} + \theta Mar_t + \mu_i + \delta_{it} \qquad (3.19)$$

Where,

- $Bank_{it}$, $Fintech_{it}$, and $Char_{it}$ are the bank efficiency, bank investment in technology innovation, and characteristic variables of bank i at the time t, respectively.
- $\mathrm{Mar_t}$ is the macroeconomic environment.
- $\propto$ is the constant.
- β, γ, and θ are the coefficient of independent variables, respectively.
- μ_i denotes unobservable individual-specific effect.
- δ_{it} denotes the remainder disturbance.

The coefficient value and P-value of β are the main statistical indicators, which will reveal the effect of BITI on bank efficiency regarding the second hypothesis (H_2) mentioned above.

b. Variable measurement

Bank efficiency variable

As I mentioned above, the DEA approach is employed for measuring bank efficiency. The DEA was initially proposed by Charnes et al. (1978), it has

become famous and applied in many academic and practice fields. The efficiency of the decision-making unit (DMU) is the outcome of the DEA.

$$h_j = \frac{\sum_{r=1}^{s} u_{rj} y_{rj}}{\sum_{i=1}^{m} v_{ij} x_{ij}} \quad (3.20)$$

subject to u_r and $v_i \geq 0$, and Max $h_j \leq 1$

j = 1, …, n; r = 1, …, s; i = 1, …, m

y_j and x_j are output and input of the j-th DMU

u_r is the weight of the r-th output; and v_i is the weight of the i-th input

h_j is the efficiency score of the j-th DMU. A DMU is efficient if h_j = 1, and if less than 1, it is inefficient.

For measuring efficiency value, other approaches require some assumptions, but the DEA does not need any assumptions. There is no specific DEA model; all the input and output weights are the same. However, the efficiency value may be high and biased if the measurement has significant input variables; thus, the number of inputs must be limited to minimize the DEA method's risk (Contreras, 2020; Yu et al., 2021).

Various scholars use the DEA to measure the bank efficiency variables in the finance sector, and selecting inputs and outputs is controversial (Fethi & Pasiouras, 2010). Henriques et al. (2018) used three components for input variables: fixed assets, total deposits, and personnel expenses for inputs, and output is total loans. Tamatam et al. (2019) determined that the inputs consist of total assets and deposits, while outputs include interest income, total income, and operating profit. Eyceyurt Batir et al. (2017) used loans, off-balance sheet items, labor, capital, and funds to calculate the efficiency of participation banks and conventional banks in Turkey. The value of banks' deposits, loans, and incomes are utilized to evaluate Malaysian banks' efficiency (Kamarudin et al., 2019). In Pakistan, Zhu et al. (2021) use interest, non-interest expense, interest income, and non-interest income to measure bank efficiency. In this study, the bank efficiency variable is computed by labor and capital (are inputs) and revenue (is output). The approach is like the pure DEA of Charnes et al. (1978) and Seiford and Zhu (1999).

Bank investment in technology innovation variable

The existing studies show various ways to measure bank investment in technology innovation variables. In Europe, Beccalli (2007) used the spending on hardware, software, and IT service to measure the bank technology innovation

variables, then examined its effect on bank performance. In the USA, the share of personal computers per employee and IT budget are used for evaluating the bank technology adoption by Pierri and Timmer (2022), while Shu and Strassmann (2005) employed the IT budget for measuring bank technology innovation variables. Pham et al. (2021b) used intangible assets in Vietnam and Pakistan to reflect the bank technology innovation variable. The dummy variables that illustrate the digital bank customer, digital online intensity, digital channel, and bank IT spending proxy the bank technology innovation (Carbó-Valverde et al., 2020). In India, Arora and Arora (2013) provided that bank technology innovation is proxied by technology adoption, mainly shown through advanced banking products (ATMs, mobile banking, POS, etc.). Other ways regarding the firm technology innovation measurement, Bagna et al. (2021), Chen et al. (2021a), and Ho and Mallick (2010) provided that firm technology innovation is measured by intangible assets accounting figures on the financial statements. The study by Demmou et al. (2019) showed that intangible assets play a critical role in firm performance. In Indonesia and India, Bhatia and Aggarwal (2018) and Widnyana et al. (2021) found a significant effect of intangible assets on firm performance, which means there is a significant link between firm technology innovation and firm performance. Based on that, I argue that it is possible to use intangible bank assets for proxying BITI, a critical part of the fintech industry.

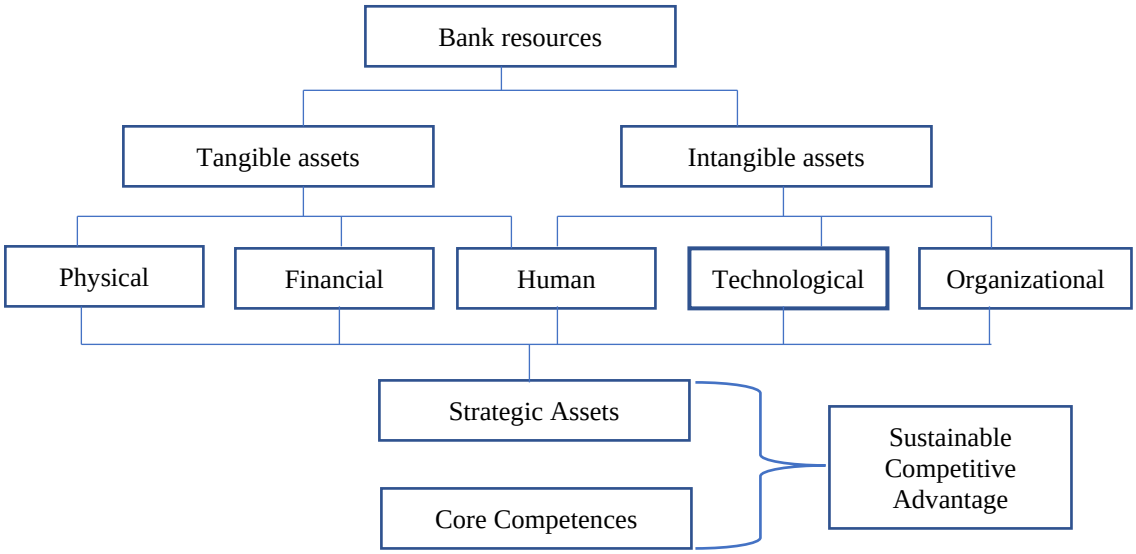


Figure 3.6 Bank resources in achieving sustainable competitive advantage

Source: Harasim (2008)

Furthermore, following Gumbau-Albert and Maudos (2022), Harasim (2008), and Reilly (2010), technology innovation regarding software, hardware, and patents is a crucial factor that plays a high weight in the intangible assets of banks. Therefore, the bank investment in technology innovation variable, which is measured by intangible assets, is highly appreciated.

Consequently, in this thesis, following Beccalli (2007), Bhatia and Aggarwal (2018), Carbó-Valverde et al. (2020), Ho and Mallick (2010), Pham et al. (2021b), the bank technology in technology innovation variable is calculated by intangible assets on the financial statements, namely the ratio of intangible assets on fixed assets (INR) and the growth rate of intangible assets (ING).

Bank characteristic variables

Bank size (SIZE)

Al-Matari (2021) found a negative relationship between bank size and bank performance in Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and The United Arab Emirates from 2000 to 2008. The author explains that due to increased management costs and the bureaucratic issue of a large bank compared with a small bank. It is similar to the findings of Batten and Vo (2019) and Menicucci and Paolucci (2016). On the other hand, the large-sized banks will be more advanced on the economic scale than the small-sized banks, namely, banking product diversification and extending branches. The positive effect of bank size on bank performance is found in the study by Pham et al. (2021b) in Vietnam and Pakistan from 2011 to 2019 and Phan et al. (2020) in Indonesia. Besides, Ali and Puah (2019) discussed that the strong brand name image and market power are the advanced factors of large-sized banks that help enhance performance in Pakistan. In this study, we choose Vietnam, a developing country like Indonesia and Pakistan; thus, we expect a positive effect of bank size on bank performance.

Bank age (AGE)

Reputation and experience, which are presented by bank age, are the critical factors of bank operation (Chiu & Chen, 2009; Karim et al., 2010; Mester, 1996). Generally speaking, people are more confident transacting with elderly banks than others. I argue that it is the advantage factor, which increases bank competitiveness and helps reduce the operation cost; thus, I expect a positive effect of bank age on efficiency. Following Chiu and Chen (2009), Pham et al. (2021b), and Pham and Quddus (2021), in this study, bank age is calculated by the logarithm of the number of years from the original launch to the time t.

Macroeconomic environment

Following Chen and Lu (2021), Kapelko and Lansink (2015), Lee et al. (2021), Phan et al. (2016), and Tamatam et al. (2019), the consumer price index and gross domestic product are selected to reflect the external environment that effect on bank efficiency. In detail, the consumer price index is proxied by inflation, while GDP's annual percentage growth rate measures GDP. Following World Bank, these measures are calculated as definitions: “Inflation, as measured by the consumer price index, reflects the annual percentage change in the cost to the

average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals, such as yearly. The Laspeyres formula is generally used", and "The annual percentage growth rate of GDP at market prices is based on constant local currency. Aggregates are based on constant 2015 prices, expressed in US dollars. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without deductions for depreciation of fabricated assets or depletion and degradation of natural resources".

Hermes and Nhung (2010), Phan et al. (2016), and Vu and Nahm (2013) stated that stable macroeconomic conditions provide a favorable environment for improving bank efficiency. However, in emerging countries with high volatility of the key macroeconomic indicators, their effects on bank efficiency might differ. In Vietnam, Vu and Nahm (2013) found that higher GDP and lower inflation positively affect bank efficiency. Phan et al. (2016) gave that GDP and inflation are significantly negative in Bangladesh and Indonesia, but these macroeconomic variables are positive in Vietnam. Another study by Vo and Nguyen (2018) stated the positive link between economic growth and bank efficiency, while inflation negatively impacts performance. Overall, there is no consistency between existing studies about the effect of macroeconomic conditions on bank efficiency in Vietnam. However, I argue that under the impact of bank fintech, the interaction between macroeconomic variables and bank fintech on efficiency performance will provide interesting findings.

c. Data collection

According to the report of SBV 2012, after being significantly influenced by the GFC of 2008-2009, most commercial banks in Vietnam have paid more attention to applying emerging technologies to improve their performance. By scanning the bank's annual reports for 2010 and 2011, I explored that 23 banks were fundamentally using emerging technologies to restructure and enhance performance and competitiveness. Therefore, 23 banks are highly appreciated to meet the requirement of the bank fintech definition and bank investment in technology innovation. The core banking system utilizes emerging technologies regarding data on the cloud and real-time transactions, connecting multiple bank branches to optimize costs and provide the best customer experience. Data storage is built up based on the shared data between bank branches. The centralize data on the cloud are used for deciding customer and internal management. The new job regarding the emerging technology application shows that the banks pay more attention to technology innovation.

In 2010 and 2011, 20/23 banks applied the new core banking system; 17/23 banks built the data storage, which will be optimized in the future; 7/23 banks

have new positions regarding chief/committee information officers, who duty with emerging technology adoption. Besides, 3/23 banks aimed to restructure; 21/23 banks focused on enhancing competitiveness; 19/23 banks aimed to improve performance; and 2/23 banks toward automatic banks. **Table 3.8** provides the detail of technologies and the aim of applying technologies.

Based on the data collection capability and available data, the bank-level data is obtained from annual reports and audited financial statements of 23 commercial banks from 2011 to 2020. Vietstock, a trusted statistical organization in the Vietnamese stock exchange market, provides these documents. The data on the macroeconomic environment is collected from the World Bank database.

d. Data analysis

Based on the panel data of 23 banks from 2011 to 2020 and according to Wooldridge (2001), Arellano and Bond (1991), and Hansen (1982), I apply the Fixed effect approach (FE) and the Random effect approach (RE) to estimate the regression models above. The Pooled method is not used in the process because the Pooled approach considers all observations as cross-section data, while both time-series and cross-section components are considered simultaneously by FE and RE. The variation between units is the different points in the FE and RE analysis techniques. The FE technique assumes that the variation between units correlates with explanatory variables, while the RE technique considers that the variation between units is random or does not correlate with the independent variables.

FE is interested in analyzing the impact of variables that vary over time between the dependent and independent variables within a bank. Each bank has characteristics that might or might not influence the predictor variable. When using FE, there are two assumptions. First, there is a correlation between the bank's error term and the dependent variable, which means something within the observation might affect or bias the dependent variable. FE removes the effect of those time-invariant characteristics or estimates the net effect of independent variables on dependent variables. Second, those time-invariant characteristics are unique to the individual and do not correlate with other individual characteristics[2].

[2] *The fixed-effects model controls for all time-invariant differences between the individuals, so the estimated coefficients of the fixed-effects models cannot be biased because of omitted time-invariant characteristics. One side effect of the features of fixed-effects models is that they cannot be used to investigate time-invariant causes of the dependent variabs. Technically, time-invariant characteristics of the individuals are perfectly collinear with the dummies. Substantively, fixed-effects models are designed to study the causes of changes within an entity. A time-invariant characteristic cannot cause such a change, because it is constant for each entity" (Kohler & Kreuter, 2005)..*

Table 3.8 Bank fintech (applying emerging technology) selection

No.	Bank	Implement emerging technologies	Purpose	Year
1	ABB	Change/replace core banking system Data storage	restructure	2011
2	ACB	Change/replace core banking Data storage (cooperate with Open Solution and Microsoft) Chief information officer	competitiveness performance	2010
3	BAB	Change/replace core banking system	competitiveness	2010
4	BID	Data storage	performance	2010
5	CTG	Change/replace core banking system Data storage (cooperate with IBM) Chief information officer	competitiveness performance	2010
6	EIB	Change/replace core banking system	competitiveness performance	2010
7	HDB	New technologies for retail banking Change/replace the internal process management system	competitiveness performance	2011
8	KLB	Change/replace core banking system (cooperate with TCBS)	competitiveness performance	2010
9	LPB	Committee of transformation Change/replace core banking system Data storage	competitiveness performance	2011
10	MBB	Committee of transformation Change/replace core banking system Data storage	competitiveness performance	2010
11	MSB	Committee of transformation Change/replace core banking system (service desk) Data storage Cooperate with McKinsey	restructure competitiveness effectiveness	2010
12	NAB	Change/replace core banking system (core Flexcube) Data storage (Datacentre 141)	restructure competitiveness effectiveness	2011
13	NVB	Change/replace core banking system Data storage (cooperate with VietUnion and NTTData)	effectiveness Scale up	2010
14	OCB	Data storage (cooperate with IBM)	effectiveness	
15	SCB	Data storage (cooperate with IBM, Cisco)	effectiveness	2010
16	SHB	Change/replace core banking system (Corebanking intellect) Internal management system (Intellectreport) Data storage	competitiveness performance	2011
17	SSB	Data storage Emerging technology in payment (cooperate with Open Way) Change/replace core banking system	competitiveness performance	2010
18	STB	Data storage (Data warehouse) Management information system R&D in IT, fingure recognition	competitiveness performance	2009
19	TCB	Data storage Change/replace core banking system	competitiveness performance	2010
20	TPB	Data storage New technologies	competitiveness unique products automatic bank	2010
21	VCB	Change/replace core banking system Data storage	automatic bank effectiveness	2010
22	VIB	Chief information officer Change/replace core banking system	competitiveness performance	2011
23	VPB	Committee of IT application Change/replace core banking system (Temenos)	competitiveness performance	2010

Source: Annual reports of 23 banks of 2010 and 2011

RE is interested in analyzing the impact of differences across entities on the dependent variable. RE assumes that the error term of the entity does not correlate with the predictors, which means it allows for time-invariant variables to play the role of explanatory variables. Furthermore, in RE, those individual characteristics

might or might not impact the independent variables, leading to bias omitted variables in the model.

The Hausman test chooses a suitable estimation result between FE and RE. Following Gujarati and Porter (2009) and Kohler and Kreuter (2005), the Hausman test is employed to decide the suitable estimation results between FE and RE, with the null hypothesis being that the preferred model is RE versus the alternative FE. The basic test regarding the unique errors is correlated with the regressors.

FE and RE are famous in data analysis for panel regression, but these still have some limitations. Gujarati and Porter (2009) stated that the FE or RE estimation result might have heteroskedasticity and/or autocorrelation issues, which are tested by employing the Modified Wald test and Breusch- Pagan Lagrangian test (for heteroskedasticity) and the Wooldridge (for autocorrelation), respectively.

In this study, there is no serial correlation in the specification in a panel with the null hypothesis of the Wooldridge test for autocorrelation. The Modified Wald test for heteroskedasticity is available for FE models, while the Breusch-Pagan Lagrangian test is helpful for RE models. The null hypothesis (heteroskedasticity) is homoskedasticity. It also means the residuals are distributed with equal variance at each level of the predictor variable. It is typically denoted that $H_0: \sigma_i^2 = \sigma^2$ or $H_a: \sigma_i^2 \neq \sigma^2$.

