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The Impact of fintech innovations and financial standards on bank performance: Evidence from selected commercial banks in ASEAN

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The Impact of Fintech Innovations and Financial Standards on Bank Performance: Evidence from Selected Commercial Banks in ASEAN

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Declaration Page

I hereby declare that this DBA dissertation is my original work and it has been written by me in its entirety. I have duly acknowledged all the sources of information which have been used in this dissertation.

This DBA dissertation has also not been submitted for any degree in any university previously.

Kiyono Hasaka

18 April 2019

Abstract

In the rapidly evolving financial technology (fintech) landscape, there has been an increase in the number of the industry research papers and articles on fintech adoption and innovations. However, there are relatively few empirical studies that provide a quantitative analysis of the effects of fintech and financial standards on bank performance using financial indicators. This dissertation attempts to fill this research gap by identifying and analysing the impact of commercial banks' adoption of mobile banking technologies on bank financial performance in five countries that adopted financial standards in the Association of Southeast Asian Nations (ASEAN). Using the longitudinal panel data from 2010-2017 of 36 local commercial banks in Singapore, Malaysia, Philippines, Thailand and Brunei Darussalam in ASEAN, this empirical research found banks' adoption of mobile banking technologies had the following results: (1) it positively impacted banks' fee income, operating costs, consumer loans, money market deposits and profitability; (2) its effects were much larger for smaller banks in the Philippines and Thailand; and (3) that financial standards showed a significant mediating effect on bank profitability for both big banks and small banks in ASEAN. Overall, this research concludes that both fintech and financial standards have a positive impact on the financial performance of selected commercial banks in ASEAN.

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Abbreviations

AEC	ASEAN Economic Community
AMBD	The Autoriti Montari Brunei Darussalam
API	Application Programming Interface
ASEAN	Association of Southeast Asian Nations
ATM	Automated Teller Machine
BIS	Bank for International Settlements
BNM	Bank Negara Malaysia
BOT	Bank of Thailand
BSP	Bangko Sentral ng Pilipinas
CAR	Capital Adequacy Ratio
CDO	Chief Digital Officer
CGI-MP	Common Global Implementation-Market Practice
DFS	Digital Financial Services
Fintech	Financial Technologies
FIX	FIX Trading Community
FpML	Financial products Markup Language
GDP	Gross Domestic Product
IEC	International Electrotechnical Commission
IFC	International Finance Corporation
ISO	International Organization of Standardization
ITMX	Interbank Transaction Management and Exchange
MAS	The Monetary Authority of Singapore
MMF	Money Market Funds
MSME	Micro, Small and Medium Enterprise
MT	Message Type
M&A	Merger & Acquisition
NAPAS	National Payment Corporation of Vietnam
NETS	Network for Electronic Transfers

NPL	Non-Performing Loan
NRPS	National Retail Payment System
OLS	Ordinary Least Squares
OFWs	Overseas Filipino Workers
PayNet	Payments Network Malaysia Sdn Bhd
PSD2	Payment Services Directive Two
QFB	Qualifying Full Bank
RBI	Reserve Bank of India
RINTIS	PT Rintis Sejahtera
RPV	Resources- Processes-Values
RTGS	Real Time Gross Settlement
RTP	Real Time Payments
ROA	Return on Assets
ROE	Return on Equity
SEP	Standard Essential Patents
SEPA	Single Euro Payment Area
SMEs	Small and medium sized enterprises
SWIFT	Society for Worldwide Interbank Financial Telecommunications
TAG	Technical Advisory Group
TC68	ISO Financial Services Technical Committee 68
XML	Extensible Markup Language

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Dedication

To my husband James Gomez and my family in Tokyo.

1. Introduction

1.1 Overview

Broadly, financial technologies (fintech) refer to a combination of new technologies and innovations that offer a wide spectrum of financial services, such as mobile payments, e-wallets, marketplace lending, robo-advisory and digital currencies. Fintech has been experiencing strong growth worldwide. Global investment in fintech ventures have almost doubled from U$13.3 billion in 2014 to U$50.8 billion in 2017 (KPMG, 2018). In 2018, global fintech rocketed to a record U$111.8 billion mainly driven by M&A and buyouts, up 120% from 2017, according to the KPMG Pulse of Fintech 2018 report. The number of fintech deals also increased sharply from just above 1,100 in 2013 to nearly 2,200 in 2018, highlighting continued appetite from investors for innovations in the financial sector. Geographically, the US is the leading region which accounted for almost half of global fintech investment in 2018, with U$52.5 billion mainly funded through M&A, followed by Europe with total investment of U$34.2 billion. In Asia, total fintech investment reached U$22.7 billion in 2018, an increase from U$12.5 billion in 2017, with the biggest deal of China's Ant Financials for U$14 billion (KPMG, 2018).

Fintech investments in the Association of Southeast Asian Nations (ASEAN)[1] were around U$14 million in 2012, but the number significantly increased to U$338 million in September 2017 according to 2018 ASEAN Fintech

[1] The Association of Southeast Asian Nations (ASEAN) was established on 8 August 1967 by the founding members of Indonesia, Malaysia, Philippines, Singapore and Thailand with the purpose of promoting regional cooperation in Southeast Asia. Today, ASEAN comprises ten countries in Southeast Asia including Brunei Darussalam, Vietnam, Laos, Cambodia and Myanmar. More information, see https://asean.org/

Census Report by EY. The following Figure 1 shows the growth of fintech investment in ASEAN:

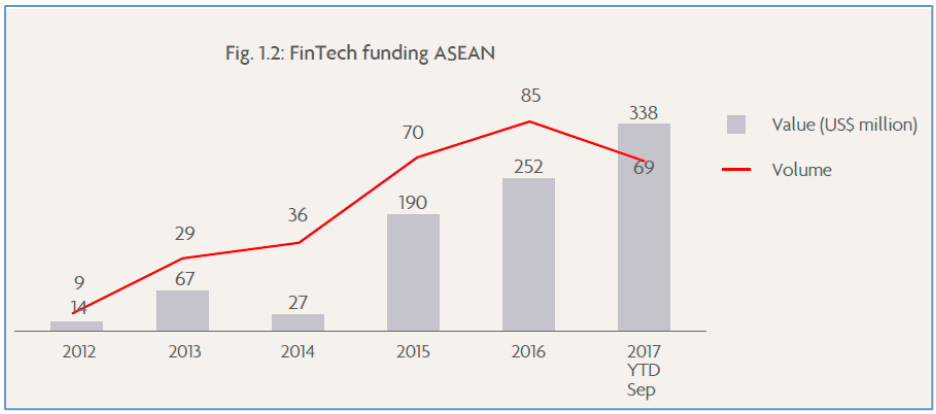

Figure 1: Fintech funding in ASEAN (Source: UOB (2017) State of Fintech in ASEAN)

It was in 2015 when fintech investment in ASEAN shot up to U$190 million from U$27 million in 2014, a big jump by 604%. It is estimated that fintech investments in ASEAN in 2018 exceeded the $5.7 billion, up by 30% from 2017 (Deloitte, 2018). In addition to the traditional method of funding from angel investors and venture capitalists, crowdfunding, venture debt and bank venture funds have also contributed to the rise in ASEAN fintech investments. This rise in funding is driven in part by the 2025 ASEAN Economic Community (AEC) Vision to attract fintech investments and innovations to close the digital gap and create more inclusive and integrated financial market infrastructures for consumers and businesses. It is estimated that more than 70% of the region's total population – more than 450 million individuals are unbanked[2]. The AEC Vision supports its community's digital readiness covering micro, small and medium-sized enterprises (MSMEs) and lower income groups, technological innovation and open regulatory

[2] The Business Times (2018) Going cashless in ASEAN, 23 August 2018

initiatives thereby offering the opportunities for fintech growth and financial inclusion across the ASEAN region.

Demand for fintech in ASEAN is accelerated by the rapid adoption of internet and a rising rates of cellular/mobile phone penetration as shown in Figure 2 below:

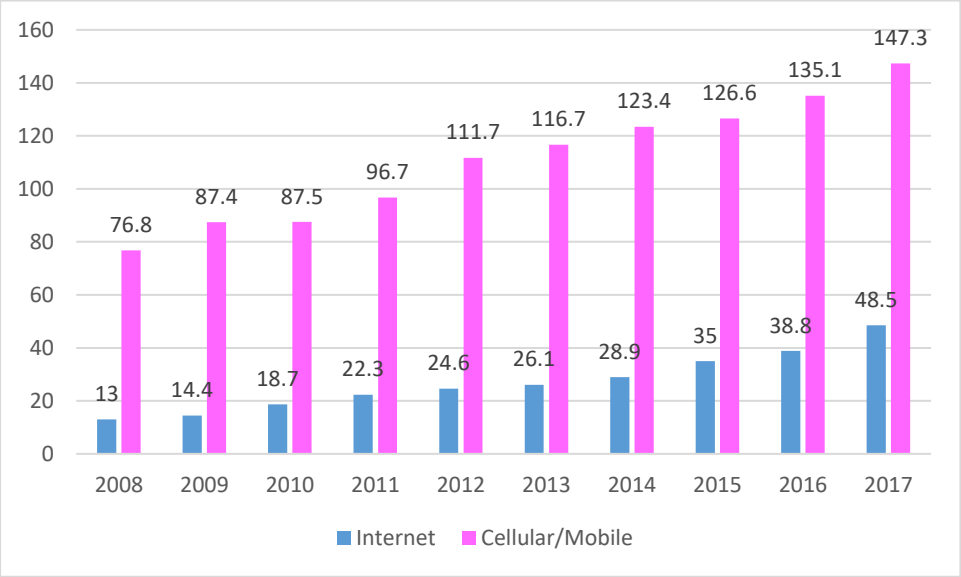

Figure 2: Trend in Internet Service and Cellular/Mobile Phone Density per 100 Persons in ASEAN, 2008-2017 (Source: ASEAN Statistical Yearbook (2018)

The region has been experiencing very rapid growth in the use of the internet and cellular/mobile phones in the last decade. Figure 2 shows that the total number of cellular/mobile phone subscribers in the region nearly doubled from 76.8% in 2008 to 147.3% in 2017. Likewise, the total number of internet subscribers in ASEAN reached 48.5 per 100 population in 2017, as compared to only 13 in 2008.

Fintech adoption in ASEAN is further accelerated by a high proportion of young population as shown in the following figure:

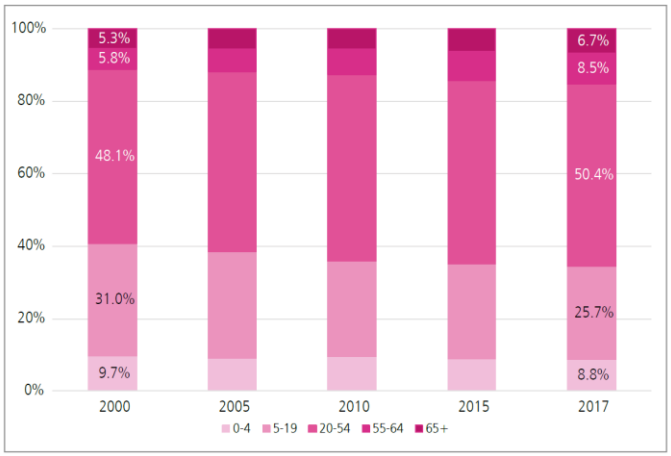

Figure 3: Population age structure (% to total) in ASEAN, 2000-2017 (Source: ASEAN Statistical Yearbook (2018)

With the growing population reaching 642.1 million in ASEAN in 2017[3], the region is also known as having a high proportion of young and productive working-age people who are historically under-served by banks. The population below the age of 19 and between the age of 20 and 54 years accounted for 34.5% and 50.4% of the region's total population respectively in 2017. While the share of youth population has decreased from 40.7% in 2000 to 34.5% in 2017, the share of productive working-age population has increased from 48.1% to 50.4% during the same period. Financial inclusion continued to be a strong focus for fintech investments and innovation in ASEAN. Thus, fintetch solutions targeted to the needs of unbanked and underbanked people tend to attract investments. Most of the focus of fintech has been on payments and mobile wallets as the first step towards financial inclusion. The following figure reflects share of fintech investments in ASEAN with payments and mobile wallets attracting the highest level of funding compared to other financial services:

[3] Total number of population in ASEAN is 642.1 million in 2017 almost doubled from 355.2 million in 1980 More information, see ASEAN Key Figures 2018.

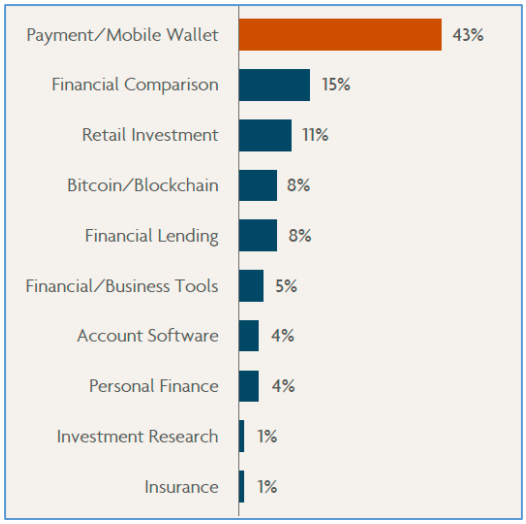

Figure 4: Share of ASEAN fintech investments (Source: UOB (2017) State of Fintech in ASEAN)

The main drivers of the payments innovation boom has been an expansion of internet access and rising mobile and smart phone subscriptions as shown in Figure 2. Since payments and mobile wallets attract fintech investments the most in this region, this dissertation thus narrowed down the research focus to the mobile banking market.

In parallel, fintech standardization has also gathered momentum. Under the umbrella of International Organization for Standardization (ISO), industry experts are collaborating together to develop and adopt common standards for evolving fintech landscape and drive global interoperability. Firstly, Fintech Technical Advisory Group (TAG) was established under the ISO Financial Services Technical Committee 68 (TC68) in March 2017.[4] TAG is an advisory sounding board for financial industry stakeholders and fintech companies to discuss data and technology standards requirements for secure global commerce. Secondly, a new ISO Technical Committee 307 Blockchain and distributed ledger technologies was

[4] SWIFT (2017) ISO 20022 for unifying fintech

setup in May 2017 to support interoperability and data exchange among users, applications and systems.[5] Thirdly, ISO 20022, universal financial industry message scheme developed under the ISO TC68 has been widely adopted globally to standardize financial technologies and financial messaging across different financial market infrastructures covering payments, securities, treasury, trade and cards business domains.[6] SWIFT[7] acts as the Registration Authority for ISO 20022.

In the area of international payments, SWIFT MT is the de facto financial standards. SWIFT was founded in Belgium in 1973 with the aim to establish common standards for financial messages to be exchanged in the SWIFT network securely. SWIFT currently links more than 11,000 banks, financial institutions and corporates located in more than 200 countries and territories worldwide. These SWIFT member institutions are exchanging an average of 32 million standard messages per day[8].

Adoption of the payment standards accelerated in Asia Pacific when the central banks introduced a domestic high value payment system – Real Time Gross Settlement System (RTGS) as early as 1990s and selected SWIFT MT standards to operate the RTGS. Most of the RTGS in Asia Pacific such as Singapore, Thailand, Philippines, Malaysia, Hong Kong, Taiwan, Australia and New Zealand adopted SWIFT MT standards. The RTGS participants of commercial banks were required to adopt SWIFT MT standards to transfer funds through the RTGS as well as for cross-border funds transfers. Some of the RTGS participant banks in ASEAN have

[5] ibid
[6] ibid
[7] SWIFT is the global provider of secure financial messaging services – see www.swift.com
[8] In Nov 2018, SWIFT recorded an average of 32 million SWIFT FIN MT messages per day. Traffic grew by 10.2 % versus November 2017 which brings the year-to-date growth to +11.4% (www.swift.com)

been members of SWIFT as early as 1980s and are certified by SWIFT to exchange standardised financial transactions with their counterparts.

While the SWIFT MT standards continue to be used and maintained in line with the payment market requirements, in recent years, SWIFT has been working to develop and promote ISO 20022 standards which address many of the shortcomings of MT standard.[9] ISO 20022 is a data rich and well-structured message standard and it supports local character sets, such as Japanese and Chinese and its XML syntax is easily integrated in modern computing systems. First introduced in 2004 for Single Euro Payment Area (SEPA) in Europe, ISO 20022 has been adopted by financial market infrastructures in more than 90 countries for payments and securities transactions replacing legacy formats. In the Asia-Pacific, China, Japan, India and Brunei Darussalam's RTGS already operate on a live mode using ISO 20022. It is projected that by 2025, ISO 20022 will dominate global high-value payments, supporting 79% of the volume and 87% of the value transactions worldwide[10]. ISO 20022 is also the principal standard in the real time retail payments adopted in Europe (Sweden, Denmark), Canada, and Asia Pacific (e.g., Hong Kong, Australia, Singapore, Malaysia, Thailand, Philippines).[11]

In the context of ASEAN, as part of the AEC 2025 Vision, member states are engaged in the modernization and integration of their financial market infrastructures including payment clearing and settlement systems that will set the stage for regional real time payment framework. In 2012, ISO 20022 standards were endorsed by all the ten ASEAN central banks to be adopted as a common financial

[9] See SWIFT (2018) SWIFT ISO 20022 Migration Study Consultation Paper
[10] ibid
[11] ibid

standard for regional financial integration. In 2017, Memorandum of Understanding (MOU) was also signed between major regional payment system operators, such as NETS in Singapore, PayNet in Malaysia, ITMX in Thailand, NAPAS in Vietnam and RINTIS in Indonesia covering a broad consensus to use ISO 20022 financial standard as a first step toward regional real time payments connectivity.[12] However, to operationalize the MOU, ASEAN seems to lack a regional regulatory framework that exists in other regional markets such as the European Union. Lacking regulatory mandates, for example, Payment Services Directive 2 (PSD2) which has opened commercial banks in Europe to greater innovation and competition through open banking regulations, ASEAN will need to build further consensus to shift towards regional innovation and interoperability.[13] As ASEAN is a highly diverse region in many areas – from socio-economic conditions to languages, cultures, politics and religions, while lacking the regional regulatory framework, having a common financial standard like ISO 20022 to conduct financial transactions efficiently and securely is beneficial. Currently, ISO 20022 payment systems are being used in Singapore, Brunei Darussalam, Malaysia, Thailand and the Philippines. The standards adoptions are ongoing in the rest of the ASEAN countries as well as across the regions in the US, UK, Europe and Africa as well. ISO 20022 offers any financial business the opportunity to speak in a common business language based on the standard methodologies, processes and repository thereby facilitating interoperability among different financial systems and user communities across different countries.

[12] Ovum & ACI Worldwide (2018) 2018 ASEAN Payments Insight Survey
[13] ibid

1.2 Problem Statement

"As fintech developments remain fluid, the impact on banks and their business models is uncertain. While some market observers estimate that between 10–40% of revenues and 20–60% of retail banking profits are at risk over the next 10 years, others claim that banks will be able to absorb the new competitors, thereby improving their own efficiency and capabilities" (Bank for International Settlements, 2017).

In the consultative document, BIS warned that incumbent banks' revenue and profits were at risk while highlighting opportunities for the banks to absorb fintech market entrants through acquisitions and by enhancing their service and product offerings for their customers. BIS sighted the estimates by McKinsey (2015) who observed the risk of loss to fintech by 2025 of up to 40% in consumer finance and up to 60% in retail banking profits. This translates into about 9% of that business' ROE, which McKinsey estimated to be about 10-12% currently. In terms of payment business within banks, McKinsey estimated that 30% of revenues and 35% of profits are at risk.

Similarly, PwC in the 2017 annual Global FinTech Report argued that large financial institutions across the world could lose 24% of their revenues to financial technology companies over the next three to five years. They revealed consumer banking such as personal loans was seen as most at risk following the poll of the more than 1,300 financial industry executives. 88% of the people polled said they feared their business was at risk to standalone fintech companies in areas such as payments, money transfers and personal finance.

China has been a good example of the fintech mass adoption. Alipay and Tenpay (WeChat) have made a significant mark in the consumer payments and finance space. Also online-only banks like MYbank and WeBank have broadened financial access for a large unbanked/underbanked population. This resulted in leapfrogging of retail customers from cash into e-payments, bypassing cards adoption, thus depriving the traditional Chinese banks' potential sources of income. E&Y (2017) sighted the estimated opportunity loss of U$ 22.8 billion in bank card fees alone in 2015, and that may rise to an estimated U$ 60 billion by 2020.

The ASEAN Finance Ministers' and Central Bank Governors' Meeting (AFMGM) held in Singapore in April 2018 also highlighted the significance of global fintech trends in transforming the financial industry[14]. AFMGM encouraged closer collaboration amongst the member states to enhance capabilities and tap fintech opportunities while ensuring financial stability. As part of the ASEAN economic integration, AFMGM also recognized the potential of secure, efficient, and interconnected payment systems to further promote ASEAN economic integration and encouraged wholesale payment systems linkages within ASEAN though the adoption of international standards (e.g., ISO 20022).

As a global fintech hub, Singapore is facing stiff fintech competition. PwC's Global FinTech Report (2017) found 73% of traditional financial institutions in Singapore believed they were at risk of losing business to fintech. The Monetary Authority of Singapore (MAS) in 2017 also stressed the fact that banks in Singapore who did not take any action against the rise of fintech could lose more than 5% of

[14] For more information, refer to the Joint Statement of the 4th ASEAN Finance Ministers' and Central Bank Governors' Meeting (AFMGM). https://asean.org/storage/2018/04/Joint-Statement-of-the-4th-AFMGM-6-April-2018-Singapore1.pdf

their operating income from disintermediation. In the Financial Stability Review report dated 30th November 2017, the MAS strongly advised all banks operating in Singapore to take the relevant actions against fintech disruptions. They stated that most of the operating income reduction would come from disintermediation in the payments space as more fintech companies offer payment options that compete directly with banks.

Similarly, Bank Negara Malaysia (BNM)'s Governor Datuk Muhammad Ibrahim (2016) warned of potential revenue disruption from fintech innovations in Malaysia. At the Global Islamic Finance Forum in 2016, Datuk Muhammad Ibrahim told financial institutions to embrace fintech as an opportunity rather than treating it as an unwelcoming threat. He stressed that "the potential impact of such technological disruptions is significant. An estimated 10% to 40% of overall banking revenue could be at risk by 2025 due to fintech innovations outside banking institutions that are able to achieve a significant pricing advantage".

Bangko Sentral ng Pilipinas (BSP) Governor Nestor A. Espenilla, Jr. (2018) also urged all banks in the Philippines to stay abreast with the trends and developments in fintech. "New technologies such as mobile banking, social networking, big data and cloud computing are advancing quickly and causing "disruptions" in the industry he said. To remain competitive and relevant, and to optimize benefits, banks need to identify growth opportunities and establish synergies with new players" (The BSP, 2018). As part of the digitalization strategy, the BSP is currently implementing the National Retail Payment System (NRPS) to establish a safe, affordable and interoperable payment ecosystem which will become the platform for fintech innovations. In relation to the NPRS, The BSP issued the Memorandum in November 2018 to announce the establishment of the

Task Force on the adoption of the international standards ISO 20022 for the Philippines' payments and settlement systems to facilitate global interoperability.[15] The BSP also recognized the huge potential of fintech to help drive financial inclusion and also lower remittance costs for the country's over 10 million Overseas Filipino Workers (OFWs) who largely support domestic economic expansion.

In Thailand, government is actively promoting fintech development and digital innovation as part of the nation's broader Smart Cities and Thailand 4.0 projects. In particular, Bank of Thailand (BOT) is taking the lead in creating a fintech ecosystem and facilitating fintech adoption among local banks by undertaking several initiatives such as hosting the 2018 Bangkok Fintech Fair and launching the National e-Payment Master Plan to turn the country into a cashless society. In the 2018 Fintech Fair, the BOT Governor Veerathai Santiprabhob emphasised three guiding principles for fintech development: productivity, by enhancing efficiency and reducing costs; immunity, by helping banks and businesses to manage and mitigate risks and; inclusivity, by facilitating financial access for unbanked and underbanked populations (BOT, 2018). Given the rising fintech companies impacting the value chains of traditional banks, the BOT is "committed to supporting adoption of fintech by financial institutions and promoting fintech innovation while ensuring that key risks can be contained" (BOT, 2018).

The Autoriti Montari Brunei Darussalam (AMBD) is the central bank in Brunei Darussalam that supports the establishment of competitive and innovate fintech ecosystem by also leveraging on expertise in Islamic finance. This is part of

[15] The BSP Memorandum (2018) is available here: http://www.bsp.gov.ph/downloads/regulations/attachments/2018/m033.pdf

country's Wawasan 2035, a nationwide plan that set out the economic vision of Brunei Darussalam over the next two decades. The 2035 vision is about developing a diversified dynamic and sustainable economy and establishing an international Islamic finance hub while largely reducing the reliance on oil businesses. Yusof Abdul Rahman, Managing Director, AMBD observed significant Islamic fintech developments in a number of countries which provided a new gateway for new players to tap the economic opportunities in the region (AMBD, 2017). AMBD and MAS signed a FinTech Cooperation Agreement in May 2018 to foster innovation in financial services between Brunei Darussalam and Singapore. This will facilitate information sharing about fintech developments and establish a framework for both authorities to provide support for fintech companies to better understand the regulatory regime and opportunities in each jurisdiction (AMBD, 2018).

The general business problem is that fintech is rapidly disrupting the traditional banking intermediary business model by new technology-driven business thereby making them obsolete. Examples include mobile banking and crowd platforms allowing peer-to-peer payments, lending and borrowing thereby bypassing intermediaries. These changes pose a serious threat to the traditional banks who are facing significant revenue at risk if they do not respond. At the same time, fintech can complement banking businesses as it can help create new innovative products and services and reduce cost and risk through automation. Therefore, the specific business problem to address in this research is three-fold:

1) whether investments in fintech would lead to better bank performance across all the financial indicators of revenue streams, cost structures and balance sheet components or the specific financial indicators only

2) whether investment in fintech lead to better bank performance across all commercial banks or the selected banks with the specific characteristics, such as small or big banks with the specific business focus

3) whether financial standards influence the relationship between fintech innovations and bank performance

1.3 Purpose Statement

The purpose of this research is two-fold. First, to analyse the impact of fintech innovations on bank performance in ASEAN using a variety of financial indicators. Second, to evaluate whether the adoption of financial standards has any measurable effect on the fintech innovations and bank performance. The financial indicators are sourced from bank income statements and balance sheets. The fintech innovations are measured by ASEAN banks' adoption of mobile banking technologies. The financial standards are measured by ASEAN banks' years of financial standards adoption.

The panel data samples of 36 local commercial banks in Singapore, Malaysia, Thailand, Philippines and Brunei Darussalam in ASEAN were selected for this research because all of the 36 banks are publicly listed thus their historical financial data is readily available. The panel data analysis is selected as it allows for time-series analysis to obtain deeper understanding of the technology diffusion and adoption by different banks over time.

Also local commercial banks, which generate businesses predominantly in the domestic markets, are only selected for this research to measure the fintech effects on their domestic operations. For example, global banks operating in ASEAN are excluded from this research as their operation in this region is much smaller than their home countries and only historical financial data of their HQ is available.

The five ASEAN countries were selected for this research as those that adopted financial standards for their national payment operations as well as for

cross border financial operations over the last few decades, hence historical standards effects can be observed and tracked. This compared with the rest of the ASEAN member states in Indonesia, Myanmar, Cambodia, Vietnam and Laos whose national payment systems are based on proprietary formats, thus they have not adopted international financial standards for their domestic payment operations.

FY 2010 to FY 2017 was selected as the research period for the following reasons. First, post global financial crisis in 2010 was when banks began focusing on technological investments and innovations. It was also the time when banks started adopting mobile banking technologies as there was rising rates of mobile and smart phone usage and broadband penetration. Second, FY 2017 was chosen as the end period as this was the time when the relevant financial data was available while undertaking and finalising this research during 2019.

In short, this research will examine how a variety of bank performance measures (income streams, cost structures, balance sheet constructs) is impacted by banks' adoption of mobile technologies and financial standards in the five ASEAN countries over the period 2010-2017. In particular, this research will also determine whether the fintech effect is heard across all banks or the selected banks only with specific characteristics such as the size of the bank.

This study will seek to fill the gap in fintech research in the ASEAN banking industry as there is no major empirical research presently available in this region. It aims to provide central banks, banks and financial institutions operating in ASEAN and also other parts of the world with a deeper understanding of the financial impact of the fintech innovations and financial standards.

This empirical research of fintech from the financial perspective will be useful to all banks as it will provide measurable answers to the factors against the importance of the fintech investments and adoptions thereby leading to better business practices, performance and economic contribution in ASEAN. It will also provide an insight into the effects of financial standards on bank performance in the evolving fintech landscape. Increasing this type of knowledge is vital for academics as well as for industry practitioners who seek information about the initial success achieved by the fintech innovations and investments and financial standards adoptions by commercial banks in ASEAN.

1.4 Chapter Outline

This dissertation is divided into five main chapters. Chapter 1 provides introduction, problem statement and purpose statement. Chapter 2 provides literature review of theories of technological innovations, fintech, financial standards and impact of fintech innovations, financial standards and macroeconomis on bank performance. Chapter 3 focuses on research framework, theoretical constructs, hypotheses, methodology, sample data, research variables and analytical method. Chapter 4 provides data analysis results of regressions and the status of the hypotheses tested. Chapter 5 concludes this dissertation.

2. Literature Review

This section reviews the literature on the theories of technological innovations, financial standards, macroeconomics as well as contemporary literature on fintech development. Fintech is a relatively recent development, hence very little scientific research has been conducted. Some works look at the impact of fintech on bank performance and these are growing and evolving in pace with the development of new technologies. However, little research to date has been undertaken to evaluate the impact of fintech on bank performance in Asia. Additionally, there has been no major empirical research to date that explores the link between the fintech innovations and financial standards and bank performance in ASEAN. This research aims to fill that gap. Since academic research in fintech and financial standards is limited, as they are still evolving in pace with the development of new technologies, a number of whitepapers, government reports and industry research papers are also reviewed.

2.1 Theories of Technological Innovations

Several theoretical frameworks from different perspectives provide insights into the economic and organizational benefits of technological innovations (Schumpeter, 1934, 1942 and Henderson & Clark, 1990). According to the economic theory, Schumpeter (1934, 1942) defined the concept of innovation based on entrepreneurship as a driver for economic development. The core of Schumpeter's (1934) definition of innovation is entrepreneurship as a stimulus for economic development. Entrepreneurship that would create new combinations of purposes and methods would result in innovation, as he wrote … "the entrepreneurs function is to combine the productive factors to bring them together…(p.76).

According to Schumpeter, innovation is defined as the commercial or industrial application of something new, a new product, process or method of production, a new market or source of supply, a new form of commercial, business or financial organization (Schumpeter, 1934).