Suppose the estimation result of FE or RE has the heteroskedasticity or/and the autocorrelation issue. In that case, I will use the Feasible Generalized Least Square (GLS) to overcome the problems; it is highly appreciated (Gujarati & Porter, 2009). The GLS approach is developed from the basic model:

$$y_{it} = x_{it}\beta + \epsilon_{it} \tag{3.21}$$

Where:

- i = 1, …, m is the number of units (or panels)
- t = 1, …, T_i is the number of observations for panel i

The model above can be written:

$$\begin{bmatrix} y_1 \\ \vdots \\ y_m \end{bmatrix} = \begin{bmatrix} x_1 \\ \vdots \\ x_m \end{bmatrix} \beta + \begin{bmatrix} \epsilon_1 \\ \vdots \\ \epsilon_m \end{bmatrix} \tag{3.22}$$

Following that, the variance matrix of the disturbance term can be written:

$$E[\epsilon\epsilon'] = \Omega = \begin{bmatrix} \sigma_{1,1}\Omega_{1,1} & \dots & \sigma_{1,m}\Omega_{1,m} \\ \vdots & \vdots & \vdots \\ \sigma_{m,1}\Omega_{m,1} & \dots & \sigma_{m,m}\Omega_{m,m} \end{bmatrix} \quad (3.23)$$

For estimation, the coefficient vector β is assumed to be the same for all panels.

In the classical regression model (OLS), $E[\epsilon_{it}] = 0$; $Var[\epsilon_{it}] = \sigma^2$; and $Cov[\epsilon_{it}, \epsilon_{js}] = 0 \; if \; i \neq j \; and \; t \neq s$. In this case, Ω will be:

$$\Omega = \begin{bmatrix} \sigma^2 I & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & \sigma^2 I \end{bmatrix} \quad (3.24)$$

However, in many cross-sectional datasets, each panel's variance differs. The heteroscedastic model of the GLS approach assumes that:

$$\Omega = \begin{bmatrix} \sigma_1^2 I & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & \sigma_m^2 I \end{bmatrix} \quad (3.25)$$

In the GLS approach, the individual identity matrices along the diagonal of Ω may be replaced with a more general structure to allow for serial correlation, where the correlation parameter is common for all panels. The restriction of common autocorrelation parameters is reasonable when the individual correlations are nearly equal and the time series is short. If the condition of a common autocorrelation parameter is appropriate, it allows for more information to estimate the autocorrelation parameter to produce a more reasonable estimation of regression coefficients.

Furthermore, bank performance might be measured by bank efficiency, calculated by the DEA approach. The value of bank efficiency is from zero (0) to (1); thus, I use the Tobit model for the robustness check of the estimation results using the Pooled, FE, RE, and GLS approach (Bremmera et al., 2008; Eyceyurt Batir et al., 2017; Faruq & Yi, 2010).

The Tobit model can be written as follows:

$$y_{it}^* = \alpha + x_{it}\beta + \epsilon_{it} \quad (3.26)$$

$$y_{it} = \begin{cases} y^* & if \quad 0 \leq y^* \leq 1 \\ 0 & if \quad y^* < 0 \\ 1 & if \quad 1 < y^* \end{cases} \quad (3.27)$$

Where,

- y_{it}^* is the latent variable

- y_{it} is bank efficiency measured by the DEA approach
- x_{it} is a (k x 1) vector of explanatory variables
- β are the coefficients of explanatory variables
- α is the intercept
- ϵ_{it} is the error term

Besides that, before employing the FE, RE, GLS, and Tobit for estimating the effect of BITI on bank efficiency, the correlation matrix and variance inflation factor (VIF) is applied for diagnosing the multicollinearity issue and determining the eligibility of variables in the proposed model.

The correlation value between pair-wise variables is denoted $r = [-1, +1]$. There are three kinds of correlation between pair variables:

- $-1 \leq r < 0$: there is a negative correlation between variables (or when one variable decreases, the other increases, and vice versa)
- $0 < r \leq 1$: there is a positive correlation between variables
- $r = 0$: No correlation between variables

Following Gujarati (2004) and Nam et al. (2005), if the absolute value of the correlation coefficient between variables ($|r| \geq 0.8$), it indicates the signs of multicollinearity.

The equation for calculating VIF for variable X_i below:

$$VIF_i = \frac{1}{1-R_i^2} \tag{3.28}$$

Where, R_i^2 is the coefficient of determination of linear regression $X_i = f(X_1, \dots, X_k)$ with $i \neq k$.

Based on the proposed model above and Gómez et al. (2020) and Gujarati and Porter (2009), the multicollinearity issue is present when the VIF value is higher than the VIF threshold ($VIF_{threshold} = 4.0$) for the linear regression model with less than ten independent variables.

3.7 Data collection

As mentioned above, the thesis uses both primary data and secondary data, which are obtained as below:

3.7.1 Primary data

In this thesis, the primary data serves for the qualitative study of the investigation of the effect of fintech company growth on bank performance from four perspectives of the BSC approach. The data is collected through semi-structured interviews with interviewees who are bank managers and lecturers in the finance banking field.

The orientation questionnaire with four perspectives of the BSC approach and corresponding ingredients is compiled from reviewing existing publications. Besides, in this stage, an appointment for an interview is also conducted by phone and email.

Eight individual interviews are conducted from February to April 2022 at the respondents' offices. Each interview takes about 2-3 hours. The survey's basic information is illustrated in **Table 3.4**, and the response of interviewees are described and discussed below.

3.7.2 Secondary data

Besides primary data, secondary data is an indispensable part of this thesis for serving two quantitative studies. *First*, the time-series dataset of the investigation of the effect of fintech popularity on bank stock return is obtained from the raw data of Google Trends and bank stocks in the Vietnamese stock exchange market. *Second*, the panel data regarding the investigation of the effect of bank investment in technology innovation on bank efficiency is collected from the bank-audited financial statements, annual reports, and the World Bank database.

Following the selected fintech-related keywords, the GSVI of 16 keywords is extracted from Google Trends; a useful search trends feature that shows how frequently a given search term is entered into the Google search engine. Google Trends is a trusted database that provides significant data for various research fields, including finance research. Based on the raw data from Google Trends, the fintech popularity variables are computed.

Vietstock, a trusted statistical organization in the Vietnamese stock exchange market, provides the components for computing the bank stock price index. Following that, the time series of the bank stock return variable is calculated.

Based on the formulation of the DEA approach, the inputs and outputs of bank efficiency are captured from annual reports, which are disclosed on banks' websites. Besides, the bank fintech variables and other bank-level variables are calculated based on the audited financial statements, which are the public data on the website of banks and statistical organizations such as Vietstock.

The database of the World Bank provides the key macroeconomic environment indicators of most countries in the world, including Vietnam. In this thesis, the growth rate of GDP and inflation are captured from the World Bank database.

4 RESULTS AND DISCUSSION

This section reports and discusses the results of three studies. *Firstly*, the qualitative study results are revealed; it reveals the view of eight interviewees about the effect of fintech company growth on four perspectives of bank performance. *Secondly*, the estimation results of the effect of fintech popularity on bank stock return are presented. *Thirdly*, the effect of bank technology innovation on bank efficiency is estimated and reported. *Finally*, the result of the effect of the fintech industry on bank performance is aggregated.

4.1 Effect of fintech company growth on bank performance

Following the research methodology above, the qualitative study of the effect of fintech company growth and bank performance in Vietnam is conducted. The result of the semi-structured interview is presented and discussed below:

4.1.1 Opinion about fintech company growth

The result of the semi-structured interview shows that all respondents agree that the fintech company is dramatically rising, illustrated by the growing number of fintech companies, fintech transactions, fintech users, and especially fintech brand identity. Momo is the best brand name in the Vietnamese fintech industry, and even bank managers also use Momo for their budget management and payment in life. In detail, using Momo to pay monthly bills such as electricity, water supply, recharge mobile phone, and internet. Besides, they often use Momo to pay for meals in the shopping center and buy on e-commerce platforms.

Regarding P2P lending, the respondents are interested in discussing borrowers and the approval process of loans rather than lenders. They reveal that while the number of borrowers and the value of loans increase, the credit criteria requirements are reduced. It is a big problem for the P2P lending model to solve. The issues of non-repayment and non-performing loans regarding high-interest rates and borrowers' low level of financial knowledge might create social unrest in the future. The interest rate is often triple the bank loan interest rate or even 1000% per year. Borrowers with low income and literacy levels quickly fell into the trap of predatory online lenders. The poor borrowers might be poorer due to online loans.

The IT infrastructure is appreciated for fintech company growth, but the interviewees are concerned about cybersecurity and the macroeconomic environment. According to their experience of traveling abroad and using smartphones in foreign countries, they evaluate that the growing number of smartphones, the speed of the internet, and the launch of 5G are advantageous factors for fintech development in Vietnam compared with other countries in

Southeast Asia. However, the issues regarding information security in Vietnam are really a concern. The respondents give that the goals of critical data protection seem to be missed by the operators and governors. Furthermore, the middle-income trap refers to the situation whereby Vietnam is facing the fall of transition to a high-income economy due to rising costs and declining competitiveness, which is also a negative factor of fintech development.

Despite many official documents issued by the government to facilitate fintech growth, the respondents still negatively view the current fintech regulations. The adaptation to the rise of fintech is low, which is the barrier to fintech development. Based on the Chinese fintech industry lesson, the Vietnamese government seems to be careful regarding the implications of fintech policy.

Except for mobile payment and P2P lending, the respondents are not interested in other business models like insurance, crowdfunding, and cryptocurrency. Despite confirming the most critical role of disruptive technologies in the banking industry, they lack knowledge about technology to discuss.

4.1.2 Effect of fintech company growth on four perspectives of bank performance

After the semi-structured interview, I recognize that there is a difference in view about the effect of fintech company growth on bank performance between bank managers and lecturers. First, the bank managers verified the rise of the fintech company and its impact, but they stated that the scale of the fintech company is smaller than that of commercial banks; hence, the effect is very light. Second, by the side of lecturers, they have a neutral view, namely, at present, the impact of fintech company growth on bank performance is weak, but it is a critical factor to change the banking industry structure. The fintech company is dramatically growing and creating fear of banks. In the banking market, the share of the fintech companies is growing and threatens the incumbents. In line with society's development trend, the role of fintech will be leveled up; the incumbents need to have the adoption strategy. Allying with fintech companies and commercial banks is considered a reasonable strategy, which benefits both entities.

When asking the respondents what the positive or negative effect of fintech company growth on bank performance is, most respondents said that, at present, a fintech company is a positive factor for commercial banks. In detail, it is a pressure of banking digitalization to enhance bank performance. Besides, the fintech company growth creates new room, which is the potential market for banks in the future. For example, the financial literacy of the non-banked population will be improved; they might open a bank account to experience it as an opportunity for banks. Furthermore, cooperation with the fintech companies helps banks save IT investment and operation costs. Based on these opinions

about the positive effect of fintech companies on bank performance, I conclude that there is a positive effect of fintech company growth on bank performance in Vietnam.

Answering the questions regarding the effect of fintech company growth on the financial, customer, internal process, and learning and growth perspectives of the commercial banks, the critical ingredients and a sign of influence are aggregated in **Table 4.1**.

a. Fintech company growth and financial perspective

Three critical ingredients of the financial perspective are influenced by fintech company growth. The first is the service income. The respondents show that in the first stage, the growth of fintech apps and fintech companies might reduce the bank service income due to decreasing small transactions via banks. However, in the long term, the race to deliver banking products via smartphone will increase bank service income and revenue through cross-selling products.

Table 4.1 Effect of fintech company growth on bank performance

Perspectives	Orientation ingredients	Determined ingredients	Relationship	Percentage*
Financial	Revenues, cost structure, asset utilization, profitability, economic value added, valuation, service income.	Service income (revenue)	Negative (short-term)	100%
			Positive (long-term)	
		Return on investment	Positive	87.5%
			Negative (IT investment efficiency)	62.5%
		Valuation	Positive	50%
			Negative	50%
Customer	Customer loyalty, customer retention, new customers, trust, reliability satisfaction	Customer loyalty	Negative	100%
		Customer satisfaction (in retail banking products)	Negative (younger)	100%
			Insignificant (older)	75.0%
		Trust and reliable	Positive	62.5%
Internal process	Effective in producing and delivering products, risk management, after-sale services, operation systems	Operation efficiency	Positive	100%
		Producing and delivering product	Positive	62.5%
		Risk management	Positive	50%
			Negative	50%
Learning and growth	Employee satisfaction, skills, knowledge, efficiency, training courses	Training and development programs	Positive	100%
		Employees capability	Positive	87.5%
		Employee satisfaction and retention	Negative	62.5%

*Note: * means the percentage of respondents who agree with the effect of fintech companies on the ingredient*

Source: The author

The second is the ratio of return on investment, especially the return on IT investment. The respondents provide that most commercial banks increased IT investment a few years ago to enhance bank performance, but it seems that the investment is not efficient. The reasons might be the bank itself; namely, IT and

human capability are weak. IT investment success requires banks to meet professional skills and experience in the IT industry.

The third ingredient is bank valuation. The respondents agree that there is a significant effect of fintech company growth on bank valuation, but the signs of influence vary. On the one hand, the fintech company helps increase bank value through its impact on growing intangible bank assets, leveling up banks' role in the finance industry, and further prosperity when disruptive technologies are optimized. On the other hand, due to the positive information about fintech in the media, many people believe that the fintech company is better than banks and the fintech company might replace commercial banks, which reduces the bank value.

Overall, there are both positive and negative views about the effect of fintech company growth on a bank's financial perspective. In the short term, fintech company growth is harmful from a bank's financial perspective, but in a long time, the bank's financial indicator will be improved by its effect. However, the thesis aims to investigate the impact of fintech company growth on bank financial perspective in the current context to provide an overview picture of the relationship between fintech and banks; thus, I conclude that within the scope of this thesis, there is a negative effect of fintech company growth on bank financial perspective in the current context.

b. Fintech company growth and customer perspective

Three critical ingredients could see the effect of fintech company growth on bank customer perspective. First, there are many banks where customers use fintech products (via fintech apps) instead of bank products (via front-of-desk transactions). The mobile payment app is the first selection, and the next is an online lending app. According to the respondents' experience, these customers are young and interested in experiencing new technology-related things. Therefore, it is easy to conclude that the rise of fintech company growth is a negative factor in bank customer loyalty.

Second, all participants admit that retail banking products might not compete with fintech products. Fintech products are a more convenient and quick process than banking products. It is why there are many young customers to leave the bank; they want to experience the use of fintech products. The respondents confirm that older customers are more loyal than the young to retail banking products due to fintech company growth.

Third, after some scandals of fintech companies regarding excess high-interest rates and transaction security, people have a negative view of fintech company growth, but it is a positive factor in leveling up bank reliability and trust. Therefore, the respondents agree that banks get more benefits in trust and reliability from the rise of fintech company growth.

Overall, although fintech company growth increases the bank trust credit, it decreases bank customer loyalty and satisfaction, especially impacting young customers, key customers in the digital era. Besides, I argue that in the future, when the fintech companies are mature, the issues regarding high-interest rates and transaction security are overcome, fintech will gain customer trust. Thus, I believe that, at present, fintech company growth is threatening the bank from the customer's perspective. Therefore, I argue that there is a negative effect of fintech company growth on the bank customer perspective.

c. Fintech company growth and internal process perspective

The ingredients of the internal process perspective consist of operation efficiency, producing and delivering products, and risk management. All interviewees agree that fintech company growth is the critical motive for the digital transformation of commercial banks. However, the efficiency of IT investment does not meet the expectation; increasing IT investment signals transition. In the digital era, if the banks do not want to be behind in the digitalization race with fintech companies and other commercial banks, increasing IT investment to enhance efficiency is a mandatory requirement. Thus, most participants agree that the rise of fintech company growth is a good motive for improving bank operation performance.

In terms of promoting operation and production, under the pressure of fintech company growth, investment in technology innovation is considered the factor enhancing efficiency. The respondents reveal that new banking products have been launched in recent years. Besides, the effectiveness of delivering products has been improved rather than before. The ways of producing and delivering products of the fintech companies are referenced and applied for enhancing bank internal processing performance, which is evaluated as effective and brings many benefits for the banks. Therefore, fintech company growth is a positive factor in producing and delivering banking products.

Risk management is also an interesting topic in the survey that takes more time to discuss. The interviewees reveal that the risk management system is regularly adjusted to adapt to changes in monetary policy and the business environment. The technology of risk management systems is often upgraded to catch up with the latest technology, but it seems to be not effective. The respondents explain that the workforce quality does not meet the digital transition requirement and new risk management system versions. Besides, the transition cost (e.g., the price of the new version and training cost) is also a big problem when the new versions are updated.

Furthermore, the synchronization between the old and new/upgraded versions is also an issue regarding the risk management system in the transition procedure.

When the interviewees are asked to give a positive or negative assessment about the effect of fintech company growth on the risk management system, they tend to avoid giving the exact answer instead of referring to the risk management process. Therefore, I could not determine the effect of fintech company growth on bank risk management.

Overall, fintech company growth is a positive factor in enhancing bank internal operation performance and producing bank products, which is proof to conclude there is a positive effect of fintech company growth on internal bank processes.

d. Fintech company growth and learning & growth perspective

All interviewees agree that an employee is a critical object greatly affected by the impact of the digitalization process. In line with this trend and under fintech company growth pressure, many training and development programs are designed to educate and empower employees to achieve the adaptation strategy targets. The employee's ability is enhanced throughout training courses to interact and recognize customer needs, office technology efficiency, and cross-sells in the digital era. Besides, communication skills are also improved through the number of training hours. Furthermore, technological knowledge is also the main content, which has played an increasing role in the training content. Thus, all interviewees believe that the fintech company growth effect increases the number of training courses and development programs to improve employee knowledge and skills, especially regarding technological literacy.

The respondents assess that the training and development courses help to enhance the employees' capability, especially regarding communication skills and technological literacy. After training, the bank's performance (from a financial perspective) is improved. The interviewees agree that due to the pressure of fintech company growth, the number of training courses (including self-training/learning) is increasing and enhancing employees' capability.

However, the respondents also reveal the dark side of the effect of fintech company growth on bank staff, which is the leave out of elderly employees caused by the fast change of technologies in the banks. They can not adapt to the changing technology condition and the high pressure of the digitalization process. Most interviewees agree that it is a crucial reason for their unsatisfied with the job. The younger employees could quickly adapt to new technologies, but they must face high pressure. They also seem to be not satisfied with their current jobs. Based on that, I believe that fintech company growth negatively affects employee satisfaction and the probability of job retention in banks.

Overall, I argue that employee dissatisfaction might be overcome by the increase in training courses and development programs, which are meant to

enhance employees' capability. Therefore, I conclude that the effect of fintech company growth on the bank learning and growth perspective is positive.

4.2 Effect of fintech popularity on bank stock return

Based on the research methodology above, the effect of fintech popularity and bank stock return is presented and discussed in this sub-section. The descriptive statistic and unit root test will introduce the variables' characteristics, which are the background of the next analysis. The estimation results of the VAR-Granger and Copula approach provide evidence for discussion.

4.2.1 Descriptive statistic and unit root test

The features of variables are shown in **Table 4.2** and **Figure 4.1**. There are 209 observations, which are the weekly data from 2017w46 to 2021w47. **Figure 4.1** is the graphical diagnostic of the variables' movement. There are no shocks in all variables. $Return_{mean}$ indicates that the average return of 8 banks is 0.0020713 (about 0.2%/week), and $Return_{min}$= -0.131544 and $Return_{max}$= 0.1301236 mean the investors can lose and gain the largest return at approximately 13.15% and 13.01%, respectively. With the weekly data, the maximum and minimum bank stock return might volatility within the approximate interval [-0.13, 0.13], which are very higher when compared with the basic interest rate in Vietnam (about 9%/year); thus, I argue that the change of bank stock return in Vietnam stock exchange market is very risky for the investors.

Table 4.2 Descriptive statistics and unit root test

Variable	Obs.	Mean	Std. Dev.	Min.	Max.	Dickey-Fuller test	Phillips–Perron test
Return	209	.0020713	.0378595	-.1315444	.1301236	-12.004***	-12.055***
$fin^{fintech}$	209	.3393684	.1807558	0	1	-12.433***	-12.508***
fin^{pay}	209	.3462506	.1760233	0	1	-12.200***	-12.333***
fin^{lend}	209	.1839054	.1022469	0	1	-13.013***	-13.110***
fin^{mon}	209	.4098034	.1475019	0	1	-12.494***	-12.772***
fin^{wall}	209	.3462138	.1820644	0	1	-12.358***	-12.465***
fin^{pro}	209	.4271674	.145622	0	1	-12.815***	-12.999***

Note: *, **, and *** are significant at the 10%, 5%, and 1% levels, respectively

Source: The author

The means of fintech popularity variables give that the highest searching volume keyword regards the product (fin^{pro}_{mean}= 0.4271674), next is the money, payment, wallet, and fintech in general, and the lowest is lending (fin^{lend}_{mean} = 0. 1839054). Based on that and connected to the component of variables as shown in **Table 3.6**, I discuss that searching for fintech products (the term "Thanh toán online," "E-money," and "Cho vay ngang hàng") is the priority of investors. They pay more attention to the primary products of fintech, which can replace traditional banking products. After that, they will find out information about the

features of fintech products, namely, fintech money, fintech payment, fintech wallet, and fintech lending. I discuss that it is suitable with the routine of searching for investors; after understanding the basic information of fintech, they desire to get more in-depth information about fintech.

Besides, the descriptive statistics table also reveals an interesting finding, the general keywords of fintech are less interesting to the investors than keywords of product, money, payment, and wallet. It might be explained by the deep penetration of fintech (the term "Công nghệ tài chính," "Fintech," and "Financial technology") in socio-economic life. Thus, the users do not need to spend more time finding out information about fintech; instead, they focus on searching the specified fintech.

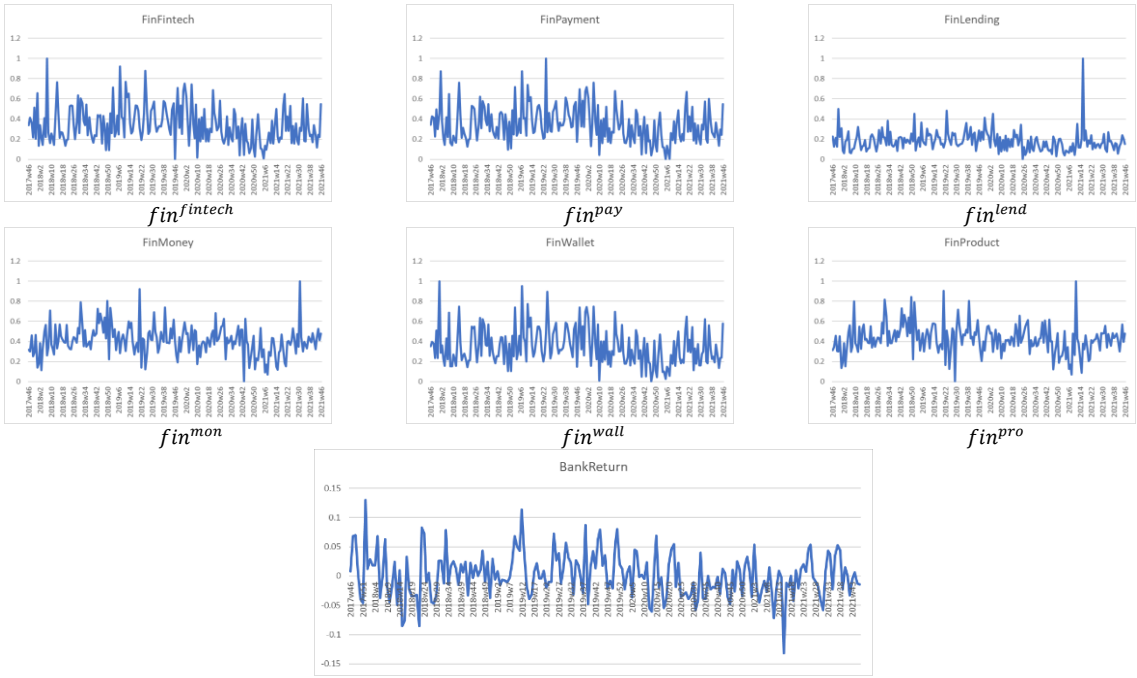


Figure 4.1 The movement of variables

Source: The author

Before estimating the relationship between time-series variables, the mandatory requirement is that the series be stationary or stochastic. If the series is non-stationary or possesses a unit root, the estimation results between series variables might be spurious or nonsense (Brockwell & Davis, 2016). Based on that, the graphical diagnostic and stationary test (or unit root test) is first employed for examining the stochastic series

Figure 4.1 shows the movement of seven variables, including six kinds of fintech variables and bank stock return, which are used for estimating the relationship between fintech by Google search and bank performance. The graphic diagnosis indicates that all series are stochastic. In detail, the fluctuation

of $fin^{fintech}$, fin^{pay}, fin^{lend}, fin^{mon}, fin^{wall}, $and\ fin^{pro}$ are around 0.40, 0.35, 0.18, 0.41, 0.35, and 0.43, respectively, whereas $Return$ fluctuates around 0 (zero).

Furthermore, I use the Dickey and Fuller (1979) and Phillips and Perron (1988) tests, commonly applied with the null hypothesis of unit autoregressive root in a series. If the original series is not stationary, the first series's first difference will be considered the typical way to deal with stochastic trends.

The estimation results show that all null hypotheses are rejected at the 1% confidence level; this means all variables are stationary at the first level. In detail, the specific value of statistics for the unit root test of each series is presented in **Table 4.2**. The statistics value of the Dickey and Fuller test are -12.004, -12.433, -12.200, -13.013, -12.494, -12.358, and -12.815 for the series of $Return$, $fin^{fintech}$, fin^{pay}, fin^{lend}, fin^{mon}, fin^{wall}, $and\ fin^{pro}$, respectively; while of the Phillips and Perron tests are -12.055, -12.508, -12.333, -13.110, -12.772, -12.465, and -12.999 for the corresponding series. It can be seen that the maximum value of the statistic of the Dickey and Fuller test and Phillips and Perron test for testing the presence of unit roots are -12.004 and -12.055, respectively, which are less than -2.57, a critical value; thus, the null hypothesis is rejected. Based on that, I can conclude that the original variables are eligible for further quantitative analysis.

4.2.2 Specific fintech popularity and bank stock return

As I presented above, seven time-series models are formulated. It consists of six specific models illustrating the link between pairs variables of fintech popularity and bank stock return and one aggregation model describing the association between six kinds of fintech popularity and bank stock return. In this sub-section, the relationships between pairs variables of fintech popularity and bank stock return are presented below:

The pre-estimation stage of choosing the optimal lags plays the most crucial role in the processing data series, especially for the Vector autoregression model (VAR) model estimation. Based on Ivanov and Killian (2001), Lütkepohl (2005), and Pfaff (2008), the test of lag-order selection is conducted. Following Lütkepohl (2005), the main statistical values of the Akaike's information criterion (AIC), the Hannan and Quinn information criterion (HQIC), the Schwarz's Bayesian information criterion (SBIC), and the prediction error (FPE) for choosing the optimal lags are estimated, as shown in **Table 4.3**. Due to the weekly data being employed, if considerations of statistical values are inconsistent, the AIC is a priority in considering the optimal lags (Huynh, 2019; Ivanov & Killian, 2001; Nasir et al., 2019). Besides, Ivanov and Killian (2001) suggested that the AIC should be considered to select the optimal lags for the VAR model.

Table 4.3 The lag-order selection of specific models

	Model 1. $Return_t = f(fin_t^{fintech})$				**Model 2.** $Return_t = f(fin_t^{pay})$			
Lag	FPE	AIC	HQIC	SBIC	FPE	AIC	HQIC	SBIC
0	.000043	-4.37101	-4.3579*	-4.33859*	.000041	-4.42685	-4.41374	-4.39443*
1	.000043	-4.38228	-4.3429	-4.28502	.00004*	-4.45815*	-4.41882*	-4.3609
2	.000043*	-4.3828*	-4.31724	-4.22071	.00004	-4.44685	-4.38129	-4.28476
3	.000044	-4.35986	-4.26806	-4.13292	.000041	-4.41973	-4.32794	-4.19279
4	.000045	-4.32744	-4.20943	-4.03567	.000043	-4.39004	-4.27203	-4.09827
	Model 3. $Return_t = f(fin_t^{lend})$				**Model 4.** $Return_t = f(fin_t^{mon})$			
Lag	FPE	AIC	HQIC	SBIC	FPE	AIC	HQIC	SBIC
0	.000015	-5.43138	-5.41827	-5.39896	.000031	-4.6932	-4.68009*	-4.66078*
1	.000014	-5.51814	-5.4788	-5.42088	.00003	-4.71116	-4.67182	-4.6139
2	.000013*	-5.60185*	-5.53628*	-5.43975*	.000031*	-4.71645*	-4.65088	-4.55435
3	.000013	-5.58547	-5.49368	-5.35853	.000031	-4.69841	-4.6066	-4.47147
4	.000013	-5.5752	-5.45718	-5.28342	.000032	-4.66419	-4.54617	-4.37241
	Model 5. $Return_t = f(fin_t^{wall})$				**Model 6.** $Return_t = f(fin_t^{pro})$			
Lag	FPE	AIC	HQIC	SBIC	FPE	AIC	HQIC	SBIC
0	.000043	-4.37561	-4.3625*	-4.34319*	.000031	-4.71639	-4.70327*	-4.68397*
1	.000043	-4.38616	-4.34682	-4.2889	.00003*	-4.73262*	-4.6932	-4.63536
2	.000043*	-4.38863*	-4.32306	-4.22653	.00003	-4.73154	-4.66598	-4.56945
3	.000044	-4.36674	-4.27495	-4.1398	.000031	-4.70196	-4.61017	-4.47502
4	.000045	-4.33774	-4.21973	-4.04597	.000032	-4.66663	-4.54861	-4.37485

*Note: * is the suggestion of lag-order selection*

Source: The author

Table 4.3 presents the main statistical value of six specific models, which illustrate the relationship between pairs variables of bank stock return and fintech popularity. The four main statistical values of model 1 ($Return_t = f(fin_t^{fintech})$) are inconsistencies; thus, the AIC is considered for selecting optimal lags. The lags of two (2) are selected for model 1 with AIC = -4.3828. The lag of one (1) is the optimal lag of model 2 ($Return_t = f(fin_t^{pay})$), due to the consistency of the FPE (0.0004), AIC (-4.45815), and HQIC (-4.41882). The four statistical values of FPE (0.00013), AIC (-5.60185), HQIC (-5.53628), and SBIC (-5.43975) indicate that two (2) is an optimal lag of model 3 ($Return_t = f(fin_t^{lend})$). The statistical value FPE (0.00031) and AIC (-4.72645) agree that the optimal lags of model 4 ($Return_t = f(fin_t^{mon})$) is two (2). It is also the optimal lags of model 5 ($Return_t = f(fin_t^{wall})$) with FPE (0.000043) and AIC (-4.388863). The statistical value of FPE (0.00003) and AIC (-4.73262) support the optimal lags of one (1) of model 6 ($Return_t = f(fin_t^{pro})$). The selected optimal lags are used for the next analysis.

Next, following Dolado et al. (1990), Huynh (2019), Johansen (1988), Lütkepohl (2005), and Nasir et al. (2019), the error-correction approach to estimate the cointegrating relationship between pair variables of the model 1-6. The co-integration test is significant in determining the relationship between variables that persist in the short-run or long-run. In this sub-section, the Johansen

test is employed for testing the cointegration of pairs variable (k=2) with null hypotheses of trace test that the number of cointegration vectors is rank r = r* < k.

Table 4.4 The co-integration test of specific models

Model 1. $Return_t = f(fin_t^{fintech})$					**Model 2.** $Return_t = f(fin_t^{pay})$				
Rank	LL	Eigenvalue	Trace Statistic	5% critical value	Rank	LL	Eigenvalue	Trace Statistic	5% critical value
0	387.73811	.	152.250	15.41	0	348.7448	.	241.3153	15.41
1	436.41076	0.37516	54.9048	3.76	1	421.5307	0.50335	95.7436	3.76
2	463.86315	0.23298			2	469.4025	0.36891		
Model 3. $Return_t = f(fin_t^{lend})$					**Model 4.** $Return_t = f(fin_t^{mon})$				
Rank	LL	Eigenvalue	Trace Statistic	5% critical value	Rank	LL	Eigenvalue	Trace Statistic	5% critical value
0	514.41508	.	151.825	15.41	0	431.9411	.	132.0206	15.41
1	563.90943	0.38011	52.8371	3.76	1	472.62479	0.32502	50.6533	3.76
2	590.32797	0.22528			2	497.95142	0.21706		
Model 5. $Return_t = f(fin_t^{wall})$					**Model 6.** $Return_t = f(fin_t^{pro})$				
Rank	LL	Eigenvalue	Trace Statistic	5% critical value	Rank	LL	Eigenvalue	Trace Statistic	5% critical value
0	388.51388		151.980	15.41	0	380.7060		234.4007	15.41
1	437.52183	0.37719	53.9648	3.76	1	443.77956	0.45473	108.2538	3.76
2	464.50421	0.22949			2	497.90646	0.40575		

Source: The author

The estimation results in **Table 4.4** show that trace statistics are always higher than the 5% critical value in all ranks; thus, I can conclude that no pair-variables persist in the long run. In detail, the trace statistic at rank 0 (r = 0) of model 1-6 are 152.2501 ($Return_t = f(fin_t^{fintech})$), 241.3153 ($Return_t = f(fin_t^{pay})$), 151.8258 ($Return_t = f(fin_t^{lend})$), 132.0206 ($Return_t = f(fin_t^{mon})$), 151.9807 ($Return_t = f(fin_t^{wall})$), and 234.4007 ($Return_t = f(fin_t^{pro})$), respectively, which are higher than 15.41 of 5% critical value. Therefore, the VAR estimation is appreciated for assessing the effect of fintech popularity on bank stock return.

Motive from Huynh (2019) and Nasir et al. (2019), the VAR-Granger approach is employed to estimate the causal relationship between fintech popularity and bank stock return. The estimation results are shown in **Table 4.5**. It illustrates the statistical value of the effect of the variable in the row on the variable in the column. The null hypothesis is that the variable in the row is not a Granger cause variable in the column.

The two bi-directional causalities between pair variables are validated: $Return$ and fin^{pay} and $Return$ and fin^{lend}. In detail, the statistical value of the effect of $Return$ on fin^{pay} is 4.4872, which permits to rejection of the null hypothesis at a 5% significant level; whereas the null hypothesis of the effect of fin^{pay} on $Return$ is rejected at a 10% significant level (statistical value is 2.8908). The statistical value of the effect of $Return$ on fin^{lend} and the effect of fin^{lend} on $Return$ are 18.42 and 23.696, respectively, which allows concluding the bi-directional causality between $Return$ and fin^{lend} at a 1% significant level. The findings show that the search volume of keywords regarding the two largest segments of the fintech industry (lending and payment) might predict the change in bank stock return, which support the statement of Buchak et al. (2018) and Iman (2019) about the relationship between traditional banks and fintech segments in the digital era. Besides, according to my observation in Vietnam, the link between the two largest fintech segments and bank performance is clearly indicated by the collaboration between banks and fintech in merging customers using payment and lending products. The banks can extend the number of customers through the advanced ways to deliver products of the fintech companies, while experience in the banking industry is the bank's strength in cooperation with the fintech companies.