Schumpeter also introduced a theory of disruption known as "creative destruction", a concept in economic innovation. In his book *In Capitalism, Socialism, and Democracy* (1942), he defined the term "creative destruction" as a process of creating net economic benefits in the capitalist system. Making a reference to Marxism, Schumpeter uses the term "creative destruction" to explain why capitalism would lead to its own destruction and would be overtaken by socialism. New entrepreneurs create and generate economic value from their disruptive innovations and replace and transform the earlier value of the established enterprise's way of doing things. He wrote as follows:

> *"The opening up of new markets, foreign or domestic, and the organisational development from the craft shop and factory to such conceives as U.S. Steel illustrates the same process of industrial mutation – if I may use that biological term – that incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one. This process of Creative Destruction is the essential fact about capitalism*." (p. 83)

Schumpeter argues that it is the entrepreneurs' disruptions of radical innovation into the capitalist structure that is the real force for sustained long-term economic growth. He highlights that entrepreneurs' innovations could constantly destroy the old ones who may have enjoyed a monopolistic power previously. The entrepreneurs

introduce new innovative products and services thereby gaining market share at the expense of their non-innovating competitors. Schumpeter claims that large firms with monopoly power are key to the success of innovate activities. Large firms can enjoy economies of scale in production and innovation which make sufficient resources available for successful completion of the innovative activities.[16]

Schumpeter's theory has led to a number of empirical research that focused on two relationships: (1) between firm size and innovation and (2) between market concentration and innovation.[17] Fisher and Temin (1973) found a positive and increasing relationship between innovative inputs and firm size was neither necessary nor sufficient to imply a positive and increasing relationship between innovative output and firm size given economies of scale related to larger firms. Kamien and Schwartz (1982) investigated into cross-industry analysis of firms and concluded that with the exception of the chemical sector, there was little support for the hypothesis of a more than proportionate effect of firm size either on R&D or on innovative output.

Schumpeter is still influential among economists today including his former student, Alan Greenspan. The former chairman of the US Federal Reserve reiterated Schumpeter's creative destruction in the rise of globalisation. He observed that the US embraced globalisation over the decades that resulted in higher standards of living. He also argued that globalisation is a process of creative destruction whereby a very considerable amount of turmoil goes on in the process. He gave the example of hiring people and firing a million workers a week in the US. Greenspan

[16] Schumpeter (1942) Capitalism, Socialism, and Democracy
[17] Link (1980) Firm Size and Efficient Entrepreneurial Activity: A Reformulation of the Schumpeter Hypothesis. Journal of Economy, 88, 4: 771-782 (p.772)

highlighted that while people gained from the benefits of globalisation and economic development, it was important to address the problem of the minority who were trapped on the adverse side of the creative destruction in the capitalist economy.

Following Schumpeter's definition of creative destruction, there are different kinds of innovations defined and their impact on the firm capabilities. Organizational theory assumes that technological innovations are based on organizational culture, dynamism and routines. Henderson & Clark (1990) introduced the concepts of architectural innovation that complements the view on radical or incremental innovations. Their idea is described in the following Figure 5 which classifies innovations in two dimensions. The horizontal dimension captures an innovation's impact on components whereas the vertical refers to the impact on the linkages between components.

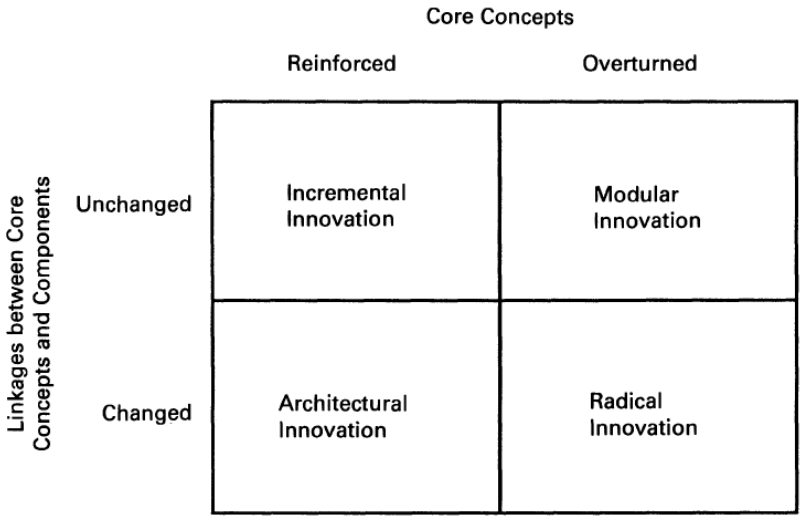

Figure 5: A framework for defining innovation (Source: Herderson & Clark,1990)

The core of the architectural innovation is a clear distinction between the components of a product and the ways they are integrated into the system that is the product "architecture". The architectural innovation is a reconfiguration of the

existing components which are connected and integrated in a new way. They gave an example of a ceiling fan with the motor hidden from view and insulated to reduce the noise, improvements in blade design or in the power of the motor would be incremental innovations. When the main components would be largely the same (e.g., blade, motor, control system), a portable fan would be an architectural innovation (e.g., smaller blade and motor size) whereby using many existing components in a new architecture. Their classification suggests that one innovation maybe less radical or more architectural, not to suggest every innovations should be classified into four quadrants. A move from the ceiling fan to central air conditioning would be a radical innovation. It is called modular innovation, if component knowledge is destroyed but architectural knowledge is enhanced (e.g., change from analogue to digital phone). The significance of the notion of architectural innovation is that while the component knowledge required for innovation had not gone through modification, the architectural knowledge had changed. Architectural knowledge tends to be tacit and embedded in the organizational routines. As a result, recognizing architectural knowledge and effectively responding are often extremely challenging due to the organizational dynamism of different communication channels, information filters and strategies in managing architectural knowledge.

The definition of architectural innovation is useful as it provides insight into different types of innovations and organizational capabilities where innovation both enhances and destroys competence often in subtle ways. It postulates why incumbents fail at what appeared to be incremental innovation but are actually architectural innovations (Henderson and Clark, 1990).

The alternative theory of innovations is elaborated by Clayton Christensen. In his book, *The Innovator's Dilemma* (1997), he describes his theory of "disruptive innovation" as a process by which a product or service takes root initially in simple applications at the bottom of a market and then relentlessly penetrates the market and eventually displaces established competitors. Christensen provides an explanation of the failure of the best companies when they confront certain types of market and technological change. Managers in the best companies typically face a dilemma because by doing the very best things for them to succeed – listen to customers, invest aggressively in new technologies and build distinctive capabilities to continue to service the existing big customers – they run the risk of missing out on new innovation waves and ignoring rivals with disruptive innovations. The following picture describes two important elements of the theory of disruptive innovation by Christensen: (1) sustaining innovation by incumbents and (2) disruptive innovations by new entrants.

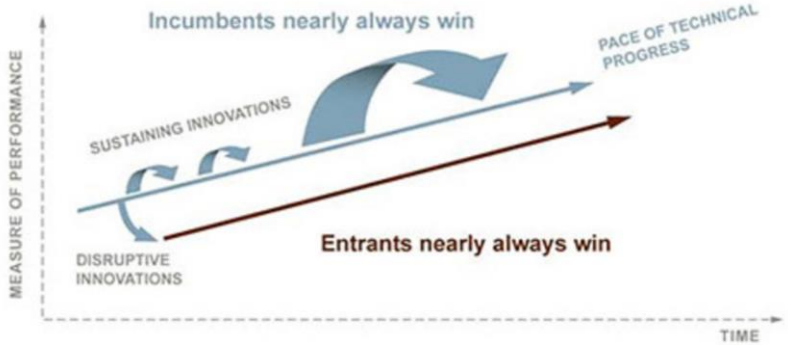

Figure 6: Theory of Disruptive Innovation (Source: Christensen, 1997)

Incumbents pursuing sustaining innovations means that they innovate faster in line with the pace of technical progress than the majority of their customers' needs evolve. This is typically to service their most demanding and sophisticated customers at the top of the market where incumbents nearly always win as they can

charge high price premiums. As a result, the incumbents eventually end up producing products or services that are actually too expensive, too sophisticated, and too complicated for many customers in their market to adopt.

However, the consequence of pursuing the sustaining innovations means that the incumbents unwittingly open the door to "disruptive innovations" at the bottom of the market. An innovation that is disruptive allows many new customers at the bottom of a market to have accessible and affordable products or services and secures a foothold at the low end of the market and eventually upends an industry. Characteristics of disruptive innovations in their initial stages can include: lower gross margins, smaller target markets, and simpler products and services. Because these lower tiers of the market offer lower gross margins, they are unattractive to the incumbents to penetrate into the market, creating space at the bottom of the market for new disruptive competitors to emerge. Christensen proposed the Resources- Processes-Values framework whereby tangible and intangible resources an organization had and the processes that employees used to transform resources into value added products and services determine whether an incumbent will succeed or fail to respond to disruptive innovations (Christensen, 2000).

In summary, the theories of innovations contributed by different authors such as Schumpeter (1934, 1942), Henderson and Clark (1990) and Christensen (1997) can explain different types of innovations, disruptive forces and start-ups which are shaping the world from the economic development point of view, organizational point of view and resource process value standpoint. Schumpeterian's view of globalisation as a creative destruction through innovation provides an insight into the adverse side where those being disrupted suffer in the imperfect capitalist economy. Christensen's theory of disruptive innovation offers

an alternative way of looking at innovation that takes root initially at the bottom of the market and eventually displaces established competitors. All theories highlight the importance of firms to sustain competitive positions by continuous innovations.

Although these theories provide an understanding of the disruptive effects, they fail to explain the current fintech and digitization era in which new technologies such as mobile apps, distributed ledger technologies and artificial intelligence allow different industries to cross-connect with consumers and to one another at the same time. Disruption is no longer challenging a single industry and a single low end of the market. Disruptions may come where new technologies emerge and spread exponentially. Having looked at the theories of technological innovations and disruptions, the following section will focus on the literatures on financial technologies – fintech.

2.2 Financial Technologies – fintech

Financial Technologies or "fintech" is rapidly transforming the current financial services industry by stimulating innovations and making the financial ecosystem more efficient and customer-focused. Examples of fintech innovations of peer-to-peer lending, cryptocurrency trade and deep learning are increasingly providing individuals and corporates with more convenient and low cost financial services.

McKinsey (2016) examined the fintech and remittances from a financial inclusion perspective. He aimed to quantify macroeconomic and social impacts and benefits of digital finance for individuals and small and medium sized enterprises (SMEs) in emerging economies. His observations included successful digital remittances in the markets with solid digital infrastructures and financial regulations. The research offered a country analysis for forecasting digital finance environment

in 2027 with estimated number of people to be newly included in the financial system, gross domestic product (GDP) boost, new jobs, new deposit and credit growth. The research focused on digitalization of financial services in the emerging countries to help reduce costs for both consumers and also make it more profitable for service providers to serve larger range of customers.

Similarly, the International Finance Corporation (IFC) in 2017 reviewed digital financial business opportunities in emerging markets in Asia and Africa. It looked at how fintech was reaching the poor and unbanked individuals given that more than half of the world's unbanked individuals reside in these two regions. India has the highest unbanked recorded at 20.6% of the word's total, followed by China at 11.6%. Besides banking efforts to spread digital payments through fintech partnership, the IFC observed the importance of Asian governments and regulators' involvement in supporting and encouraging fintech to provide funding to SMEs and innovative solutions for banks. It argued that Asian banks had managed to efficiently integrate with fintech solutions and proactively sought ways to reduce costs and meet customer needs by choosing to partner rather than competing with startups. The IFC (2017) also stated that African banks were generally slower in adapting to the change except for South Africa which had well-regulated banking sector and digital banking roadmap with fintech solutions. It concluded that fintech had a positive impact on the Asian banking sector as it gives access to a larger market at a lower cost. However, African banks often had direct competition between mobile operators. Therefore, they will require more integration efforts than Asian banks.

Continuing a review of the fintech trends in emerging markets, KPMG (2016) researched further into the market in India. Many fintech companies are

working to contribute toward achieving deeper financial inclusion and enabling payments in remote areas in India. More importantly, the report revealed the importance of the regulator, Reserve Bank of India (RBI) which is playing a 'laudable role' to support the fintech sector development. At the same time, RBI is espousing a cautious approach in addressing concerns around consumer protection and law enforcement. India is also well-known for its international remittances that constitute large GDP shares supporting the national economy. India faced the issue of high costs of receiving payments, especially the smaller size of remittances that made it extremely expensive for beneficiaries. This issue triggered a big opportunity for fintech companies in India being committed to address it well and come up with efficient remittance platforms. This report also developed a framework to help India create a key fintech hub through cross-industry collaboration and benchmarking. For banks in India, the report recommended to adopt a four-pronged strategy; investments, partnerships, market value chain and collaborations. It emphasized the need to connect with key industry stakeholders in order to develop the fintech sector, such as universities, research institutes, government, regulators, startups, investors, users, financial institutions, tech vendors, incubators, accelerators and innovation labs.

Having looked at India, the next focus is China. Ernst & Young and DBS (2016) published a report that described fintech revolution in China. As Chinese fintech investments commanded the largest share of global investment in 2016, it reflected the massive potential for a digital financial marketplace. With high levels of internet and mobile penetration, China is already the world's largest e-marketplace for consumers such as Taobao & Tmall (Alibaba), Tencent (WeChat) and JD.com. These Chinese technology giants are investing heavily in new

technologies to support next-generation financial services focused on e-commerce, payments and remittances. Financial subsidiaries of Alipay and Tenpay dominate the payment markets and facilitate mobile payments. As a result, China's incumbent banks are having the challenging times. In 2015, net profit growth for China's commercial banks reduced to a pedestrian 2.4%, with bigger banks registering their slowest growth in years. It is expected that the incumbents will have a tougher time once the nation-wide Social Credit System is built by 2020 as the potential of fintech market will open up further.

The Bank of New York Mellon (2016) also analysed the growing capabilities of fintech in both retail and wholesale payments arenas. In its report, "Innovation in Payments: The Future is Fintech", the bank argues that "without a doubt, the "era of fintech" is upon us and banks can't merely be mindful of this; they must also have a clear plan in place in order to adapt to and benefit from fintech-fuelled changes". They observed the fintech disruption in the wholesale payment market could come from two forms: large tech companies within the financial services and numerous fintech startups having the potential for driving disintermediation. They also analysed the current challenges in fintech implementation, how to strategize and monetize fintech opportunities and put forward recommendations for banks to increase engagement with the fintech community in order to position firmly in the digital age.

Lastly, Kuo Chuen & Teo (2015) researched on emergence of fintech and developed LASIC principles (Low margin, Asset light, Scalable, Innovative, and Compliance easy) to analyse two successful fintech companies of Alibaba and M-PESA. They argued that fintech would bring lower business costs and profit margins. In relation to international remittance costs, by drawing an example of M-

PESA mobile payment solution in Kenya, the LASIC principles were applied to analyse M-PESA's business model of utilizing innovative technologies to keep low margin business and make operations scalable while keeping affordable prices for consumers and meeting compliance. M-PESA exhibited the LASIC principles and explained how they could reflect the success of fintech business. They concluded that being able to capitalize on the LASIC principles are not sufficient but investing into financial inclusion and serving the underbanked and unbanked is key for long term success and sustainability.

In summary, literature related to fintech address two main issues; 1) Global challenges of financial inclusion and fintech as a key driver to create more inclusive financial eco-system. 2) fintech has the potential threats for driving disintermediation. 3) banks are integrating with fintech solutions to enhance customer experience and reduce cost. 4) governments and regulators are influencing fintech development and adoption. Having reviewed the literatures on fintech, the following section will look at the impact of new technologies / fintech on bank performance.

2.3 The Impact of fintech on Bank Performance

There have been growing studies about the impact of new technologies / fintech on bank performance globally. In order to select the relevant articles to answer the research questions about the link between fintech innovations, financial standards and bank performance, a comprehensive search was performed using the three main science databases; EBSCO, Science Direct and ProQuest. The search was restricted to the peer-reviewed scientific journal articles published from the period of 2012 to 2017 with keywords; 'fintech', 'financial technolog*', 'digital*',

‘mobile bank*’, ‘innovat*’, ‘bank performance’, ‘financial impact’, ‘roe’, ‘roa’, ‘standard*’, ‘ISO 20022’. In addition, Google scholar was also used to locate the relevant articles using the same keywords. Since Google scholar was unable to filter the peer-reviewed articles, the search results were then counterchecked against the top journal rankings by Scimago, American Economic Review, UT Dallas Ranking and the Financial Times to select the peer-reviewed journal articles. Based on the search, total 45 peer-reviewed journal articles were found; 6 articles from the independent search and 39 articles from the literature review by the researchers of Tilburg University. The following discussion below will introduce the relevant research works.

The most recent study was published by Hornuf, Lohwasser and Schwienbacher (2018) who investigated key drivers for banks to form alliances with fintech and impact of bank-fintech alliances on the market valuation of banks in Canada, France, Germany and the UK. Using hand-collected information on strategic alliances from bank websites, Crunchbase database and Factiva for 2007-2017 by the hundred largest banks in each of the four countries, they found 469 alliances. Of the 469 alliances, majority is characterised by product-related collaborations (54%), followed by financial engagements (43%). They collapsed the data into a panel dataset for the period from 2007 to 2017 for bank-year observations. They found that banks are significantly more likely to form alliances with fintech when they pursue a well-defined digital strategy and/or employ a Chief Digital Officer (CDO). Employing a CDO increases the number of bank-fintech interactions by two to three times. The coefficients of bank which is listed on stock exchanges and bank assets are statistically significant and have a positive effect in all the regressions, meaning large and listed banks interact with more fintech than

small and private banks. The bank ROA is significantly negative in most regressions indicating that banks with poor profitability maybe particularly interested in a higher number of fintech partnerships which maybe an effort to accelerate a transformation process. They found that markets react more strongly if digital banks rather than traditional banks announce a fintech alliance. Their results suggest that stocks of digital banks benefit from alliances, which may result from being better able to internalize the fintech's expertise.

Rega (2017) performed an empirical analysis on a data panel of 38 European Banks to determine the impact of bank innovations on financial performance measured by the ROE between 2013 and 2015. The study was based on secondary data collected from the annual reports for the European banks spanning three years in which fintech innovations have been invested in by banks. She used R and STATA 12.0 to analyse the data and found a significant positive association between fintech and bank profitability as financial innovation can create both cost-cut and cross-sell opportunities for the banks. She also found the existence of a negative relationship between the number of physical branches and bank profitability. She also found more digitally-oriented banks such as Nordea, SwedBank, Fineco and mBank had shown growing profitability (ROE of 13-15%) at a time of falling interest rates as well as a strong focus on building a customer-oriented bank for the future.

Another research was undertaken by Scott, Reenen and Zachariadis (2017) who analysed the impact of adopting SWIFT technologies on bank performance. SWIFT represents a financial network based technological infrastructure for worldwide interbank telecommunication. They used the dataset of 6,848 banks in Europe and North America who adopted SWIFT from 1977 to 2006. In order to

measure the financial impact, they focused on the Return on Sales as a performance measure. They found the adoption of SWIFT technologies had large effects on the Return on Sales in the long-term. As technological adaptation and diffusion often takes time, the impact of innovation is unlikely to be realised in the short term. Interestingly, their main result showed that the returns from SWIFT investment could take up to ten years to be fully realized as they observed an extremely weak or negative result within the first few years of the adoption of SWIFT. Also the profitability effects were larger for smaller banks who benefit from relatively higher returns than the larger banks. Their research contradicts with Schumpeter's scale economy theory whereby large firms with monopoly power are key to the innovative activities. Their empirical evidence suggests that despite smaller operations, small banks also achieve significant leverage from the SWIFT technologies adoption and benefit from relatively higher returns than the larger banks.

Campanella and Dezi (2016) researched about the effect of the Internet of Things to analyse the existing relationship between the products offered by the sample of 3,692 banks located in 28 European countries in 2013 and the banks' profitability measured by relative return on equity. Their findings of this empirical research, based on the classification analysis method showed that a high ROE for banks is expressed by the following characteristics: the ability to offer IoT services to retail and corporate customers as well as a large number of home banking and traditional investment services.

Tunay and Akhisar (2015) analysed the interaction between internet banking and performance measured by ROE and ROA. They used panel causality tests on banking data of 30 advanced and emerging European countries for the

period of 2005 – 2013. The performance data of aggregated banking ROE and ROA ratios at the country level was sourced from the IMF Financial Soundness Indicators. They found in Euro Area countries, causality from Internet banking to bank profitability are determined accurately strong and unidirectional. In countries outside the Euro Area, they could not observe significant causality relationships between variables. Therefore, the only significant causal relationship found was under the influence of the Euro Area countries. The more advanced internet banking practices in European countries illustrated the stronger the performance of the banks. But less developed European countries did not show any significant correlation due to lack of infrastructure and customer habits.

There are some in-country studies about the impact of the financial technologies on bank performance. Japparova and Rupeika-Apoga (2017) researched on commercial banks in Latvia from 2010 to 2015 to examine the fintech influence on bank performance measured by the ROA, the ROE and the capital adequacy ratio (CAR). Total 23 commercial banks in Latvia are divided into two groups; those specialised in international customers servicing (BI) and those specialised in domestic customers servicing (BD). They found the ROA, ROE and CAR index was higher for BD because BI was more dependent from internal and external factors of a bank. In summary, fintech development affected the retail banking sector of BD that actively digitalized their operations. Those banks categorised as BD had more flexible and had a focused policy to new customers and existing customers by new digital tools as compared to BI whose change and digital adoption was slower.

Abbasi and Weigand (2017) performed a comprehensive review of peer-reviewed scientific journals investigating the impact of digital financial services

(DFS) on firm performance from 2006 to 2016. DFS is defined as the broad range of financial services accessed and delivered through digital channels, including payments, credit, savings, remittances, insurance and financial information. The term "digital channels" refers to the internet, mobile phones, ATMs, POS terminals, NFC-enabled devices, chips, cards, biometric devices, tablets, phablets and any other digital system. Abbasi and Weigand identified 39 articles that appeared in a wide range of peer-reviewed scientific journals that investigated the effect of DFS on bank financial growth and profitability (See Appendix 2). Of the 39 articles, 60% were published by top-ranked journals like Elsevier, Emerald, Inderscience, Taylor & Francis, Wiley and Springer. They found all of the 39 articles focused on the banking sector and almost all articles used quantitative techniques except for one study (Kennedy and Jacky, 2013) which used qualitative method. Regression analysis was the most popular research methodology used in 70% of the studies (See Appendix 1). Geographically the most investigated regions were Europe followed by USA and south Asia; there was not a single research on ASEAN member states. The average sample size was 534, with the largest number of banks in the USA followed by European countries. They identified different dependent and independent variables used in the research on the impact of DFS on firm performance. Among the research variables, the ROE and the ROA were the most common dependent variables; approximately two-third of all studies cited them (see Appendix 2). In order to control the effect of other variables on the financial performance at the same time while examining the DFS relationship, many studies used different control variables. These include bank size, macroeconomic data such as GDP, inflation and job growth (see Appendix 2). They observed that despite rapid DFS advancement in the last ten years, the factor affecting firm performance

did not get reasonable attention in the academic literature. One of the reasons was that almost all the researchers limited their research to banking sector while ignoring other sectors such as mobile network operators and new fintech entrants. Let's closely look at the bank size which was the most frequency applied in the past research as a control variable.

2.3.1 The Size Factor

There are number of studies about the relationship between bank size and bank performance. Supporting Schumpeter's theory, an increase in the bank size can also increase bank efficiency by allowing banks to enjoy economies of scale by spreading technological investment costs over a larger asset base, thereby reducing their average costs. Increasing banks' assets can also allow banks to embrace economies of scope as they can reduce risks by diversifying banking operations across different business lines and across different countries (Mester 2010). Lowering risks may lead to promote profitability by reducing losses or indirectly by making liability holders willing to accept lower returns, thereby reducing banks' funding costs (Regehr & Sengupta, 2016).

On the other hand, bigger size and scale economies are not the only factors to affect bank performance. Small banks may be able to diffuse new technologies easily due to agility and flexibility. They may establish stronger relationship with local businesses and customers than large banks, allowing them access to proprietary information useful in setting contract terms and making better credit assessment and decisions (Berger, Allen, Miller, Petersen, Raghuram, and Stein, 2005). Fries and Taci (2005) undertook a study on bank cost efficiency in 15 transition countries covering 289 banks from 1994 to 2001. They concluded that

bank performance was related to the changes in incentive, structural and institutional reforms and the rule of law. They also found that an average-sized bank in the sample operated at a point that is close to constant returns to scales, while the smaller banks in the sample operate with significant unrealized economies of scale. DeYoung and Hunter (2001) also argued that small banks tended to offer a higher degree of personalized interaction. High-touch personal service becomes more difficult as an organization grows larger. Large banks tended to service large customers. They explained that in many cases differences in bank size were pre-determined by the economic size of the local market and the restrictiveness of local branching rules.

Regehr & Sengupta (2016) also supported that small community banks had shown significant scale economies in banking between the pre-crisis and post-crisis expansions. While the smallest banks can benefit significantly from growth, the advantages of growth become progressively smaller until they are exhausted. For most mid-sized community banks, the increase in returns relative to size is modest; these banks would need large increases in size to realize significantly higher returns on assets. The relationship between size and profitability remains unchanged between the pre-crisis and post-crisis expansions. In other words, they find the post-crisis economic and regulatory environment has not disproportionately affected the size-profitability relationship for small community banks.

In summary, there has been a growing focus on the importance of technological innovations and its impact on bank performance in the past few years. A number of studies were undertaken to explore the effects of fintech on bank performance globally. There are mixed results about positive and negative effects of fintech on bank performance depending on various factors, such as bank size,

strategy, regulation and macroeconomic environment. The ROA and the ROE were the most commonly used performance measures and regression analysis was the most popular research technique. Geographically the most investigated regions were Europe followed by USA and South Asia. Therefore, there is a clear research gap to fill in ASEAN as to date there is no empirical study undertaken on the impact of fintech on bank performance. The following section will look at some of the literatures on the role of standards as an enabler for innovations.

2.4 Standards as an Enabler for Innovation

There has been increasing research about the importance of standards for information and communication technology as an enabler for innovations. First of all, let's define the term standards. The most commonly used definition of standards is offered by the International Organization for Standardisation (ISO) as follows: standard as "a document, established consensus and approved by a recognized body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context" (ISO/IEC, 2004). Other definitions of standards highlight the industry best practices that provide guidance in managing services, products, processes and systems. For example, SPRING, the national standardization body in Singapore, defined standards that facilitate industry transformation, improve quality, increase market access, raise productivity, enables interoperability and boost consumer confidence (SPRING, 2018). SWIFT, the international standards setting organization and the global provider of secure financial messaging services emphasised the collaborative efforts of defining standards and sharing market

practices with the financial community in order to enable automation, cost reduction and efficiency.

The proliferation of financial technologies in various systems and applications that need to be interconnected within larger market infrastructures presents challenges, requiring standards disciplines to achieve interoperability among networked products (Blumenthal and Clark, 1995; David and Shurmer, 1996; Jakobs et al., 2011). Interoperability is the term that is often used to describe the benefit of standards because it enables organizations to seamlessly manage different systems and applications. Generally, interoperability has three levels; business, syntax and semantics. Business interoperability enables organisations to seamlessly execute business goals and objectives. Syntax interoperability aligns the exchange of data between different applications in the right protocols and valid formats, while semantics interoperability ensures the consistent meaning of the information (SWIFT, 2017). Research was undertaken to understand the role of standards in supporting technological innovations including defining and creating a common ground upon which innovation technology may be developed and scaled (Blind, 2016; Blind, 2012; Blind and Hipp, 2003; Blind and Jungmittag, 2008; Blind and Gauch, 2009; Allex and Sriram, 2000; Tassey, 2000; Swann, 2010).

The systematic perspective on innovation has made many researchers and policymakers aware of importance of standards as a powerful institutional mechanism that shape technological innovation and change. There is a variety of roles of standards in enabling innovation emphasized by a number of innovation research (Porter, 1990; Lundvall, 1992; Ehrnberg and Jacobsson, 1997; Smith, 1997; Allen and Sriram, 2000; Tassey, 2000, Swann, 2010). Through a systematic analysis of understanding key standards factors that influence innovation, Bergek

(2008) defined standards which are linked to four different functions: legitimacy, influence on the direction of search, development of positive externalities and knowledge development and diffusion.

Swann (2000) conducted the first comprehensive survey on the existing literature on standards and identified the following factors that enabled innovation:

- Standardization helps to build focus, cohesion and critical mass in the emerging stages of technologies and markets
- Standards for measurements and tests help to demonstrate to the customer that their innovative products possess the features they claim to have, but also acceptable levels of risks for health, safety and the environment
- Standards codify and diffuse state of the art in science, technology and best practice
- Open standardization processes and standards enable a competition between and within technologies and contribute therefore to innovation-led growth.

Overall, standardization generates standards, which are an essential component of companies' infrastructure. Consequently, they enable innovation, but also try to protect from undesirable outcomes (Swann 2000). Swann and Lambert (2010) used data from the British Community Innovation Survey (CIS) to examine whether standards constrain or enable innovation. The results showed that standards enabled and constrained innovation. Amongst the 60% of companies who responded that standards were a source of information for innovation activities, the majority also confirmed that regulations – and not standards – were a constraint on their innovation activities. Simultaneously, amongst those companies for which standards were not a source of information for their innovation activities,

regulations were not perceived as a constraint on their innovation activities. In addition, they also found that those survey respondents who mentioned that standards informed and constrained, were also those who were more successful in many of the CIS measures of innovation. It means those who responded that standards informed their innovation were more innovative than those who said standards did not inform. However, unexpectedly companies, which were constrained by regulations, were more innovative based on the CIS measures of innovation than those which were not constrained.

Blind (2006) found a positive influence of companies' R&D-intensity on their likelihood to join standardization processes based on survey data covering the German electrotechnical and machinery industry. Blind et al. (2011) also looked at the Dutch innovation survey with companies active in the Dutch standardization institute NEN and conducted similar analyses with a focus on services. Whereas they found a linear relationship between service companies' R&D intensity and their likelihood of being involved in standardization, there was an inverted U-shape for the influence of companies' turnover with market innovations on their inclination to join standardization processes. Although these studies explained the participation in standardization by various innovation measures, they claimed not a causal relationship between R&D or innovation activities and standardization. Therefore, these findings can also be referred to indicate a general positive relationship between innovation and standardization.

As for the qualitative analysis, Blind et al. (2010) undertook research about the impact of international ICT standards based on quantified expert opinions from three standardization organizations. The results showed that ICT standards had a

positive impact on innovation, especially on product variety, the degree and speed of adoption of new products and services.

The above literature examined the role of standards as an enabler and supporter for technological innovations as standards define and create a common ground upon which technology can be developed, adopted and scaled for innovation. In contrast, some literature argued that a dual role of the standards as informing and also constraining innovation depending on the age of the standards, i.e., both rather old and rather new standards constrained innovation. Additionally, people's perception of mixing the standards as equal to regulations may have mistakenly responded to the survey as constraining innovation.

2.4.1 The impact of standards on firm performance

Numerous studies have demonstrated a positive impact of standards on firm performance. Wakke and Blind (2016) investigated how the participation within formal standardization process is related to the financial performance of 1,561 German companies. Participation in standardization is measured by the number of committee seats within the German Institute for Standardization. The hypothesis is that standard setters not only benefit from the possibility to monitor and shape the development of standards but also access a wide range of knowledge sources in the standards committee. Their results demonstrated that participation within formal standardization was in general positively related to firm performance. They also found within the service industries a striking pattern for technology-developing service providers, only the combination of patenting and standardizing tended to be positively related to firm performance.