Table 4.5 Granger causality of pair variables in the specific models

Variable	Return	$fin^{fintech}$	**Variable**	Return	fin^{pay}
Return	-	5.298*	Return	-	4.4872**
$fin^{fintech}$	3.4975	-	fin^{pay}	2.8908*	-
Variable	Return	fin^{lend}	**Variable**	Return	fin^{mon}
Return	-	18.42***	Return	-	.6059
fin^{lend}	23.696***	-	fin^{mon}	4.3291**	-
Variable	Return	fin^{wall}	**Variable**	Return	fin^{pro}
Return	-	6.3459**	Return	-	.25404
fin^{wall}	2.4163	-	fin^{pro}	2.4719	-

*Note: *, **, and *** are significant at the 10%, 5%, and 1% levels, respectively.*
The null hypothesis is that the variable in the row is not a Granger cause variable in the column.
Source: The author

There are two uni-directional causalities of pair variables: from $Return$ to $fin^{fintech}$ at a 10% significant level with a statistical value is 5.298, and from $Return$ to fin^{wall} at a 5% significant level with a statistical value is 6.3459; which means the effect of $Return$ on the search volume of fintech (in general) and wallet is more weight than the opposite direction. I argue that the findings are interesting: the change in bank stock return predicts fintech popularity and fintech popularity in wallet. It might demonstrate the increased financial literacy about the link between fintech and banks (Morgan & Trinh, 2020). Following the change of bank stock return, they search for information about fintech.

Furthermore, there is another uni-directional causality from fin^{mon} to $Return$ at a 5% significant level with a statistical value of 4.3291. It means there is a significant effect on search volume of fintech money (the term "mobile money" and "tiền điện tử") on bank stock return. In fact, Almulla and Aljughaiman (2021) and Ky et al. (2021) found a significant effect of mobile money on conventional finance institutions. The popularity of mobile money affects bank customer's behavior in deposits, loans, and payment, which influences bank performance. Besides, **Table 4.5** also reveals that there is no evidence to conclude the relationship between $Return$ and fin^{pro}, due to the statistical values of pair variables (0.25404 and 2.4719) being lower than the critical value; thus, it could not reject the null hypothesis of the effect of $Return$ on fin^{pro}, and the effect of fin^{pro}on $Return$.

$Return$ might be predicted by three variables (fin^{pay}, fin^{lend}, and fin^{mon}), while $Return$ is a predictive factor of 4 variables (fin^{pay}, fin^{lend}, $fin^{fintech}$, and fin^{wall}). Based on that, the relationship between bank stock return and fintech popularity is confirmed which consist with Buchak et al. (2018), Navaretti et al. (2018), Tang (2019), and Thakor (2020) about the relationship between bank and fintech in the digital era. However, most existing publications agree that there is a stronger impact of fintech on banks than the opposite. Besides, the estimation results also show no evidence to conclude the causality between $Return$ and fin^{pro}.

Based on the estimation results above, I explore the interesting findings. First, although the volume of searching fintech product keywords is highest, there is no relationship between searching fintech popularity in products and bank stock return. I discuss that the reason regards the curiosity of investors about fintech products. They want to explore fintech products rather than a reference for making investment decisions, whereas the feature of fintech, such as fintech popularity in payment, lending, and money, are critical references for investment decisions. Second, in most cases, the bank stock return is the impact factor of fintech popularity ($fin^{fintech}$, fin^{pay}, fin^{lend}, and fin^{wall}), while only fin^{pay} and fin^{lend} are the significant factors of bank stock return. Therefore, I consider that bank stock return is more influence on fintech popularity than the opposite.

Based on the estimation results by VAR-Granger and the optimal lags of specific models, the regression analysis will be run to identify the effect of specific fintech popularity on bank stock return. The regression analysis results are presented in **Table 4.6**.

The F-value in **Table 4.6** gives that the estimation result of model 4 $Return_t = f(fin_t^{mon})$ is not significant (F-value = 1.49 less than the critical value); other models are significant at different levels. In detail, models 1, 2, 3, and 5 are significant at a 1% of level with F-value are 5.94, 9.30, 5.69, and 6.92,

respectively; model 6 is at a significant level of 10% with an F-value is 2.36. It means the regression model's independent variables might explain the bank stock return change.

Table 4.6 Effect of specific fintech popularity on bank stock return

Variable	**Model 1:** $\boldsymbol{Return_t = f(fin_t^{fintech})}$	**Model 2:** $\boldsymbol{Return_t = f(fin_t^{pay})}$	**Model 3:** $\boldsymbol{Return_t = f(fin_t^{lend})}$
$Return_{t-1}$	.1325252* [1.90]	.0981091 [1.41]	.1829064** [2.58]
$Return_{t-2}$	-.0766004 [-1.10]	-	-.038792 [-0.55]
$fin_t^{fintech}$	.0576098*** [4.11]	-	-
$fin_{t-1}^{fintech}$	.0152585 [1.05]	-	-
$fin_{t-2}^{fintech}$	.0206214 [1.41]	-	-
fin_t^{pay}	-	.0575004*** [3.99]	-
fin_{t-1}^{pay}	-	.0254605* [1.70]	-
fin_t^{lend}	-	-	.0461059* [1.78]
fin_{t-1}^{lend}	-	-	.0118123 [0.46]
fin_{t-2}^{lend}	-	-	.0951207*** [3.83]
Cons	-.030072*** [-3.76]	-.0268714*** [-3.76]	-.0267309*** [-3.58]
F-Value	5.94***	9.30***	5.69***
Optimal lags	2	1	2
Variable	**Model 4:** $\boldsymbol{Return_t = f(fin_t^{mon})}$	**Model 5:** $\boldsymbol{Return_t = f(fin_t^{wall})}$	**Model 6:** $\boldsymbol{Return_t = f(fin_t^{pro})}$
$Return_{t-1}$	.1788104** [2.55]	.1264746* [1.82]	.1795226*** [2.59]
$Return_{t-2}$	-.000443 [-0.01]	-.0854798 [-1.23]	-
fin_t^{mon}	-.0111405 [-0.61]	-	-
fin_{t-1}^{mon}	.0017777 [0.10]	-	-
fin_{t-2}^{mon}	.0152764 [0.84]	-	-
fin_t^{wall}	-	.0622664*** [4.53]	-
fin_{t-1}^{wall}	-	.0130122 [0.90]	-
fin_{t-2}^{wall}	-	.0247475* [1.71]	-
fin_t^{pro}	-	-	-.0091719 [-0.51]
fin_{t-1}^{pro}	-	-	-.0078764 [-0.44]
Cons	-.0010636 [0.09]	-.0329392*** [-4.11]	.0089404 [0.84]
F-Value	1.49	6.92***	2.36*
Optimal lags	2	2	1

*Note: *, **, and *** are significant at the 10%, 5%, and 1% levels, respectively.*

Source: The author

The estimation results show that the $fin_t^{fintech}$ coefficient is 0.0576098 and a significance level of 1%, which means that the increase in the search volume of fintech increase the bank stock return. The finding is evidence to conclude that there is a positive effect of fintech popularity on bank stock return.

The coefficients of fin_t^{pay} and fin_{t-1}^{pay} are 0.0575004 (significance level of 1%) and 0.0254605 (significance level of 10%), respectively. It means the increase or decrease of bank stock return at week t depends on the increase or decrease of search volume of fintech popularity in payment at week t and t-1. Besides, the estimation results reveal that the fintech popularity in wallet is also

a positive predictor of bank stock return, which is proven by the significant positive coefficients of the fintech popularity in wallet variables, namely the coefficients of fin_t^{wall} and fin_{t-2}^{wall} are 0.0622664 (significance level of 1%) and 0.0247475 (significance level of 10%), respectively. Based on the findings, I conclude that there is a positive effect of fintech popularity in payment on bank stock return.

Regarding the hypothesis (H_{1b}) of the negative effect of fintech popularity in lending on bank stock return, the estimation results of model 3 ($Return_t = f(fin_t^{lend})$) is used for discussion. The coefficients of fintech popularity in lending are significantly positive; namely, the increase or decrease of volume search of fintech lending at the week t and t-2 correspondingly increases in bank stock return at the week t. In detail, give that the fin_t^{lend} and fin_{t-2}^{lend} coefficients are 0.0461059 (significance level of 10%) and 0.0951207 (significance level of 1%), respectively.

4.2.3 Total fintech popularity variables and bank stock return

In this sub-section, the effect of fintech popularity on bank stock return is considered in the aggregation model, which demonstrates the link between the contemporary of the six fintech popularity and the bank stock return variable. Like the data analysis process of the relationship between specific fintech popularity and bank stock returns, selecting the optimal lags and examining the cointegration between variables are firstly conducted. **Table 4.7** shows that the statistical value of FPE (2.3e-16), AIC (-16.1445), and HQIC (-15.4561) indicate that two (2) are the optimal lags of the aggregation model. The trace statistic value at rank 0 (r=0) is 699.7386 (higher than 124.24 of 5% critical value) is the evidence to conclude the absence of a long-run relationship between $Return$ and six kinds of fintech popularity variabe. Following that, the VAR-Granger is employed for the aggregation model.

The estimation results in **Table 4.8** confirm the bi-directional causality between $Return$ and fin^{lend} as found above; thus, we conclude a significant link between the volume of searching P2P lending and bank stock return. The development of P2P platforms on the internet brings more advanced lending products than before for fintech companies and traditional banks (Bachmann et al., 2011; Wan et al., 2016). The curiosity about exploring P2P lending products leads to extending the credit market, which supports enhancing bank performance. Furthermore, when the bank's performance is appreciated, the motive is to push a marketing campaign to increase the lending customer in cyberspace (Domazet & Neogradi, 2019; van Thiel & van Raaij, 2019). Through our observation of the digital marketing campaign of Vietnamese banks, especially regarding e-loans, we argue that the bi-directional causality between $Return$ and fin^{lend} is similar to the argument above.

Table 4.7 Lag-order selection and co-integration of the aggregation model

Panel A. The lag-order selection					**Panel B.** The co-integration test				
Lag	FPE	AIC	HQIC	SBIC	Rank	LL	Eigenvalue	Trace Statistic	5% critical value
0	5.4e-16	-15.2966	-15.2507	-15.1831*	0	1430.9964	.	699.7386	124.24
1	3.8e-16	-15.6509	-15.2837	-14.7432	1	1528.5637	0.61042	504.6039	94.15
2	2.3e-16*	-16.1445*	-15.4561*	-14.4425	2	1611.7536	0.55236	338.2241	68.52
3	2.9e-16	-15.9055	-14.8958	-13.4092	3	1658.7395	0.36490	244.2523	47.21
4	3.5e-16	-15.7467	-14.4158	-12.4561	4	1702.5996	0.34542	156.5323	29.68
					5	1741.4048	0.31266	78.9219	15.41
					6	1765.9074	0.21080	29.9165	3.76
					7	1780.8657	0.13457		

The aggregation model: $Return_t = f(fin_t^{fintech}, fin_t^{pay}, fin_t^{lend}, fin_t^{mon}, fin_t^{wall}, fin_t^{pro})$
*Note: * is the suggestion of lag-order selection*
Source: The author

However, **Table 4.8** gives no evidence to confirm the bi- and uni-directional causality from $Return$ to other fintech variables. The difference in estimation results between specific models and aggregation models might be explained by the existing internal issues of the multi-dimensional of the regression model (Abadir et al., 1999; Gordon, 1968); when one more independent variable is added to the model, which affects the estimation of the coefficients. In this case, the statistical values of the coefficient provide the evidence to accept the null hypothesis that $Return$ does not indicate Granger causality with the fintech popularity variables, and the fintech popularity variable does not indicate Granger causality with $Return$.

Besides, **Table 4.8** provides something interesting. The participants seem not to search only for a particular fintech keyword; they tend to find the fintech information group. The multi-link between fintech-related keywords in searching behavior is found in **Table 4.8**. There is a significant influence of this fintech keyword on another, which means the action of searching this fintech might predict the others.

Table 4.8 Granger causality for pair variables in aggregation model

Variable	Return	$fin^{fintech}$	fin^{pay}	fin^{lend}	fin^{mon}	fin^{wall}	fin^{pro}	ALL
Return	-	1.9395	.15928	16.096***	1.2721	2.4653	1.1427	28.882***
$fin^{fintech}$	3.3195	-	1.8912	156.67***	2.9112	3.9989	.75953	179.51***
fin^{pay}	3.5353	.84315	-	127.93***	2.1413	7.5292**	.80516	152.71***
fin^{lend}	25.61***	.49132	.91805	-	3.7406	.47894	1.5426	38.559***
fin^{mon}	2.7433	9.7181***	1.555	1.8949	-	2.7632	2.1868	23.438**
fin^{wall}	2.2384	.63603	3.1008	168.83***	2.2134	-	.62177	191.63***
fin^{pro}	2.9429	11.781***	2.0084	.35991	.1992	3.2744	-	24.218**

The aggregation model: $Return_t = f(fin_t^{fintech}, fin_t^{pay}, fin_t^{lend}, fin_t^{mon}, fin_t^{wall}, fin_t^{pro})$
*Note: *, **, and *** are significant at the 10%, 5%, and 1% levels, respectively.*
The null hypothesis is that the variable in the row is not a Granger cause variable in the column.
Source: The author

In detail, there is the uni-directional causality from $fin^{fintech}$ to fin^{lend}, from fin^{pay} to fin^{lend} and fin^{wall}, from fin^{mon} to $fin^{fintech}$, from fin^{wall} to fin^{lend}, and from fin^{pro} to $fin^{fintech}$. I argue that the interconnection between kinds of fintech popularity might be the sign for predicting the development of the sub-sector of fintech through the search volume. For instance, after searching for information about fintech payment, the users tend to search for information about fintech lending and fintech wallet regarding factors of fintech payment.

Furthermore, I explore that fin^{lend} is staying in more relationships than others; the influence of $fin^{fintech}$, fin^{pay}, and fin^{wall}, on fin^{lend} are considered as subsidized activities for P2P lending popularity. I argue that it is suitable for the Vietnamese economy for the following reasons. Vietnam is a developing country where people are constrained to access conventional credit (front-of-desk transactions) (Archer et al., 2020; Duy et al., 2012; Le, 2012). Thus, the P2P lending platform opens the chance to access credit for borrowers and a new investment channel for savers (Bachmann et al., 2011; Feng et al., 2015).

Following the estimation results by VAR-Granger and the optimal lags of two of the aggregation models, the regression analysis shall be run to determine the effect of fintech popularity on bank stock return. The regression results are illustrated in **Table 4.9**.

Table 4.9 Effect of fintech popularity on bank stock return

Variable	$Return$	Variable	$Return$	Variable	$Return$
$Return_{t-1}$	.1559549** [2.01]	fin_{t-2}^{pay}	-.0120493 [-0.32]	fin_{t}^{wall}	.1128298 [1.64]
$Return_{t-2}$	-.0734844 [-0.96]	fin_{t}^{lend}	.0418523 [1.56]	fin_{t-1}^{wall}	-.1409726* [-1.78]
$fin_{t}^{fintech}$	-.1003209 [-1.47]	fin_{t-1}^{lend}	.0065759 [0.25]	fin_{t-2}^{wall}	.093766 [1.17]
$fin_{t-1}^{fintech}$	.1355067* [1.84]	fin_{t-2}^{lend}	.039088 [1.15]	fin_{t}^{pro}	-.010437 [-0.30]
$fin_{t-2}^{fintech}$	-.0635769 [-0.89]	fin_{t}^{mon}	-.0125449 [-0.36]	fin_{t-1}^{pro}	-.0299092 [-0.85]
fin_{t}^{pay}	.0334295 [0.83]	fin_{t-1}^{mon}	.0267434 [0.76]	fin_{t-2}^{pro}	-.0230221 [-0.66]
fin_{t-1}^{pay}	.0225771 [0.50]	fin_{t-2}^{mon}	.0300841 [0.86]	Cons	-.0338611** [-2.39]
F-Value	2.35***		Optimal lags	2	

*Note: *, **, and *** are significant at the 10%, 5%, and 1% levels, respectively.*

Source: The author

The F-Value is 2.35 in **Table 4.9** reveals that the regression result of the model is a significant level of 1%, or there is at least one independent variable in the model that might explain the change in bank stock return.

The coefficients of $fin_{t-1}^{fintech}$ and fin_{t-1}^{wall} are 0.1355067 and -0.1409726, respectively, and both are significant levels of 10%. This finding is different from the estimation results by Granger for the aggregation model. In the aggregation model, the Granger approach provides a significant relationship between fin^{lend} and $Return$, but the regression analysis result does not confirm it and even does not provide a significant effect of fin^{lend} on $Return$. Therefore, in this case, based on the regression analysis results, I might conclude that there is a positive effect of fintech popularity on bank stock return for the reason of $fin_{t-1}^{fintech}$ coefficient is significantly positive. The significantly negative fin_{t-1}^{wall} coefficient permits to conclude that there is a negative effect of fintech popularity in payment on bank stock return. No evidence is found to conclude the effect of fintech popularity in lending on bank stock return.

4.2.4 Copula estimation

As I mentioned above, the VAR Granger's estimation results are again validated by Copula estimation, which is a robustness check about the relationship between fintech popularity and bank stock return. **Figure 4.2** shows the Kendall-plot graphic used to visually diagnose the inter-relationship between pair variables. If the Kendall plot is in or under the 45-degree line, the pairs variable is diagnosed with a non-dependency structure, or there is no evidence to conclude the link between variables. Otherwise, if the Kendall plot lies above the 45-degree line, the pairs variables are determined to have a dependency structure.