A similar approach focusing on the role of standardization in nanotechnology addressing both companies and research institutes was undertaken by Blind and Gauch (2009). The responses from the experts revealed that the main motivations to join standardization in this emerging technology were finding agreed rules leading to interoperability, compatibility, common terminology and better dissemination. Commercialization of research results by standardization also had a high legal security in new fields of science and technology (e.g. reducing risks of liability) and better links and collaboration with other researchers and developers, thus lead to better performance (Blind and Gauch, 2009).

With regards to the link between standards patents and innovations, Pohlmann, Neuhausler and Blind (2015) analysed the effect of owning standard essential patents (SEP) on firm performance. They treated SEP as greater innovative output. They used the dataset of firms participating in international standard setting organizations and patent counts and patent value indicators to measure the effect on firm performance. They highlighted the fact that the process of establishing a standard can be very costly for participating firms since standard development requires people engagement and create travel expenses for regular meetings and discussions. Nevertheless, they also found benefits from standard development processes such as reinforcing user confidence and acceptance and consequently creating new markets and the growth of the existing businesses. Combining patented technology essential for a standard and demand royalty fees is a practice to recoup a company's R&D investments as standards setting can generate licensing revenues and offer greater freedom in facilitating technology and their own products/services. Their results showed an inverse U-shaped relationship between owning SEP on a firm's ROA. I.e., the financial performance of companies active

in technology-related markets integrated their patent portfolio with technology standards to improve their financial performance. Let's now look at the financial standards used in the financial industry.

2.4.2 ISO 20022 Financial Standards as an enabler for innovation

ISO 20022 is part of the ISO standards that focuses on standardizing and automating financial communication and transactions. Also known as the universal financial industry message scheme, ISO 20022 is open standard and a recipe to build financial messages and reflects financial business models and processes. There are currently more than 220 ISO 20022 adoption initiatives across 90 countries worldwide in the financial business domains of payments, cash management, securities, trade and treasury.

The ISO 20022 recipe is based on three layers of architecture: the top layer provides the key business concepts; the middle layer provides logical messages or message models; and the bottom layer deals with syntax to physically represent and transmit the logical messages. It is the top layer of the key business concepts that is, in principle, independent of any technical syntax, the area to look for ISO 20022 standards to be shared and re-used in a blockchain standardisation context (Lindsay, 2016).

There has been a growing number of articles about the value of ISO 20022 standards as a key enabler for innovations and a unifier for financial technologies. Growing proliferation of financial technologies is transforming the financial services industry as both innovative and disruptive forces. Numerous startups emerged in the industry and created a plethora of widely differing standards that are non-interoperable and incompatible with the existing market infrastructures thereby

hindering the broader adoption of new technologies (Lindsay, 2016). The main argument is that the ISO 20022 standards as open and collaborative standard and tech-neutral business language for the financial industry that provides rich and proven data model and global interoperability thereby enabling to unify different financial technologies (Hasaka, Alaerts and O'Connor, 2017). Examples of ISO 20022 standards application for unifying fintech include distributed ledger technologies, smart contracts, Application Programming Interfaces (APIs), real time payments and securities transaction lifecycle. A number of articles about ISO 20022 standards were contributed by the standards subject matter experts in the financial service sector including banks, regulators and standardization bodies and associations as summarised in the table below:

Table 1: List of the articles about ISO 20022 standards

Authors (Year)	ISO 20022 application	Focus / Methodology
Hasaka, O'Connor, Dobbing & Alaerts (2017)	Financial Technologies in general	Survey, Discussion paper
Lindsay (2017)	Financial Technologies in general	Information paper
Lindsay (2016)	DLT	Information paper
Tompkins, Jafri & Arjani (2015)	Interbank payments and cheques in Canada	Quantitative & qualitative data analysis with interviews
Bracaglia, Monetta&Vanobberghen (2015)	Card payments	Case Study
Lindsay (2015)	Real-time payments	Case Study
Passi (2015)	E-invoicing in Italy	Case Study
Durkin (2014)	Corporate and CGI MP	-

Retzer (2013)	Co-existence with ISO 15022	-
Gillis & Pillay (2012)	Payments interoperability in South Africa	Case Study
Mermigidis (2010)	Securities	-
Goswell (2006)	Payments and securities and SWIFT's role	-
Greene, Rysman, Schuh&Shy (2014)	Costs/benefits analysis of UK fast payments	Case Study
Arjani (2015)	Interbank payments in Canada	Quantitative, Discounted Cash Flow Analysis
Tenhunen&Penttinen (2010)	Effect of carbon footprint of paper vs the e-invoicing practices	Qualitative, structured interviews
Chapman, Chiu, Jafri&Saiz (2015)	Interbank payments in Canada	Case Study

The common themes found across the literatures on ISO 20022 standards are three-fold. Firstly, all articles considered the value of ISO 20022 standards as key enabler for technological innovations. Secondly, Journal of Payments Strategy & Systems and Journal of Securities Operations & Custody are two main publications that feature the ISO 20022 standards and its benefits from the business practitioners' point of view. Thirdly, ISO 20022 standards are still new to the academic world and thus research frameworks and methodologies are still under-developed.

In summary, there has been a growing focus on the importance of standards for enabling technological innovations in the last few decades. Many studies were undertaken to explore important roles of standards in facilitating innovation. While well-designed and implementable standards can support innovation, premature standards may have negative impacts on innovation including imposing constrains

by decreasing flexibility. Because of this dual nature of standards, strategic approaches for timely and appropriate standards are critical for innovations. However, this is especially challenging for complex systems integrating different emergent technologies today with more devises and applications with different technology bases interconnected to each other. In the financial industry, time critical financial data are transmitted between parties real-time and multiple standards co-exist in the same function and asset class. Among them, ISO 20022 is the most commonly used standards for payment clearing and settlement and regulatory reporting today. Having looked at the theories of technological innovations and financial standards, the following section will briefly review the ASEAN economy and banking sectors.

2.5 Macroeconomic Effects

2.5.1 Impact of macroeconomics on bank performance

Financial performance of the ASEAN commercial banks is also directly and indirectly influenced by external, macroeconomic factors, such as economic growth, inflation rates, foreign exchange rates. Banks operating in the country with higher economic growth tend to enjoy lower cost of doing businesses as they can easily find prospective customers and borrowers with lesser cost (Mongid, 2016). However, during economic upturn, banks tend to make more investment to grow businesses thereby increasing costs instead of necessarily leading to increase revenues. Some empirical studies about macroeconomic effects on bank performance showed mixed results. Mongid (2016) examined the determinants of cost inefficiency of 504 banks in ASEAN – Indonesia, Malaysia, Singapore, Thailand, the Philippines, Cambodia, Brunei Darussalam and Vietnam from 2008

to 2012. Using ordinary least squared regression analysis, they found the cost inefficiency was positively determined by inflation rates as well as bank specific variables such as loan loss provisions, personnel expenses and capital adequacy ratio. It means that countries with high inflation rates tend to be less efficient in banking. During high inflations, banks tend to spend more to catch up with increasing expenses such as salary. At the same time, banks tend to follow the central bank policy to increase interest rates. Higher interest rates are mostly for compensating deposits and not to increase loan rates to keep the loan portfolio quality. Therefore, banks spend more to counter inflation rates thereby reducing cost efficiency. Hence, macroeconomics directly affected bank inefficiency.

In the earlier study, Mongid, Tahir and Haron (2012) studied the determinants of cost inefficiency of ASEAN banks in Indonesia, Malaysia, Singapore, Thailand, the Philippines and Vietnam using a panel dataset of 625 banks from 2003-2008. Tobit regressions were used for the data analysis. Their results indicated that cost inefficiency is positively correlated with economic growth, meaning economic growth contributed to lower cost efficiency. They explained that when economic growth increases, the demand for bank loans from businesses and individuals increases to finance investments and consumption. Banks then raise more capital to fulfil this business demands but the capital costs are higher during a period of high economic growth. Although the costs of raising capital are partly compensated by increasing revenue from the loans, banks incur higher cost to meet the demand for loans thereby leading to cost inefficiency.

Similarly, Shen, Liao, and Weyman-Jones (2009) studied financial performance of 285 commercial banks across ten Asian countries including five ASEAN member states of Indonesia, Malaysia, the Philippines, Singapore and

Thailand from 1998 to 2005. Using the stochastic frontier approach, they reviewed a variety of macroeconomic variables as well as environmental variables across ten countries, such as GDP, GDP per capita, inflation, unemployment ratios and population density. They found these external factors as well as internal bank specifics such as the managerial ability affected bank efficiency. For example, higher density contributed to an increase in banking costs. One reason given was in higher density area, banks may force to open more branches to compete for customers. The effect of GDP was negative, suggesting banks benefit more from the technological change and diversification and expansion of their business, which substantially reduce their operational expenses. The positive sign of inflation means the higher inflation, the higher costs it may incur since the inflation may increase the input prices involved in the banking production process. Thus, their results evidenced macroeconomic and environmental conditions as equally important determinants to increase bank cost efficiency.

Zetin (102) also studied the determinants of financial performance for Islamic and conventional banks in Gulf Cooperation Council (GCC) countries from 2002 to 2009. They used panel data of 13 Islamic banks and 38 conventional banks covering bank-specific internal variable such as ROE and ROA, macroeconomic variables and ownership structure variable. They found evidence a direct positive relationship between macroeconomic conditions and bank performance whereby both GDP and inflation rates clearly affected performance for both Islamic and conventional banks. The GDP was positively correlated with ROA and ROE of conventional banks while inflation was negatively correlated with ROA and ROE of both Islamic and conventional banks. They provided evidence of a strong relationship between macroeconomic conditions and banking sector performance.

Overall, the empirical results provide evidence that financial performance of Islamic and conventional banks was affected by internal factors and external factors, but not by foreign ownership.

In contrast, Athanasoglou (2006) examined the profitability behaviour of bank-specific variables and macroeconomic variables of South Eastern European (SEE) credit institutions over the period of 1998-2002 covering 132 banks as of 2002. SEE includes Albania, Bosnia-Herzegovina, Bulgaria, Croatia, FYROM, Romania and Serbia-Montenegro. Using a linear regression model, they tested the effect of the macroeconomic environment on ROA and ROE of the credit institutions, such as inflation rates and real GDP per capita income. Their results showed that real GDP per capita growth did not have a significant influence on bank performance. On the other hand, inflation positively and significantly affected profitability. They explained that with inflation, bank income increased more than bank costs, which may be viewed as the result of the failure of bank customers (comparative to bank managers) to forecast future inflation. Let's now look at the economic conditions in the five ASEAN countries covered in this research.

2.5.2 GDP in the sample countries in ASEAN

Since its establishment in 1967, the Association of Southeast Asian Nations (ASEAN) has ten members in total - Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Viet Nam and celebrated the 50th anniversary in 2017. ASEAN's current combined gross domestic products (GDP) is about U$2.77 trillion in 2017. The region is collectively ranked

as the fifth largest economy in the world[18]. The following figure shows the trends of ASEAN GDP total valued and per capita from year 2000 to 2017.

Figure 7. ASEAN GDP Total Value and per capita 2000-2017 (Source: ASEAN Secretariat (2018), ASEANstats database)

The trend in ASEAN GDP per capita follows closely the trend for the total GDP. After the fall experienced during the Asian Financial Crisis in 1998 and the Global Finance Crisis in 2008, the ASEAN GDP per capita continued to increase and reached U$4,308 in 2017. The following figure shows the trends in GDP per capita by different ASEAN member states where Singapore and Brunei Darussalam were considerably higher than the other countries with U$57,772 and U$28,986 respectively in 2017.

[18] ASEAN Key Figures 2018, Economy

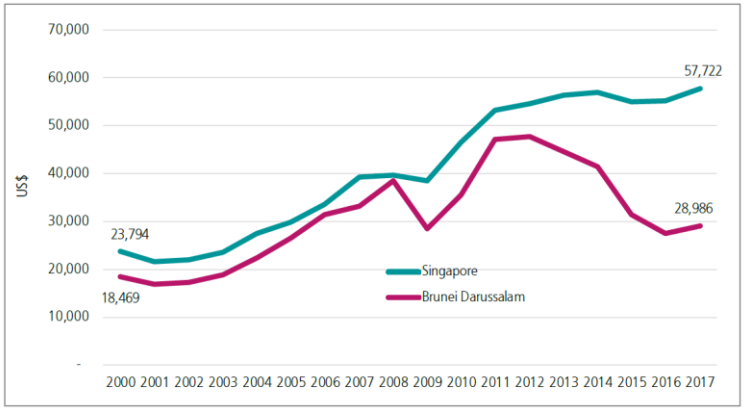

Figure 8: GDP per capita in Singapore and Brunei Darussalam (U$) 2000-2017 (Source: ASEAN Secretariat (2018), ASEANstats database)

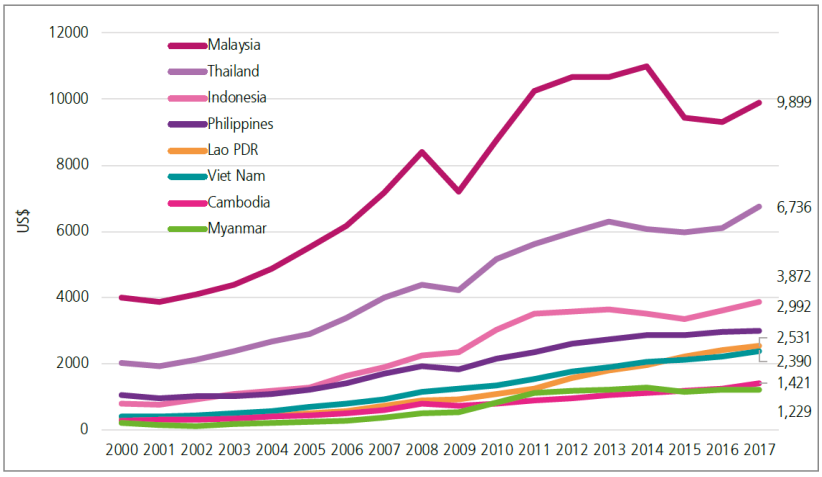

Figure 9: GDP per capita in other ASEAN Member States (U$) 2000-2017 (Source: ASEAN Secretariat (2018), ASEANstats database)

The GDP per capita reached U$9,899 for Malaysia in 2017, U$6,736 for Thailand, U$3,872 for Indonesia, U$2,992 for Philippines, U$2,390 for Vietnam, U$2,531 for Laos, U$1,421 for Cambodia, and U$1,229 for Myanmar. While GDP per capita increased significantly in all the member states during 2000-2017, very rapid increases were mainly recorded in Laos (with an increase of 662.0%), Myanmar (502.3%), Vietnam (492.3%) and Cambodia (394.0%).

The breakdown of GDP by three main economic sectors are agriculture, manufacturing and services. The country comparison of the GDP breakdown is as follows:

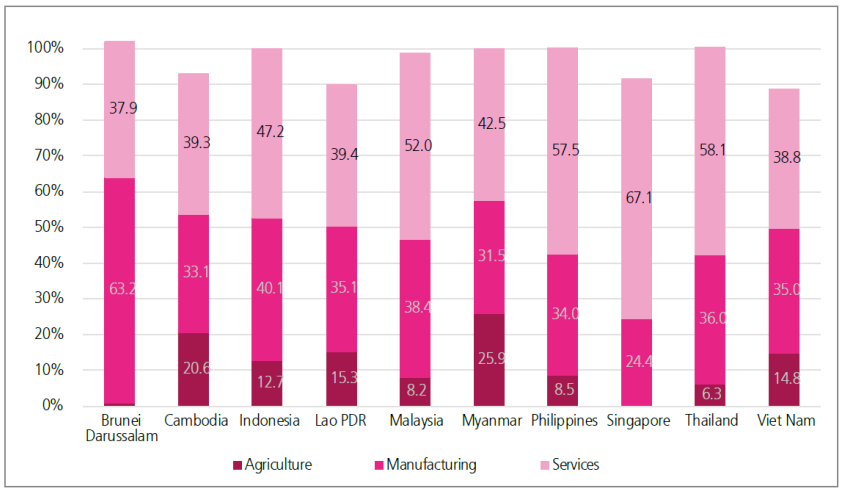

Figure 10: GDP share by main economic sectors (%) in ASEAN 2000-2017 (Source: ASEAN Secretariat (2018), ASEANstats database)

Singapore has the largest share of services sector at more than two-thirds of the country's total GDP (67.1%) in 2017, followed by Thailand (58.1%), Philippines (57.5%) and Malaysia (52.0%). On the other hand, majority of Brunei Darussalam's economy was contributed by the manufacturing sector reflecting the importance of the oil industry (63%). The agriculture sector includes farming, fishing, and forestry and it still played an important role in the economy of Myanmar and Cambodia with the share of 25.9% and 20.6% of total GDP in 2017 respectively. Appendix 4 provides a snapshot of banking landscape in the ASEAN member states in this research scope.

Some of the ASEAN economies are forecasted to continue to grow by more than 5% in 2019-2021, faster than the rates booked in 2012-2016 but some of the

member states are projected to experience slower growth according to 2019 OECD Development Centre Report as shown below:

Table 2: Real GDP Growth in ASEAN (Source: OECD Development Centre)

	2017	2018	2019	2019-23 (average)	2012-16 (average)
ASEAN-5 countries					
Indonesia	5.1	5.2	5.2	5.3	5.3
Malaysia	5.9	4.9	4.8	4.6	5.1
Philippines	6.7	6.4	6.5	6.6	6.6
Thailand	3.9	4.5	4.1	3.7	3.4
Viet Nam	6.8	6.9	6.7	6.5	5.9
Brunei Darussalam and Singapore					
Brunei Darussalam	1.3	2.0	2.3	2.0	-1.3
Singapore	3.6	3.5	2.9	2.7	3.5
CLM countries					
Cambodia	7.0	7.0	6.9	6.9	7.1
Lao PDR	6.9	6.6	6.8	7.0	7.6
Myanmar	6.8	6.6	6.9	7.0	7.3
China and India					
China	6.9	6.6	6.3	5.9	7.3
India	6.7	7.5	7.3	7.3	6.9
Average of ASEAN-10	5.3	5.3	5.2	5.2	5.1
Average of Emerging Asia	6.5	6.6	6.3	6.1	6.8

Singapore is projected to post 2.7% annual growth from 2019-2023 but the growth is almost 1% slower than its average of 3.5% in 2012-16. Malaysia's GDP is projected to increase by 4.6% in 2019-2023 due to strong domestic consumption, but 0.5% slower than growth in 2012-2016. The Philippines' economy is estimated to grow annually by 6.6%, the same growth rate in 2012-16. Remittances from Overseas Filipino Workers continue to be an important source of funds for private consumption. Thailand's GDP is projected to grow 3.7% annually, an increase from 3.4% in 2012-2016. Brunei Darussalam's GDP is estimated to rise annually by 2% from 2019-2023, reviving the average of negative 1.3% in 2012-2016. The oil price recovery would reflect higher export earnings.

3. Research Framework

Drawing from the literature reviewed above, this section looks at the research framework that includes the definition of bank performance, theoretical

framework, research hypotheses, research methodology, sample data, research variables and analytical methods.

Three economic theories were used to build research hypotheses: (1) Technological Innovations, (2) Standards Effects and (3) Macroeconomics. Each theory was reviewed to empirically investigate the impact of fintech innovations and financial standards on financial performance across different commercial banks in Singapore, Malaysia, Philippines, Thailand and Brunei Darussalam.

Multivariate panel regression, which is a quantitative research methodology, is selected to empirically test the research hypotheses on whether there is any correlation between different research variables about the fintech innovations, bank performance and financial standards. The R, ExPanDar tool is used to run the multivariate panel regression models.

Multiple data samples are used to analyse the impact of fintech innovations and financial standards on bank performance. The independent research variables are the fintech innovations whose effect is measured by banks' adoption of mobile banking technologies. The mediating effect of the financial standards is measured by banks' adoption of ISO 20022 standards. As for the dependent variables, a variety of financial indicators from bank income statements and balance sheets is used to run the regression models.

As for the analytical methods, the coefficients are estimated separately for each of the financial indicators by employing ordinary least squares (OLS) regressions on a sample of all banks. The mediator effect of financial standards is tested by following the research method of Baron and Kenny (1986). For the

dependent research variable of bank performance, the following definition will be used in this research.

3.1 Definition of bank performance

Bank performance, also known as financial performance, is a measure of how well a bank can use assets and resources from its primary mode of business and generate revenues. Following the research of DeYoung (2007), a similar set of bank-level performance measures is selected from income statements and balance sheets of the ASEAN commercial banks in order to determine the impact of the mobile banking technologies on each financial indicator as follows:

- Income Statement: bank interest income, interest expense, non-interest income (fee income) and non-interest expense
- The asset side of the balance sheets: cash, securities, loans, return on assets and non-performing loans
- The liability and equity side of the balance sheets: deposits, return on equity and core tier 1 capital ratio

The above financial indicators are the dependent variables that measure the impact of the mobile banking technologies to specifically identify the most affected banking service and/or product as a result of mobile banking innovations. The Research Variables Section 3.6 will explain the selected financial variables and how they are employed for this research model. In fact, many researchers have only selected few financial measures, with ROA and ROE being the most common indicators for their fintech impact analysis (Rega, 2017; Campanella and Dezi, 2016; Tunay and Akhisar, 2015; Japparova and Rupeika-Apoga, 2017). This research will follow the approach by De Young (2007) to use a variety of financial

indicators which will allow this study to measure the impact of mobile banking technologies on different banking products and services separately.

3.2 Theoretical Framework

As discussed in the theories of technological innovations, several research studies have expanded on the Schumpeterian concept of entrepreneurial technological innovations. The definition of fintech innovations adopted in this research is also based on Schumpeter's theory where the role of entrepreneurs is a key driving force for economic development. It is the entrepreneurial function that combines business goals, processes and models that would result in innovation. This research also looks at how fintech innovations are developed and adopted by banks and how they impacted bank performance. If a bank is using certain assets to generate revenues, which of its product/service is most affected by mobile technologies and its contribution to the generation of revenue. If any operating cost is reduced, this research will examine whether such cost reduction is caused by the adoption of fintech innovations and/or financial standards. This research framework is based on three main theories: (1) Technological Innovations, (2) Standards Effects and (3) Macroeconomics. Each theory is reviewed to identify the following:

- Whether fintech innovations affect across all the financial indicators or the specific financial indicators only
- Whether fintech innovations affect across all commercial banks or selective ones with specific characteristics and with the specific business focus
- Whether financial standards influence the relationship between fintech innovations and bank performance

Three main economic theories will be used to support this research model to look at fintech impact on bank performance from different perspectives. They are: (1) Schumpeter's theory of technological innovation; (2) Network and interoperability theories of financial standards and (3) Macroeconomic conditions. Following Scott, Reenen and Zachariadis (2017) who assessed the impact of the adoption of SWIFT financial messaging services on bank performance from the theoretical perspective, this research will also employ a combination of these theories to better understand how mobile banking technologies would affect different parts of commercial banking products/services, business processes and business models and how they impact different bank financial indicators over the years. The theoretical model illustrated below will help to build hypotheses on how they impact bank performance:

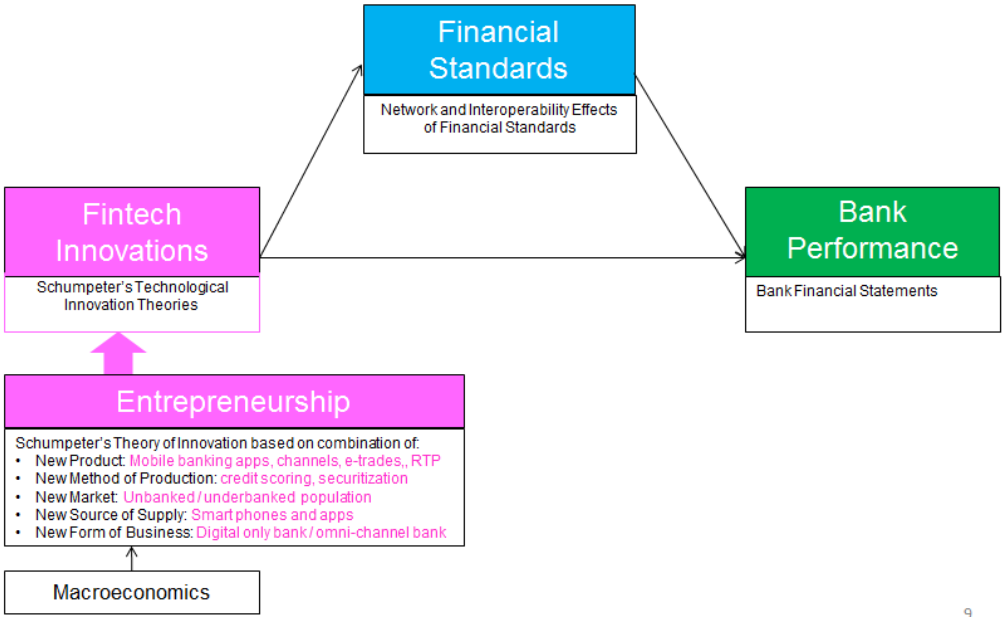

Figure 11: Theoretical Framework

3.3 Research Hypotheses

3.3.1 Theories of Technological Innovation

In terms of fintech innovations, Schumpeter's definition of entrepreneurial innovation as a key driving force for economic development is highly relevant. It is the entrepreneurs' functions that create and generate net economic benefits from their innovations of "something new --- a new product, process or method of production, a new market or source of supply, a new form of commercial, business or financial organization" (Schumpeter, 1934). Each of these concepts is described below with the application of mobile banking innovations in ASEAN.

New Product / Service

Product or service innovation happens with the introduction of "something new". In the ASEAN banking industry, new digital banking product / service innovations can be traced back from the introduction of Automated Teller Machines (ATM), electronic trading of securities and foreign exchange, online banking to mobile banking today. The first ATM was introduced in ASEAN in the 1970s - in Singapore and Indonesia in 1979, Malaysia and Brunei Darussalam in early 1980s, Thailand in 1983 and the Philippines in 1981 (DBS, 2015). The ATM was a revolutionary technology adoption in the banking sector, enabling banks to automate routine customer transactions such as balance inquiry, cash deposits and withdrawals thereby reducing human intervention. In the 1980s, development of electronic securities and foreign exchange trading platforms emerged. At the same time, banks and central banks in ASEAN began to join the Society of Worldwide International Financial Telecommunication (SWIFT) which was founded by financial institutions in 1973 with the aim to standardize and automate financial transactions. Internet banking became widespread in the 1990s with diffusion of

internet technologies world-wide. The current era is focused on mobile banking and mobile technology innovations. Mobile banking is defined as the provision and availing of banking and financial services with the help of mobile telecommunication devices (Rajnish and Stephan 2007). Also called as an emerging facet of e-banking, mobile banking offers a rich platform for automated banking and other financial services (Wessel and Drennan 2010). In ASEAN, mobile banking is one of the fastest growing financial products / services offered by commercial banks. With the rapid growth of mobile phone penetration in the ASEAN region, ranging from 176% in Thailand, 148% in Singapore, 140% in Malaysia, 127% in Brunei Darussalam to 110% in the Philippines, many people have multiple phones to make calls, exchange messages, purchase phone credits and make payments (ASEAN Statistics, 2018). Mobile banking offers a wide range of services including bank account inquiry, bill payments, funds transfers as well as linking to e-commerce for purchasing goods and services. A recent innovation in mobile banking is an application (app) that allows for investing and trading stocks, bonds, foreign exchange, and mutual funds on the mobile app with real time alerts of market information allowing for timely trading and investment decisions. For banks, self-service, mobile trading capabilities provide them with fee income arising from the trading activities. Mobile banking also allows consumers to apply for loans and finances such as car loans, mortgages, personal loans and credit cards and refinance and repayment of these loans and finances. They are all technological innovations because mobile banking creates new financial products / services available through mobile phones (See Appendix 3 for the functionalities matrix of mobile apps in the selective ASEAN commercial banks).

New Production Process

Process innovation occurs with the introduction of a "new process or method of production". The banking industry and its business processes have been transformed by the advancement of information technologies. Changes in information flows, business flows and financial market infrastructure have dramatically changed the ways in which banks assess the creditworthiness of their customers, process payments, and produce and distribute their products and services. For example, in terms of retail lending, one of the most important process innovations is credit scoring. In ASEAN, credit scoring models are widely adopted by almost all commercial banks for credit assessment, approvals and establishment. Banks have adopted a behavioural scoring methodology to monitor a customer's credit quality and credit limit renewals and collection scoring to formulate debt collection strategies, thus improving debt collection efficiency. With the technology development, loan applications, especially consumer loans have increased, and they are now routinely evaluated using credit scoring tools rather than manually using human judgement (Frame, Scott, White and Lawrence, 2004; DeYoung, 2004 and 2007). At the same time, outstanding loans have significantly increased in Thailand and Malaysia where the household debt to GDP ratio hit a record high at 88% and 85% in 2017 respectively (Reuters, 2018). Given growing loan businesses and non-performing loans, secondary markets are also being developed to securitize loans and manage risks of non-performing loans. Instead of earning interest margins from holding customer loans, such as mortgages, car and credit card loans in their portfolios, banks can earn separate fees by originating the loans, securitizing the loans for trading in the secondary markets whereby interest income flows to the investors that purchase the securities backed by these loans (DeYoung, 2004). This

has changed the process and business model of banks as a credit provider to households (Stein, 2002).

Another example of process innovation is instant payments that are processed within seconds using the recipient's mobile phone number in replacement of the recipient's bank account number and funds are credited to the payee's account almost immediately. Also known as a real time payment service, instant payments offer a convenient alternative to cards with 24/7/365 service availability and both payer and payee receive immediate confirmation. The instant payment technologies provide additional fee income and enhanced liquidity management for banks with real-time liquidity position notifications and alerts, providing the ability to monitor their cash position real time and better manage risks (Finastra, 2018).

New market

Technological innovation also occurs with the opening of a new market. In the context of ASEAN, more than 70% of the population in the region are unbanked without formal financial service access (UOB, 2016). Indonesia and the Philippines have huge unbanked populations in the ASEAN region with low credit history and low household debts reflecting high potential for mobile banking penetration. In the case of the Philippines, it has the fastest growing market for mobile phones and smartphones in ASEAN, and is expected to show a robust mobile banking growth due to the current low banking penetration rate (UOB, 2016). At the same, the Philippines is a cash-heavy country as people make more than 2.5 billion payments per month worth U$ 74 billion and only 1% of these consist of e-payments. Many individuals of the unbanked population have mobile phones and use internet and social media. Mobile technologies provide a channel to tap into the unbanked

population and grow market shares at the expense of their non-innovating competitors. One of the main challenges to introduce the unbanked population to the financial sector is lack of personal identification documents and credit history. Under-developed financial infrastructure and logistical and delivery challenges especially in the rural areas also make it difficult for the unbanked population to access formal financial services. The large unbanked/underbanked population of ASEAN makes it an attractive region for banks and fintech companies to develop solutions and to make the financial eco-system more inclusive. ASEAN commercial banks, particularly in the Philippines, tie up with the regulators and fintech companies to bridge the financial gap and offer services to this underserved segment, which is a new market and not the traditional target customer segment of banks in the region.