Based on **Figure 4.2,** the diagnosis of graphical shows that there is a non-dependency structure between 2 pairs of variables: $Return$ and fin^{mon}, and $Return$ and fin^{pro}, because the defined points lie on the 45-degree line. In contrast, other pair variables (four pair variables: $Return - fin^{fintech}$, $Return - fin^{pay}$, $Return - fin^{lend}$, and $Return - fin^{wall}$) are determined to have the structural dependency because their defined points are above the 45-degree lines.

Besides the diagnosis by Kendall-plot graphics, the dependency structure between variables is confirmed again by the estimators of three famous families of Copula, which are Gumbel, Clayton, and Normal (Gaussian), as mentioned above.

Furthermore, the fit goodness test will be conducted to select the suitable tail-dependency structure between the estimation results of three Copulas. However, Embrechts (2009) and Huynh et al. (2020) provide that the fit goodness test will pass approximately 99.9% of Copula's approaches; thus, in this thesis, I argue that the fit goodness test is not necessary to be conducted. Following Embrechts (2009) and Huynh et al. (2020), the highest log-likelihood value is considered for selecting the fittest tail-dependency.

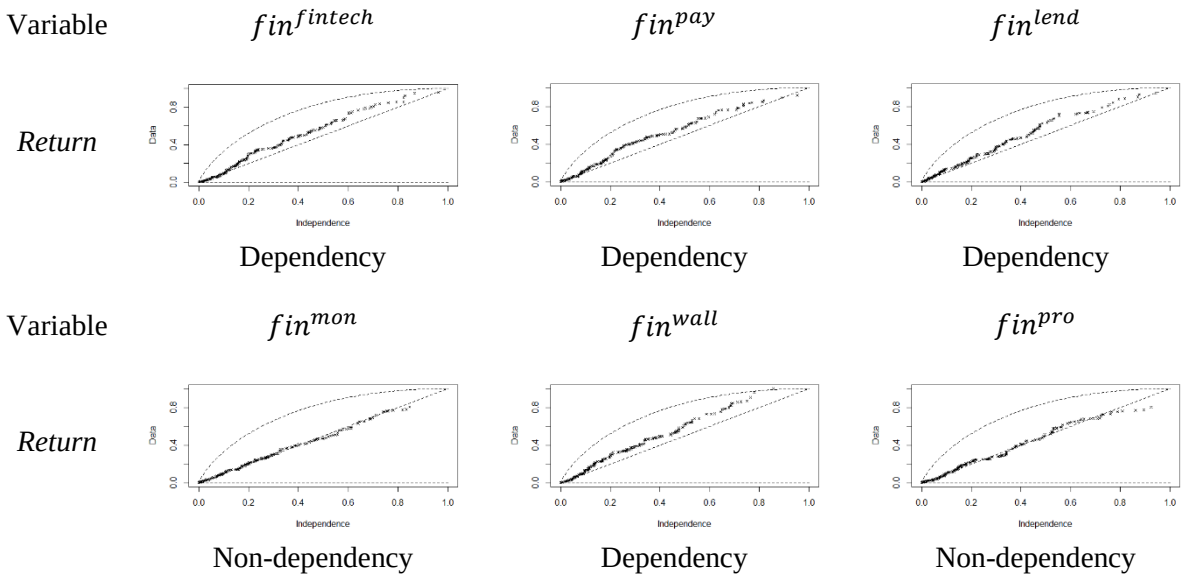


Figure 4.2 Kendall-plot graphics illustrating the dependency structure

Source: The author

Based on the graphical diagnosis above, the tail-dependence of four dependency structures by Kendall-plot diagnosis of pairs variables are validated by estimating the parameter and log-likelihood of Clayton, Gumbel, and Normal Copula, shown in **Table 4.10**.

Table 4.10 Estimated parameter and log-likelihood by the Copula

		$Return$ - $fin^{fintech}$	$Return$ - fin^{pay}	$Return$ - fin^{lend}	$Return$ - fin^{wall}
Clayton	Parameter	13.1362	2.1091	10.7072*	7.9939
	Log-likelihood	7.897	10.22	3.131	7.622
Gumbel	Parameter	1.205	1.217	1.1	1.222
	Log-likelihood	7.842	7.568	2.223	10.15
Normal	Parameter	0.2892*	0.3237*	0.1408	0.3058***
	Log-likelihood	8.429	10.71	1.915	9.486

Note: (*) is considered the fittest estimation

Source: The author

Table 4.10 shows that the column of $Return$ - $fin^{fintech}$, the log-likelihood of Clayton, Gumbel, and Normal is 7.897, 7842, and 8.429, respectively, which the highest log-likelihood belonging to Normal; thus, the dependency structure between $Return$ and $fin^{fintech}$ is determined a normal shape. It means the probability of simultaneous increase or decrease between bank stock return and fintech popularity is equal. The same with the case of $Return$ - $fin^{fintech}$, at the column of $Return$ - fin^{pay} and $Return$ - fin^{wall}, the highest log-likelihood are 10.71 and 9.486, respectively, belonging to Normal (compared with Clayton and Gumbel). It means the simultaneous changes of pairs of variables are equal.

In the column $Return$ - fin^{lend} the comparison of the log-likelihood of Clayton (3.131), Gumbel (2.223), and Normal (1.915), the highest log-likelihood is Clayton; thus, the structural dependency between $Return$ and fin^{lend} is determined as a left-tail, which means in case of simultaneous decrease between bank stock return and fintech popularity in lendings is higher than in other cases.

The estimation result by Copulas confirms the significant relationship between $Return$ and fin^{lend}. However, this relationship is more robust in the case of downward than upward. The investor's taste can explain it in bank stocks and the habit of searching lendings-related keywords on Google. The decrease in searching fintech lending volume reduces bank income expectations, influencing bank stock performance. Besides, investors are paying less attention to searching for information regarding fintech lending than before, which indicates that the investors are not enthusiastic about the bank stocks and might find other opportunities in other stocks. Furthermore, as I mentioned earlier, interest incomes are the highest proportion of the Vietnamese banks' income; hence, the decrease in bank stock returns is a sign of decreased interest incomes, which leads to changing the investor habit in searching for fintech lending information.

Consequently, through the estimation results and discussion above, I conclude that:

- *First, there is a significant relationship between fintech popularity and bank stock return, as well as fintech popularity in payment and lending in the fintech industry, which are also significantly linked to bank stock return. The effect of fintech popularity on bank stock return is positive, and the simultaneous change in the increase or decrease of two variables is equal.*

- *Second, most evidence shows that the effect of fintech popularity in payment (including in wallet) on bank stock return is positive. The increase in volume search of payment and wallet predicts the rise in bank stock return.*

- *Third, fintech popularity in lending is determined to be a significant positive factor in predicting the change of bank stock return; especially, it is meaningful in the simultaneous change in the decrease of both variables.*

Overall, I found that there is a positive effect of fintech popularity (including in payment and lending) on bank stock return.

4.3 Effect of bank investment in technology innovation on bank efficiency

Following the research methodology above, in this sub-section, the quantitative research on the effect of BITI on bank efficiency is demonstrated. The descriptive

statistic is first presented to get insight into data characteristics. Next, the FE, RE, GLS, and Tobit models are employed to estimate the effect. In parallel with the data analysis, the discussion is also presented.

4.3.1 Descriptive statistic and multicollinearity test

Table 4.11 shows the main features of all variables used to estimate the effect of BITI on bank efficiency. Most variables have 230 observations for 23 commercial banks in 10 years (2011-2020), except the INF and GDP variables have ten observations, representing a yearly and repeated macroeconomic condition for each bank in 2011-2020.

Table 4.11 Descriptive statistic

Variable		Definition	Obs.	Mean	Std. Dev	Min.	Max.
Bank	EFF	Bank efficiency	230	.5269759	.1932101	.0112239	1
Fintech	INR	Intangible assets on fixed assets	230	.4761392	.1940598	.0236898	.9812289
	ING	Growth rate of intangible assets	230	.2795915	1.004721	-.9987441	11.45088
Char	AGE	Bank age	230	3.084361	.4795883	1.098612	4.143135
	Age (years)*		230	24.19565	11.15711	3	63
	SIZE	Bank size measured by total assets	230	11.91671	1.01973	9.623798	14.23204
	Size (billion VND)*		230	251,086.7	295,721.4	15,120.37	1,516,686
Mar	INF	Inflation	10	.0548258	.0492765	.006312	.1867773
	GDP	GDP growth rate	10	.0595946	.0118046	.0290584	.0707579

Trading code of 23 banks: ABB, ACB, BAB, BID, CTG, EIB, HDB, KLB, LPB, MBB, MSB, NAB, NVB, OCB, SCB, SHB, SSB, STB, TCB, TPB, VCB, VIB, and VPB. Data is from 2011 to 2020
Proposed model (Equation 3.19): $Bank_{it} = \propto + \beta Fintech_{it} + \gamma Char_{it} + \theta Mar_t + \mu_i + \delta_{it}$
** denotes the original variable before the logarithm.*
Source: The author

The DEA approach measures EFF with the inputs of the number of employees, capital, and revenue output. EFF_{mean} is 0.527, which reveals the bank is slightly over the average efficiency level. It means the Vietnamese banks have average efficiency. EFF_{max}= 1 and EFF_{min}= 0.011223 indicates the large difference between the highest and lowest efficiency. Following my observation, it might be explained by the bank scale and bank strategy in operation. Small banks (e.g., TCB, STB, and HDB) focus on investment in technology innovation to increase bank performance, especially regarding service income from non-conventional products, whereas the interest income still plays the highest weight for large banks (e.g., BID, CTG, VCB). Large banks tend to expand credit scales to increase revenue rather than increase income from services through investment in technology innovation. Besides that, in the context of the Vietnamese banking industry, the significant difference in efficiency between banks might be explained because of bank competition and market power (Le et al., 2020; Nguyen & Nghiem, 2020). Furthermore, the macro condition is also a significant factor

that leads to the difference in efficiency between banks (Batten & Vo, 2019; Vo, 2016).

As mentioned above, bank investment in technology innovation is proxied by the ratio of intangible assets on fixed assets (INR) and the growth rate of intangible assets (ING). The average INR is nearly 50% (INR_{mean} = 0.4761392), and there is an equal capital allocation for intangible and tangible assets. I argue that it is a good signal that the bank is interested in financial innovations and technologies. However, there is a large difference between INR_{max} = 0.9812289 and INR_{min}= 0.0236898, which indicates that a bank allocates most capital for investing in technological innovation, whereas another bank does not.

The average ING is about 27.96%/year (ING_{mean} = 0.2795915), which is higher than INF_{mean} = 0.0548258 and ING_{mean}= 0.595946. I argue that it is a good signal that the growth rate of intangible assets in banks is better than the change in economic conditions, which is also used to explain the dramatic change in bank technology innovation in recent years. The banks focus on adapting to the fintech company growth in the post-financial crisis of 2008-2009. Besides, I argue that it also might signal changes in bank managers' minds about the role of technological innovation.

The average bank age is 24 years old (Age_{mean} = 24.19565), which indicates that most banks have eligible experience in the banking industry. The youngest is 3 (Age_{min} = 3), which is TPB in 2011. TPB was established in 2008 as the youngest bank in the sample. To my knowledge, TPB is one of the fastest banks in applying disruptive technologies to enhance performance in the sample period. The oldest bank is BID (typically called BIDV); in 2020, its years old is 63 (Age_{max} = 63). According to my observation, BIDV is very slow to apply advanced technology to its operations compared with other banks.

The bank size is proxied by total assets in billion VND. $Size_{mean}$ = 251,086 billion VND, just over 10 billion USD. In comparison with the banks in Southeast Asia, the Vietnamese banks' total assets are smaller than others, especially in Thailand, Malaysia, and Singapore (McKinsey&Company, 2015; UOB, 2022). The smallest bank is just over 15,000 billion VND ($Size_{min}$ = 15,120 billion VND), while the largest is over 100 times of smallest bank ($Size_{max}$ = 1,516,686 billion VND). The smallest and largest banks are TPB and BID, respectively. They might be represented in two opposing cases in the Vietnamese banking industry. Small banks actively apply disruptive technology, while large banks seem passive with the sharp change in financial technologies.

Next, two external variables represent macroeconomic conditions: inflation (INF) and gross domestic product growth rate (GDP). In the studied period, INF_{mean}= 0.0548258 and GDP_{mean}= 0.0595946 give that GDP is slightly higher

than INF (5.96% compared with 5.48%), which means Vietnam's economic development might be slightly significant within the sample period. It is a favorable condition for Vietnamese commercial banks. However, the movement of INF is more fluctuated than that of GDP ($INF_{Std.Dev}$= 0.0492765 > $GDP_{Std.Dev}$= 0.0118046), which might indicate the instability of the economy. Furthermore, in line with the study by Hermes and Nhung (2010), in the transition economy, the proper macroeconomic environment and bank efficiency are improved by adequate GDP and inflation. Therefore, I argue that in the sample period, the macroeconomic conditions are favorable for the bank operation, and it might positively impact bank efficiency as the proposed model of the study.

The multicollinearity test is employed before the proposed model (as mentioned in the previous section) is estimated for the panel data (Gujarati & Porter, 2009). Following Gómez et al. (2020) and Gujarati and Porter (2009), the correlation matrix between pair-wise variables and variation inflation factor (VIF) are employed to diagnose the multicollinearity issue.

Table 4.12 Correlation matrix and variance inflation factor

Variable	VIF	EFF	INR	ING	AGE	SIZE	INF	GDP
EFF	-	1.0000						
INR	1.11	-0.1989	1.0000					
ING	1.02	-0.0612	0.0879	1.0000				
AGE	1.64	0.4353	0.1534	0.0879	1.0000			
SIZE	1.68	0.7238	-0.0899	-0.0846	0.5870	1.0000		
INF	1.12	-0.1983	-0.1156	0.0937	-0.2353	-0.2739	1.0000	
GDP	1.01	-0.0567	0.0095	-0.0240	-0.0217	-0.0367	-0.0600	1.0000

Source: The author

Table 4.12 gives that the correlation values between bank fintech variables (INR and ING) and bank efficiency (EFF) are negative, namely, $r_{INR-EFF}$= -0.1989 and $r_{ING-EFF}$= -0.0612, which is a signal of when bank increases in technology innovation, bank efficiency decrease. The correlation values between two key bank characteristics and bank efficiency are positive ($r_{AGE-EFF}$= 0.4353 and $r_{SIZE-EFF}$= 0.7238), which indicates that mature banks are more efficient than young banks, and the bank efficiency might be improved by extending bank size. The maximum absolute values of correlation coefficients between variables belonging to pair-wise variables SIZE and EFF ($|r_{SIZE-EFF}|$) is 0.7238 less than 0.8, which indicates that the multicollinearity issue is absent in the proposed model. Furthermore, the VIF values of these variables show that $VIF_{maximum}$ = 1.68 (belonging SIZE) < $VIF_{thresold}$ = 4.00 of the model less than ten explanatory variables (Gómez et al., 2020; Gujarati & Porter, 2009). Therefore, I can conclude that all variables are eligible for the next analysis.

4.3.2 Estimation models

Following the descriptive statistic and multicollinearity test above, the proposed model is modified to get insight into the effect of BITI and bank efficiency before employing the estimators for analysis. In detail, there are six modified models with specific variables as below:

First, the effect of bank characteristics and macroeconomic conditions on bank efficiency is estimated:

$$EFF_{it} = \propto + \gamma_1 AGE_{it} + \gamma_2 SIZE_{it} + \theta_1 INF_t + \theta_2 GDP_t + \mu_i + \delta_{it} \quad (4.1)$$

Second, the bank investment in technology innovation variables (INR and ING) are added:

$$EFF_{it} = \propto + \beta_1 INR_{it} + \beta_2 ING_{it} + \gamma_1 AGE_{it} + \gamma_2 SIZE_{it} + \theta_1 INF_t + \theta_2 GDP_t + \mu_i + \delta_{it} \quad (4.2)$$

Third, the interaction between bank characteristics and bank investment in technology innovation variables is added too:

$$EFF_{it} = \propto + \beta_1 INR_{it} + \beta_2 ING_{it} + \gamma_1 AGE_{it} + \gamma_2 SIZE_{it} + \theta_1 INF_t + \theta_2 GDP_t + \varphi_1 INR_{it} \times AGE_{it} + \mu_i + \delta_{it} \quad (4.3)$$

$$EFF_{it} = \propto + \beta_1 INR_{it} + \beta_2 ING_{it} + \gamma_1 AGE_{it} + \gamma_2 SIZE_{it} + \theta_1 INF_t + \theta_2 GDP_t + \varphi_2 INR_{it} \times SIZE_{it} + \mu_i + \delta_{it} \quad (4.4)$$

$$EFF_{it} = \propto + \beta_1 INR_{it} + \beta_2 ING_{it} + \gamma_1 AGE_{it} + \gamma_2 SIZE_{it} + \theta_1 INF_t + \theta_2 GDP_t + \varphi_3 ING_{it} \times AGE_{it} + \mu_i + \delta_{it} \quad (4.5)$$

$$EFF_{it} = \propto + \beta_1 INR_{it} + \beta_2 ING_{it} + \gamma_1 AGE_{it} + \gamma_2 SIZE_{it} + \theta_1 INF_t + \theta_2 GDP_t + \varphi_4 ING_{it} \times SIZE_{it} + \mu_i + \delta_{it} \quad (4.6)$$

With the six models above, the P-value and coefficients of bank investment in technology innovation variables and the interaction between BITI and bank characteristics variables are the key statistical indicators that are discussed. The statistical values of β indicate the effect of BITI on bank efficiency, while the statistical values of φ are used to detect the impact of bank characteristics on the relationship between BITI and bank efficiency.

4.3.3 Estimation results by FE and RE

As I mentioned above, FE and RE are firstly employed to estimate the models. Then, the Hausman test is applied to choosing the appreciated estimation results between FE and RE. Next, the heteroskedasticity and autocorrelation issues are tested.

Table 4.13 shows that all statistical value rows permit rejection of the null hypothesis that all coefficients in the model are equal to zero at a 1% significant level, or at least one independent variable in the model can explain the change in bank efficiency. Besides, the R-square rows of the columns of FE and RE show that the independent variables in the model can explain around 54%-59% of the change in bank efficiency ($R-Square_{min}$= 0.5445 and $R-Square_{max}$= 0.5956), the rest of the change is explained by other factors not mentioned in the model. I argue that these R-square are high appreciated for evaluating the effect of BITI on bank efficiency.

P-values and coefficients of independent variables in **Table 4.13** show that all SIZE coefficients are positive at a significance level of 1%, meaning bank efficiency tends to increase with the extension of bank scales (increase total assets). Moreover, all coefficients of INF are optimistic, too, at a significant level of 1%-5%, which reveals that the Vietnamese banks' efficiency depends more on the inflation indicator. With the proper inflation of Vietnam, an emerging country (INF_{mean}=0.0548258, about 5%), I argue that it shows suitable macroeconomic conditions for improving bank efficiency. Following the findings, a large bank is more efficient than a small one, and bank efficiency increases with high inflation. The positive effect of bank size is consistent with Pham et al. (2021b) and Phan et al. (2020); due to the strong brand name and market power, large-sized banks are more efficient than small-sized banks. The sample for estimation reveals that most large-sized banks are state-own banks; they are the most powerful arm of government to imply the monetary policy; thus, they can earn a higher profit than others, especially in developing countries (Janjua et al., 2014; Nguyen et al., 2017; Vo & Nguyen, 2018). The positive association between inflation and efficiency is the same as the study by Pham et al. (2021b). The average inflation in the sample is about 5.48%; I argue that proper inflation increases bank efficiency and economic growth in an emerging economy like Vietnam (Hermes & Nhung, 2010).

The AGE coefficients are also positive at a significance level of 10%-1%. It means the efficiency of mature banks is higher than young banks. I argue that it might be explained by the advantages of experience and reputation in the banking industry (Chiu & Chen, 2009; Godlewski et al., 2012; Karim et al., 2010). With a long history and well-known banks easily occupy customers' trust. I argue that it is a critical factor in increasing bank efficiency.

Table 4.13 Estimation results by FE and RE

	FE	**RE**	**FE**	**RE**	**FE**	**RE**
Variable	**Model 1**		**Model 2**		**Model 3**	
Cons.	-2.1648***	-1.762069***	-2.187435***	-1.74802***	-2.978382***	-2.54451***
	[-10.75]	[-10.12]	[-10.81]	[-10.00]	[-11.42]	[-10.42]
INR	-	-	.0890651	.0418294	2.157619***	2.051156***
	-	-	[1.51]	[0.75]	[4.68]	[4.41]
ING	-	-	-.0000501	.0001347	-.0041269	-.0038581

	-	-	[-0.01]	[0.02]	[-0.68]	[-0.61]
AGE	.1299637**	.0532881	.1291733*	.046089	.3876267***	.2885146***
	[1.97]	[1.20]	[1.96]	[1.06]	[4.56]	[4.13]
SIZE	.1898248***	.1778372***	.1882895***	.1769421***	.1908197***	.1835337***
	[8.16]	[9.98]	[8.07]	[10.05]	[8.56]	[10.61]
INF	.5953438***	.3494045**	.6252868***	.346391**	.5656234***	.2994112**
	[3.69]	[2.31]	[3.84]	[2.25]	[3.63]	[2.01]
GDP	-.0629179	-.2299926	-.0750627	-.2462109	-.2063193	-.365437
	[-0.12]	[-0.44]	[-0.15]	[-0.46]	[-0.42]	[-0.72]
INR*AGE	-	-	-	-	-.6805055***	-.658018***
	-	-	-	-	[-4.52]	[-4.33]
Obs.	230	230	230	230	230	230
R-Square	0.5491	0.5445	0.5543	0.5477	0.5956	0.5888
Statistical value	61.81***	244.68***	41.67***	241.99***	42.08***	282.41***
Hausman test	16.95***		32.71***		31.34**	
Wald test	179.58***	-	174.50***	-	204.92***	-
Wooldridge test	42.649***	-	43.246***	-	49.787***	-
	FE	**RE**	**FE**	**RE**	**FE**	**RE**
Variable	**Model 4**		**Model 5**		**Model 6**	
Cons.	-2.65033***	-2.423034***	-2.201918***	-1.796061***	-2.19717***	-1.771119***
	[-8.02]	[-7.60]	[-10.98]	[-10.25]	[-10.80]	[-10.00]
INR	1.209036*	1.588321**	.1021189*	.0531714	.0930426	.0457918
	[1.90]	[2.53]	[1.74]	0.96]	[1.56]	[0.82]
ING	-.0015642	-.0021325	.2131056**	.2051713**	.0474107	.031595
	[-0.25]	[-0.33]	[2.22]	[2.07]	[0.58]	[0.38]
AGE	.1171235*	.0335535	.1547093**	.065824	.1303694**	.0477141
	[1.78]	[0.77]	[2.33]	[1.47]	[1.97]	[1.08]
SIZE	.2318635***	.2385114***	.1824326***	.1753553***	.1886193***	.1782194***
	[6.85]	[7.89]	[7.84]	[9.90]	[8.07]	[10.00]
INF	.5923044***	.3248686**	.6613409***	.3923632**	.0063472***	.3612294**
	[3.64]	[2.13]	[4.08]	[2.56]	[3.88]	[2.33]
GDP	-.1194199	-.2938771	-.1042054	-.2624081	-.000671	-.2348936
	[-0.23]	[-0.56]	[-0.21]	[-0.50]	[-0.13]	[-0.44]
INR*SIZE	-.0968096*	-.1328988**	-	-	-	-
	[-1.77]	[-2.47]	-	-	-	-
ING*AGE	-	-	-.0721191**	-.0693356**	-	-
	-	-	[-2.22]	[-2.08]	-	-
ING*SIZE	-	-	-	-	-.0043258	-.0028668
	-	-	-	-	[-0.59]	[-0.38]
Obs.	230	230	230	230	230	230
R-Square	0.5612	0.5538	0.5651	0.5583	0.5551	0.5488
Statistical value	36.54***	254.40***	37.12***	251.10***	35.65***	242.09***
Hausman test	9.11		32.14***		30.72***	
Wald test	-	-	166.87***	-	175.99***	-
Wooldridge test	-	44.858***	55.065***	-	44.367***	-
Bre. and Pa. test	-	173.68***				

Note: *, **, and *** are significant level at 10%, 5%, and 1%, respectively

Model 1: $EFF_{it} = \propto + \gamma_1 AGE_{it} + \gamma_2 SIZE_{it} + \theta_1 INF_t + \theta_2 GDP_t + \mu_i + \delta_{it}$

Model 2: $EFF_{it} = \propto + \beta_1 INR_{it} + \beta_2 ING_{it} + \gamma_1 AGE_{it} + \gamma_2 SIZE_{it} + \theta_1 INF_t + \theta_2 GDP_t + \mu_i + \delta_{it}$

Model 3: $EFF_{it} = \propto + \beta_1 INR_{it} + \beta_2 ING_{it} + \gamma_1 AGE_{it} + \gamma_2 SIZE_{it} + \theta_1 INF_t + \theta_2 GDP_t + \varphi_1 INR_{it} \times AGE_{it} + \mu_i + \delta_{it}$

Model 4: $EFF_{it} = \propto + \beta_1 INR_{it} + \beta_2 ING_{it} + \gamma_1 AGE_{it} + \gamma_2 SIZE_{it} + \theta_1 INF_t + \theta_2 GDP_t + \varphi_2 INR_{it} \times SIZE_{it} + \mu_i + \delta_{it}$

Model 5: $EFF_{it} = \propto + \beta_1 INR_{it} + \beta_2 ING_{it} + \gamma_1 AGE_{it} + \gamma_2 SIZE_{it} + \theta_1 INF_t + \theta_2 GDP_t + \varphi_3 ING_{it} \times AGE_{it} + \mu_i + \delta_{it}$

Model 6: $EFF_{it} = \propto + \beta_1 INR_{it} + \beta_2 ING_{it} + \gamma_1 AGE_{it} + \gamma_2 SIZE_{it} + \theta_1 INF_t + \theta_2 GDP_t + \varphi_4 ING_{it} \times SIZE_{it} + \mu_i + \delta_{it}$

Source: The author

There is an interesting finding regarding the insignificant impact of GDP on bank efficiency: the coefficients of GDP are positive but insignificant. It might be explained by the stable growth of GDP in the sample period, which is shown by the GDP variable characteristics GDP_{mean}= 0.0595946, $GDP_{Std.Dev}$= 0.0118046,

GDP_{min}=0.0290584, and GDP_{max}= 0.0707579. Because of the GDP variable stability, the effect of GDP on EFF is not revealed by the estimation results.

Except that model 1 does not consider the effect of bank technology innovation on bank efficiency, other models included the bank technology innovation variables. It is inconsistent in the estimation results of the effect of bank technology innovation on EFF between models. The coefficients of INR by models 3, 4, and part of 5 are positive significance levels of 1%-10%, while the rests are not significant. Only ING coefficients of model 5 are a positive significance level of 5%, and estimation results of other models provide the evidence to accept the null hypothesis of no meaningful link between ING and EFF. Based on the significant positive link between INR and ING and EFF, it might be stated that there is an absence of the "productivity paradox" in the sample. In detail, the finding is a supportive factor for improving bank efficiency by increasing BITI.

The impact of bank characteristics on the relationship between BITI and bank efficiency is shown by P-value and coefficients of INR*AGE, INR*SIZE, ING*AGE, and ING*SIZE. The estimation shows a negative effect of bank age on the association between BITI and bank efficiency. In detail, the coefficients of INR*AGE and ING*AGE are harmful significance levels of 1% and 5%, respectively, which might be explained by the slowness of banks technology innovation adoption. As the discussion about the effect of fintech company growth on bank performance by the BSC (outcome of the qualitative study), the issues of bank technology innovation adoption are regarding bank human quality resources. According to my observation, due to its long history, the staff of mature (older) banks are not young and face many problems in bank technology innovation adoption.

The coefficients of INR*SIZE are negative and significant at the 10% and 5% levels with the estimation results by FE and RE, respectively, whereas the coefficients of ING*SIZE are negative but insignificant. As mentioned in the description (4.3.1), most large banks are elder; thus, this finding partly supports the impact of bank age on the link between BITI and bank efficiency. Large banks and elder banks decrease the impact of BITI on bank efficiency.

The model estimation results by FE and RE might have heteroskedasticity and autocorrelation issues. The rows of the Hausman test indicate that the null hypothesis of the preferred estimation result by RE of models 1, 2, 3, 5, and 6 are rejected 1% significant level with the Hausman test values are 16.95, 32.71, 31.34, 32.14, and 30.72, respectively. It means the estimation results by FE are higher appreciated to explain the effect of BITI on bank efficiency than RE. The Hausman test value of model 4 is 9.11, which is evidence of accepting the null hypothesis; the estimation result by RE is better than FE. Based on the Hausman

test estimation, heteroskedasticity and autocorrelation issues are tested. If the FE estimation is more appreciated than RE, the Modified Wald test and Wooldridge test will be employed to examine the heteroskedasticity and autocorrelation issues, respectively. In detail, two tests are applied for models 1, 2, 3, 5, and 6. If the RE estimation is better than FE, the Breusch-Pagan Lagrangian and Wooldridge tests are utilized to estimate the effect of heteroskedasticity and autocorrelation on the model. In this thesis, these are applied to model 4.

The Wald test row shows that models 1, 2, 3, 5, and 6 has heteroskedasticity issue with the statistical value of 179.58, 174.50, 204.92, 166.87, and 175.99, respectively, which permit to rejection of the null hypothesis of homoskedasticity. With the estimation result of model 4 by RE, the row of the Bre. and Pa. test gives that the statistical value is 173.68, higher than the critical value, which also allows rejecting the null hypothesis of homoskedasticity. Therefore, I conclude that all estimation results of six models by FE or RE have heteroskedasticity at the significance level of 1%.

The null hypothesis that there is no serial correlation in the models (six models) is rejected by the evidence of the statistical value of the Wooldridge test row, namely 42.649, 43.246, 49.787, 44.858, 55.065, and 44.367 for model 1, 2, 3, 4, 5, and 6, respectively. Based on that, I conclude that autocorrelation issues exist in the models at the significance level of 1%.

4.3.4 Estimation results by GLS

Based on the data analysis mentioned above, the GLS approach is employed to overcome the issues of heteroskedasticity and autocorrelation. The estimation results by GLS are presented in **Table 4.14**.

The null hypothesis that all coefficients in the model are equal to zero is rejected by the support of statistical values of six models corresponding to 160.37, 181.79, 204.62, 214.93, 183.99, and 181.94 at the significance level of 1%, which means there is at least one independent variable might explain the change of bank efficiency.

The same with the estimation results by FE and RE, the coefficients of SIZE and INF by GLS are positive significance levels of 1%-10%. The coefficients of GDP are not significant.

Table 4.14 Estimation results by GLS

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Cons.	-1.13399***	-1.04155***	-1.88745***	-1.66355***	-1.085919 ***	-1.04889***
	[-8.17]	[-7.54]	[-7.72]	[-5.59]	[-7.77]	[-7.56]

INR	-	-.0976398**	1.831383***	1.165358**	-.0916918*	-.0962307**
	-	[-2.02]	[3.88]	[2.11]	[-1.92]	[-1.99]
ING	-	-.0003803	-.0018887	-.0024159	.1389152*	.0294942
	-	[-0.12]	[-0.55]	[-0.64]	[1.92]	[0.61]
AGE	.0192566	.0288237	.2707736***	.0192218	.0427611	. .0289131
	[0.65]	[1.00]	[4.12]	[0.67]	[1.55]	[1.01]
SIZE	.1347925***	.128616***	.1394991***	.1840452***	.1287971***	.1292199***
	[10.90]	[10.69]	[11.75]	[6.98]	[10.92]	[10.71]
INF	.2713685**	.2658321**	.1954753	.2308783*	.2777406**	.2705661**
	[2.09]	[2.05]	[1.55]	[1.76]	[2.17]	[2.09]
GDP	-.1069441	-.1483876	-.1543906	-.0391128	-.2044459	-.1552972
	[-0.29]	[-0.40]	[-0.44]	[-0.11]	[-0.56]	[-0.42]
INR*AGE	-	-	-.6377515***	-	-	-
	-	-	[-4.10]	-	-	-
INR*SIZE	-	-	-	-.109085**	-	-
	-	-	-	[-2.28]	-	-
ING*AGE	-	-	-	-	-.0476823*	-
	-	-	-	-	[-1.93]	-
ING*SIZE	-	-	-	-	-	-.002821
	-	-	-	-	-	[-0.62]
Obs.	230	230	230	230	230	230
Statistical value	160.37***	181.79***	204.62***	214.93***	183.99***	181.94***

Note: *, **, and *** are significant level at 10%, 5%, and 1%, respectively

Model 1: $EFF_{it} = \propto + \gamma_1 AGE_{it} + \gamma_2 SIZE_{it} + \theta_1 INF_t + \theta_2 GDP_t + \mu_i + \delta_{it}$

Model 2: $EFF_{it} = \propto + \beta_1 INR_{it} + \beta_2 ING_{it} + \gamma_1 AGE_{it} + \gamma_2 SIZE_{it} + \theta_1 INF_t + \theta_2 GDP_t + \mu_i + \delta_{it}$

Model 3: $EFF_{it} = \propto + \beta_1 INR_{it} + \beta_2 ING_{it} + \gamma_1 AGE_{it} + \gamma_2 SIZE_{it} + \theta_1 INF_t + \theta_2 GDP_t + \varphi_1 INR_{it} \times AGE_{it} + \mu_i + \delta_{it}$

Model 4: $EFF_{it} = \propto + \beta_1 INR_{it} + \beta_2 ING_{it} + \gamma_1 AGE_{it} + \gamma_2 SIZE_{it} + \theta_1 INF_t + \theta_2 GDP_t + \varphi_2 INR_{it} \times SIZE_{it} + \mu_i + \delta_{it}$

Model 5: $EFF_{it} = \propto + \beta_1 INR_{it} + \beta_2 ING_{it} + \gamma_1 AGE_{it} + \gamma_2 SIZE_{it} + \theta_1 INF_t + \theta_2 GDP_t + \varphi_3 ING_{it} \times AGE_{it} + \mu_i + \delta_{it}$

Model 6: $EFF_{it} = \propto + \beta_1 INR_{it} + \beta_2 ING_{it} + \gamma_1 AGE_{it} + \gamma_2 SIZE_{it} + \theta_1 INF_t + \theta_2 GDP_t + \varphi_4 ING_{it} \times SIZE_{it} + \mu_i + \delta_{it}$

Source: The author

The mixed results of the link between INR and EFF are found in **Table 4.14**. There are three negative relationships (models 2, 5, and 6) and two positive relationships (models 3 and 4) of INR on EFF. In detail, the INR coefficients are -0.976398 (5%), 1.831383 (1%), 1.165358 (5%), -0.0916918 (10%), and -0.0962307 (5%) for five models including bank investment in technology innovation variables, respectively. Besides, only one coefficient of ING is significant at a level of 10%, belonging to model 5 ($\beta_2^{model\ 5}$ = 0.1389152), others are insignificant. Based on the findings of the negative relationship between INR and EFF, I argue that it supports the productivity paradox hypothesis, which means the increase in BITI decreases bank efficiency. The findings of the negative effect of BITI on bank efficiency robust the estimation results by FE and RE as above.