New source of supply

Innovation also occurs with the identification of a new source of supply of raw materials or half-manufactured goods, irrespective of whether this source already exists or whether it has first to be created (Schumpeter, 1934). In the context of mobile banking, banks typically have a choice to adopt mobile banking technologies in-house or outsource. In terms of outsourcing, vendors can supply platforms and components which banks can then customize with their own features and brand. Some vendors can offer a part of the larger solution such as mobile banking app design or a complete mobile solution including front-end and back-end system integration with other financial applications and systems. In the drive to reduce costs, banks in ASEAN are increasingly switching from in-house developments to outsourcing. According to 2018 ASEAN Payments Insight Survey, in-house developments are expected to fall from 40% to 36% of payment

applications over the next two years. On the other hand, the use of off-the-shelf vendor solutions shows a significant growth from 8% to 13% and customized third-party solutions from 23% to 25% over the same period respectively.

While most commercial banks in ASEAN have mobile banking apps for each country they operate in, a consolidation of such applications that enable regional and cross-border transactions is the current landscape. For example, Singapore and Thailand have embarked on connecting PayNow and PromptPay, the two national real time payment systems based on the same financial standards - ISO 20022. It reflects the approach of the ASEAN central banks to make regional and cross-border payment operations interoperable and harmonious using the ISO 20022 international standards. With that, consumers and businesses in both countries will access through online banking or mobile wallets to easily transfer money instantly and securely using their mobile numbers in Singapore and Thailand. Vendors can leverage the experience they gained working with financial market infrastructure and banks in the region to offer standardized and integrated payment framework based on ISO 20022 standards.

New form of organization

Innovation is also defined as the commercial or industrial application of a new form of organization. The new bank business model that has emerged in ASEAN over the last few years is a digital-only bank. UOB has recently announced the launch of ASEAN's first mobile-only bank, TMRW in Thailand (UOB, 2019). TMRW is the mobile-only bank that is designed to target ASEAN millennials who transact mainly on their mobile phones. This comes as ASEAN's digital generation forms the third-largest base of digitally savvy consumers after China and India. The

digital bank aims to attract three to five million customers in the next five years. TMRW is built from scratch and uses data to bring personalised functions and information to each customer's needs (UOB, 2019).

CIMB Group in Malaysia also launched a fully digital bank to serve customers in Vietnam and the Philippines in 2019. As the investment banking joint-venture in the country, CIMB Bancom Capital Corp aims to deliver value-added advisory and cross-border capital market services to Filipino corporates looking to expand and grow across ASEAN and capitalize on CIMB branches in the region to originate inbound deals to the Philippines. CIMB Philippines teamed up with 8,000 merchant partners including 7-Eleven and DragonPay, both known for their convenience store network for cash deposit, withdrawal, and payment touch points.

In 2016, Singapore's DBS Group opened India's first mobile-only bank called digibank. The mobile-only bank model uses a wide range of technologies - from biometrics to artificial intelligence to introduce a new way of conducting banking transactions. They adopted a natural language technology which allows the phone to effectively understand what customers are saying and communicate effectively. Embedded soft token security replaced the need for one-time passwords via SMS. DBS India had more than 2 million customers in 2018.

The new business model of a digital-only bank, also called a neobank, clearly has some advantages over physical banks such as reducing operating costs as there is no physical infrastructure. They provide digital banking services exclusively through a browser or a mobile app thereby lowering staff costs and can potentially pass through these savings in lower loan rates and higher interest rates on deposit savings. As DBS Group Holdings chief executive Piyush Gupta said

DBS' cost-to-income ratio for running the digital bank in the long term will be "far more efficient than traditional brick-and-mortar banking". As Schumpeter defined the term “creative destruction” as a process of creating net economic innovation in the capitalist system, entrepreneurs create and generate economic value from their disruptive innovations and replace and transform the earlier value of the established enterprise’s way of doing things. ASEAN commercial banks typically focus on omni-digital channel customers who use both bank branches and mobile/online banking channels. However, demand for the omni-channel use seems to be shifting to digital-only bank as evidenced by DBS, UOB and Maybank as lesser customers visit bank branches and prefer using digital channels for most banking transactions. The growing importance of digital banking throughout ASEAN opens opportunities for incumbent banks as well as fintech companies a new way of doing business. The commercial banks in ASEAN with an entrepreneurial mindset can introduce new innovative organization models such as a combination of neobank and omni-digital channels to take advantage of digital technologies thereby protecting and gaining market shares instead of being disrupted and replaced by the new entrants.

Size Effect

Schumpeter (1950) also argued that the effect of innovation was greater on a larger size firm with the capital to invest in research and development and thus yield a greater return on the investment in the technological innovation. The large firms are perceived to enjoy the economies of scale by spreading technological investment costs over a larger asset base, thereby reducing their average costs. Larger firm size is more likely to accommodate a wider range of activities and products, which may allow the firm to invest in R&D process and explore new business opportunities.

Nevertheless, in the context of mobile banking technology adoption in ASEAN, there are relatively small commercial banks due to smaller economic size of the local markets. In contrast to Schumpeter's theory that suggest larger size firms are more conductive to rapid innovation, Scherer (1984) argues that smaller firms, with only modest levels of market power, may be more likely to be rapid innovators because of the competitive pressures that are absent in the "quiet life" world of monopoly. Dos Santos and Peffers (1995) found mixed results regarding firm size and the impact of ATM adoption on market share and income gains. They found no economies of scale or scope for ATM adoption that favour larger institutions in particular, however, they did not find any significant results to suggest that such a technology can specifically benefit smaller firms either. Lacity et al. (2014) found certain technologies, such as cloud computing can provide equal benefits to both large and smaller firms albeit in different ways. Therefore, bigger size and scale economies are not the only factors that affect bank performance. Small banks can potentially diffuse new technologies easily due to agility and flexibility. They may establish stronger relationships with local businesses and customers than large banks, allowing them access to proprietary information useful in setting contractual terms with their customers and making better credit assessment and decisions (Berger, Udell, Allen, Miller, Petersen, Raghuram, and Stein (2005). Fries and Taci (2005) undertook a study on bank cost efficiency in 15 transition countries covering 289 banks for the period of 1994-2001. They concluded that bank performance was related to the changes in incentive, structural and institutional reforms and the rule of law. They also found that an average-sized bank in the sample operated at a point that is close to constant returns to scales, while the smaller banks in the sample operate with significant unrealized economies

of scale. They suggested that consolidation of smaller banks in the region would enable greater cost efficiency in banking.

DeYoung and Hunter (2001) argued that small banks tended to offer a higher degree of personalized interaction. However, they also added that delivering high-touch personal service would become more difficult as an organization grows larger, and large banks tended to service large customers. Of particular interest for this research is to hypothesize in a contrary manner to Schumpeter's theory that small banks in ASEAN, such as the Thai and Filipino banks may hold certain advantages over the large banks in Singapore and Malaysia in terms of leveraging on the mobile technologies to serve the local customers. For example, small banks may adapt faster to internal and external changes in their business environment whereas large banks may respond slowly to technological adoption due to legacy systems that require configurations (Dos Santon and Peffers, 1995; Scott et al., 2017). Empirical evidence of the fintech effect on small banks would be interesting as it would mean that small banks achieve benefits from mobile technology adoption that outweigh more obvious big bank advantages such as larger resources, assets, expertise and economies of scale. Based on the above theory of technological innovations that mobile banking innovations can also benefit smaller banks in the ASEAN markets, this research firstly proposes the null hypothesis and the alternative hypothesis that link mobile banking technologies and bank performance:

- *Hypothesis$_0$: Adoption of mobile banking technologies has no impact on all financial indicators across all banks*

The decision to accept or reject the null hypothesis is dependent on the value of the test statistics obtained from the data at hand. The alternative hypotheses are

developed to test a relationship between mobile banking technologies and bank performance. In terms of hypothesizing bank income streams, mobile banking typically generates two types of income for banks: interest margins from customer loans and deposit accounts and transaction fees. For the latter, there are three main types of fee income: (1) deposit account maintenance and payment fees associated with bill payments and funds transfers; (2) loan fees related to credit cards, mortgages and car loans; and (3) investment and trading of stocks, bonds, foreign exchange and mutual funds. In the case of payment fees, the Bank of Thailand enforced all banks to waive the payment fee and activate service usage in 2018. However, prior to 2018, payment fees were an important source to Thai commercial banks. For example, Thailand's PromptPay instant payment service used by both consumers and businesses is priced from 2 baht to 15 baht per payment depending on the size of the transaction (Bangkok Post, 2018, Kasikorn Bank, 2019). For Singapore, consumer payments via FAST mobile payments are waived but corporate payments are priced around S$ 0.20 to S$ 0.70 per payment, higher than the traditional batch payments of Giro fee for S$ 0.10-S$ 0.30 per payment. Thus, mobile banking services enable banks to gain fee-based revenue related to payments.

Moreover, based on the extant literature on fee-based income at commercial banks, DeYoung & Rice (2003) found that technological developments were most closely associated with increased non-interest income rather than interest-based income. Based on the strong statistical associations among fee-based income, bank characteristics, market conditions, technological development and bank performance, DeYoung & Rice (2003) found that the banks which stressed customer relationships and service quality tended to generate more fee-based income and that the new financial technology adoption such as cashless transactions

and mutual funds were associated with higher levels of fee income in the banking system. They also found that increase in fee-based income tended to be associated with higher profitability, higher variation in profits and a worsened risk-return trade-off for the average commercial banks in the US. In the context of ASEAN, mature markets like Singapore has seen a low interest environment therefore net interest margins have shrunk and become a less important part of banks' business strategies. Hence, fee-based business has become an important source of revenue for banks in ASEAN as well. In response to the competitive fintech threats and opportunities, many banks take advantage of new mobile technologies to change their production and distribution strategies and have shifted their business focus from the traditional interest-based business to fee-generation business. Based on these arguments, it can be hypothesized that mobile banking technologies will have a larger effect on banks' fee incomes rather than interest incomes as follows:

- *Hypothesis1a: Adoption of mobile banking technologies will have a bigger impact on* ***small banks than on large banks in terms of fee income***

From a cost perspective, for enabling mobile banking capabilities, banks will need to invest significant resources in human capital as well as to renew and integrate their core banking platforms. At the same time, because of significant investments into the new banking system, banks should generate new income streams as well as reduce their operational costs. For example, to introduce a new faster payment service in the UK, there is an estimated fixed cost of around £150 million to £200 million to invest in technology and human capital to develop the system initially. Additionally, it requires £0.10 million to £0.50 million for each participating bank in the UK to connect to the new payment system (Vocalink, 2009).

The significant investment into the new mobile banking system should also aim to reduce operating costs for banks. Operating costs of a new service with frontier technology may be lower than the operating costs of existing networks. For example, the ACH and Fedwire in the US have protocols initially developed for older computational technology such as mainframe, long before servers and the internet became widely used. A new faster payments service can provide most—and perhaps more—of the functionality of the existing ACH system; hence, the unit cost of such services may be lower (Greene et. al, 2014).

Cost savings can be achieved if banks can seize this opportunity to integrate their back-office systems. Some banks may move toward a payment hub architecture, which helps usher innovation into production and thus expedites revenue growth. Often, however, it is more cost-effective for banks to integrate payment platforms through multiple, smaller integration points, such as the fraud management system or the transaction banking system (PwC 2016). Based on case examples from around the world, McKinsey (2015) estimated that banks could reduce their payments-related IT spending by 10% to 20% when they integrate their payments architecture.

Furthermore, mobile technologies help cut costs associated with legacy payments systems. According to National Australia Bank which went-live with a new real-time payment platform in Australia based on ISO 20022 standards, it stated the ability to slash administration costs as it will allow the bank to easily reconcile and investigate into received payments because their customers of consumers and corporates are able to send related documents alongside payments real-time (NAB, 2016). Banks also have the opportunity to pursue internal system upgrades and retire outdated legacy systems when they adopt new technologies.

Such internal system upgrades and efficiency can create benefits for banks that go beyond real-time payments, including enabling them to streamline the internal operations, mitigate risks by gaining valuable insights into real time payment activities.

Additionally, mobile banking technologies help to reduce operational costs of handling cash and checks. Cash is still a popular payment option in Singapore, Thailand and the Philippines. At hawker centres in Singapore for example, most people buy food in cash. Cheques are also still used for similar purposes for low value retail transactions although the volume is decreasing. Cash and cheques impose a large cost on society in terms of manual handling of printing, counting, storing, transferring and reconciling. The adoption of mobile payment technologies by consumers and banks will result in drastic cost savings and higher productivity as it eliminates manual operations. Based on the above arguments, the following is hypothesized to link mobile banking technologies and small banks' operating costs:

- *Hypothesis1b: Adoption of mobile banking technologies will have a bigger impact on* ***small banks than on large banks in terms of operating costs***

Further evidence in the literature offers insight into the effect of technological innovations on bank lending relationship with customers. Consistent with the wide interpretation that smaller transaction lending facilitated by technological innovations as opposed to larger relationship-driven lending appears to affect bank performance. Relationship lending is often associated with commercial lending where banks acquire borrowers' information through the relationship by monitoring the borrower performance over time under credit contracts and or through the provision of other services such as deposit accounts

(Allen, Saunders, and Udell 1991; Petersen and Rajan, 1994). Hence, there is a time factor involved in the relationship lending. Some studies specifically assessed the length of the bank-borrower relationship and the loan rates in addressing the issues of adverse selection and moral hazard in which banks offer higher rates in the first period when borrower types are unknown. The banks reduced rates in later periods after borrower types have been revealed (Diamond 1989, Pertersen and Rajan 1993). They also found that collateral requirements were related to the length of the relationship. Borrowers pay a high rate and pledge collateral early in the relationship and they pay a lower rate and reduce collateral later after they have an established relationship with their banks. In contrast, transaction-driven lending such as personal loans, credit card loans, car loans and mortgages are typically small in size, one-time loans or loans for non-recurring credit needs whereby relationship effects are substantially less important. Mobile technologies are able to better facilitate transaction-driven lending which is often one off / non-recurring consumer loan businesses, such as accepting and channelling customer application for car loans, housing loans and credit cards. The differentiation between relationship lending and transaction lending is important as the mobile technologies effect is different and its impact is lager on the latter. Therefore, the following hypothesis is developed to assess the impact of transaction-driven consumer loans on bank performance:

- *Hypothesis1c: Adoption of mobile banking technologies will have a bigger impact on **small banks' consumer loans** than on large banks'*

While technologies affect the lending relationship between banks and customers in terms of transaction-driven consumer loans, mobile technologies also allow banks to enhance and protect customer relationship through the provision of value-add

services through the mobile channel. New services include real time payment tracking and transparency of payment charges, and screening for anti-money laundering and financial crime compliance. Provision of innovative services which can be easily distributed through the mobile banking apps will increase customer stickiness and boost revenue. The banks can also explore cross-sell opportunities with the existing customer base such as investments, loans and foreign exchange. According to the survey responded by the UK banks who adopted real time payment technologies of the Faster Payment System (FPS) in 2008, two-thirds of the banks were very positive that the new payments could deliver new revenue streams, with potential revenues in the business to consumer segment reaching £2.9 billion by 2018 and £1.9 billion in the business to business space (Vocalink, 2009). Hence, mobile technologies will have a positive impact on bank performance as it provides opportunities to generates new incomes and reduce costs.

Overall, increase in revenue, such as fee-based income and reduction in operating costs tend to be associated with higher profitability. The formula for bank profitability of both ROE and ROA has the same numerator, net income, which is calculated by subtracting total expenses from total revenues.

- The ROA, the ratio of annual net income to total assets is an indicator of how profitable a company is relative to its total assets of invested capital. Total assets are the sum of its total liabilities and shareholder's equity - financing sources used to fund the operations of the company. It gives an idea as to how efficient a company's management is at using its assets or invested capital to generate earnings.
- The ROE is the amount of net income returned as a % of shareholders equity. It is calculated by dividing annual net income by average shareholders'

equity. It measures how much profit a company generates with the money shareholders have invested in. ROE illustrates how effective the company is at turning the cash put into the business into greater gains and growth for the company and investors.

ROA and ROE are the two most popular financial indicators to measure the technological impact on bank performance. In this research, ROA and ROE will be also used to hypothesize that fintech innovation would lead to financial performance as follows:

- *Hypothesis1d: Adoption of mobile banking technologies will have a bigger impact on **small banks' ROA** than on large banks'*
- *Hypothesis1e: Adoption of mobile banking technologies will have a bigger impact on **small banks' ROE** than on large banks'*

Mobile banking innovations based on new mobile product/service offered through a new process and business model should help the banks, especially the smaller banks located in the countries with large unbanked and under-served populations, e.g., the Philippines and Thailand will drive higher performance than larger banks in the mature markets in Singapore and Malaysia. Mobile technologies are in the hands of consumers as well as micro, small and medium sized enterprises (MSMEs) who were historically unbanked or underserved yet majority of them own a mobile phone. Small banks in ASEAN should be able to equally take advantage of the same mobile technologies which are relatively cheap and easy to adopt and help them generate additional revenues and reduce operating costs thereby driving higher profitability.

3.3.2 Theories of Standards

There have been a growing number of studies about the role of standards in enabling technological innovations and managing the proliferations of different fintech adoptions. The systematic perspective on innovation has made many researchers and policymakers aware of the importance of standards as a powerful institutional mechanism that shapes technological innovation and facilitates interoperability. (Blind, 2016; Blind, 2012; Blind and Hipp, 2003; Blind and Jungmittag, 2008; Blind and Gauch, 2009; Allex and Sriram, 2000; Tassey, 2000; Swann, 2010). These results presented a positive impact of standards on new technological innovations as standards can establish a common business language by agreed definitions of terms, adding legitimacy to stimulating social acceptance. Standards can also reduce uncertainty and conflicts thereby increasing consumer and investor confidence and developing and diffusing new knowledge within innovation systems.

ASEAN Economic Community – the AEC 2025 Blueprint encapsulates the development of regional payment framework. The Blueprint specifies adoption of ISO 20022 by 2025 as a key objective for regional financial integration and development of payments and settlement systems within the ASEAN markets. ISO 20022 is international financial standard that is widely adopted by the financial market infrastructures around the world. For the regional financial integration projects, ISO 20022 is also the standard of choice for the development of efficient, secure and interoperable payment clearing and settlement system as evidenced in Pan Europe and the Southern African Development Community regions. The regional payment framework provides benefits such as interoperability and network externalities by shared IT investment by the region to develop a standardised

payment system to reduce cost and risk of operations. SWIFT is the ISO 20022 Registration Authority to develop and maintain standard repository that contains global and market-specific standard definitions. Some of the benefits from ISO 20022 standards adoption are as follows:

- Open standard and widely accepted as the de facto standard for the global financial community, facilitating global interoperability with other markets
- Richness of data including extended remittance information, regulatory reporting and tax information
- "Future proof", easily applicable to new technologies and business constructs as they emerge
- XML technical syntax provides greater ease in technical integration and information interchange

The terms interoperability and network externalities are often associated with the benefits of the financial standards which are defined further below.

Interoperability

Interoperability is the term that is often used to describe the benefit of standards. Interoperability is defined as the ability of diverse systems and organizations to work together ("inter-operate") (Gillis and Pillay, 2012). Financial standards facilitate interoperability as it enables any organizations to seamlessly manage different systems and applications using a common business language. In the context of ASEAN, each country has its own currency and monetary system, thus, the creation of interoperable payment clearing and settlement systems are paramount in enabling the safe and efficient financial operations thereby facilitating

regional economic development. Usage of the same financial standards for payment operations has been highly recognized as key enabler in regional and global interoperability, innovation, competition and cost efficiency. Generally, interoperability has three levels; business, syntax and semantics. Business interoperability enables organisations to seamlessly execute business goals and objectives. Syntax interoperability aligns the exchange of data between different applications in the right protocols and valid formats, while semantics interoperability ensures the consistent meaning of the information (SWIFT, 2017). The adoption of ISO 20022 for the ASEAN regional framework will enhance interoperability in all three levels. Standards define minimum business requirements regarding the use of payment market infrastructure (technical, functional and security specifications). Syntax and semantics specifications can also be defined in the form of message implementation guidelines and technical schemas to ensure consistent implementation of standards and information exchanges in alignment with global market practice. Hence, standards ensure a common understanding of business and technical requirements. Gillis and Pillay (2012) described that a major objective of adopting standards is to "enhance security within the payment system in the area of the prevention of fraud, increasing trust, integrity, access to and confidence in the payment system". ASEAN central banks, banks and the financial community that adopt the same financial standards to attain interoperable payment systems can potentially lead to higher financial performance since it enables seamless, secure and efficient operations.

Network Externalities

There has been an increase in the number of studies about network effects in a business environment. Also known as network externalities, the value of a

product or service increases according to the number of people using it. For example, SWIFT provides a secure network for financial industry and its network is being used by over 11,000 banks, financial institutions and corporates around the world. The greater the number of SWIFT users, the greater the value of the SWIFT financial standards and messaging services. There are two kinds of network externalities. One is direct network externalities that arise when users, such as SWIFT members derive greater utility from a network as more members adopt it. Indirect network externalities occur when independent software vendors make more complementary applications for the network and increase user utility further (Gandal, 1995). Positive externalities are created when more users join the network that increase in value to each member. The network effect can create a bandwagon influence as the network becomes more valuable and more institutions join, resulting in a positive feedback loop. SWIFT members' usage of financial standards within its network develops further positive externalities and contribute to the form of network effects which are benefits to users of the network with an increase in the number of users (Hogan, Sheehny and Jayasuriya, 2015; Porter, 1990; Lundvall, 1992; Ehrnberg and Jacobsson, 1997; Smith, 1997; Allen and Sriram, 2000; Tassey, 2000, Swann, 2010; Blind, 2009; Bergek, 2008; Smith, 1997). Standards can also develop network externalities and contribute to the form of network value add which are benefits to the standards users of the network with an increase in the number of users (Hogan, Sheehny and Jayasuriya, 2015; Porter, 1990; Lundvall, 1992; Ehrnberg and Jacobsson, 1997; Smith, 1997; Allen and Sriram, 2000; Tassey, 2000, Swann, 2010; Blind, 2009; Bergek, 2008; Smith, 1997). Based on the standards theories of facilitating interoperability and creating network externalities,

I have hypothesized that financial standards are to mediate the relationship between fintech innovations and bank performance as illustrated below:

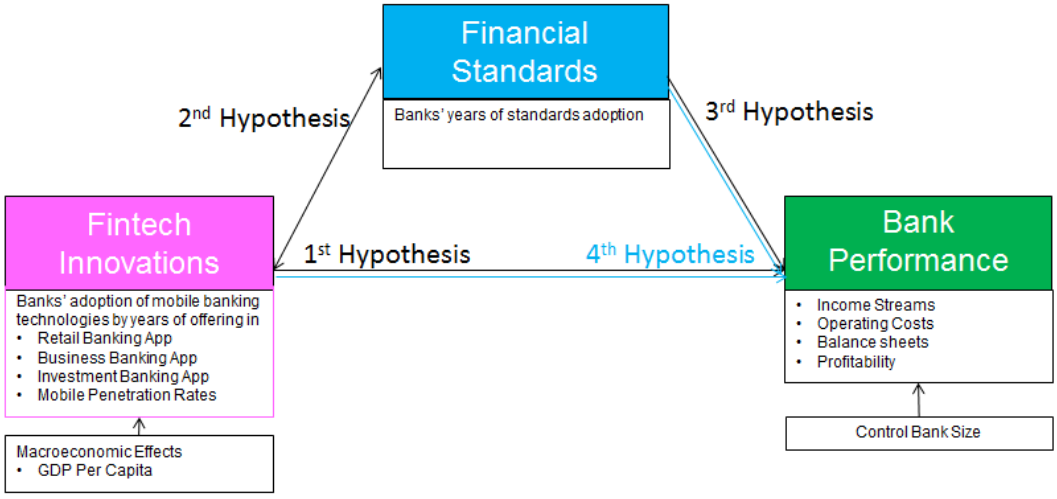

Figure 12: Research Hypotheses

The above diagram shows "Fintech Innovations" as input and "Bank Performance" as output. This causal relationship is mediated by the financial standards. The fintech innovation will be measured by the adoption of mobile banking technologies by 36 local commercial banks in ASEAN5. As of end 2017, 31 out of 36 sample banks in ASEAN5 offer mobile banking services. In order to test the mediator effect, a four-step-approach defined by Baron and Kenny (1986) will be used:

1. Test an independent research variable X is correlated with a dependent variable Y (First Hypothesis)
2. Test X is correlated with a mediator (Second Hypothesis)
3. Test the mediator is correlated with a dependent variable Y (Third Hypothesis)
4. Multiple regression with X and the mediator predicting Y (Fourth Hypothesis)

The effects of the mediator, financial standards in this research were measured by the status of each bank's adoption of ISO 20022 standards which were implemented

to the real time payment systems in Singapore and Thailand by this research period of 2017. Philippines, Malaysia and Brunei Darussalam. The status of each bank's adoption of the ISO 20022 is counted from the year that a bank first started its ISO 20022 payment service to present as cumulative years of standards adoption. The first hypothesis mentioned in the earlier part of this chapter covered the Step 1 of the mediator test approach by Baron and Kenny to test the correlation between X (banks' adoption of mobile banking technologies) and Y (bank performance). As for Step 2 to test correlation between banks' adoption of mobile banking technologies and the financial standards, firstly, the null hypothesis is developed:

- *Hypothesis$_0$: Banks' adoption of mobile banking technologies will not impact the adoption of financial standards*

The decision to accept or reject the null hypothesis is dependent on the statistical test. The alternative hypotheses are developed to test a relationship between mobile banking technologies and financial standards adoption as follows:

- *H_1: Banks' adoption of mobile banking technologies will impact the adoption of financial standards*

Globally, the financial industry's adoption of mobile banking technologies along with other emergent technologies, such as big data analytics and Application Programming Interfaces (APIs) are formulating new business models and opportunities thus positively impacting banks' overall performance. These changes brought by new technological development and adoption by the industry have significantly affected the ways financial standards are being developed to increase efficiencies and meeting standards user requirements in the ASEAN markets. Some of the recent developments include agile and faster standards development to keep

up with the pace of new technology development. Also, APIs development methodology using ISO 20022 associated with open banking and mobile banking operations is being formalised with governance framework for consistent and standardised implementation of APIs in the financial industry. Adoption of financial standards help banks adopt new technologies efficiently and consistently with their industry counterparts using common terminology, improve data quality and automation. The financial standards also facilitate technological innovations and interoperability among and positive network externalities thereby improving overall bank performance and profitability as a result. Based on these arguments and following Step 3 of the mediator test approach, null hypothesis is first developed to examine the linkage between financial standards and bank performance:

- *Hypothesis$_0$: Adoption of financial standards has no impact on all financial indicators across all banks*

The alternative hypotheses are proposed to test the correlation between financial standards and the bank's overall profitability:

- *Hypothesis$_1$a: Adoption of financial standards will have a bigger impact on* ***small banks' ROA*** *than on large banks'*
- *Hypothesis$_1$b: Adoption of financial standards will have a bigger impact on* ***small banks' ROE*** *than on large banks'*

Finally, in relation to Step 4 of the mediator test approach, the following null hypothesis is developed to test the combined effects of the financial standards and banks' adoption of mobile banking technologies to predict bank performance below:

- *Hypothesis$_0$: Adoption of both mobile banking technologies and financial standards has no impact on all financial indicators across all banks*

The decision to accept or reject the null hypothesis is dependent on the regression results. The alternative hypotheses are developed to test a relationship between mobile banking technologies and the banks' overall profitability:

- *Hypothesis$_1$a: Adoption of both mobile banking technologies and financial standards will have a bigger impact on **small banks' ROA** than on large banks'*
- *Hypothesis$_1$b: Adoption of both mobile banking technologies and financial standards will have a bigger impact on **small banks' ROE** than on large banks'*

3.3.3 Macroeconomic and Market Effects

Financial performance of the ASEAN commercial banks is also directly and indirectly affected by macroeconomic factors such as GDP growth, interest rates, inflation rates and exchange rates. Evidence from the Asia financial crisis in 1997 and Global financial crisis in 2008 suggested that bank-specific characteristics together with macroeconomic conditions explained some of the bank failures. Banks operating in the country with higher economic growth tend to enjoy lower cost of doing businesses as they can easily find prospective customers and borrowers with lesser cost (Mongid, 2016). However, during economic upturn, banks tend to make more investment to grow businesses thereby increasing costs instead of necessarily leading to increase revenues. Some empirical studies about macroeconomic effects on bank performance showed mixed results. Mongid, Tahir

and Haron (2012) studied the determinants of cost inefficiency of ASEAN banks and found a positive correlation between economic growth and lower cost efficiency. Similarly, research by Shen, Liao, and Weyman-Jones (2009) and Zetin (2012) evidenced a direct positive relationship between external macroeconomic conditions, internal bank specifics and financial performance whereby both GDP and inflation rates affected performance. In contrast, Athanasoglou (2006) examined the profitability behaviour of bank-specific variables and macroeconomic variables of South Eastern European institutions such as inflation rates and real GDP per capita income. Their results showed that real GDP per capita growth did not have a significant influence on bank performance. On the other hand, inflation positively and significantly affected profitability.

When a bank experiences financial losses, such losses will eventually reduce bank profitability. During the Asia financial crisis in 1997, ROA and ROE felll sharply across all ASEAN commercial banks. After the fall experienced, GDP per capita recovered and continued to increase and reached U$4,308 regionally in 2017. GDP per capita varies across different ASEAN member states where Singapore and Brunei Darussalam were considerably higher than the other countries with U$57,772 and U$28,986 respectively in 2017. The GDP per capita reached U$9,899 for Malaysia, U$6,736 for Thailand and U$2,992 for the Philippines in 2017 (ASEAN Statistics, 2017).

Additionally, other market characteristics are likely to affect bank performance such as tax and regulatory regimes. In this research, two research variables of GDP per capita and mobile phone penetration rates are added as the additional independent variables to assess the statistical relationship between mobile banking technologies and bank performance.

3.4 Research Methodology

The main focus of this research is to analyse empirically if the impact of fintech innovations on financial performance differs across different ASEAN commercial banks or selective small or big banks. It will also determine whether the fintech innovations would lead to better performance across all the financial indicators or only selective ones. Additionally, it aims to empirically investigate the effects of financial standards on bank performance in the ASEAN. Therefore, a quantitative research method is selected to empirically test the research hypotheses on whether there is any correlation between fintech innovations, bank performance and financial standards.

Drawing on the literature reviewed, regression analysis is one of the most common research methodologies. Therefore, this research is carried out using multivariate panel regressions using R, ExPanDaR to determine the effects of the mobile banking innovations and messaging standards on bank performance. The ExPanDaR means Explore Panel Data with R, a package developed by Joachim Gassen for exploratory panel data analysis and each observation is identified by cross-sectional and time series identifiers and that variables are organized by columns.

3.5 Sample Data

This study will use multiple data samples to analyse the impact of fintech innovations on bank performance of the thirty-six local commercial banks in ASEAN – Singapore, Malaysia, Thailand, Philippines and Brunei Darussalam as follows:

- Bank financial statements from 2010 to 2017 retrieved by Capital IQ
- Annual reports from 2010 to 2017 retrieved from each bank's website
- Each bank's mobile banking capabilities retrieved by AppAnnie
- Sample banks' mobile banking capabilities retrieved by AppAnnie, an app analytics platform
- News and announcements of the sample banks websites to identify their fintech strategies, activities and performance
- Website of the central banks in the sample countries to identify the fintech regulations and payment landscape
- Website of the bankers' associations / payment operators in the sample countries to retrieve the lists of the participant banks to the national payment systems
- Peer-reviewed journal articles (EBSCO, Science Direct, and ProQuest)
- Industry Research Reports
- Government Whitepapers
- Press to identify bank fintech strategies, activities and performance

Historical data for a period of 2010-2017 was selected. Tracking historical data upon recovery from the global financial crisis in 2010 to present is relevant as technological innovations rapidly evolved in the industry post global financial crisis. Further, the eight-year span is selected because the data remained stable and available over this period of time.