The P-value and sign of INR*AGE, INR*SIZE, and ING*AGE follow the estimation results by FE and RE. In detail, the coefficient of INR*AGE ($\varphi_1^{model\ 3}$), INR*SIZE ($\varphi_2^{model\ 4}$), and ING*AGE ($\varphi_3^{model\ 5}$) are -0.6377515, -0.109085, and -0.0476823, and significance levels of 1%, 5%, and 10%, respectively. It means that large and older banks are the factors that negatively affect the relationship between BITI and bank efficiency.

Table 4.15 Estimation results by Tobit

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Cons.	-1.072***	-.95274***	-1.6157***	-1.9358***	-.98561***	-.94735***
	[-8.83]	[-7.63]	[-7.10]	[-6.03]	[-7.73]	[-7.45]
INR	-	-.1508377***	1.606114***	1.984331***	-.1514983***	-.150289***
	-	[-3.24]	[3.14]	[3.07]	[-3.27]	[-3.23]
ING	-	.0024664	-.0006709	-.0022581	.1606368	-.0221961
	-	[0.29]	[-0.08]	[-0.26]	[1.20]	[-0.20]
AGE	.0063934	.0246503	.2238591***	.0035274	.0356949	.024738
	[0.28]	[1.08]	[3.61]	[0.15]	[1.45]	[1.08]
SIZE	.1351***	.12663***	.13264***	.21529***	.12654***	.126144***
	[12.50]	[11.61]	[12.31]	[7.48]	[11.64]	[11.35]
INF	-.0040389	-.0836308	-.1454704	-.0746539	-.0560139	-.0874092
	[-0.02]	[-0.45]	[-0.80]	[-0.41]	[-0.30]	[-0.47]
GDP	-.4952295	-.4972189	-.6163151	-.5488201	-.5097659	-.5019729
	[-0.66]	[-0.68]	[-0.86]	[-0.77]	[-0.70]	[-0.69]
INR*AGE	-	-	-.57200***	-	-	-
	-	-	[-3.45]	-	-	-
INR*SIZE	-	-	-	-.18052***	-	-
	-	-	-	[-3.31]	-	-
ING*AGE	-	-	-	-	-.0534101	-
	-	-	-	-	[-1.18]	-
ING*SIZE	-	-	-	-	-	.0022427
	-	-	-	-	-	[0.22]
Obs.	230	230	230	230	230	230
Statistic value	171.17***	181.44***	193.03***	192.17***	210.60***	181.49***

*Note: *, **, and *** are the significant level at 10%, 5%, and 1%, respectively*

Model 1: $EFF_{it} = \propto + \gamma_1 AGE_{it} + \gamma_2 SIZE_{it} + \theta_1 INF_t + \theta_2 GDP_t + \mu_i + \delta_{it}$

Model 2: $EFF_{it} = \propto + \beta_1 INR_{it} + \beta_2 ING_{it} + \gamma_1 AGE_{it} + \gamma_2 SIZE_{it} + \theta_1 INF_t + \theta_2 GDP_t + \mu_i + \delta_{it}$

Model 3: $EFF_{it} = \propto + \beta_1 INR_{it} + \beta_2 ING_{it} + \gamma_1 AGE_{it} + \gamma_2 SIZE_{it} + \theta_1 INF_t + \theta_2 GDP_t + \varphi_1 INR_{it} \times AGE_{it} + \mu_i + \delta_{it}$

Model 4: $EFF_{it} = \propto + \beta_1 INR_{it} + \beta_2 ING_{it} + \gamma_1 AGE_{it} + \gamma_2 SIZE_{it} + \theta_1 INF_t + \theta_2 GDP_t + \varphi_2 INR_{it} \times SIZE_{it} + \mu_i + \delta_{it}$

Model 5: $EFF_{it} = \propto + \beta_1 INR_{it} + \beta_2 ING_{it} + \gamma_1 AGE_{it} + \gamma_2 SIZE_{it} + \theta_1 INF_t + \theta_2 GDP_t + \varphi_3 ING_{it} \times AGE_{it} + \mu_i + \delta_{it}$

Model 6: $EFF_{it} = \propto + \beta_1 INR_{it} + \beta_2 ING_{it} + \gamma_1 AGE_{it} + \gamma_2 SIZE_{it} + \theta_1 INF_t + \theta_2 GDP_t + \varphi_4 ING_{it} \times SIZE_{it} + \mu_i + \delta_{it}$

Source: The author

4.3.5 Estimation results by Tobit

Furthermore, the value of EFF is from zero (0) to one (1); hence, I use the Tobit approach to robustness check the estimation results by FE, RE, and GLS. The estimation results by Tobit can be seen in **Table 4.15**.

The null hypothesis that all coefficients in the model are equal to zero is rejected at a 1% significant level for six models. In detail, the statistical values of the six models are 171.17, 181.44, 193.03, 192.17, 210.60, and 181.49, respectively (higher critical value), which permits the conclusion that there is at least one explanatory variable might be used for explaining the bank efficiency change.

The estimation results by Tobit validate the significance and sign of the coefficient of INR and SIZE, which GLS finds. Two positive signs and three negative signs of the INR coefficients, namely, $\beta_1^{model\,2}$ = -0.1508377, $\beta_1^{model\,3}$ = 1.606114, $\beta_1^{model\,4}$ = 1.984331, $\beta_1^{model\,5}$ = -0.1514983, and $\beta_1^{model\,6}$ = -0.1502893 are significance level of 1%. The SIZE coefficients are positive and significant at a 1% level. Besides, Tobit's estimation results confirmed the negative impact of bank age and size on the relationship between INR and EFF. In detail, the coefficients of INR*AGE and INR*SIZE are -0.5720031 and -0.1805206, respectively, and a significance level of 1%.

However, the estimation results by Tobit do not provide significant evidence regarding the effect of corresponding variables of ING, INF, GDP, ING*AGE, and ING*SIZE on bank efficiency.

4.3.6 Lag effect of BITI on bank efficiency

Following Bashayreh and Wadi (2021), Lee et al. (2021), Pham et al. (2021a), and Phan et al. (2020), the lag of BITI might influence bank performance; thus, I formulate the model for estimating this concern. The model is as below:

$$EFF_{it} = \propto + \omega_1 INR_{i,t-1} + \omega_2 INR_{i,t-1} + \gamma_1 AGE_{it} + \gamma_2 SIZE_{it} + \gamma_3 INF_t + \gamma_4 GDP_t + + \mu_i + \delta_{it} \quad (4.7)$$

The statistic value row in **Table 4.16** shows that the null hypothesis that all coefficients in the model are equal to zero is rejected at a 1% significant level. It also means the estimation results are significant, or at least one independent variable in the model might explain the change of the dependent variable. In detail, the statistic values of FE, RE, GLS, and Tobit are 43.83, 245.97, 162.31, and 159.38, respectively.

The P-value and coefficients of SIZE by four approaches in **Table 4.16** robust the estimation results above regarding the positive effect of bank size on bank efficiency, namely, all SIZE coefficients are significantly positive at a 1% level. The INF coefficients by FE and GLS are 1.054096 (significance level of 1%) and 0.6780286 (significance level of 5%), respectively; others are insignificant. It supports the findings of the positive effect of INF on EFF above. All AGE and GDP coefficients of the four approaches are not significant.

The INR_{t-1} coefficients by FE and Tobit are 0.0991059 significance level of 10%, and -0.1686798 significance level of 1%, while RE and GLS are insignificant. The ING_{t-1} coefficient by Tobit is -0.0340262 significance level of 1%, and others are insignificant. Based on these findings, I conclude that the lag of BITI is negative with bank efficiency.

Table 4.16 Estimation results of the lag model of BITI variable

Variable	FE	RE	GLS	Tobit
Cons.	-2.410886***	-1.907835***	-1.135492***	-.9388503***
	[-10.76]	[-9.80]	[-7.35]	[-6.54]
INR_{t-1}	.0991059*	.0606069	-.0437627	-.1686798***
	[1.72]	[1.08]	[-0.87]	[-3.29]
ING_{t-1}	.1758143	-.0204444	-.0099505	-.0340262***
	[0.96]	[-0.77]	[-0.57]	[-2.61]
AGE	.0611454	.0097342	.0069096	.0122528
	[0.74]	[0.19]	[0.24]	[0.48]
SIZE	.2175459***	.1983952***	.1378578***	.1319964***
	[7.77]	[9.81]	[10.27]	[10.66]
INF	1.054096***	.5297402	.6780286**	-.4469602
	[3.12]	[1.62]	[2.36]	[-1.05]
GDP	.2110538	-.1188542	.0595816	-.7129583
	[0.42]	[-0.23]	[0.15]	[-0.93]
Obs.	207	207	207	207
R-Square	0.5964	0.5892	-	-
Statistic value	43.83***	245.97***	162.31***	159.38***
Hausman test	48.15***		-	-
Wald test	115.00***	-	-	-
Wooldridge test	29.586***	-	-	-

*Note: *, **, and *** are the significant level at 10%, 5%, and 1%, respectively*

Model: $EFF_{it} = \propto + \omega_1 INR_{i,t-1} + \omega_2 INR_{i,t-1} + \gamma_1 AGE_{it} + \gamma_2 SIZE_{it} + \gamma_3 INF_t + \gamma_4 GDP_t + + \mu_i + \delta_{it}$

Source: The author

In general, based on the estimation results by FE, RE, GLS, and Tobit, I conclude that the mixed findings regarding the effect of BITI on bank efficiency are found as mentioned above, but I evaluate that the negative relationship between INR and EFF is the main finding with these reasons. *First*, the relationship between INR and EFF by FE and RE is positive, but the models have heteroskedasticity and autocorrelation. Thus, the estimation results by FE and RE are less reliable than by GLS because GLS estimation has overcome two issues of heteroskedasticity and autocorrelation. *Second*, the Tobit approach, an alternative estimator, provides booster estimation results about the link between INR and EFF. *Third*, the negative association between INR and EFF is robust by consideration of the interaction between INR and bank characteristics on bank efficiency. *Finally*, there is a negative link between the lag of BITI and bank efficiency.

In this thesis, the main finding regarding the negative effect of BITI on bank efficiency is different from the previous studies by Frei et al. (1997), Tamatam et al. (2019), and Wang et al. (2020) but consistent with Pham et al. (2021b) about the negative link between technology innovation and bank efficiency in developing countries. I argue that the finding is suitable for the SBV (2020) report about the effectiveness of BITI. The report reveals that there has been a vast of BITI in developing mobile banking and internet banking about ten years ago, but the investment is not efficient. The third reason might explain it. *First*, Vo and Nguyen (2018) show that the Vietnamese government's restructuring policy is

the root cause of the inefficiency of commercial banks. The increase in transition cost declines bank efficiency, while the IT investment is ineffective. *Second*, it might be the low level of financial literacy and acceptance of mobile banking and internet banking customers, which affects the effectiveness of the digital transformation process and the efficiency of banks. In Vietnam, Morgan and Trinh (2020) indicated that low-level financial literacy decreases fintech adoption, and Van et al. (2021) show that trust and perceived risk are significant factors in the acceptance of using mobile banking. *Third*, it might be that the Vietnamese commercial banks have not paid attention to BITI to enhance bank efficiency, which leads to the low impact of bank fintech on bank efficiency. It might signal that banks' digitalization and transformation strategies are only symbolic, not substantial.

Consequently, through the estimation results and discussion about the effect of BITI on bank efficiency, I conclude that bank investment in technology innovation negatively affects bank efficiency.

4.4 Research result aggregation

Based on the estimation results and discussion above, the effect of the fintech industry on bank performance is aggregated as in **Table 4.17**. Most effects are positive (6/9), while the negative effect is the minority (3/9).

Table 4.17 Research result aggregation

Effect of the fintech industry on bank performance			Effect
RO1	R_1	Effect of fintech company growth on bank performance	positive
	R_{1a}	Effect of fintech company growth on the financial perspective	*negative*
	R_{1b}	Effect of fintech company growth on the customer perspective	*negative*
	R_{1c}	Effect of fintech company growth on the internal process perspective	positive
	R_{1d}	Effect of fintech company growth on the learning & growth perspective	positive
RO2	R_2	Effect of fintech popularity on bank stock return	positive
	R_{2a}	Effect of fintech popularity in payment on bank stock return	positive
	R_{2b}	Effect of fintech popularity in lending on bank stock return	positive
RO3	R_3	Effect of bank investment in technology innovation on bank efficiency	*negative*

Note: RO1, RO2, and RO3 are research objective 1, 2, and 3, respectively; and R_i is the research result i

Source: The author

Based on the content of the discussion, it is clear that the fintech company growth is a pressure, which negatively links to bank financial indicators (R_{1a}) and bank customer loyalty (R_{1b}). Bank investment in technology innovation enhances and upgrades the bank technology system seems to be ineffective, which is harmful to bank efficiency (R_3). However, fintech company growth promotes bank performance by enhancing bank internal processes (R_{1c}) and improving bank employees' knowledge and skills (R_{1d}). The popularity of fintech is a positive factor in bank stock return (R_2, R_{2a}, and R_{2b}), while fintech company growth is positive with overall bank performance (R_1).

The findings are mixed results, but I prefer the positive effect of the fintech industry on bank performance in the case of Vietnam, which is consistent with the results of the semi-structured interview and fintech popularity. Regarding the existence of a productivity paradox in Vietnamese banks, I argue that, like the historical flow of fintech, bank investment in technology innovation is the root of bank life, although it is ineffective. The bank technologies must be regularly updated; it helps the bank maintain competitiveness, while the latest technology helps the bank break through the competition. In Vietnam, Techcombank is a typical case of applying disruptive technology to breakthroughs in business; others seem to be behind Techcombank in the digital transformation process.

5 CONCLUSION

This section presents the main points of the thesis procedure. Based on the findings, the implications are proposed. Besides research contributions, the limitations and directions for further research are also mentioned in this section.

5.1 Conclusions

Motive from the fintech development on the globe and the contemporary debate in academics on the relationship between banks and fintech in the digital era, I strategies to explore the relationship by finding and fulfilling the gap in this field. In the fintech industry, Vietnam is an attractive market, with a growing number of fintech companies and room for development. In line with rising fintech research studies globally, some scholars studied fintech in Vietnam. By reviewing the relevant studies, I explore that most studies have not clarified the link between fintech and banks, especially regarding quantitative studies that seem rare. Besides, most quantitative studies about the relationship between banks and fintech have focused on developed countries, such as the USA, Europe, and China. Few studies are in developing countries, such as Indonesia, Nigeria, and Jordan. The study in Vietnam, a developing country, is rare. Therefore, the effect of the fintech industry on bank performance in Vietnam is conducted. The findings will provide empirical evidence to enrich the knowledge in this field.

The study aims to evaluate the holistic effect of the fintech industry on bank performance. To achieve the research aim, I designed three research studies. *First*, based on the BSC and its application in the finance industry, the qualitative research regarding the effect of fintech company growth on financial, customer, internal process, and learning and growth perspectives of bank performance is conducted through the semi-structured interview. *Second*, I use Google search to measure fintech popularity, which proxies the fintech industry development. Then, the effect of fintech popularity on bank stock return is investigated. *Third*, I use DEA for measuring bank efficiency; then, it is used to examine the effect of bank investment in technology innovation on bank efficiency.

5.1.1 Effect of fintech company growth on bank performance

After confirming respondents, the semi-structured interviews with eight interviewees are conducted from February to April 2022. Following the semi-structured orientation questionnaires, the evaluation of the effect of fintech company growth on the financial, customer, internal process, and learning & growth perspectives are collected.

Most views agree that fintech company growth is a pressure for banking transformation to enhance performance. Besides, it creates new opportunities for

banks to penetrate the latest market and extend their banking products. Therefore, I conclude that there is a positive effect of fintech company growth on bank performance.

Fintech company growth decreases the bank service income and increases bank investment in technology innovation, negatively linking bank financial profit indicators. Besides, fintech company growth might signal the bank's poor prospects, which reduces bank valuation on the market. Therefore, I conclude that there is a negative effect of fintech company growth on financial perspective.

The advancement of fintech products compared with conventional banking products is a significant factor affecting bank customer loyalty and satisfaction, especially the young customers, who tend to use the advanced products and get new experiences. It is the main reason for concluding that there is a negative effect of fintech company growth on the bank customer perspective.

Under the pressure of fintech company growth, the banks focus on more disruptive technology adoption, which is a significant factor in enhancing internal bank operations and producing the performance of banking products. The respondents generally evaluate the bank's internal process as more efficient than before. Therefore, I conclude that there is a positive effect of fintech company growth on the bank's internal process.

Fintech company growth is a cause of bank employee dissatisfaction, but the increase in training courses and development programs is overcome. In general, fintech company growth brings more benefits for bank employees and banks. Therefore, I conclude that there is a positive effect of fintech company growth on the learning & growth perspective.

5.1.2 Effect of fintech popularity on bank stock return

The time-series model illustrates the relationship between fintech popularity and bank stock return. Based on Google Trend and fintech-related keywords, the raw data on fintech popularity is collected. Next, the EFA method is applied to reduce the number of fintech popularity variables and validates the selected keywords. Six kinds of fintech popularity variables are established: wallet, money, fintech (in general), product, lending, and payment. Then, motive from the study by Cheng and Qu (2020), the standardized maximum-minimum processing of these variables is used for the next analysis. For matching the data of the fintech popularity variables, the continuous trading of the listed banks is considered the mandatory requirement of bank selection; thus, the eight banks, which are the biggest in Vietnam, are selected to measure the bank stock return. Vietstock, a trusted statistical organization in the Vietnamese stock exchange market, provides the data to compute the bank stock return variable.

The pre-estimation tests of Dickey and Fuller (1979) and Phillips and Perron (1988), and Lütkepohl (2005) are used for validating the stationary, optimal lags, and co-integration of the data series. Next, the VAR-Granger is employed to determine the causality relationship between fintech popularity and bank stock return. Then, the Gumbel, Clayton, and Normal families of the Copula approach are applied to confirm the relationship between variables through the dependency structure test.

The positive effects of fintech popularity, fintech popularity in payment and lending on bank stock return are explored through estimation results and discussion. It indicates that fintech popularity plays the role of supplement in promoting bank stock return. Moreover, some interesting findings are found. *First*, the link between bank stock return and fintech popularity in lending is more sensitive to the simultaneous negative change of variables. *Second*, the link from fintech popularity to bank stock return is weaker than in the opposite direction. *Third*, some changes of pairs variables in uptrend and downtrend are equal, such as pairs of fintech popularity in payment and bank stock return and fintech popularity in lending and bank stock return.

5.1.3 Effect of bank investment in technology innovation on bank efficiency

Motive from the study by Anagnostopoulou (2008), Beccalli (2007), Ho and Mallick (2010), and Pham et al. (2021b), I formulate the panel model to illustrate the effect of bank investment in technology innovation on bank efficiency. The DEA approach is employed to measure the bank efficiency variables. Besides, the bank characteristic (size and age) and macroeconomic conditions (inflation and GDP) are added to the model as the control variables. Intangible assets are used for measuring the bank investment in technology innovation variables. The raw data is collected from the audited financial statements and annual reports, which Vietstock provides. The FE, RE, and GLS are first applied for estimation. Then, the Tobit approach is applied for the robustness check.

Through various estimation results and discussions, I found a negative effect of bank investment in technology innovation on bank efficiency. Moreover, some interesting findings are found, such as bank age and size are the slowness factor of bank digitalization, which means the efficiency of more extensive and older banks is lower than small and young banks.

5.2 Research contribution

Following the research procedure and findings, this thesis provides several contributions from both theoretical and practical perspectives.

5.2.1 Theoretical contribution

The main theoretical contribution is to explore (1) the positive effect of fintech popularity on bank stock return, (2) the negative effect of bank investment in technology innovation on bank efficiency, and (3) the positive effect of fintech company growth on bank performance.

Besides, the thesis provides some interesting contributions:

First, Google search is a powerful tool to measure investor attention in cyberspace. For example, in France, Aouadi et al. (2013) used Google search to measure investor attention on the stock exchange market and investigate its effect on trading volume and volatility. Smales (2021) indicated that the fear regarding the "coronavirus" of investors measured by Google search highly correlates with the volatility of global market return. de Area Leão Pereira et al. (2018) stated that the term "Donald Trump" in Google Trend significantly influences the volatility of stocks in Mexico, Japan, Australia, and Brazil. In this thesis, Google search is proxied to measure the fintech development in Vietnam, which provides evidence of Google search application for measuring a novel issue in the digital era. Besides, the intangible assets on the financial statements reflect the level of bank IT investment through technological innovation, including software, hardware, and patents, which are used for proxying the bank fintech variable. Two novel fintech measurements enrich the knowledge regarding fintech and bank performance.

Second, the study used two methods to estimate the relationship between time series variables: the VAR-Granger and the Copula. While the VAR-Granger is the conventional method widely used in finance research, the Copula is considered the emerging method that provides information about the dependency structure between variables. Many studies applied the Copula for conducting quantitative research. For example, Sun (2019) used the Copula to analyze the relationship between the price of oil, gold, stock, and exchange rate in China. The results indicated that the contagious risks between prices are significantly strong in the downtrend. In BRICS (including Brazil, Russia, India, China, and South Africa), using the Copula approach for data analysis, Kumar et al. (2019) indicated significant market dependency structures among stock and foreign exchange. Huynh et al. (2020) stated that there are contagion risks in stock returns between Vietnamese banks, which are analyzed by the Copula approach. Following these studies, this thesis applies the Copula approach for estimating the dependency structure between fintech development and bank stock return, providing novel evidence of the Copula application in finance research.

Third, the bank fintech variable is proxied by the technology innovation investment of commercial banks, which is a novel concept regarding the fintech

definition. Bank fintech relates to the digitalization or transformation of traditional financial institutions in the new age. Following Gumbau-Albert and Maudos (2022), Harasim (2008), and Reilly (2010), bank technological innovation is possibly measured through intangible assets that reflect the level of bank information technology investment. In the banking industry, Marinč (2013) and Martin-Oliver and Salas-Fumas (2011) agreed that intangible assets reflect effective IT investment. Based on that, I proposed using intangible assets to proxy the bank fintech variable in this thesis. I argue that it is a novel measure regarding fintech measurement that supplements new knowledge in the field of fintech research.

Fourth, the Balanced Scorecard is the famous approach for evaluating firm performance through four perspectives: financial, customer, internal process, and learning & growth. Many studies applied the BSC to assessing firm performance. For example, in Thailand, Tippong et al. (2020) investigated the impact of the Sufficiency Economic Philosophy on the performance of logistics firms using the BSC. The results gave that while the financial perspective is affected at a moderate level, other perspectives are at a high level. In the Korean banking industry, Kim and Davidson (2004) indicated that the effect of IT expenditures on bank performance using four perspectives of the BSC is significant, and these effects are different and depend on the level of expenditure. Using data from pharmaceutical distribution companies in Iran, Mehralian et al. (2017) revealed a positive impact of total quality management implementation on firm performance using the BSC. In this thesis, through the semi-structured interview, the ingredients of four perspectives are validated, illustrating the effect of fintech company growth on bank performance using the BSC. The thesis provides an interesting case study in Vietnam about using the BSC to evaluate the relationship between fintech company growth and bank performance. Besides, I argue that the study outcome is also meaningful for further research, especially for extending the investigation scale.

Furthermore, regarding the used theories for proposing the research hypotheses, the thesis proves that the consumer and disruptive innovation theories are insufficient for explaining the effect of fintech popularity on bank stock return. The impact of bank-fintech alliances is a significant factor that might explain the positive effect of fintech popularity on bank performance. The banks can gain more benefits from fintech company growth. Besides, there is a presence of productivity paradox theory regarding bank investment in technology innovation on bank efficiency in Vietnam. However, bank fintech adoption is necessary to remain competitive and adapt to fintech growth in the digital era.

5.2.2 Practical contribution

There are some practical contributions below:

First, the thesis provides scientific evidence about the link between fintech popularity and bank stock return. It offers that fintech popularity is a significant factor that might predict bank stock returns. Thus, it should be considered the reference source for making decisions of investors and bank managers. Besides that, the empirical estimation results by Copula offer that before making decisions, investors should evaluate the simultaneous trend between bank stock return and search volume, especially in the case of a downtrend. In addition, fintech popularity in cyberspace might be an indicator that might affect bank adaptation strategy in the context of fintech company rise; hence, it should be evaluated carefully.

Second, the finding shows that the effect of bank investment in technology innovation on bank efficiency is negative, and bank investment in technology innovation is ineffective. It shows that the digitalization and transformation strategy of commercial banks need to be revised. I suggest that bank managers should think about changes in the ways of investment in technology innovation. The bank-self technology investment might be replaced by external collaborations or outsourcing, such as cooperation with fintech companies to deliver products and enhance bank performance. Besides, macro policy support is necessary for increasing bank investment in technology innovation effectiveness. For example, improving financial literacy and upgrading IT infrastructure policies will increase banking product adoption (e.g., cashless transactions and online loans).

Third, the overview of a fintech company growth in Vietnam and its effect on four financial, customer, internal process, and learning and growth perspectives of bank performance provide insight into the opportunities and threats for banks and fintech firms. It is a significant reference to making a suitable strategy in the high competition in the finance industry.

5.3 Implication

Based on the findings above, I propose several important implications for stakeholders.

First, the thesis is meaningful for investors holding or planning to own the bank stock. The thesis provides empirical evidence about the effect of the fintech industry on bank performance through qualitative and quantitative approaches. Some findings show a negative link between the fintech industry and bank performance, but its connection is very slight. The large-scale commercial banks might explain it compared with fintech companies. However, in the future, when the fintech company is mature, the weight of the fintech company effect will be improved; hence, I suggest that the investors have a long-term investment and trading strategy to adapt to the rise of fintech company growth. Besides, Google

search and simultaneous trend of variables might be considered the predictive factors of bank stock movement and significant references for trading decisions.

Second, most bank managers agreed that fintech company growth is negatively linked to customer and employee behavior, which are critical factors of bank performance. The banks are more competitive in scale and trusted than the fintech companies, but they are behind in technology applications for operating. Therefore, the banks need to have a suitable strategy to adopt with the rise of fintech. Motive from the discussion of Bömer and Maxin (2018), Holotiuk et al. (2018), Hornuf et al. (2020), Klus et al. (2019), and Thakor (2020), three kinds of fintech adoption strategy that the bank might consider to apply, namely, bank investment in technology innovation to upgrade and renew the current technology system, outsourcing, and collaboratory with the fintech company. However, the bank investment in technology innovation faces the productivity paradox issue, while outsourcing has many potential risks. In my opinion, collaboratory is a suitable strategy for the bank to adapt to the fintech rise. The combination of banks and fintech companies benefits both customers and participants.

Third, the estimation results show a weak relationship between the fintech industry and bank performance, but through the Vietnamese fintech industry overview and outcome of the qualitative study, I believe that the role of fintech in the finance industry and the economy will be enhanced in Vietnam. Following Frost (2020), Shapiro et al. (2022), and WB (2022), the fintech industry is the factor that changes the market structure and public policy. Therefore, I suggest policymakers consider the fintech industry factor in the relationship between banks and the economy before deciding on public policy. The suitable policy will create a convenient environment for both banks and fintech development that will help to increase the added value for the economy.

5.4 Limitations and directions for further research

The imperfect process is a constant being in every scientific research. In this thesis, one qualitative study and two quantitative studies are conducted to investigate the effect of the fintech industry on bank performance in Vietnam. The thesis has some limitations in the conducting process, which might influence thesis outcomes and conclusions. In this sub-section, these limitations regarding three research studies are presented. These limitations will help the readers avoid overemphasizing or minimizing findings within the research context of the relationship between fintech and banks in Vietnam. Then, the directions for further research are proposed based on these limitations. I argue that the directions will foster research on the emerging topic regarding the effect of the fintech industry on bank performance.

Regarding the effect of fintech company growth on four perspectives of bank performance:

The qualitative study regarding the investigation of the effect of fintech company growth and four perspectives of bank performance has some limitations, which might be the direction for further research. *First*, due to conducting the individual interview, all respondents are not in the group to discuss and argue about the orientation questionnaire. Hence, there is no consistency between respondents about the fintech company growth and the ingredients of the four perspectives of bank performance. The interview outcomes are aggregated and presented based on the respondents' majority opinions. In my opinion, gathering the respondents into a group and guiding them to discuss to unify the critical ingredients will be better. Based on that, I suggest that further research might use the Delphi method to determine the crucial elements of bank performance. The Delphi method's results will be more effective than the current method in the thesis.

Second, the study has not determined the weight of perspectives and ingredients. I argue that the element weight of bank performance needs to be identified and recognized accurately, providing each element's role in the aggregated indicator. The Analytic Hierarchy Process (AHP) is a powerful method to identify the decision elements, which is appreciated for determining the element weight. The integration between BSC and AHP is applied to various industries, such as manufacturing (Lee et al., 2008; Sundharam et al., 2013) and finance (Pérez et al., 2017). Therefore, further study should consider the combination of BSC and AHP for evaluating bank performance under the pressure of fintech company growth.

Regarding the effect of fintech popularity on bank stock return:

The quantitative study of the effect of fintech popularity by Google search and bank stock return has some limitations, which might be considered for further research. *First*, the scope of the study is limited to Vietnam, a developing country; it is just a case study. As mentioned above, the fintech industry plays an important role in developing countries; thus, its relationship might be different in other developing countries. Therefore, further research should investigate this effect in other countries, such as Thailand, Malaysia, the Philippines, etc. Besides, the group of countries such as Southeast Asia, South Asia, Africa, etc., where the same macroeconomic conditions are also interesting. These further studies will enrich the knowledge regarding the effect of fintech popularity on bank stock.

Second, the effect of fintech popularity on bank stock return is determined by the data analysis approaches of VAR-Granger and three famous Copula (Normal, Clayton, and Gumbel). Besides, other approaches of ARIMA and

ARCH/GARCH, which might play the role of alternative estimators, are also effective in predicting the relationship between time-series variables. Therefore, I suggest that further studies apply these alternative estimators for further research.

Third, as mentioned before, there are many ways to measure the fintech development variables. One of the effective techniques for measuring variables in cyberspace and social media platforms is the text mining method. Based on the unstructured documents (e.g., reports, papers, voices, etc.) regarding fintech, the fintech development variables might be measured through a text analysis approach. Following the massive amount of information about fintech in cyberspace, I suggest that the text mining approach be used to measure the fintech development variable and investigate its link with bank performance in further research. It will enrich the relevant knowledge.

Fourth, in the study, the fintech popularity variables are measured based on the fintech product classification (fintech, payment, and lending). However, according to Das (2019), Lee and Shin (2018), and Puschmann (2017), fintech might be classified by technology (blockchain, machine learning, cloud, etc.) or business model (payment, wealth management, crowdfunding, capital market, etc.), which are the significant dimensions of fintech variable measurement. Thus, I suggest that these dimensions should be considered for further research, which will provide a holistic of fintech development and enrich the knowledge of the relationship between fintech and bank performance.

Regarding the effect of bank investment in technology innovation on bank efficiency:

Despite several interesting findings, the study regarding the effect of bank investment in technology innovation on bank efficiency still has some limitations. *First*, the DEA is highly appreciated for measuring bank efficiency in Vietnam than others. However, the Stochastic and Non-stochastic frontier analyses are also useful in measuring firm efficiency (Amornkitvikai & Harvie, 2010; A. Kumar et al., 2020). Thus, I suggest that further research consider these approaches for measuring bank efficiency. Investigating the effect of bank investment in technology innovation on bank efficiency by measuring these approaches will enrich the existing knowledge.

Second, the study used financial measurement for calculating the bank investment in technology innovation variables. Besides that, other approaches, such as the non-financial measurement and text mining method, are also significant in measuring bank investment in technology innovation variables. For example, Cheng and Qu (2020) used the text mining approach to construct the bank fintech index, which shows the technology innovation application of

commercial banks in China. Based on the annual report, Kriebel and Debener (2020) used the text mining method to measure the bank fintech component of US banks listed on the New York stock exchange market from 1993 to 2018. Non-financial measurement is proxied by transaction amount of digital banking channel, the number of scientific and technological staff (Zuo et al., 2021), or the survey (Diener & Špaček, 2021). I argue that these approaches should be considered for further research, providing a holistic view of the effect of bank fintech on bank performance.

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LIST OF CURRENT PUBLICATIONS

Journals

1. **Tien Phat Pham**, Boris Popesko, Abdul Quddus, Ny Thi Kieu Nguyen. 2021. Innovation and Bank Efficiency in Vietnam and Pakistan. *Scientific Papers of the University of Pardubice, Series D: Faculty of Economics and Administration*, 29(2), pp. 1-11. ISSN: 1804-8048. (**Scopus**)
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1. **Tien Phat Pham**, Abdul Quddus, Arif Ibne Asad, Boris Popesko, Sarfraz Hussain. 2021. *The factors of fintech: A literature review*. DOKBAT 2021 - 17th International Bata Conference for Ph.D. Students and Young Researchers, May 20, 2021, Zlin, The Czech Republic, pp. 395-405. ISBN: 978-80-7678-025-5.
2. **Tien Phat Pham**, Boris Popesko. 2020. *Covid-19, a chance for mobile payment*. ICBF 2020 - International Conference on Business and Finance, August 27-28, 2020, University of Economics Ho Chi Minh, Vietnam, pp. 456-464. ISBN: 978-604-301-028-2.
3. **Tien Phat Pham**, Abdul Quddus. 2020. *The role of performance on firm value: The moderation model of innovation in Vietnam*. DOKBAT 2020 - 16th International Bata Conference for Ph.D. Students and Young Researchers, September 02-03, 2020, Zlin, The Czech Republic, pp. 421-433. ISBN: 978-80-7454-935-9.
4. Abdul Quddus, Drahomíra Pavelková, Sarfraz Hussain, **Tien Phat Pham**. 2021. *The moderating impact of economic policy uncertainty on the relationship between investment in working capital and profitability*. CBMEE 2021 - International Scientific Conference Contemporary Issues in Busisness, Management and Economics Engineering, May 13-14, 2021, Vilnius, Lithuania, pp. 1-10. eISSN 2538-8711/eISBN 978-609-476-260-4.
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Member of Research Project No. ***IGA/FaME/2022/001*** "The relationship between economic policy uncertainty, investment behaviour, and corporate innovation" A study on Visegrad economies" – Guarantor: Prof. Ing. Drahomira Pavelkova, Ph.D.

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