Capital IQ is used to extract historical income statements and balance sheets of total 36 ASEAN commercial banks. Capital IQ is a market intelligence platform designed by Standard & Poor's that provides research data on private and public

companies. The platform is used extensively in financial modelling and is widely used in academic and corporate research including commercial and investment banking, equity research and asset management.

In order to identify clearly which performance measure was highly impacted by the mobile banking innovations, this research closely looked at the compositions of the bank income statements and balance sheets. Each component of the bank income and costs in the income statement was reviewed and the following components were selected for this regression analysis:

Income: interest income from customer loans and deposits and non-interest income such as fees and commissions from FX, investments, securities and other trading activities are counted as fintech innovations as banks' revenue streams. However, this analysis excludes the components of rental income and gain on properties and other fixed assets (categorised as Gain (Loss) on Sale of Assets in Capital IQ) as these fixed assets are unlikely impacted by the adoption of mobile banking technologies.

Costs: for enabling mobile banking technologies, banks need to invest significant resources in human capital and upgrade their co-banking platforms and integrating with the real time payment technologies. Such investment cost is reflected in the salaries and other employment benefits, Selling General & Administrative Expenses (SG&A) and other operating expenses (e.g., computerisation, revenue-related and IT-related) are counted for this analysis. A number of the cost components are excluded from the analysis as they were unlikely impacted by the adoption of mobile banking technologies, such as occupancy

expenses, amortization of goodwill and intangible assets, occupancy expenses and loss on real estate property and on affiliates.

The asset side of the balance sheet, such as different types of loans and the liability and equity side of the balance sheets including different deposit types are separately analysed. As for bank profitability, the adjusted ROA and the ROE based on the adjusted net income which derived from the selected revenues and costs are used for this multivariate panel regression analysis.

In terms of identifying each banks' mobile app capabilities and its release year, AppAnnie (www.appannie.com) is used to identify different services offered by different apps, such as bank account and investment services and loan and payment services (See Appendix 8 for Mobile Banking App Capabilities of Sample Banks). AppAnnie is a free app analytics platform that tracks app ranking movements over time. Based on the information available on AppAnnie, capabilities matrix was manually created to compare different banks' mobile app functionalities and features.

3.6 Research Variables

The theoretical framework and the research hypotheses in the earlier sections identified different research variables that can be used to measure the financial performance of ASEAN commercial banks who adopted mobile banking technologies. This research input is twofold. First, the fintech innovation effect, which is measured by banks adoption of mobile banking technologies in three types of banking segments; retail banking, business banking and investment banking. Second, the financial standards effect which is measured by banks' adoption of ISO 20022 standards. The focus of the research is to see if different financial indicators

across different commercial banks in ASEAN are impacted by mobile banking technologies and financial standards to identify the most affected banking product/service and bank characteristics such as small or big banks.

The research output of the dependent variables is bank performance. The bank performance is defined as a measure of how well a bank can use assets and resources from its primary mode of business and generate revenues. This research draws the past empirical research on internet, mobile and digital banking effects by also looking at a comprehensive set of 20 separate financial indicators, such as income streams, cost structures, balance sheet components and profitability as shown in Table 3. This allows the researcher to gain more insight into which performance measure is affected the most by the fintech innovations.

Table 3: Summary of Research Variables

Name of Variable	**Label**	**Description**
Independent Variables for Fintech Innovations		
MOB_AGER	X1t	Age of the retail mobile banking app offered by banks from the first release year to 2017
MOB_AGEB	X2t	Age of the business/corporate mobile banking app offered by banks from the first release year to 2017
MOB_AGEI	X3t	Age of the investment mobile banking app for trading securities offered by banks from the first release year to 2017
GDP_PC	X4t	GDP per capita of sample countries from 2010-2017
MOB_PEN	X5t	Mobile phone penetration rate of sample countries from 2010-2017
Mediator Variable for Financial Standards		
ISO_AGE	X6t	Age of the ISO 20022 standards adopted by sample banks from 2010-2017
Dependent Variables for Bank Performance		
a. Income Statement		
IINC_ASS	Y1t	Total Interest Income / Total Assets
IEXP_ASS	Y2t	Total Interest Expenses / Total Assets
FINC_ASS	Y3t	Total Noninterest Income (Fee Income) / Total Assets

SALA_ASS	Y4t	Total Salaries / Total Assets
SGA_ASS	Y5t	Total Selling General & Admin Exp / Total Assets
b. B/S (Assets)		
CASH_ASS	Y6t	Total Cash / Total Assets
SEC_ASS	Y7t	Total Securities / Total Assets
LOAN_ASS	Y8t	Total Loans / Total Assets
COMM_LOAN	Y9t	Total Commercial Loans / Total Loans
CONSM_LOAN	Y10t	Total Consumer Loans / Total Loans
NPL_LOAN	Y11t	Non-performing Loans / Total Loans
Adj_ROA	Y12t	Adjusted Return on Assets shows the ratio of average net profits to average assets
c. B/S (Liabilities and Equity)		
DEPO_ASS	Y13t	Total Deposits / Total Assets
DD_DEP	Y14t	Total Demand Deposits / Total Deposits
MM_DEP	Y15t	Money Market and Savings Account Deposits / Total Deposits
TD_DEP	Y16t	Total Time Deposits / Total Deposits
CT1_CAP	Y17t	Core Tier 1 Capital Ratio %
Adj_ROE	Y18t	Adjusted Return on Equity shows the ratio of average net profits to average shareholders' equity
Control Size - Grouping Criteria		
GROUP_SZ		Size of the full sample of 36 banks. Take the median asset size; Large Banks > U$ 20.1B < Small Banks
MOB_NON		1=Mobile banks and 0=Non-mobile banks as of 2017
GROUP_MSZ		Size of the subset of 31 mobile banks. Take the median asset size; Large Banks > U$ 28.9B < Small Banks
Fixed Effects		
Bank Name		
Year		

Referencing from literature reviews (DeYoung, 2007), a variety of financial variables from the income statements and balance sheets is used as dependent variables to estimate the regression specifications separately for each of the performance measures using ordinary least squares (OLS) techniques.

For measuring the effect of financial standards, each bank's status of the financial standards readiness is measured by their adoption of ISO 20022 standards.

A dummy variable is created that takes a value of 1 if the bank is ISO 20022 enabled, otherwise it takes a value of 0. The coefficient associated with the dummy variables will indicate the possible association with bank performance.

In order to control the bank size, sample banks were divided into two groups by the median asset size: small banks below US$ 47B and above for big banks. The subset of the thirty-one mobile banks were also divided into two groups by the median asset size of US$ 28.9B. Since there is a significant difference between mean and standard deviation of the bank asset size, the median is selected to categorize them by big or small banks based on the mean of the asset.

3.7 Analytical Methods

This research will take a multivariate panel regression analysis that consists of panel data of bank financials from 2010-2017 in which a variety of financial indicators are regressed over input research variables denoting each bank's adoption status of mobile banking technologies in three types of business segments: retail banking, business banking and investment banking. It also includes the evaluation of the effect of financial standards on bank performance. The following model is created to examine the relationship between the fintech innovations, financial standards and bank performance:

$$Y_{it}=c+\alpha*MOB\_AGE_{it}+\Sigma\beta_i X_{it}+\varepsilon_{it}$$

Where Y presents bank profitability as well as other performance measures of bank $_i$ at time $_t$

c is a constant term.

α is a coefficient that provides the main static test. A statistically significant value for α indicates a bank performance. The coefficients are estimated by employing OLS regressions on a sample of all banks.

MOB_AGE is an independent variable for the years of the mobile banking application offered by ASEAN commercial banks. There are three kinds of mobile banking apps as follows:

- MOB_AGE**R**: mobile retail banking for account inquiry and payments
- MOB_AGE**B**: mobile business banking for SMEs and corporates
- MOB_AGE**I**: mobile investment banking that facilitates securities trading

MOB_PEN is an independent variable of mobile phone penetration rates of sample countries

GDP_PC is GDP per capita is an independent variable of sample countries

i indexes bank level observations and the subscript t indexes time in years of adoption.

X_{it} is control bank size.

ε_{it} is the disturbance term.

The following equation model for a linear relationship between the mobile banking technologies and bank performance is developed:

$$Y_{it} = c + \alpha * MOB\_AGE_{it} + \varepsilon_{it}$$

Considering all the research variables mentioned above, the following equation model is developed:

Y_{it} (2010-2017) = c + α*MOB_AGER$_{it}$

+ MOB_AGEB$_{it}$

+ MOB_AGEI$_{it}$

+ MOB_PEN$_{it}$ (Mobile Phone Penetration Rates)

+ GDP_PC$_{it}$ (GDP Per Capita)

+ ISO_AGE$_{it}$ (Mediator of Financial Standards)

+ SIZE$_{it}$ (Bank size effects)

+ n_i (Bank Name fixed effects)

+ T_t (Year/time fixed effects)

In order to measure the effect of standards, a 4-step-approach by Baron and Kenny (1986) in testing mediation will be used as follows:

1. test X is correlated with $Y = \beta_0 + \beta_1 X + \varepsilon$

2. test X is correlated with Mediator (ISO_AGE) $M = \beta_0 + \beta_1 X + \varepsilon$

3. test Mediator is correlated with $Y = \beta_0 + \beta_1 M + \varepsilon$

4. multiple regression with X and mediator predicting $Y = \beta_0 + \beta_1 X + \beta_2 M + \varepsilon$

Following the regression modelling strategy of Scott et. al. (2017), individual bank level fixed effects (n_i) and year/time fixed effects (T_t) were included in this research model to control for permanent unobserved heterogeneity. Country GDP per capita and mobile phone penetration rates are the additional independent variables that are

included in the model to analyse the macroeconomic and market effects on bank performance.

4. Data Analysis Results

This research focuses on the effect of fintech innovation measured by the adoption of mobile banking technologies and financial standards on a variety of financial indicators of selected commercial banks in ASEAN – Singapore, Malaysia, Thailand, Philippines and Brunei Darussalam from 2010 to 2017. ASEAN commercial banks' adoption of mobile banking began as early as the 1990s when the rapid adoption of mobile phones and short messaging system (SMS) were offered by telecom companies. For example, by 2005, about 5.5 million Filipinos were already using the mobile phones as virtual wallets, making the country as a leader in the region in mobile financial transactions.[19] For the Philippines, remittances from family members working abroad are crucial lifelines for their families back home, and mobile phones facilitate cash-out transactions by SMS[20]. The mobile banking trends continued to grow rapidly especially when Apple released the first iPhone in 2008 and banks started offering their mobile banking applications to consumers and businesses.

4.1 Mobile Banking Landscape in ASEAN

Among the research sample of five ASEAN member states, Thailand recorded the highest number of mobile subscribers for 121 million, followed by the Philippines for 115 million in 2017. This is a significant increase since 2010 where the number of mobile subscribers was 71 million in Thailand (64.1% growth) and 83 million in the Philippines (34% growth). In comparison, the growth was significantly lower for less populous countries with a smaller number of mobile subscribers for 42 million in Malaysia (+23.1% from 2010), 8.4 million in

[19] Forbes (2007) The Philippines' Mobile Phone Revolution 10/22/2007.
[20] BSP (2018) announced that remittances from overseas Filipinos posted a new record high at U$3 billion in Dec 2017, accounted for 10% GDP.

Singapore (+13.83%) and 544 thousand in Brunei Darussalam in 2017 (+24.74% from 2010).

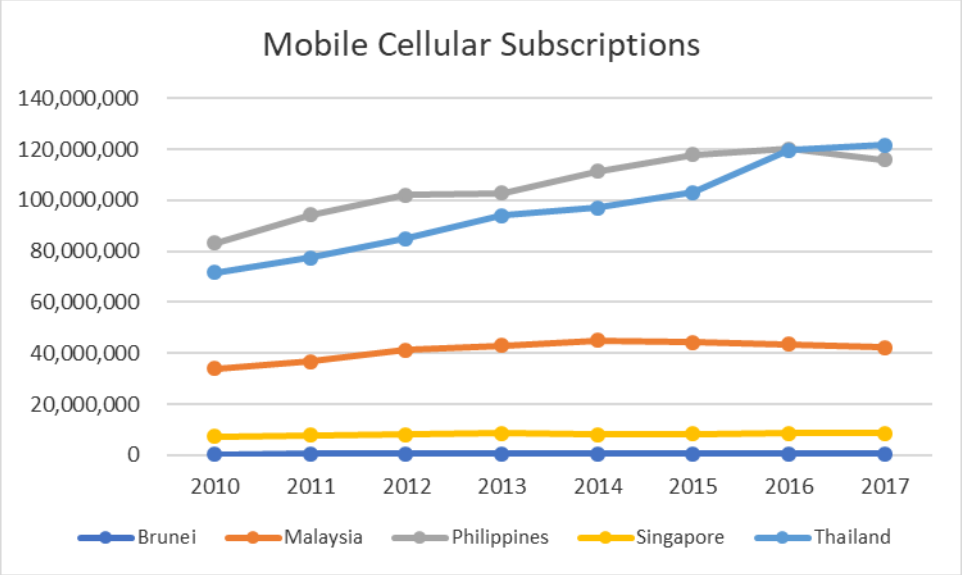

Figure 13: Mobile cellular subscriptions in the selected ASEAN countries

In parallel to the growing mobile users, there has been a rapid increase in the fixed broadband users. Thailand again recorded the highest number of subscribers for 8.2 million (+127.24% from 2010), followed by the Philippines for 3.3 million (+89.8% from 2010). Brunei Darussalam also recorded a strong growth by 89.9% from the same period.

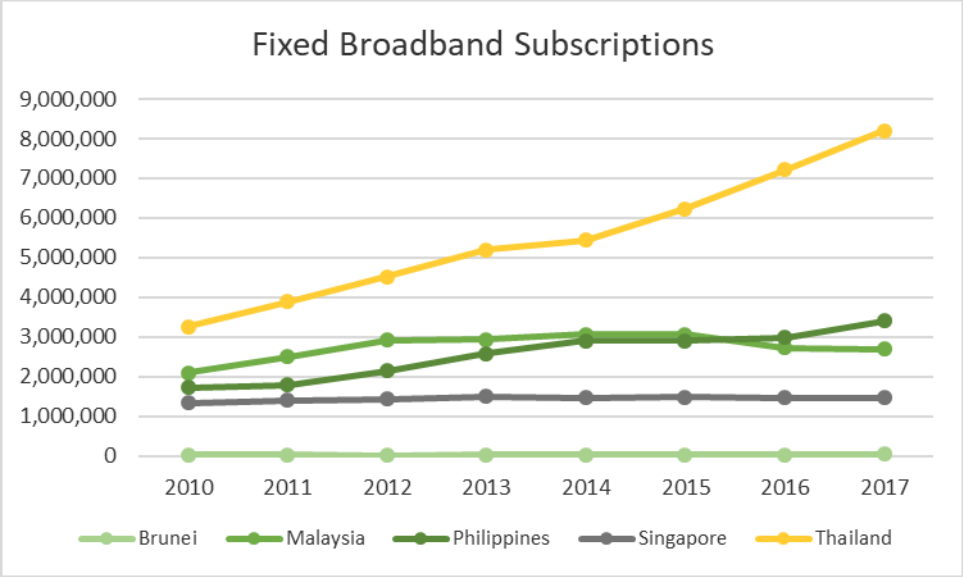

Figure 14: Fixed broadband subscriptions in the selected ASEAN countries

Across the region, mobile and internet banking has progressed at different paces. In the less developed markets like the Philippines and Indonesia, the mobile banking penetration is relatively slower compared to more developed countries of Singapore, Malaysia and Thailand. In the case of Thailand, mobile banking overtook online banking in 2015 in terms of transaction volume and the number of users as people increasingly preferred mobile devices as shown in Figure 11:

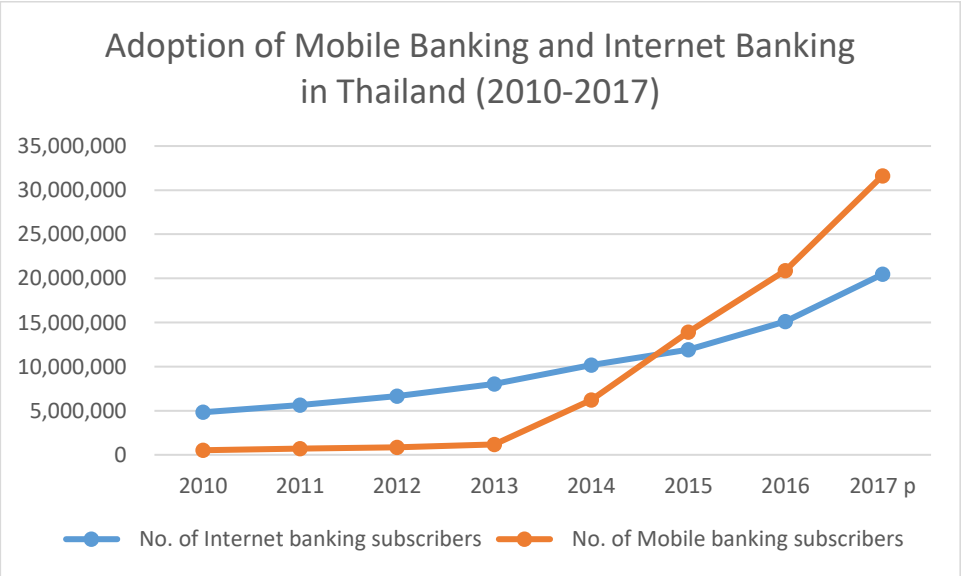

Figure 15: Adoption of mobile banking and internet banking in Thailand

(Source: Bank of Thailand, 2018)

On the other hand, in Malaysia, banking transactions were mainly executed by internet. The number of mobile banking users in Malaysia has increased from 898,472 in 2010, to 11.34 million, a significant growth by 1163% over the last eight years. The number of internet banking users has also increased at the average annual growth rate of 13.2% over the past five years as follows:

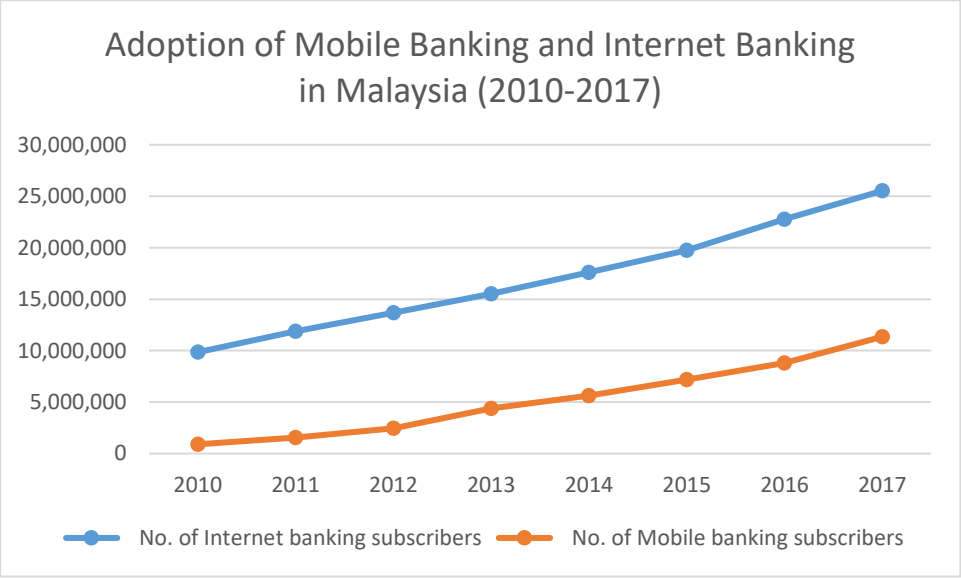

Figure 16: Adoption of mobile banking and internet banking in Malaysia

(Source: Bank Negara Malaysia, 2019)

In Singapore, mobile banking has recently overtaken branch banking by popularity, with a 15% jump during the past 12 months, according to market research company J.D. Power. However, only 67% of the mobile banking users in Singapore indicated regular use compared to the US (78%) and China (75%) according to a study by Australian telecom network Telstra in 2017.[21] In Singapore, almost one in three adults falls into the category of millennials aged 18 to 34 years

[21] Today Online (2017) Singapore playing catch-up in mobile banking use: Study

old — and smartphone ownership among millennials is very high at 99%. Of the eight markets studied by Telstra in the same report including the US and China, Singapore ranks sixth in mobile banking usage by the millennials. Wallet share for millennials was relatively low, at 22 per cent, indicating that Singapore was lagging in terms of riding the millennial value growth curve (Telstra, 2017).

Brunei Darussalam has a high mobile phone penetration per 100 inhabitants of 127.4% in Q2/2017, with a large proportion of the mobile phones used being smartphones capable of internet access, according to the Authority of Info-communications Technology Industry of Brunei Darussalam (AITI).[22] AITI also found that mobile broadband penetration (handset) per 100 inhabitants in Brunei Darussalam reached 121.4% in Q2/2017. In parallel, a number of digital payments has also been rapidly increasing. According to AMBD's 2018 survey of bank payment services, both internet banking and mobile application banking have reached 135% from 2016 to 2017, while card usage has also increased to 33% to $1.98 billion over the same period.[23]

In the Philippines, there are more people with mobile phones than bank accounts. Bangko Sentral ng Pilipinas (BSP) found during the 2017 Financial Inclusion Survey where the number of Filipino adults with a formal account was estimated at 15.8 million or 22.6% of total adult population. This was a slight improvement from 22% from the last survey conducted in 2015. It means more than 70% of the populations transact mainly in cash due to lack of access to formal financial services. Financial exclusion is closely associated with risks and costs associated with handling cash as people typically use cash instead of electronic

[22] For more information, refer to AITI: https://www.aiti.gov.bn/SitePages/Statistics.aspx
[23] AMBD (2018) Digital Payment Roadmap for Brunei Darussalam 2019-2025

means for daily financial transactions. Mobile phones act as a bridge between financial services and daily life including receiving remittances from their family members working abroad. The 2017 Financial Inclusion Survey found that 38% of Filipinos reported having a smart phone while 42% used the internet at least once a month of which 86% connected to the internet via mobile data. Such access to technology was particularly high in the urban areas and Metro Manila area. Nearly half (46 %) of Filipinos with bank accounts who have access to the Internet and mobile banking felt "ambivalent" about electronic payments due to issues of hacking, personal security breaches and unsafe access according to the survey. There are still concerns on the "availability, trust, and distance" of ATMs and electronic platforms. PayMaya and GCash are the most popular e-payments, with roughly one third of adults aware of these mobile money services.

4.2 Status of Mobile Banking Adoption by Sample Banks in ASEAN

Among the sample of 36 local commercial ASEAN banks, 31 banks offer mobile banking applications in 2017, a significant increase compared to 2010 where there were only 5 mobile banks:

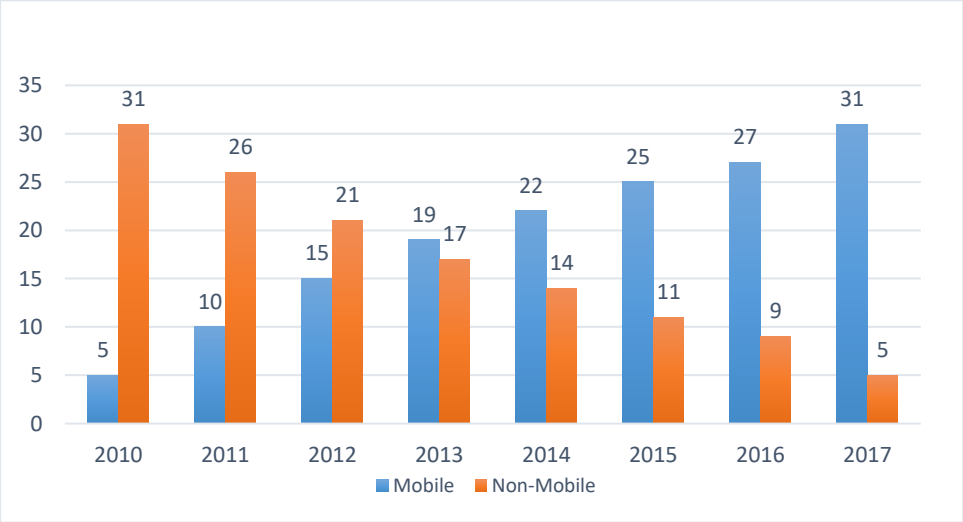

Figure 17: Mobile Banking Adoption by selected ASEAN commercial banks

The number of mobile banks doubled in 2011 and tripled in 2012. Year 2013 was the tipping point where a number of mobile banks (19) exceeded the number of non-mobile banks (17). The number of mobile banks has gradually increased since then and as of 2017. Appendix 3 lists sample mobile banks and non-mobile banks in ASEAN 5 which are divided into two different groups by the median asset of U$47.7 billion. The following table shows the name of the banks who released mobile banking applications from 2010 to 2017:

Table 4: Mobile Banking Adoption by sampe banks from 2010-2017

2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**Total**
DBS	SCB	BDO	Baiduri	TMB	UOB	PNB	Ambank	
Mbank	RHB	PB	BB	Kiatnakin	SBC	LH	Affin	
OCBC	HL	AUB	CIMB TH	Thanachart	Union		China	
Kbank	BPI	Ayudhya	TISCO				Metro	
CIMB	KTB	RCBC						
5	5	5	4	3	3	2	4	**31**

Those highlighted in green are the small banks with the average assets of less than U$47.7 billion. The early adopters of mobile banking technologies are big banks based in Singapore, Malaysia and Thailand in 2010. OCBC in Singapore offers mobile banking the longest period since 2008, followed by CIMB in Malaysia since 2009. For the full name of the banks, please refer to Appendix 3.

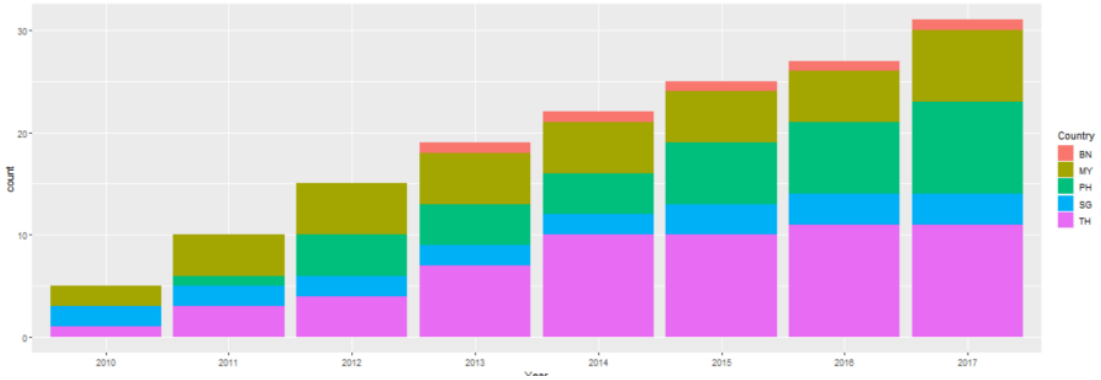

Figure 18: Mobile banking adoption in the selected ASEAN countries

The above figure reflects mobile banking adoption by country; Thailand in pink, Singapore in blue, Philippines in green, Malaysia in brown and Brunei Darussalam in orange. All mobile banks released the mobile banking applications through the Apple App Store and/or Google Play Store. Features of the mobile banking applications include account enquiry to bill payments, peer-to-peer payments, mortgage and housing loan application, insurance application and mutual funds investments. Appendix 9 lists a number of mobile banking features offered by each sample bank.

4.3 Status of Real time Payment Adoption by Sample Banks in ASEAN

In March 2014, Singapore launched real time funds transfer service, Fast and Secure Transfer (FAST) which is based on ISO 20022 financial standards. It was started by 14 participating banks – DBS, OCBC, UOB and Malaysian banks operating in Singapore, such as CIMB, RHB, Maybank as well as foreign banks (ANZ, Citibank, Deutsche Bank, Far Eastern Bank, HSBC, The Royal Bank of Scotland, Standard Chartered Bank, Sumitomo Mitsui Banking Corporation (ABS, 2014). In September 2015, Hong Leong Bank operating in Singapore joined FAST along with Bank of China, BNP Paribas, The Bank of Tokyo-Mitsubishi UFJ and

Mizuho Bank (ABS, 2015). In July 2017, Singapore launched a new peer-to-peer funds transfer service, PayNow which allowed users to transfer funds using the recipient's mobile number or Singapore NRIC/FIN through FAST with 24/7, 365 days service availability (ABS, 2017).

In 2016, Thailand launched PromptPay real time payment service. PromptPay allows users to easily transfer funds real time using the recipients' mobile phone number and national identity. The Philippines also launched InstaPay real time payment service in 2018, Malaysia's Real time Payment Platform was launched in January 2019. It is called DuitNow that allows for instant credit transfers to bank accounts that are addressed by mobile numbers and national identity number with immediate 24x7 funds availability. However, Brunei Darussalam is currently adopting a real time retail payment infrastructure which is set to go live in 2020. However, 2018-20 data is out of the scope of this research.

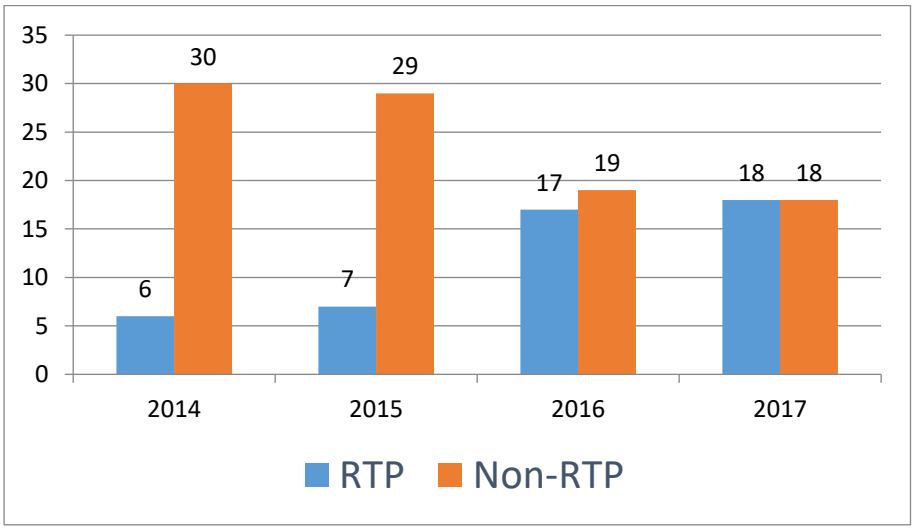

Figure 19. Realtime Payment Technology Adoption by Selected Commercial Banks in ASEAN

By the end of 2017, 18 commercial banks operating in Singapore and Thailand were offering real time payment service to their customers.

4.4 Regression Analysis

In this section, the results of the multivariate panel regression models will be presented based on the research variables of income statements and balance sheets.

4.4.1 Effect of mobile technology on the income statement variables

Table 5 shows the results of the multivariate panel regressions that tested the effects of banks' adoption of mobile banking technologies on the income statement variables. Years of mobile banking adoption was counted from the first year of the mobile app released by the sample banks to the year 2017. Panel regression models were run separately for a full sample of 36 commercial banks in ASEAN (288 observations) and the subset of 31 mobile banks (248 observations) for the period of 2010-2017. For the independent research variables, three types of mobile banking apps were used; 1. Retail banking app for consumers (MOB_AGE**R**); 2. Business banking app for corporates and SMEs (MOB_AGE**B**); and 3. Investment banking app for securities and fx trading (MOB_AGE**I**). In addition, additional independent research variables of GDP Per Capita and Mobile phone penetration rates were included in the panel regressions to measure the effects of macroeconomic and market conditions. Coefficients were indicated in the table with probability value (p-value) as follows: *p<0.1; **p<0.05; ***p<0.01. This research specifically reviews the coefficients with the p-value of less than 0.01 and 0.05 with the adjusted R^2 of more than 50% as statistically significant.

Table 5a shows a full sample of 36 banks and Table 5b highlights a subset of 31 mobile banks which are further divided into 15 small banks (Table 5c) and 16 large banks (Table 5d) by the median asset size of U$28.9B. Since there is a

significant difference between mean and standard deviation of the bank asset size, the median is selected to divide the sample banks into two groups. As shown in Table 5a, the full sample's interest income (INC_ASS) was positively affected by the retail banking app (MOB_AGER, 0.152***) and negatively affected by the business banking app (MOB_AGEB, -0.087**) with the adjusted R^2 at 84.3%. Interest expenses were positively affected by the retail banking app with the adjusted R^2 at 66.8%.

Table 5a: Effect of mobile technology on income statement (Full sample)

Estimation method: OLS				
Full Sample (2010-2017: 288 observations)				
Independent Variables	MOB_AGER (Retail)	MOB_AGEB (Business)	MOB_AGEI (Investment)	Adj R-sq
Dependent Variables				
IINC_ASS	0.152***	-0.087**	0.037	0.843
IEXP_ASS	0.085***	-0.016	0.002	0.668
FINC_ASS	0.083**	0.01	0.087***	0.617
SALA_ASS	0.029***	-0.032**	0.01	0.836
SGA_ASS	-0.009	0.005	0.013**	0.884
Fixed Effects: Bank Name and Year				
*p<0.1; **p<0.05; ***p<0.01				

The full sample's fee income (FINC_ASS) was positively affected by the retail banking app and investment banking app at 0.083** and at 0.087*** respectively with the adjusted R^2 at 61.7%. The fee income includes securities trading fees, account service fees, foreign exchange fees, loan and credit usage fees. Bank salary was positively affected by the retail banking app (SALA_ASS, 0.029***) and negatively affected by the business banking app (-0.032**) with the adjusted R^2 at 83.6%. Selling General & Admin (SG&A) expenses were affected by the mobile investment app at 0.013** with the adjusted R^2 at 88.4%.

As for the subset of the mobile banks, there are 31 banks which adopted mobile banking apps as of 2017. They are divided into two groups by the median asset size; small mobile banks for less than USD 28.9B and large mobile banks for more than USD 28.9B.

Table 5b: Effect of mobile technology on income statement (Mobile banks)

Estimation method: OLS				
All Mobile Banks (2010-2017: 248 observations)				
Independent Variables	MOB_AGER (Retail)	MOB_AGEB (Business)	MOB_AGEI (Investment)	Adj R-sq
Dependent Variables				
IINC_ASS	0.078**	-0.076*	0.036	0.843
IEXP_ASS	0.025	-0.007	0.001	0.717
FINC_ASS	0.068*	0.015	0.087***	0.611
SALA_ASS	0.028**	-0.032**	0.009	0.81
SGA_ASS	-0.009*	0.005	0.013***	0.923
Fixed Effects: Bank Name and Year				
*p<0.1; **p<0.05; ***p<0.01				

A separate regression model was run for the subset of the mobile banks in Table 5b with the split of small mobile banks and large mobile banks which were also displayed in Table 5c and Table 5d. Key finding is that mobile technology did not affect interest income and interest expense across small and large mobile banks. Instead small banks' fee income was positively affected by the mobile technology at 0.220*** with the adjusted R^2 at 59.7%, supporting the first hypothesis. This finding is also consistent with DeYoung (2007) as new technologies tend to affect fee income rather than interest income/expense as part of diversification strategy to reduce their reliance on the traditional intermediary businesses. Bank salary and SG&A expenses of small banks were negatively affected by the business banking app and the retail banking app, supporting the first hypothesis on the operating cost reduction. For example, a yearly increase in the adoption of business banking app

would reduce small banks' salary expenses by 0.060%. As shown in Table 5d, large banks' income statements were largely unaffected, supporting the first hypothesis of the mobile technology effect on small banks.

Table 5c: Effect of mobile technology on income statement (Small banks)

Estimation method: OLS				
Small Mobile Banks (2010-2017: 120 observations)				
Independent Variables	MOB_AGER (Retail)	MOB_AGEB (Business)	MOB_AGEI (Investment)	Adj R-sq
Dependent Variables				
IINC_ASS	0.059	-0.124	0.074	0.727
IEXP_ASS	-0.024	-0.012	-0.049	0.741
FINC_ASS	-0.001	0.06	0.220***	0.597
SALA_ASS	0.032	-0.060**	0.021	0.748
SGA_ASS	-0.019**	0.008	0.031***	0.871
Fixed Effects: Bank Name and Year				
*p<0.1; **p<0.05; ***p<0.01				

Table 5d: Effect of mobile technology on income statement (Large banks)

Estimation method: OLS				
Large Mobile Banks (2010-2017: 128 observations)				
Independent Variables	MOB_AGER (Retail)	MOB_AGEB (Business)	MOB_AGEI (Investment)	Adj R-sq
Dependent Variables				
IINC_ASS	0.038	-0.04	0.017	0.891
IEXP_ASS	-0.028	-0.017	-0.024	0.753
FINC_ASS	0.008	-0.042*	-0.027	0.812
SALA_ASS	0.003	-0.017*	0.002	0.886
SGA_ASS	0.01	0.002	0.006	0.939
Fixed Effects: Bank Name and Year				
*p<0.1; **p<0.05; ***p<0.01				

4.4.2 Effect of mobile technology on the balance sheet variables - assets

Table 6 shows the effects of mobile banking technologies on full sample's asset side of the balance sheets. The result demonstrated that among the asset types, consumer loans were most affected by the mobile investment app (CONSM_LOAN, 1.562**) with higher adjusted R^2 at 82%. The mobile investment banking app facilitates e-trading of stocks, bonds, mutual funds and fx which are typically associated with a line of credits for trading and margin finance. Therefore, consumer loans are highly related to the investment banking app.

Table 6a: Effect of mobile technology on the asset side of the balance sheets (Full sample)

Estimation method: OLS				
Full Sample (2010-2017: 288 observations)				
Independent Variables	MOB_AGER (Retail)	MOB_AGEB (Business)	MOB_AGEI (Investment)	Adj R-sq
Dependent Variables				
CASH_ASS	-0.963	1.515	2.369	0.343
SEC_ASS	-4.56	6.062	7.28	0.092
LOAN_ASS	-0.281	1.923	0.386	0.363
COMM_LOAN	1.037	-1.348	-0.662	0.76
CONSM_LOAN	-0.588	0.524	1.562**	0.82
NPL_LOAN	-0.091	0.154	0.238*	0.477
Adj_ROA	0.108***	-0.017	0.014	0.61
Fixed Effects: Bank Name and Year				
*p<0.1; **p<0.05; ***p<0.01				

In contrast to commercial loans that require long borrower-bank relationship and face to face due diligence to grant the business loans, consumer loans are typically transaction-driven and one-off and loan applications and activation notifications can be channeled through mobile technologies. Overall, the adjusted ROA excluding non-mobile technology related income and cost for full sample banks were

positively impacted by the mobile banking adoption (Adj_ROA, 0.108***) with the adjusted R^2 at 61%.

As for the subset of the mobile banks as shown in Table 6b, 6c and 6d, two main financial indicators of consumer loans and the adjusted ROA were affected by mobile technology. Among the variables, the most significant finding came from the consumer loans which were positively affected by the mobile investment banking app, and its effect was much larger on small banks as shown in Table 6c, supporting the first hypothesis. (CONSM_LOAN, 5.834***; 71.8% adjusted R^2). This is the highest coefficient whereby a yearly increase in the investment banking app adoption will grow small banks' consumer loans by 5.834%.

Table 6b: Effect of mobile technology on the asset side of the balance sheets (Mobile banks)

Estimation method: OLS				
All Mobile Banks (2010-2017: 248 observations)				
Independent Variables	MOB_AGER (Retail)	MOB_AGEB (Business)	MOB_AGEI (Investment)	Adj R-sq
Dependent Variables				
CASH_ASS	0.4	1.375	2.449	0.341
SEC_ASS	-3.922	6.066	7.407	0.089
LOAN_ASS	1.604	1.757	0.485	0.311
COMM_LOAN	0.163	-1.261	-0.695	0.744
CONSM_LOAN	0.048	0.471	1.604**	0.813
NPL_LOAN	-0.154	0.177	0.244**	0.434
Adj_ROA	0.082**	-0.01	0.014	0.646
Fixed Effects: Bank Name and Year				
*p<0.1; **p<0.05; ***p<0.01				

Table 6c: Effect of mobile technology on the asset side of the balance sheets (Small banks)

Estimation method: OLS				
Small Mobile Banks (2010-2017: 120 observations)				
Independent Variables	MOB_AGER (Retail)	MOB_AGEB (Business)	MOB_AGEI (Investment)	Adj R-sq
Dependent Variables				
CASH_ASS	-0.128	1.921	5.517	0.314
SEC_ASS	-8.428	10.04	17.017	0.072
LOAN_ASS	0.193	4.288	2.96	0.277
COMM_LOAN	1.509	-1.596	-2.345	0.744
CONSM_LOAN	0.557	1.501	5.834***	0.718
NPL_LOAN	-0.195	0.036	0.510*	0.305
Adj_ROA	0.054	-0.003	0.189***	0.566
Fixed Effects: Bank Name and Year				
*p<0.1; **p<0.05; ***p<0.01				

The adjusted ROA of small banks was positively affected by the investment banking app at 0.189*** with the adjusted R^2 at 56.6%. The following Table 6d shows the results of the panel regression on large mobile banks. Overall cash assets and securities assets were positively affected by the business banking app and investment banking app. Loan assets were negatively affected by the investment banking app whereas consumer loans and commercial loans remained unaffected. Non-performing loan of large banks were positively affected by the business banking app at 0.164** with the adjusted R^2 at 75.3%. The adjusted ROA of large banks was positively affected by the retail banking app at 0.096** lower than the small banks' coefficients at 0.189***, supporting the first hypothesis.

Table 6d: Effect of mobile technology on the asset side of the balance sheets (Large banks)

Estimation method: OLS				
Large Mobile Banks (2010-2017: 128 observations)				
Independent Variables	MOB_AGER (Retail)	MOB_AGEB (Business)	MOB_AGEI (Investment)	Adj R-sq
Dependent Variables				

CASH_ASS	-0.492	0.634**	0.868***	0.71
SEC_ASS	-0.061	0.383	0.755***	0.79
LOAN_ASS	0.566	0.211	-1.112***	0.862
COMM_LOAN	0.048	-0.487	0.937	0.723
CONSM_LOAN	0.204	-0.536*	0.047	0.98
NPL_LOAN	-0.035	0.164**	0.095	0.753
Adj_ROA	0.096**	-0.009	-0.046	0.765
Fixed Effects: Bank Name and Year				
*p<0.1; **p<0.05; ***p<0.01				

4.4.3 Effect of mobile technology on the balance sheet variables-liability & equity

Table 7 shows regression results that tested the impact of mobile banking technologies on full sample's liability and equity side of the balance sheets. The most significant result was the investment banking app that facilitated trading of the securities and fx positively affected money market deposits (MM_DEP, 1.756***, 90.6% adjusted R^2) and negatively affected demand deposits (DD_DEP, -0.661***, 91.8% adjusted R^2) and fixed deposits (TD_DEP, -1.311**, 82.8% adjusted R^2) .

Table 7a: Effect of mobile technology on the liability and equity side of the balance sheets (Full sample)

Estimation method: OLS				
Full Sample (2010-2017: 288-188 observations)				
Independent Variables	MOB_AGER (Retail)	MOB_AGEB (Business)	MOB_AGEI (Investment)	Adj R-sq
Dependent Variables				
DEPO_ASS	-0.88	0.17	-0.023	0.496
DD_DEP	0.383	-0.077	-0.661***	0.918
MM_DEP	0.008	0.497	1.756***	0.906
TD_DEP	-0.433	-0.389	-1.311**	0.828
CT1_CAP	0.387*	-0.21	0.310*	0.72
Adj_ROE	0.3	0.466	-0.316	0.608
Fixed Effects: Bank Name and Year				
*p<0.1; **p<0.05; ***p<0.01				

Consistent with the past research, mobile technologies allow mobility and flexibility for customers to conveniently move funds from low/zero interest bearing demand deposits to higher yield money market deposits. As for the equity side of the balance sheet of full sample, no statistical significance was observed.

On the subset of the mobile banks shown in Table 7b, 7c and 7d, the investment banking app largely affected money market deposits, especially small banks' (MM_DEP, 5.916***, 80.9% adjusted R^2). It means a yearly increase in mobile investment banking service will increase the money market deposits by 5.916%.

Table 7b: Effect of mobile technology on the liability and equity side of the balance sheets (Mobile banks)

Estimation method: OLS				
All Mobile Banks (2010-2017: 248 observations)				
Independent Variables	MOB_AGER (Retail)	MOB_AGEB (Business)	MOB_AGEI (Investment)	Adj R-sq
Dependent Variables				
DEPO_ASS	-1.051	0.172	-0.037	0.441
DD_DEP	0.371	-0.077	-0.662***	0.911
MM_DEP	0.233	0.47	1.758***	0.881
TD_DEP	-0.771	-0.379	-1.334**	0.822
CT1_CAP	0.618***	-0.223	0.324**	0.437
Adj_ROE	-0.041	0.535	-0.324	0.696
Fixed Effects: Bank Name and Year				
*p<0.1; **p<0.05; ***p<0.01				

Table 7c: Effect of mobile technology adoption on the liability and equity side of the balance sheets (Small banks)

Estimation method: OLS
Small Mobile Banks (2010-2017: 120 observations)

Independent Variables	MOB_AGER (Retail)	MOB_AGEB (Business)	MOB_AGEI (Investment)	Adj R-sq
Dependent Variables				
DEPO_ASS	-1.174	0.788	-0.302	0.367
DD_DEP	0.819	-0.9	-0.891	0.877
MM_DEP	0.526	3.376**	5.916***	0.809
TD_DEP	-2.048	-2.476	-5.509***	-0.778
CT1_CAP	0.887***	-0.873**	0.394	0.303
Adj_ROE	-0.64	0.554	1.238**	0.663
Fixed Effects: Bank Name and Year				
*p<0.1; **p<0.05; ***p<0.01				

The adjusted ROE of small banks were positively affected by the investment banking app at 1.238** with the adjusted R^2 at 66.3%. Core Tier 1 Capital (CT1_CAP) ratio which is a useful indicator to evaluate banks' capital quality and financial strength was positively affected by the retail banking app and negatively affected by the business banking app. However the model was not well-defined due to the low adjusted R^2 at 30.3%, hence was not evaluated further. The following table 7d shows the panel regression results on large mobile banks.

Table 7d: Effect of mobile technology on the liability and equity side of the balance sheets (Large banks)

Estimation method: OLS				
Large Mobile Banks (2010-2017: 128 observations)				
Independent Variables	MOB_AGER (Retail)	MOB_AGEB (Business)	MOB_AGEI (Investment)	Adj R-sq
Dependent Variables				
DEPO_ASS	-1.183**	0.002	0.017	0.72
DD_DEP	-0.499***	0.319**	-0.599***	0.981
MM_DEP	0.342	-0.924**	0.493	0.976
TD_DEP	0.387	0.779*	-0.022	0.947
CT1_CAP	0.092	0.073	0.244*	0.552
Adj_ROE	0.805*	0.613	-0.780**	0.76
Fixed Effects: Bank Name and Year				
*p<0.1; **p<0.05; ***p<0.01				

There are some negative effects of the mobile technologies on large banks' liability and equity side of the balance sheets. Overall deposits and demand deposits were negatively affected by the retail banking app at -1.183** and -0.499*** respectively. Money market deposits were negatively affected by the business banking app at -0.924 with the adjusted R^2 at 97.6% as well. The adjusted ROE was negatively affected by the investment banking app at -0.780** with the adjusted R^2 at 76%. These results demonstrate that mobile technologies did not positively affect financial performance of large banks, supporting the first hypothesis for the larger technological effects on small banks.

4.4.4 Effect of mobile technology on financial standards

The panel regression results in Table 8 show a positive relationship between banks adoption of mobile banking technologies and financial standards, ISO 20022. The financial standards are mostly adopted for retail and business banking segments, therefore, the independent research variable of investment banking app was excluded from the panel regression models. The following table shows the regression results on full sample where retail banking app and business banking app positively affected banks' adoption of ISO 20022 financial standards at 0.222*** and 0.189** respectively with the adjusted R^2 at 61.4%.

Table 8a: Effect of mobile technology on financial standards (Full sample)

Estimation method: OLS			
Full Sample (2010-2017: 288 observations)			
Independent Variables	MOB_AGER (Retail)	MOB_AGEB (Business)	Adj R-sq
Dependent Variable: ISO_AGE	0.222***	0.189**	0.614

Financial standards evolve as technologies evolve, e.g., ISO 20022 APIs for addressing for real time payments using mobile number, facebook account and NRIC number. Financial standards facilitate technological innovations and interoperability thereby making new services easily and widely adoptable and usable by critical mass. The following tables show the regression results on the subset of small and large mobile banks.

Table 8b: Effect of mobile technology on financial standards (Mobile banks)

Estimation method: OLS			
All Mobile Banks (2010-2017: 248 observations)			
Independent Variables	MOB_AGER (Retail)	MOB_AGEB (Business)	Adj R-sq
Dependent Variables: ISO_AGE	0.197***	0.187***	0.611

Table 8c: Effect of mobile technology on financial standards (Small banks)

Estimation method: OLS			
Small Mobile Banks (2010-2017: 120 observations)			
Independent Variables	MOB_AGER (Retail)	MOB_AGEB (Business)	Adj R-sq
Dependent Variables: ISO_AGE	0.062	-0.055	0.302

Table 8d: Effect of mobile technology on financial standards (Large banks)

Estimation method: OLS			
Large Mobile Banks (2010-2017: 128 observations)			
Independent Variables	MOB_AGER (Retail)	MOB_AGEB (Business)	Adj R-sq
Dependent Variables: ISO_AGE	0.168**	0.260***	0.744

No major effect of mobile technologies on small banks' adoption of financial standards was observed. On the other hand, there was strong effect of the retail banking app and business banking app on large banks' adoption of financial

standards at 0.168** and at 0.260*** with the adjusted R^2 at 74.4%. A possible explanation is that among the sample mobile banks, the early standards adopters were large banks operating in Singapore which started participating in the ISO 20022 real time retail payment system launched in 2014. Therefore, statistics may have largely reflected the effect on large banks. In the later part of 2014, Brunei Darussalam launched ISO 20022-based Automated Clearing House. In 2016, PromptPay real time payment service based on ISO 20022 in Thailand was launched in 2016 by both small and large banks. As of end 2017, about 62% of the total sample banks adopted ISO 20022 financial standards and the majority was large banks. Hence, sample size and time effects likely affected the panel regression results.

4.4.5 Effect of bank adoption of financial standards on bank financial indicators

The following regression result in Table 9 shows a positive relationship between banks' adoption of financial standards and the adjusted ROA and ROE:

Table 9a: Effect of financial standards on bank ROA and ROE (Full sample and mobile banks)

Estimation method: OLS				
*# of observations	**Full Sample (*288)**		**All Mobile Banks (*248)**	
Independent Variables	ISO_AGE	Adj R-sq	ISO_AGE	Adj R-sq
Dependent Variables				
Adj_ROA	0.099**	0.594	0.071	0.641
Adj_ROE	0.173	0.605	0.007	0.692

The effect of financial standards positively affected full sample's adjusted ROA at 0.099** with the adjusted R^2 at 64.1%.

Table 9b: Effect of financial standards on bank ROA and ROE (Small and large banks)

Estimation method: OLS				
*# of observations	**Small Mobile Banks (*120)**		**Large Mobile Banks (*128)**	
Independent Variables	ISO_AGE	Adj R-sq	ISO_AGE	Adj R-sq
Dependent Variables				
Adj_ROA	0.679***	0.631	-0.05	0.757
Adj_ROE	3.105***	0.676	0.055	0.73

Adoption of ISO 20022 financial standards positively affected small banks' adjusted ROA at 0.679*** and adjusted ROE at 3.105*** with the adjusted R^2 at 75.7% and 73% respectively. In contrast, large banks profitability remained unaffected by the adoption of financial standards, supporting the third hypothesis.

4.4.6 Effect of bank adoption of mobile banking technologies combined with the financial standards on bank financial indicators

In the statistical analysis, a mediator variable serves to clarify the nature of the relationship between the independent variable and the dependent variable. Based on the research technique by Baron and Kenny (1986), regression analysis was performed to identify the relationship between the fintech innovations (3 types of mobile app technologies as independent variables) and bank profitability (adjusted ROA and ROE as dependent variables) via the inclusion of a mediator variable of financial standards. This model suggests that fintech influences the mediator variable of standards, which in turn influences the bank performance. The effect of the financial standards is measured by banks' years of ISO 20022 financial standards adoption. As of end 2017, about 62% of the total sample banks adopted ISO 20022 financial standards. The same set of variables – the adjusted ROA and

ROE were regressed by the input research variables of retail mobile banking app and business mobile banking app separately.

Table 10 shows the regression analysis of the combined effects of the retail banking app and ISO 20022 financial standards on the adjusted ROA and ROE.

Table 10a: Combined effects of the retail mobile banking technology and financial standards on ROA and ROE (Mobile banks)

Estimation method: OLS					
All Mobile Banks (2010-2017: 248 observations)					
Independent Variables	MOB_AGER (Retail)	M_MOB_AGER (Retail)	M_MOBAGER_ ISO (Retail)	Adj R-sq	Adj R-sq (ISO)
Dependent Variables					
Adj_ROA	0.088**	0.114***	-0.014*	0.647	0.65
Adj_ROE	-0.186	0.139	-0.183***	0.695	0.702
Fixed Effects: Bank Name and Year					
*p<0.1; **p<0.05; ***p<0.01					

The adjusted ROE is negatively affected by the combined effects of the retail banking app and financial standards at -0.183*** with the adjusted R^2 at 70.2%. The following Table 10b shows the regression results of the combined effects of business banking app and financial standards on the adjusted ROA and ROE. There is no statistically significant result observed.

Estimation method: OLS
All Mobile Banks (2010-2017: 248 observations)

Independent Variables	MOB_AGEB (Business)	M_MOB_ AGEB (Business)	M_MOBAGEB_ ISO (Business)	Adj R-sq	Adj R-sq (ISO)
Dependent Variables					
Adj_ROA	-0.014	-0.051	0.027	0.647	0.65
Adj_ROE	0.621*	0.279	0.284*	0.695	0.702
	Fixed Effects: Bank Name and Year				
*p<0.1; **p<0.05; ***p<0.01					

Table 10b: Combined effects of the business mobile technology and financial standards on ROA and ROE (Mobile banks)

As for the subset of small mobile banks shown in Table 10c and 10d, combined effects of the retail banking app and financial standards positively affected the adjusted ROA at 0.158*** and ROE at 0.646* with the adjusted R^2 at 60.1% and 66% respectively.

Table 10c: Combined effects of the retail mobile technology and financial standards on ROA and ROE (Small banks)

Estimation method: OLS					
Small Mobile Banks (2010-2017: 120 observations)					
Independent Variables	MOB_ AGER (Retail)	M_MOB_ AGER (Retail)	M_MOBAGER_ ISO (Retail)	Adj R-sq	Adj R-sq (ISO)
Dependent Variables					
Adj_ROA	0.094	0.039	0.158***	0.537	0.601
Adj_ROE	-0.376	-0.599	0.646*	0.649	0.66
Fixed Effects: Bank Name and Year					
*p<0.1; **p<0.05; ***p<0.01					

Table 10d: Combined effects of the business mobile technology and financial standards on ROA and ROE (Small banks)

Estimation method: OLS
Small Mobile Banks (2010-2017: 120 Observations)

Independent Variables	MOB_AGEB (Business)	M_MOB_ AGEB (Business)	M_MOBAGEB_ ISO (Business)	Adj R-sq	Adj R-sq (Mediator)
Dependent Variables					
Adj_ROA	-0.032	0.015	-0.064	0.537	0.601
Adj_ROE	0.365	0.499	0.201	0.649	0.66
Fixed Effects: Bank Name and Year					
*p<0.1; **p<0.05; ***p<0.01					

The above Table 10d shows the regression result of the combined effects of business banking app and financial standards on the adjusted ROA and ROE of small banks. The result was not statistically significant.

Table 10e: Combined effects of the retail mobile technology and financial standards on ROA and ROE (Large banks)

Estimation method: OLS					
Large Mobile Banks (2010-2017: 128 Observations)					
Independent Variables	MOB_AGER (Retail)	M_MOB_ AGER (Retail)	M_MOBAGER_ ISO	Adj R-sq	Adj R-sq (ISO)
Dependent Variables					
Adj_ROA	0.076*	0.137***	-0.024***	0.761	0.786
Adj_ROE	0.473	1.022**	-0.223***	0.747	0.763
Fixed Effects: Bank Name and Year					
*p<0.1; **p<0.05; ***p<0.01					

The above Table 10e shows the regression results of the combined effects of the retail banking app and financial standards on the adjusted ROA and ROE of large banks. Combined effects of the retail banking app and financial standards negatively affected the adjusted ROA at -0.024*** and ROE at -0.223*** with the adjusted R^2 at 78.6% and 76.3% respectively. The following Table 10f shows the regression results of the combined effects of the business banking app and financial standards on the adjusted ROA and ROE of large banks. The adjusted ROA was

positively affected by the business banking app at 0.035** with the adjusted R^2 at 78.6%

Table 10f: Combined effects of the business mobile technology and financial standards on ROA and ROE (Large banks)

Estimation method: OLS					
Large Mobile Banks (2010-2017: 128 Observations)					
Independent Variables	MOB_AGEB (Business)	M_MOB_ AGEB	M_MOBAGEB_ ISO	Adj R-sq	Adj R-sq (Mediator)
Dependent Variables					
Adj_ROA	0.008	-0.056	0.035**	0.761	0.786
Adj_ROE	0.899*	0.458	0.284	0.747	0.763
Fixed Effects: Bank Name and Year					
*p<0.1; **p<0.05; ***p<0.01					

Overall, the standards mediator affected both small and big banks and accepted Hypothesis 4 that mobile technologies combined with financial standards positively affected bank ROA and ROE.

4.4.7 Effect of macroeconomic conditions

The additional independent variable of GDP per capita was included in the multivariate panel regression models to specifically measure the effect of macroeconomic conditions on bank ROA an ROE. The following Table 11 shows the results of the panel regression analysis.

Table 11a: Effects of GDP per capita, retail banking app and financial standards on ROA and ROE (Mobile banks)

Estimation method: OLS
All Mobile Banks (2010-2017: 248 observations)

Independent Variables	M_MOBAGER_ ISO (Retail)	M_MOBAGER_ ISO (Retail)	Adj R-sq (ISO)	Adj R-sq (GDP)	GDP_PC
Dependent Variables					
Adj_ROA	-0.014*	-0.015*	0.65	0.649	0.00001
Adj_ROE	-0.183***	-0.203***	0.702	0.707	0.0003**
Fixed Effects: Bank Name and Year					
*p<0.1; **p<0.05; ***p<0.01					

Table 11b: Effects of GDP per capita, business banking app and financial standards on ROA and ROE (Mobile Banks)

Estimation method: OLS					
All Mobile Banks (2010-2017: 248 observations)					
Independent Variables	M_MOBAGEB_ ISO (Business)	M_MOBAGEB_ ISO (Business)	Adj R-sq (ISO)	Adj R-sq (GDP)	GDP_PC
Dependent Variables					
Adj_ROA	0.027	0.027	0.65	0.649	0.00001
Adj_ROE	0.284*	0.296*	0.702	0.707	0.0003**
Fixed Effects: Bank Name and Year					
*p<0.1; **p<0.05; ***p<0.01					

The adjusted ROE of all mobile banks that adopted retail banking app and business banking app was positively affected by country GDP per capita at 0.0003** with the adjusted R^2 at 70.7% which is higher than the adjusted R^2 of the previous model at 70.2%.

Table 11c: Effects of GDP per capita, retail banking app and financial standards on ROA and ROE (Small mobile banks)

Estimation method: OLS					
Small Mobile Banks (2010-2017: 120 observations)					
Independent Variables	M_MOBAGER_ ISO (Retail)	M_MOBAGER_ ISO (Retail)	Adj R-sq (ISO)	Adj R-sq (GDP)	GDP_ PC
Dependent Variables					

Adj_ROA	0.158***	0.167***	0.601	0.602	-0.00003
Adj_ROE	0.646*	0.624*	0.66	0.656	0.0001
Fixed Effects: Bank Name and Year					
*p<0.1; **p<0.05; ***p<0.01					

The above Table 11c shows no statistically significant relationship between GDP per capita, profitability and small banks adoption of retail banking apps. On the other hand, there is a relationship observed between GDP per capita, small bank's adotion of business banking app and adjusted ROE at 0.001** with the adjusted R^2 at 78% which is higher than the adjusted R^2 of the previous model at 66% as shown in the following Table 11d.

Table 11d: Effects of GDP per capita, business banking app and financial standards on ROA and ROE (Small mobile banks)

Estimation method: OLS					
Small Mobile Banks (2010-2017: 120 observations)					
Independent Variables	M_MOBAGEB_ ISO (Business)	M_MOBAGEB_ ISO (Business)	Adj R-sq (ISO)	Adj R-sq (GDP)	GDP_PC
Dependent Variables					
Adj_ROA	-0.064	-0.073	0.601	0.602	-0.00003
Adj_ROE	0.201	0.223	0.66	0.78	0.001***
Fixed Effects: Bank Name and Year					
*p<0.1; **p<0.05; ***p<0.01					

As for the subset of the large mobile banks, the following Tables 11e and 11f show a statistically significant relationship between GDP per capita, adjusted ROE and adoption of retail banking apps at 0.001*** with the adjusted R^2 at 78%

Table 11e: Effects of GDP per capita, retail banking app and financial standards on ROA and ROE (Large mobile banks)

Estimation method: OLS
Large Mobile Banks (2010-2017: 128 Observations)

Independent Variables	M_MOBAGER_ ISO	M_MOBAGER_ ISO (Retail)	Adj R-sq (ISO)	Adj R-sq (GDP)	GDP_PC
Dependent Variables					
Adj_ROA	-0.024***	-0.025***	0.786	0.787	0.00003
Adj_ROE	-0.223***	-0.234***	0.763	0.78	0.001***
Fixed Effects: Bank Name and Year					
*p<0.1; **p<0.05; ***p<0.01					

Table 11f: Effects of GDP per capita, business banking app and financial standards on ROA and ROE (Large mobile banks)

Estimation method: OLS					
Large Mobile Banks (2010-2017: 128 Observations)					
Independent Variables	M_MOBAGE B_ISO	M_MOBAGE B_ ISO (Business)	Adj R-sq (ISO)	Adj R-sq (GDP)	GDP_PC
Dependent Variables					
Adj_ROA	0.035**	0.038**	0.786	0.787	0.00003
Adj_ROE	0.284	0.337*	0.763	0.78	0.001***
Fixed Effects: Bank Name and Year					
*p<0.1; **p<0.05; ***p<0.01					

4.4.8 Effect of market conditions

The additional independent variable of Mobile Phone Penetration Rates was included in the multivariate panel regression models to specifically measure the effect of external market conditions on bank ROA an ROE. The results in Table 12a and 12b show a positive relationship between mobile phone penetration rates, retail and business banking apps and financial standards on ROA at 0.007*** with the adjusted R^2 at 66.2%, higher than the adjusted R^2 of the previous model at 65%.

Table 12a: Effects of mobile phone penetration rates, retail banking app and financial standards on ROA and ROE (Mobile Banks)

Estimation method: OLS
All Mobile Banks (2010-2017: 248 observations)

Independent Variables	M_MOBAGER_ ISO (Retail)	M_MOBAGER_ ISO (Retail)	Adj R-sq (ISO)	Adj R-sq (MOB_PEN)	MOB_PEN
Dependent Variables					
Adj_ROA	-0.014*	-0.01	0.65	0.662	0.007***
Adj_ROE	-0.183***	-0.168**	0.702	0.703	0.029
Fixed Effects: Bank Name and Year					
*p<0.1; **p<0.05; ***p<0.01					

Table 12b: Effects of mobile phone penetration rates, business banking app and financial standards on ROA and ROE (Mobile Banks)

Estimation method: OLS					
All Mobile Banks (2010-2017: 248 observations)					
Independent Variables	M_MOBAGEB_ ISO (Business)	M_MOBAGEB_ ISO (Business)	Adj R-sq (ISO)	Adj R-sq (MOB_PEN)	MOB_PEN
Dependent Variables					
Adj_ROA	0.027	0.029	0.65	0.662	0.007***
Adj_ROE	0.284*	0.292*	0.702	0.703	0.029
Fixed Effects: Bank Name and Year					
*p<0.1; **p<0.05; ***p<0.01					

The results confirm that a strong relationship between people's mobile phone adoption and bank profitability. As for the subset of small mobile banks, mobile penetration rates had a positive relationship with banks' adoption of both retail and business banking app, financial standards and ROA and ROE as shown in Tables 12c and 12d.

Table 12c: Effects of mobile phone penetration rates, retail banking app and financial standards on ROA and ROE (Small Banks)

Estimation method: OLS					
Small Mobile Banks (2010-2017: 120 observations)					
Independent Variables	M_MOBAGER _ ISO (Retail)	M_MOBAGER_ ISO (Retail)	Adj R-sq (ISO)	Adj R-sq (MOB_PEN)	MOB_PEN

Dependent Variables					
Adj_ROA	0.158***	0.092*	0.601	0.612	0.013*
Adj_ROE	0.646*	0.096	0.66	0.67	0.105**
Fixed Effects: Bank Name and Year					
*p<0.1; **p<0.05; ***p<0.01					

Table 12d: Effects of mobile phone penetration rates, business banking app and financial standards on ROA and ROE (Small Banks)

Estimation method: OLS					
Small Mobile Banks (2010-2017: 120 observations)					
Independent Variables	M_MOBAGEB_ISO (Business)	M_MOBAGEB_ISO (Business)	Adj R-sq (ISO)	Adj R-sq (MOB_PEN)	MOB_PEN
Dependent Variables					
Adj_ROA	-0.064	-0.064	0.601	0.662	0.007***
Adj_ROE	0.201	0.197	0.66	0.67	0.105**
Fixed Effects: Bank Name and Year					
*p<0.1; **p<0.05; ***p<0.01					

For the subset of large mobile banks, mobile penetration rates had a negative relationship with banks' adoption of both retail and business banking app,

Estimation method: OLS
Large Mobile Banks (2010-2017: 128 Observations)

Independent Variables	M_MOBAGER_ISO	M_MOBAGER_ISO (Retail)	Adj R-sq (ISO)	Adj R-sq (MOB_PEN)	MOB_PEN
Dependent Variables					
Adj_ROA	-0.024***	-0.029***	0.786	0.789	-0.004
Adj_ROE	-0.223***	-0.293***	0.763	0.772	-0.065**
Fixed Effects: Bank Name and Year					
*p<0.1; **p<0.05; ***p<0.01					

financial standards and the adjusted ROE at -0.065** with the adjusted R^2 at 77.2%, higher than the adjusted R^2 of the previous model at 76.3% as shown in Tables 12e and 12f.

Table 12e: Effects of mobile phone penetration rates, retail banking app and financial standards on ROA and ROE (Large Banks)

Table 12f: Effects of mobile phone penetration rates, business banking app and financial standards on ROA and ROE (Large Banks)

Estimation method: OLS					
Large Mobile Banks (2010-2017: 128 Observations)					
Independent Variables	M_MOBAGEB_ISO	M_MOBAGEB_ISO (Business)	Adj R-sq (ISO)	Adj R-sq (MOB_PEN)	MOB_PEN
Dependent Variables					
Adj_ROA	0.035**	0.031*	0.786	0.789	-0.004
Adj_ROE	0.284	0.224	0.763	0.772	-0.065**
Fixed Effects: Bank Name and Year					
*p<0.1; **p<0.05; ***p<0.01					

4.5 Discussion and the status of the hypotheses

In this section, I will discuss the results of the multivariate panel regression models presented in the earlier section and each of the four hypotheses tested. I will discuss whether regression results found any evidence that fintech innovations led to better bank financial performance: (1) across all financial indicators or selective; (2) across all sample banks or selective small or big banks with particular business focus; and (3) whether financial standards mediate the relationship between fintech innovations and bank performance.

The table has full sample of 31 mobile banks which are split into smaller and larger banks based on median assets of U$28.9 billion. A variety of financial indicators are regressed by three kinds of mobile banking technologies – retail, business and investment banking apps first released by banks and a number of years of the app in release to 2017 is counted incrementally.

My research is based on a panel data of 36 ASEAN commercial banks' adoption of fintech innovations measured by their mobile banking application (app) releases in three kinds below:

- Retail banking app: provides retail customers with mobile banking functionalities such as account inquiry, bill payments, funds transfer. Some apps offer consumers to apply for car loan and morgages, time deposit and account opening
- Business banking app: provides business owners, SMEs and corporates with business banking services which mainly focus on payment and transaction approval and account inquiry through the mobile app

- Investment banking app: offers individual and institutional investors and traders with a mobile platform to trade stocks, bonds, mutual funds and foreign exchange

Please refer to Appendix 8 for Mobile Banking App Capabilities of Sample ASEAN Banks. Multivariate panel regressions revealed whether any of these three kinds of mobile app innovations led to higher bank performance.

4.5.1 Status of the First Hypothesis

Firstly, the regression results **rejected the null hypothesis**, *Adoption of mobile banking technologies has no impact on all financial indicators across all banks* as there was a significant relationship between banks adoption of mobile banking technologies and bank performance. The following table summarizes the results of the null hypothesis$_0$ and the first hypothesis$_1$ tested:

Table 13: The Results of the Null Hypothesis$_0$ and the First Hypothesis$_1$

Hypothesis	Status	All banks			Small			Large		
Independent Variables: Mobile apps (Retail, Business, Investment)		R	B	I	R	B	I	R	B	I
H$_0$: Adoption of mobile banking technologies has no impact on all financial indicators across all banks	**Rejected**	X	X	X	X	X	X	X	X	X
H$_{1a}$: Adoption of mobile banking technologies will have a bigger impact on **small banks than on large banks in terms of fee income**	**Accepted**	X	X	O	X	X	O	X	X	X
H$_{1b}$: Adoption of mobile banking technologies will have a bigger impact on **small banks than on large banks in terms of operating costs**	**Accepted**	X	X	X	O	O	X	X	X	X
H$_{1c}$: Adoption of mobile banking technologies will have a bigger impact on **small banks' consumer loans than on large banks'**	**Accepted**	X	X	O	X	X	O	X	X	X
H$_{1d}$: Adoption of mobile banking technologies will have a bigger impact on **small banks' ROA than on large banks'**	**Accepted**	X	X	X	X	X	O	O	X	X
H$_{1e}$: Adoption of mobile banking technologies will have a bigger impact on **small banks' ROE than on large banks'**	**Accepted**	X	X	X	X	X	O	O	X	X

The effect was stronger for small banks in Thailand and Malaysia which adopted their investment banking app that facilitated trading of fx and securities instruments, such as stocks, bonds and mutual funds. Referring back to Table 5 that presents the regression results of the effects of mobile banking technologies on bank income statement, coefficients of fee-based income related to the investment banking app (0.220***) was significantly higher and its effects were larger on small banks. The data therefore illustrates that financial benefits are clearly visible in the investment banking app that facilitates e-trading of securities and foreign exchange and hence allowing banks to generate fee-based income.

On the liability side of the balance sheet, the effect of mobile banking technology, particularly the investment banking app in Table 7 positively impacted money market deposits with very high coefficients (5.916***; p-value =0.01). At the same time, demand deposits and time deposits were negatively affected by the investment banking app at -5.509*** for small banks and -1.183** for large banks respectively. These results are consistent with the past research by DeYoung (2007) where new technologies facilitate easier funds shift from low or noninterest-bearing demand deposit accounts and/or time deposit accounts to higher yielding money market funds. The positive and statistically significant effect of investment banking apps on bank performance (measured by ratio of money market deposits / total deposits) is important because it demonstrates greater financial benefits of fee income generation from e-trading activities. Therefore, the regression models showed that mobile banking technologies were statistically significant in the fee-based income, providing clear evidence to reject the null hypothesis$_0$ and accept the alternative hypothesis $_1$a, *Adoption of mobile banking technologies will have a*

bigger impact on small banks than on large banks in terms of fee income was accepted.

Regressions analysis also found a statistically significant relationship between mobile technologies and reduction of operating costs, such as selling general and admin expenses (SG&A), thus, hypothesis$_1$b *Adoption of mobile banking technologies will have a bigger impact on small banks than on large banks in terms of operating costs* was accepted. The effect was larger on small banks' reduction of SG&A.

The clear evidence was a statistically significant relationship between banks' adoption of mobile technologies and transaction-driven consumer loans, which are typically in smaller size and one-off lending businesses. This includes mortgages, car loans and credit cards which consumers can apply through mobile banking apps offered by some commercial banks in ASEAN. In contrast, relationship-driven commercial loans, which are larger in size and require due diligence face to face, were not affected by mobile technologies. Among the three types of apps, the investment banking app that facilitated securities trading of stocks, bonds, mutual funds and fx significantly affected consumer loans with the highest coefficients (5.834***) in this regression research (***p-value = 0.01) particularly for smaller banks in Thailand. Trading of securities instruments and fx are often associated with margin finance and consumer finance. Therefore, the regression models demonstrated that fintech innovations were statistically significant in the consumer loans, providing clear evidence to support hypothesis$_1$c, *Adoption of mobile banking technologies will have a bigger impact on small banks' consumer loans than on large banks'.* The e-broking and trading and associated credit lines are typically small in size and transaction-driven instead of relationship-based lending / deposit

taking business that generate interest margins over years. Based on the transaction lending theories, it is understandable that mobile banking technologies affected consumer loans rather than relationship based commercial loans.

In terms of measuring the effect of mobile banking technologies on bank profitability, Table 5 showed the regression results of the effects of mobile banking technologies on ROA and ROE of small banks, providing support to reject the null hypothesis and accept the alternative hypothesis$_1$d and hypothesis$_1$e. The effects were much larger on the small banks than on big banks' ROA and ROE. Further the innovation theories where ICT play a key role in reducing operating costs while generating new source of revenue, reflects the effect of product and process innovations arising from the mobile banking apps.

4.5.2 Status of the Second Hypothesis

Multivariate panel regression models were also run to measure the mediating effect of financial standards. The results revealed a positive relationship between banks' adoption of mobile banking technologies and financial standards. The following table summarizes the results of the null hypothesis$_0$ and the second hypothesis$_1$ tested:

Table 14: The Results of the Null Hypothesis$_0$ and the Second Hypothesis$_1$

Hypothesis 2	Status	All banks		Small		Large	
Independent Variables: Mobile apps (Retail and Business)		R	B	R	B	R	B
H_0: Banks' adoption of mobile banking technologies will not impact the adoption of financial standards	Rejected	X	X	X	X	X	X
H_1: Banks' adoption of mobile banking technologies will impact the adoption of financial standards	Accepted	O	O	X	X	O	O

The results of the regression models that show a positive relationship between banks' adoption of mobile banking technologies and banks' years of financial standards adoption – ISO 20022 at 0.172*** for retail mobile banking application and 0.202*** for business mobile banking application with the adjusted R2 at 61.2%. Therefore, the regression models showed that fintech innovations were statistically significant in financial standards, providing clear evidence to reject the null hypothesis and accept the alternative second hypothesis. The effect of mobile banking technologies is stronger for big banks' retail mobile application at 0.239*** and business mobile application at 0.199***. It means the yearly increase in the mobile banking offering by banks increase bank's adoption of ISO 20022 financial standards by 0.106. Financial standards evolve as technologies evolve, e.g., ISO 20022 APIs for addressing for real time payments using mobile number, facebook account and NRIC number. More agile and faster standards creation is the current development. The financial standards facilitate technological innovations to make new services easily and widely adoptable by critical mass.

4.5.3 Status of the Third Hypothesis

Table 9 shows the results of the regression analysis of the effect of financial standards on bank performance, showing evidence to support the third hypothesis$_1$a, hypothesis$_1$b and hypothesis$_1$c. Advent of financial standards ISO 20022 facilitate interoperability and network externalities with vastly improved payment processing efficiency and automation of financial transactions. For instance, the data processed through ISO 20022 is of a much higher quality than that provided by other formats. This helps accelerate straight-through processing, while also reducing the number of errors – saving time, costs and administrative efforts. The improved data quality

will also simplify compliance, including sanctions screening, anti-money-laundering, counter-terrorist-financing checks and support for fraud detection.

Table 15: The Results of the Null Hypothesis$_0$ and the Third Hypothesis$_1$

Hypothesis 3	Status	All banks	Small	Large
Independent Variable: Banks' Years of ISO 20022 Financial Standards Adoption				
H_0: Adoption of financial standards has no impact on all financial indicators across all sample banks	**Rejected**	X	X	X
H_{1a}: Adoption of financial standards will have a bigger impact on **small banks' ROA than on large banks'**	**Accepted**	X	O	X
H_{1b}: Adoption of financial standards will have a bigger impact on **small banks' ROE than on large banks'**	**Accepted**	X	O	X

4.5.4 Status of the Fourth Hypothesis

The following table shows the results of the regression analysis of the combined effects of financial standards and fintech innovations on bank performance that rejected the null hypothesis *Adoption of both mobile banking technologies and financial standards has no impact on all financial indicators across all banks, and accepted the alternative* fourth hypothesis1a: *Adoption of both mobile banking technologies and financial standards will have a bigger impact on small banks' ROA than on large banks'*. The results also supported the fourth hypothesis$_1$b *Adoption of both mobile banking technologies and financial standards will have a bigger impact on small banks' ROE than on large banks'*.

Table 16: The Results of the Null Hypothesis$_0$ and the Fourth Hypothesis$_1$

Hypotheses	Status	All banks		Small		Large	
Independent Variables: Mobile apps (Retail & Business adopted ISO 20022)		R	B	R	B	R	B
H_0: Adoption of both mobile banking technologies and financial standards has no impact on all financial indicators across all sample banks	**Rejected**						
H_{1a}: Adoption of both mobile banking technologies and financial standards will have a bigger impact on **small banks' ROA than on large banks'**	**Accepted**	X	X	O	X	X	O
H_{1b}: Adoption of both mobile banking technologies and financial standards will have a bigger impact on **small banks' ROE than on large banks'**	**Accepted**	X	O	O	X	X	X

4.5.5 Macroeconomic and Market Effects

According to past research, bank performance is largely affected by macroeconomic factors such as country GDP and real interest rates. Evidence from the Asia financial crisis in 1997 and Global financial crisis in 2008 suggest that bank-specific characteristics together with macroeconomic conditions explained bank failures. The following table shows the effect of GDP per capita on bank ROA and ROE.

Table 17: The Results of the Null Hypothesis$_0$ and the Macroeconomic and Market Effects

Hypotheses	Status	All banks		Small		Large	
Independent Variables: Mobile apps (Retail & Business adopted ISO 20022)		R	B	R	B	R	B
H0: Adoption of both mobile banking technologies and financial standards has no impact on all financial indicators across all sample banks	**Rejected**						
H1d: Adoption of both mobile banking technologies and financial standards will have a bigger impact on small banks' **ROA** than on large banks'	**Accepted**	X	X	O	X	X	O
H1e: Adoption of both mobile banking technologies and financial standards will have a bigger impact on small banks' **ROE** than on large banks'	**Accepted**	X	O	O	X	X	X
GDP Per Capita & **ROA**	**Nil**	X		X		X	
GDP Per Capita & **ROE**	**Positive**	O		O		O	
Mobile Phone Penetration Rate & **ROE**	**Positive**	X		O		X	
Mobile Phone Penetration Rate & **ROA**	**Positive**	O		O		X	

The regression models showed the overall influence of GDP per capita on bank ROE but not ROA. A possible reason for a stronger relationship between GDP and bank ROE is when economy grows at a faster pace, it will require higher amount of capital and create greater credits and liquidity in the market. This enhances the banking business and its penetration in ASEAN economy in terms of capital flows and investment flows into the equity markets and stimulate stock markets, thus resulting in a greater level of profitability for banking sector and greater return on equity. ROE is affected more than ROA because ROE reflects finance leverage / debts / investments which can be more influenced by external macroeconomic environment. In terms of the market effect observations, a country's mobile banking penetration rates positively impacted small banks' ROA and ROE.

Based on the above results, I can summarize that bank performance is influenced by banks' ability to leverage on new technologies to innovate – in this research, mobile banking innovations, expand the mobile banking customer base and activate their usage. Also, because the input is mobile banking technologies, the banks located in the countries like the Philippines and Thailand with a large number of mobile phone users showed greater relationship between fintech

innovations and financial performance. Drawing on the research framework based on four economic theories of technological innovations, transaction costs, standards effects and macroeconomic and market conditions, this empirical research results were interpreted as follows: (1) banks' adoption of mobile banking technologies positively impacted banks' fee-based income, consumer loans and money market deposits; (2) its effects were much larger for smaller banks in the Philippines and Thailand; and (3) financial standards showed a mediating effect on bank profitability for both big banks and small banks in ASEAN. Overall, this research concludes that both fintech and financial standards' positive impact on bank performance collectively contribute towards regional financial integration in ASEAN.

4.6 Recommendations

Following the research findings and multivariate panel regression interpretations, this section will provide recommendations for ASEAN commercial banks, ASEAN regulators / central banks and standardization bodies.

ASEAN Commercial Banks

Firstly, all staff and senior management of both small and large banks can consider developing their entrepreneurial spirit to continue leveraging on the mobile banking platform to innovate and improve customers' banking experiences. Innovation is defined by Schumpeter as something new, new services and processes enabled through mobile channels, new market expansion into the unbanked/underbanked populations with mobile phones and developing a new business model and seeking for new suppliers in accordance with the new way of

doing business. Providing education and training on entrepreneurship for people in the ASEAN banking sector may also facilitate the development of entrepreneurial mind-sets to deliver innovative banking solutions for tech-savvy customers and build more sustainable future in the region.

Secondly, both small and large ASEAN commercial banks should continue investing and enhancing their mobile banking applications and mobile technologies in line with the mobile banking user requirements. It is important to also keep track of the technological investments and its impact on fee income streams, interest income streams, different cost components and balance sheet components. Among the sample banks in ASEAN, DBS is the only bank that developed a methodology to measure the financial impact of digitization such as ROE and cost-income ratio based on customer's digital adoption and this is reflected in their annual report from 2017. Measuring and tracking the progress made in growing mobile banking customers and transactions, and quantifying financial value created though the mobile channels would further drive digitization towards cashless/cash-light economies and create more financially inclusive societies in the ASEAN region, especially in the Philippines and Thailand.

Thirdly, all ASEAN commercial banks are recommended to adopt financial standards, such as ISO 20022 to contribute to the form of standards network effects. Users can benefit from the network with an increase in the number of new users who improve value of products and services thereby leading to improve financial performance. However, in order to benefit from the financial standards, all banks should firstly implement and use the standards correctly and harmoniously to facilitate interoperability among different systems and user communities that have adopted the same standards. For consistent implementation of the standards, banks'

participation to the standards and the market practice development is recommended as they can access a wide range of knowledge sources in the standards committee and discuss and shape the specifications for more efficient adoption. Participation in the standards and market practice development can also reinforce user confidence and acceptance and consequently create new markets and growth business opportunities thus leading to higher performance.

Regulators / Central Banks

Besides ASEAN commercial banks' efforts to provide innovative solutions, the importance of regulators' involvement in supporting and facilitating fintech development is also to be noted. The ASEAN regulators of central banks are best placed to gather the industry stakeholders together to facilitate the adoption of new technologies and financial standards to create an interoperable financial ecosystem. The regulators can actively promote and build awareness around the use of financial standards and its benefits by organizing regular briefings with industry stakeholders. Stakeholders may include commercial banks, government agencies, fintech companies, investors, vendors and the media. It will be useful to create a sense of shared vision towards an interoperable financial ecosystem to enable banks and organizations to seamlessly manage different systems and applications using ISO 20022, the standards of choice for the ASEAN Economic Community.

The ASEAN regulators can also play an active role in ensuring a harmonized use of financial standards across the 10 member states to create interoperable payment clearing and settlement systems for safe and efficient financial operations thereby facilitating regional economic development. There have been ongoing efforts to harmonize the payment market practices in ASEAN and build the baseline for harmonious and interoperable payment operations. The usage of common

financial standards has been highly recognised as key enabler for an interoperable and innovative financial ecosystem for the ASEAN.

Additionally, the regulators may also consider providing industry stakeholders and players with tools and best practices for the easy adoption of new technologies and financial standards and test their compliance with these practices. Their support is especially useful for small banks in the Philippines and Thailand whose financial performance was positively affected by the adoption of mobile banking technologies but their adoption of financial standards is slower compared to large banks in Singapore and Malaysia. The regulator's support will be useful for small banks to equally benefit from the fintech innovations and financial standards and thus continue to stay competitive in a rapidly evolving financial industry.

Standardization Bodies

Standardization bodies like SWIFT and ISO technical committees can also play an important role in facilitating global interoperability and seamless financial data exchange among different user communities, applications and systems using the financial standards. Although these international standardization bodies promote and facilitate open and collaborative standards and market practice development, in reality, none of the ASEAN banks nor regulators are actively engaging global standards and market practice discussion and definition. Although participation to standards and market practice development process has been increasing from East Asian countries such as Japan, China and Hong Kong, to a large extent, global standards working groups are defined and shaped by the participants from the western countries as they have a larger financial transaction volume compared to ASEAN even if the transaction volumes from all 10 member states are combined. Having representatives from banks and regulators from the

diverse ASEAN countries in the standards working groups will be useful to incorporate different market nuances such as the use of local language to facilitate seamless financial transactions and attract investment flows and capital flows into the rapidly growing ASEAN economies. More inclusive financial standards and market practice development will help drive digitization in ASEAN and move from manual to straight-through processing operations. Leveraging financial standards will help ASEAN banks, particularly, small banks to handle higher business volumes with fewer resources thereby leading to improvement in operational efficiency.

Finally, in order to ensure consistent and correct implementation of financial technologies and financial standards, standardization bodies may consider actively lobbying regulators to consider enforcing and mandating the standards adoption in the industry. This research looked at a sample of 36 ASEAN local commercial banks, and about 33% of them were certified and listed as standards-ready banks at SWIFT. Regulatory enforcement and certification of banks to consistently implement and use financial standards will further generate and extract value of financial technologies and financial standards and lead to higher bank performance.

5. Conclusion

This research empirically tested the impact of fintech innovations and the mediating effects of financial standards on financial performance of 36 local commercial banks in ASEAN - Singapore, Malaysia, Thailand, the Philippines and Brunei Darussalam for the period of 2010 to 2017.

The results of the multivariate panel regression analysis found that fee-based income of small banks, such as securities investment fees, account service charges, foreign exchange fees were positively affected by the adoption of the mobile banking technologies. The effect of mobile technologies on financial performance was much stronger for small banks in the Philippines, Thailand and Brunei Darussalam than large banks in Singapore and Malaysia. There was also clear evidence to support the effect of mobile banking technologies on small banks' operating cost reduction in terms of SG&A while large banks remained unaffected. Among the three types of mobile banking apps, the investment banking app that facilitated trading of stocks, bonds, mutual funds and FX had a stronger effect on income statement of small banks.

On the asset side of the balance sheets, the most significant finding came from the small banks' consumer loans which were positively affected by the mobile technology of investment banking app while big banks remained unaffected. This was the highest coefficient found in the asset side of the balance sheets whereby a yearly increase in the bank's adoption of mobile banking technologies would increase the bank's consumer loans by 5.834%. Consumer loans are typically one-off, transaction-driven such as car loans, mortgages and credit cards and small banks in the Philippines, Thailand and Brunei Darussalam offer mobile banking apps with the capabilities to channel through loan applications from consumers. In

contrast, commercial loans, which are associated with longer time of borrower-bank relationship and that which requires face to face due diligence for granting business loans were not affected by mobile banking technologies.

As for the liability side of the balance sheet, another statistically significant effect was found on the small banks' money market funds which were positively affected by the mobile technology of investment banking app. Consistent with the past research by DeYoung (2007), new mobile technologies also enabled customers in ASEAN to easily and flexibly shift funds from low or non-interest bearing accounts or fixed deposit accounts to higher yield money market funds accounts. This is the highest coefficient found in this research whereby a yearly increase in the bank's adoption of investment mobile app would increase the bank's money market funds by 5.916%. At the same time, mobile technology of investment banking app negatively affected the balance of demand deposits and fixed deposits and these results are consistent with the research by DeYoung (2007). Profitability of both ROA and ROE were positively affected by banks' adoption of mobile technology of investment banking app, and its effects were much stronger on small banks.

With regards to the mediator research variable of the financial standards, the multivariate panel regression results found a strong mediating relationship between mobile banking technologies and financial standards. The effects of the financial standards in this research were measured by banks' years of ISO 20022 standards adoption. The research found a statistically significant positive relationship between mobile technology of retail banking app and small banks' ROE and ROA. Further mobile technology of business banking app positively affected large banks' ROA, however, its coefficients were small.

Additional independent variables such as a country's mobile penetration rates and GDP per capita were included in the models to see if any statistical differences were observed in the adjusted R^2 in two different multivariate panel regression models. In terms of GDP per capita, there was a statistically significant effect observed on ROE for both small and large banks but not ROA. A possible explanation for the stronger effect on ROE is if Gross Domestic Product increases yearly then ROE will also increase and, vice versa. It seems rational that if an economy grows at a faster pace than usual, it requires a higher amount of capital, credits and liquidity in the market. GDP growth would also enhance banking business and its penetration in the ASEAN economies in terms of capital inflows and stimulate the equity markets, thus leading to greater level of profitability for the banking sector and greater return on equity. Here a significant positive relationship supports the same rationale. ROE is affected more than ROA because ROE reflects greater liquidity made available through financial leverage and debts which are often influenced by macroeconomic conditions. Additionally, the market condition of a country's mobile phone penetration rates positively affected bank ROA and ROE and its effect was larger on small banks in the Philippines and Thailand with a significant growth of unbanked / underbanked populations with mobile phones.

Based on this research, the results of the multivariate panel regressions demonstrated that a positive fintech influence on the selected commercial banks in ASEAN, particularly small banks in the Philippines and Thailand. It is understandable that these countries are cash-heavy and a large proportion of populations outside the metro area are largely unbanked/underbanked but with a rapid mobile phone penetration growth. Therefore, the banks operating in these

environments can expand these new customer segments of under-served populations towards higher financial performance.

In terms of future research, firstly, the scope of this research is limited to the banking sector in ASEAN markets for an eight-year-period from 2010 to 2017. It will be beneficial to analyse the fintech effects beyond ASEAN, such as Europe where financial standards ISO 20022 was adopted by SEPA – Single Euro Payment Area about ten years earlier than Asia Pacific. Technologies and standards adoption, usage and its effects take time. Future research should take the time lag factor into consideration and cover different countries and regions with comparative banking structures to improve the research generalizability and portability of the results.

Secondly, this research looked at a variety of financial performance of local commercial banks in ASEAN. While this research used these financial measures of the banks at HQ level, a number of banks have branches and subsidiaries in the region. For example, Malaysian banks like CIMB, RHB, Maybank and Hong Leong are already participating in the real-time retail payment system in Singapore but in their home country in Malaysia, they are in the middle of implementing similar technologies. Therefore, it will be useful to have a comprehensive view of bank financials at both HQ level and regional branch/subsidiary level to determine the fintech effects.

Thirdly, the impact of financial technologies is no longer limited to the banking sector but also widely used across different industries. Especially, payment technologies which are integrated with many sectors such as e-commerce, telecommunications, media, transport, logistics, trading, government sector, etc. Take for example the recent examples of UOB–Grab partnership to jointly reach

out to unbanked population and DBS–GOJEK collaboration to offer rides to DBS/POSB card members. It will be useful to see the applicability of this research across the financial and technology sector as well as over different sectors which are equally influenced by new technologies as well as standards and regulations, such as healthcare, logistics, food and education. Analysing sample data from different sectors will provide a holistic view of the effects of fintech on firm performance.

Fourthly, although this research looked at a variety of bank financial measures, it would be useful to drill down further the cost structure, such as the specific IT spends, cost of branch operations, R&D intensity, number of full-time employees and the respective returns on technologies and human capital investments to perform robustness checks to see whether the fintech effects appear differently. For the income streams, it would be interesting to look at bank cash flow statements to see the impact of fintech on cash inflows and outflows. Due to the unavailability of the data, it was not possible to investigate into the financial effects further in this research.

Fifthly, this research focused on the supply side of technology innovations by banks. The subsequent research should analyse not only the supply side of the technologies but also the demand side of how customers are adopting and using new technologies and how actively they are using the technology and for what purpose. It would be useful to look at the digital engagement index to analyse different user segments to see the technology consumption patterns and volume and value of financial transactions.

Finally, it would be useful to analyze the dark side of financial innovations such as a global financial crisis triggered by the 'innovative process' of securitizing the subprime mortgages into collateralized securities and sell off in a secondary market which created a moral hazard and eventually led to the mortgage crisis. Further financial innovations of mobile banking's capabilities to easily channel through consumer loan applications and activation of multiple credit cards for example, may lead people overusing credits unnecessarily thereby accumulating debts and increase default risks. Thus future research can be based on primary data such as survey and interviews with consumers to understand the debtors' side experience with the dark side of fintech innovation and adoption.

This research looked at the fintech and financial standards adoption by selective local commercial banks in five ASEAN markets – Singapore, Malaysia, Thailand, Philippines and Brunei Darussalam. The full extent of the success of the ASEAN 2025 Vision and its regional financial integration for the member states to engage, modernize their payment market infrastructures and integrate them using financial standards depends heavily on regional cooperation and agreement. It also depends on widening the adoption of fintech innovations and the take up of these technological innovations and financial standards by the rest of the ASEAN countries as the standard for regional financial integration. This research shows that such efforts are still at the early stages but nevertheless ASEAN has begun the journey of financial integration using financial standards.

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Appendix

1. The Impact of Digital Financial Services on Firm's Performance: Methodology

Table 4: Articles of literature review

No	Author,Year	methodology/approach used	sample size	countries of study
1	(Dandapani et al., 2008)	regression analysis for bank specific financial variables	6566	USA
2	(DeYoung et al., 2007)	percentage change in income and balance sheet selected items	5599	USA
3	(Del Giudice et al., 2016)	classification analysis method (classification and regression tree).	3692	Europe
4	(Lin et al., 2011)	propensity-score matching and difference-in-differences methods	2487	USA
5	(Acharya et al., 2008)	structural equation modeling and multiple regression analysis	640	USA
6	(Callaway, 2011)	regression analysis	369	Turkey
7	(Hung et al., 2012)	regression and sensitivity analysis	181	Taiwan
8	(Meepadung et al., 2009)	data envelopment analysis	165	Thailand
9	(Kondo, 2010)	regression analysis	128	Japan
10	(Ciciretti et al., 2009)	financial ratio and regression and robust analysis	105	Italy
11	(Malhotra and Singh, 2006)	regression analysis	88	India
12	(Malhotra and Singh, 2009)	financial ratio analysis and multivariate analysis	85	India
13	(Malhotra and Singh, 2010)	Financial ratio analysis and multivariate analysis	82	India
14	(Akhisar et al., 2015)	regression analysis	82	23 countries
15	(Hernando and a J. Nieto, 2007)	Financial ratio and multivariate analysis	72	Spain
16	(Delgado et al., 2007)	Financial ratio Analysis and The regression analysis of scale and experience	60	Europe
17	(Ugwueze and Nwezeaku, 2016)	co-integration and causality approach	60	Nigeria
18	(Uchida et al., 2011)	financial ratio analysis	40	Bangladesh
19	(Ho and Wu, 2009)	data envelopment and principal component analysis	32	Taiwan
20	(Kennedy and Jacky, 2013)	qualitative analysis	30	Kenya
21	(Mehmood et al., 2015)	seemingly unrelated regression estimation and cobb-douglas production function	30	Pakistan
22	(Tunay et al., 2015)	demitrescu-Hurlin panel causality tests	30	Turkey
23	(M. Kamboh and E.J. Leghari, 2016)	regression analysis	30	Pakistan
24	(Stoica et al., 2015)	data envelopment and principal component analysis	24	Romania
25	(Van et al., 2015)	regression analysis	20	Vietnam
26	(Ceylan and Emre, 2011)	regression analysis	18	Turkey
27	(Mohammad and Saad, 2011)	regression analysis	15	Jordan
28	(Ceylan et al., 2008)	regression analysis for bank specific financial variables	14	Turkey
29	(Siddik et al., 2016)	regression analysis	13	Bangladesh
30	(Muhammad et al., 2013)	regression analysis	11	NIgeria
31	(Georgia and Christos, 2013)	regression analysis	11	Greece
32	(Lavinia, 2014)	regression analysis	11	Romania
33	(Georgia and Christos, 2015)	data envelopment and regression analysis	11	Greece
34	(Wu and Dash Wu, 2010)	data envelopment and principal component analysis	10	USA & UK
35	(Majid and Mohammad, 2013)	regression analysis	8	India
36	(Al-Hawari and Ward, 2006)	effect of service quality on bank profitability: structural equation modeling	4	Australia
37	(Abaenewe et al., 2013)	financial ratio analysis	4	Nigeria
38	(Sõrg and Luštšik, 2006)	activity-based-costing (ABC)	1	Estonia
39	(D. Karimzadeh et al., 2014)	regression analysis	1	Iran

Table 6: List of techniques used

No	methodology /technique used	# of articles
1	Financial ratio, percentage change (income and balance sheet) and Regression Analysis	27
2	Data envelopment and principal component analysis	5
3	Structural equation modeling	2
4	Co-integration and causality approach	2
5	Activity-based-costing (ABC)	1
6	Propensity-score matching and difference-in-differences methods	1
7	Cobb-Douglas production function	1
8	Classification analysis method	1

Source: Abbasi, T., & Weigand, H. (2017)

2. The Impact of Digital Financial Services on Firm's Performance: Research Variables

Table 7: Dependent, Independent and control variables

No	Dependent Variable	Frequency	Independent variable	Frequency	Control Variable	Frequency
1	return on equity (ROE)	25	number of ATMs	12	bank size	15
2	return on assets (ROA)	24	internet adoption	11	loans	11
3	revenue or net income	9	online or internet banking	10	deposits	11
4	non interest income	8	number of branches	7	equity	6
5	interest income	5	point of sale (POS)	5	Gross domestic product (GDP)	6
6	domestic deposits	4	number of employees	5	inflation	6
7	growth in assets	4	credit cards	4	operating cost	4
8	operating expense	3	debit cards	4	return on assets (ROA)	2
9	non interest expense to earning assets	3	website	4	job growth	2
10	staff costs	3	electronic banking	3	market share	2
11	daily reach rate/average internet users	3	mobile banking	3	non interest income	2
12	net lending to total assets	3	IT equipment	2	return on equity (ROE)	1
13	efficiency ratio	3	Bank location	2		
14	IT costs	2	telephone /Call Center Banking	2		
15	marketing expenses	2	IT expense	1		
16	interest spread	2	Customer Service Quality	1		
17	total commission and fees to assets	2				
18	earning per share (EPS)	2				
19	global deposits	1				
20	non performing loans to asset ratios	1				
21	non performing assets to net advances	1				
22	equity to liabilities	1				
23	net interest financial margin to earning assets	1				
24	price to earning ratio	1				
25	profit per branch	1				
26	equity to total assets	1				
27	asset utilization	1				
28	willingness to improve level of business	1				

Source: Abbasi, T., & Weigand, H. (2017)

3. List of Sample ASEAN Banks by Asset Size

List of Large Mobile Banks in 2017 (2010-2017 Median Assets > U$ 28.9B)

	Bank Name	Country	Mean	Std. dev.	Median
1	DBS	SG	309759.766	61380.173	321752.88
2	OCBC	SG	261722.013	57752.239	272656.35
3	UOB	SG	216028.714	38143.005	221139.185
4	Maybank	MY	147138.931	38120.783	150557.59
5	Bangkok Bank	TH	80191.874	12389.603	83024.155
6	Public Bank	MY	79699.445	15762.746	81691.495
7	Siam Commercial Bank	TH	75720.04	16814.188	81125.59
8	Krung Thai Bank	TH	76101.835	12929.669	80546.305
9	CIMB	MY	79744.836	19158.208	80391.105
10	Kasikornbank	TH	71011.905	15181.141	72527.315
11	RHB	MY	47232.798	10903.316	47500.88
12	Hong Leong Bank	MY	40496.555	8846.366	41875.635
13	Bank of Ayudhya	TH	42462.408	14211.915	37059.99
14	BDO Uni	PH	32659.061	11280.223	33242.415
15	Ambank	MY	30731.98	3681.012	32643.09
16	Thanachart	TH	30500.551	1973.781	31358.14

List of Small Mobile Banks in 2017 (2010-2017 Median Assets < U$28.9B)

	Bank Name	Country	Mean	Std. dev.	Median
1	Metropolitan	PH	27250.939	8472.335	28041.225
2	Bank of the Philippine Islands	PH	24,671.40	7,487.67	24,868.27
3	TMB	TH	23559.254	2616.003	24227.245
4	Affin	MY	15344.52	2106.249	15879.365
5	Philippine National Bank	PH	10454.764	4020.593	11672.18
6	TISCO	TH	8558.541	1766.309	8847.25
7	CIMB Thai	TH	7623.736	2033.186	8584.37
8	China Bank	PH	8555.136	3332.675	8318.235
9	RCBC	PH	8210.462	1689.397	8269.875
10	Union Bank	PH	7605.977	2466.482	7874.75
11	Kiatnakin	TH	6914.649	1194.151	7283.77
12	Security Bank Corp	PH	7918.887	4139.828	7000.56
13	LH Financial	TH	4746.564	1909.672	4868.07
14	Baiduri	BN	2469.246	356.12	2468.745
15	Asia United Bank	PH	2144.064	1067.806	2160.485

List of Non-Mobile Banks in 2017

	Bank Name	Country	Mean	Std. dev.	Median
1	Alliance	MY	11345.096	2241.382	11499.16
2	EastWest	PH	3464.054	1671.506	3107.28
3	Philippine Trust Company	PH	2363.079	396.166	2324.06
4	Philippine Bank of Communications	PH	1227.307	415.88	1264.62
5	Philippine Business Bank	PH	961.694	434.878	987.11

4. Country Snapshot

4.1 Malaysia

In the Malaysian banking system, commercial banks form the largest component comprising 8 publicly listed local commercial banks and 18 locally incorporated foreign banks. There are also 16 Islamic banks (11 domestic and 5 foreign banks), 2 international Islamic banks, 11 domestic investment banks, and 2 other financial institutions (Bank Negara Malaysia, 2019). Commercial banks in Malaysia are licensed under the Banking and Financial Institutions Act 1989 (BAFIA) by Bank Negara Malaysia, the central bank in Malaysia. The commercial banks continued to perform well in 2017 the average return on equity increased to 13% while average return on assets rose to 1.5%. The conservative earnings retention policies resulted in higher capital reserved by banks with capital ratios well above the minimum regulatory requirements and the Basel III Capital Adequacy benchmark (The Association of Banks in Malaysia, 2017). Refer to Appendix for the profile of the commercial banks in Malaysia.

4.2 The Philippines

The Philippine banking sector consists of 36 universal and commercial banks, 55 thrift banks, and 483 rural and cooperative banks[24]. The commercial bank in the Philippines are primarily owned by shareholders that accept deposits and extend credits to earn interest. They also offer personal, business, and mortgage loans, checking and savings accounts, foreign exchange, commodity trading and securities

[24] Bangko Sentral ng Pilipinas, 2019, Directory of Banks and Non-Banks Updated as of 28 January 2019

investments. A universal bank may, in addition, invest in equities of allied and non-allied companies, financial or non-financial. Of the 36 universal and commercial banks, 13 banks are publicly listed. Provided under Section 4 of Republic Act No. 8791, the operations and activities of these banks are subject to supervision of the Bangko Sentral ng Pilipinas, the central bank of the Philippines. The Philippine's economic growth is largely supported by a growing number of Overseas Filipino Workers who send home a portion of their earnings through remittances that accounted for 10% of GDP in 2017. The volume of these remittances has grown over years as more and more Filipino workers have found jobs abroad. The bulk of the remittances came from the US, UAE, Saudi Arabia, Japan and Singapore. These remittances are immediately booked for country's balance of payments which is tracked by the BSP. The recipients of the remittances are likely unbanked or underbanked because traditionally retail banking is not well developed to serve people in the remote locations. The result is that majority of Filipinos remains unbanked and are forced to turn to unregulated channels such as moneylenders, pawnshops and community or family based financial assistance. In contrast to the number of unbanked, the Philippines has a high mobile usage rate. This unleashes tremendous opportunities for the banks and financial service providers to reach the unbanked and provide financial services.

4.3 Thailand

The Thai banking sector consists of 31 commercial banks, including 14 domestic banks, 1 retail bank, 4 foreign subsidiaries, and 11 foreign bank branches (Bank of Thailand, 2019). Commercial banks in Thailand may accept deposits and grant credits to household and businesses and are registered under the Financial

Institutions Business Act B. E. 2551 (2008) and supervised by Bank of Thailand, the national central bank. Among the fintech development in Thailand, payment is the largest fintech investment share, representing 30% of the country's total 128 fintech companies, according to EY's ASEAN Fintech Census report 2018 and over the last few years the payments landscape has significantly changed. The most notable one is the use of social media, LINE which offers Rabbit LINE Pay that serves some 4.5 million users in Thailand. Besides the tech companies, Thailand's government has been actively promoting digital payments by launching their own initiatives, PromptPay, which has been playing a key role in driving digital payments. PromptPay ties ID numbers and/or mobile phone numbers with bank accounts to allow users to transfer money more easily. The platform is part of the national digital payment scheme, a project designed to move Thailand towards a cashless society. It is part of the government's Thailand 4.0 initiative, which seeks to create a value-based economy driven by innovation, technology and creativity

4.4 Singapore

Singapore is recognized as an International Financial Centre. The banking industry is a key player in the financial centre. The main factors such as a sound economic and stable political environment, conducive legal and tax policies, reputation for integrity, and strict enforcement against crime and money laundering have contributed to Singapore's IFC status which is the third largest in Asia after Japan and Hong Kong. Singapore banking sector is dominated by three local commercial banks; DBS, OCBC and UOB as well as 117 foreign banks. Most banks in Singapore cater to different types of clients – individuals, corporations or government agencies. These banks provide commercial banking, retail and private banking services.

Commercial banks are licensed under the Banking Act (Chapter 19). Their activities are also governed by MAS' Notices to Banks and guidelines issued from time to time.[25] After the financial crisis in May 1999, MAS launched a five-year liberalisation plan to strengthen the banking system. The measures included issuing a full banking licenses, Qualifying Full Bank (QFB) licenses to foreign banks, increasing the number of restricted banks, and allowing offshore banks to access to SGD wholesale business. Additionally, 40 % foreign shareholding limit in local banks was lifted. The second phase of liberalisation began in 2001 during which the restricted banks were re-classified as wholesale banks. QFBs were allowed to establish more business locations and to offer debt and special account services and offshore banks were given the chance to upgrade themselves to wholesale banks.

4.5 Brunei Darussalam

Brunei Darussalam's banking sector consists of seven licensed banks covering both conventional and Islamic banking. Baiduri Bank bought UOB Brunei's retail banking business in 2015 and became the leading commercial bank in the country. HSBC exited the market in 2016 and Bank of China entered the market thereafter. The Monetary Authority of Brunei Darussalam (AMBD) is the central bank for the banking sector, in addition to being the country's central bank. Banks in the country have high levels of liquidity, good capital adequacy ratios and well-managed levels of non-performing loans. All banks are under the supervision of AMBD, which has also established a credit bureau that centralizes information on an applicant's credit

[25] MAS (2019).

worthiness. The national currency is Brunei dollar which is pegged to the Singapore dollar.

5. Descriptive Statistics of Research Variables

Variable	N	Mean	Std. dev.	Min.	Median	Max.
Independent Variable						
MOB_AGER	288	1.955	2.444	0	1	10
MOB_AGEB	288	0.347	1.147	0	0	7
MOB_AGEI	288	0.701	1.537	0	0	7
Mediator Variable						
ISO_AGE	288	0.333	0.847	0	0	4
M_MOBAGER_ISO	288	2.045	6.112	0	0	40
M_MOBAGEB_ISO	288	0.538	2.801	0	0	28
M_MOBAGEI_ISO	288	0.684	2.62	0	0	24
Dependent Variables from Income Statements						
IINC_ASS	288	4.118	1.116	1.85	3.985	8.02
IEXP_ASS	288	1.52	0.608	0.39	1.5	4.13
FINC_ASS	288	1.457	0.698	-0.05	1.3	4.05
SALA_ASS	288	0.941	0.32	0.41	0.91	2
SGA_ASS	288	0.234	0.22	0	0.19	0.94
Dependent Variables from Balance Sheets (Asset side)						
CASH_ASS	288	14.865	61.306	0.2	5.07	890.63
SEC_ASS	288	35.794	147.346	2.3	22.51	2,484.38
LOAN_ASS	288	66.18	30.778	17.57	64.245	406.25
COMM_LOAN	270	48.806	23.079	0	50.3	97.28
CONSM_LOAN	263	20.983	20.426	0	11.14	81.42
NPL_LOAN	272	2.973	2.293	0	2.4	17.2
Adj_ROA	288	1.692	0.688	-0.19	1.665	4.87
Dependent Variables from Balance Sheets (Liability and Equity side)						
DEPO_ASS	285	71.646	10.666	0	72.9	92.12
DD_DEP	285	14.558	11.164	0	14.5	56.6
MM_DEP	285	29.045	21.318	0	29.72	77.76
TD_DEP	285	49.678	17.894	0	49.35	93.67
NPL_ASS	288	1.776	1.074	0.3	1.6	6.2
CT1_CAP	265	13.446	4.606	7.65	12.8	55.1
Adj_ROE	288	16.136	6.799	-2.18	15.655	46.6
Control Variables (Bank size, GDP and mobile penetration rates)						
SIZE_USD	288	50,183.11	74,664.77	415.77	20,123.81	387,454.91
GDP_PC	288	10,620.95	14,625.77	2,147.00	5,982.00	57,722.00
MOB_PEN	288	127.083	22.614	90	125.2	176

6. Capital IQ Definition of the Financial Indicators

Interest Income / Total Assets	IINC_ASS	Interest Income, Total is a summary line item in the banks template with the following components: Interest Income On Loans [212] and Interest Income On Investments [76]
Interest Expense / Total Assets	IEXP_ASS	Interest Expense, Total is a summary line item in the banks template with the following components: Interest On Deposits [205] and Total Interest On Borrowings [11]
Non-Interest Income / Total Assets	FINC_ASS	Non Interest Income, Total (Bank Template) is a summary line item in the banks template with the following components: Credit Card Fee [126], Income (Loss) on Real Estate Property - (Income Block) [68], Income (Loss) on Equity Invest. (Income Block) - (Bank Template) [152], Gain (Loss) on Sale of Loans - (Revenue Block) - (Bank Template) [196], Gain (Loss) on Sale of Assets - (Revenue Block) [55], Gain (Loss) on Sale of Invest. & Securities - (Rev) [61], Non Operating Income (Expenses) - (Income Block) - (Bank Template) [255], Service Charges On Deposits [298], Trust Income [338], Total Mortgage Banking Activities [79], Income From Trading Activities [337], Total Other Non Interest Income [93]
Salaries & Other Employee Benefits / Total Assets	SALA_ASS	Salaries And Other Employee Benefits is a line item in the Banks, Capital Markets, Financial Services and Insurance templates as well as a component of Selling General & Admin Expenses, Total **[102]** that represents all salary and other employee benefits provided by a Company to its employees.
Selling General & Admin Expense / Total Assets	SGA_ASS	Selling General & Admin Expenses, Total - (Template Specific) is a line item in the Banks, Insurance, Real Estate and Utility templates with the following components: Pre-Opening Costs [96], Equipment Expense [147], Selling General & Admin Expenses - (REIT / Utility Template) [299], Stock-Based Compensation SG&A Exp. [23515], Selling and Marketing Expenses [21561], General and Administrative Expenses [21562], Maintenance & Repair Expenses [24251], Net Rental Expense [24261], Contingent Rentals [24265], Minimum Rental Expenses [24269], Sublease Income - Part of Rental Expenses [24273], Other Rental Expense [24467],
Cash and its equivalents / Total Assets	CASH_ASS	Cash and Cash Equivalents is a line item across all templates that represents funds in the form of cash, readily convertible deposits, securities and other instruments having maturities of less than 3 months at the time of purchase. It includes short term, highly liquid investments that are readily convertible into known amounts of cash and are near their maturity as well as cash on hand consisting of coins, currency, undeposited checks, money orders and drafts, and deposits in banks.
Investment Securities / Total Assets	SEC_ASS	Investment Securities, Total is a line item in the Banks template with the following components: Deposits at Interest in Securities [1116], Investment in Government Securities [1170], Investment in

		Securities [1182], Investment in Municipal Securities [1198], Securities Purchased Under Agreements To Resell [1240], Equity Method Investments [24239]
Gross Loans / Total Assets	LOAN_ASS	Gross Loans is a line item in the Banks template that represents the gross amounts of loans advanced to borrowers. This item includes: Loans given to banks, Loans given to customers, Financial leases, Total portfolio loans
Commercial Loans / Total Loan	COMM_ LOAN	Commercial Loans represents Loans disbursed to a Corporation, Commercial Enterprise, or Joint Venture, usually short-term, as a source of Working Capital not backed by a Mortgage Security.
Consumer Loans / Total Loan	CONSM_ LOAN	Consumer Loans represents loans given to individuals for the purchase of domestic and household durable goods on hypothecation. It includes all forms of installment credit other than Home Mortgage Loans and Open-End Credits.
Total Deposits / Total Assets	DEPO_ASS	Total Deposits (Supple) is a supplemental line item in the Banks Template with the following components: Demand Deposits [3057], Money Market Account/Investments [3115], NOW Accounts [3121], Saving Deposits [3176], Time Deposits [3198], Other Deposits [3126]
Demand Deposit / Total Deposit	DD_DEP	Demand Deposits is a supplemental line item in the Bank template incl. Non-interest bearing checking accounts, Interest bearing checking accounts
Money Market Account / Total Deposit	MM_DEP	Money Market Account / Investments represents Short-term Interest Bearing Deposits dealt within Money Markets where money and other short-term liquid assets can be lent and borrowed to satisfy short-term financial requirements. Super Saver Money Market Accounts and Money Market Investments
Time Deposit / Total Deposit	TD_DEP	Time Deposits represents Interest Bearing Term Deposits accepted by banks for relatively longer periods of time which require prior notice for withdrawal of funds from the deposit.
Core Tier 1 Capital Ratio	CT1_CAP	Core Tier 1 Capital represents core tier 1 capital as reported by the company or can be derived by deducting 'Innovative/Hybrid Tier 1 Capital' from 'Total Tier 1 Capital'.

7. Mobile Banking App Capabilities of Sample ASEAN Banks

7.1 Large banks in MY and SG – Account related services

Bank Name	Cty	Size	Mobile App Name	App Release Year	App Types	A/C Enquiry	FX Rate Enquiry	Open A/C	Open FD
Public Bank	MY	L	PB engage	2014	Retail	YES			
Public Bank	MY	L	PB Sharelink	2012	Investment	YES	YES		
Ambank	MY	L	AmOnline	2017	Retail	YES			
RHB	MY	L	RHBNow	2011	Retail	YES			
RHB	MY	L	RHB MyHome	2017	Retail	YES			
Maybank	MY	L	Maybank MY	2017	Retail	YES		YES	YES
Maybank	MY	L	M2U	2009	Retail/Info only				
Maybank	MY	L	Maybank2E	2012	Business	YES	YES		
Maybank	MY	L	Maybank Trade	2017	Investment	YES	YES		
Hong Leong Bank	MY	L	HL Mobile	2011	Retail	YES	YES		YES
Hong Leong Bank	MY	L	HL Connect	2014	Retail	YES	YES		YES
CIMB	MY	L	CIMB Clicks	2009	Retail	YES	YES	YES	YES
CIMB	MY	L	CIMB i*Trade	2012	Investment	YES	YES		
CIMB	MY	L	CIMB EVA!	2016	Retail	YES			
UOB	SG	L	Mighty	2015	Retail	YES	YES		
UOB	SG	L	UOB Business	2016	Business	YES	YES		
OCBC	SG	L	OCBC SG Mobile	2008	Retail	YES			
OCBC	SG	L	OCBC Business	2016	Business	YES			
OCBC	SG	L	OCBC Pay Anyone	2017	Retail	YES			
OCBC	SG	L	OCBC OneWealth	2016	Investment	YES	YES		
DBS	SG	L	PayLah!	2014	Retail	YES			
DBS	SG	L	DBS Lifestyle	2010	Retail/Info only				
DBS	SG	L	digibank SG	2016	Retail	YES		YES	
DBS	SG	L	DBS iWealth	2017	Investment	YES	YES		YES
DBS	SG	L	IDEAL Mobile	2011	Business	YES	YES		YES

7.2 Large Banks in MY and SG – Investment related services

Bank Name	Cty	Size	Mobile App Name	App Release Year	App Types	Mutual Funds	Stocks / Bonds	FX	Insurance
Public Bank	MY	L	PB engage	2014	Retail				YES
Public Bank	MY	L	PB Sharelink	2012	Investment	YES	YES	YES	
Ambank	MY	L	AmOnline	2017	Retail				
RHB	MY	L	RHBNow	2011	Retail				
RHB	MY	L	RHB MyHome	2017	Retail				
Maybank	MY	L	Maybank MY	2017	Retail				
Maybank	MY	L	M2U	2009	Retail/Info only				
Maybank	MY	L	Maybank2E	2012	Business				
Maybank	MY	L	Maybank Trade	2017	Investment	YES	YES	YES	
Hong Leong Bank	MY	L	HL Mobile	2011	Retail				
Hong Leong Bank	MY	L	HL Connect	2014	Retail				
CIMB	MY	L	CIMB Clicks	2009	Retail			YES	
CIMB	MY	L	CIMB i*Trade	2012	Investment	YES	YES	YES	
CIMB	MY	L	CIMB EVA!	2016	Retail				
UOB	SG	L	Mighty	2015	Retail			YES	
UOB	SG	L	UOB Business	2016	Business				
OCBC	SG	L	OCBC SG Mobile	2008	Retail				
OCBC	SG	L	OCBC Business	2016	Business				
OCBC	SG	L	Pay Anyone	2017	Retail				
OCBC	SG	L	OCBC OneWealth	2016	Investment	YES	YES	YES	
DBS	SG	L	PayLah!	2014	Retail				YES
DBS	SG	L	DBS Lifestyle	2010	Retail/Info only				
DBS	SG	L	digibank SG	2016	Retail				
DBS	SG	L	DBS iWealth	2017	Investment	YES	YES	YES	
DBS	SG	L	IDEAL Mobil	2011	Business				

7.3 Large banks in MY and SG – Loan related services

Bank Name	Cty	Size	Mobile App Name	App Release Year	App Types	Car Loans	Mortgages	Credit Cards	Business Loans
Public Bank	MY	L	PB engage	2014	Retail				
Public Bank	MY	L	PB Sharelink	2012	Investment				
Ambank	MY	L	AmOnline	2017	Retail				
RHB	MY	L	RHBNow	2011	Retail				
RHB	MY	L	RHB MyHome	2017	Retail		YES		
Maybank	MY	L	Maybank MY	2017	Retail			YES	
Maybank	MY	L	M2U	2009	Retail/Info only				
Maybank	MY	L	Maybank2E	2012	Business				
Maybank	MY	L	Maybank Trade	2017	Investment				
Hong Leong Bank	MY	L	HL Mobile	2011	Retail				
Hong Leong Bank	MY	L	HL Connect	2014	Retail				
CIMB	MY	L	CIMB Clicks	2009	Retail				
CIMB	MY	L	CIMB i*Trade	2012	Investment				
CIMB	MY	L	CIMB EVA!	2016	Retail				
UOB	SG	L	Mighty	2015	Retail				
UOB	SG	L	UOB Business	2016	Business				
OCBC	SG	L	OCBC SG Mobile	2008	Retail				
OCBC	SG	L	OCBC Business	2016	Business				
OCBC	SG	L	Pay Anyone	2017	Retail				
OCBC	SG	L	OCBC OneWealth	2016	Investment				
DBS	SG	L	PayLah!	2014	Retail				
DBS	SG	L	DBS Lifestyle	2010	Retail/Info only				
DBS	SG	L	digibank SG	2016	Retail				
DBS	SG	L	DBS iWealth	2017	Investment				
DBS	SG	L	IDEAL Mobile	2011	Business				

7.4 Large Banks in MY and SG – Payment related services

Bank Name	Cty	Size	Mobile App Name	App Release Year	App Types	Bills/TT Payment	Real-Time Payment	QR	Apple Watch/ ApplePay
Public Bank	MY	L	PB engage	2014	Retail	YES			
Public Bank	MY	L	PB Sharelink	2012	Investment				
Ambank	MY	L	AmOnline	2017	Retail	YES			
Affin	MY	S	AffinSecure	2017	Retail	YES			
RHB	MY	L	RHBNow	2011	Retail	YES		YES	
RHB	MY	L	RHB MyHome	2017	Retail				
Maybank	MY	L	Maybank MY	2017	Retail	YES		YES	
Maybank	MY	L	M2U	2009	Retail/Info only				
Maybank	MY	L	Maybank2E	2012	Business	YES			
Maybank	MY	L	Maybank Trade	2017	Investment				
Hong Leong Bank	MY	L	HL Mobile	2011	Retail	YES			YES
Hong Leong Bank	MY	L	HL Connect	2014	Retail	YES			
CIMB	MY	L	CIMB Clicks	2009	Retail	YES			
CIMB	MY	L	CIMB i*Trade	2012	Investment				
CIMB	MY	L	CIMB EVA!	2016	Retail				
UOB	SG	L	Mighty	2015	Retail	YES	YES	YES	YES
UOB	SG	L	UOB Business	2016	Business	YES			
OCBC	SG	L	OCBC SG Mobile	2008	Retail	YES	YES	YES	YES
OCBC	SG	L	OCBC Business	2016	Business	YES			
OCBC	SG	L	Pay Anyone	2017	Retail	YES	YES	YES	
OCBC	SG	L	OCBC OneWealth	2016	Investment				
DBS	SG	L	PayLah!	2014	Retail	YES	YES	YES	YES
DBS	SG	L	DBS Lifestyle	2010	Retail/Info only				
DBS	SG	L	digibank SG	2016	Retail	YES	YES	YES	
DBS	SG	L	DBS iWealth	2017	Investment	YES	YES	YES	
DBS	SG	L	IDEAL Mobile	2011	Business	YES	YES		

7.5 Large Banks in PH and TH – Account related services

Bank Name	Cty	Size	Mobile App Name	App Release Year	App Types	A/C Enquiry	FX Rate Enquiry	Open A/C	Open FD
BDO Uni	PH	L	BDO Personal Banking	2013	Retail	YES			
BDO Uni	PH	L	BDO Deals	2012	Retail/Info only				
Bangkok Bank	TH	L	Bualuang mBanking	2013	Retail/Investment	YES			
Bank of Ayudhya	TH	L	KMA Krungsri	2012	Retail/Investment	YES			
Bank of Ayudhya	TH	L	Krungsri Biz Mobile	2015	Business	YES	YES		
Kasikornbank	TH	L	K PLUS	2010	Retail/Investment	YES	YES		
Kasikornbank	TH	L	K PLUS SME	2017	Business	YES			
Kasikornbank	TH	L	K+ Wallet	2016	Retail	YES			
Kasikornbank	TH	L	K-Corporate	2016	Business	YES			
Kasikornbank	TH	L	K-Cyber Trade	2013	Investment	YES			
Kasikornbank	TH	L	KLeasing	2014	Retail	YES			
Kasikornbank	TH	L	KS Super Stock	2015	Investment	YES			
Kasikornbank	TH	L	KS Stock Plus	2017	Investment	YES			
Krung Thai Bank	TH	L	Krungthai NEXT	2011	Retail/Investment	YES	YES	YES	
Thanachart	TH	L	Thanachart Connect	2014	Retail/Investment	YES			
Siam Commercial Bank	TH	L	SCB Easy	2011	Retail/Investment	YES			
Siam Commercial Bank	TH	L	SCB Business Net	2016	Business	YES	YES		
Siam Commercial Bank	TH	L	SCBS Stock Advisor	2014	Investment	YES			
Siam Commercial Bank	TH	L	SCB MyProvident	2017	Retail	YES			

7.6 Large Banks in PH and TH – Investment related services

Bank Name	Cty	Size	Mobile App Name	App Release Year	App Types	Mutual Funds	Stocks / Bonds	FX	Insurance
BDO Uni	PH	L	BDO Personal Banking	2013	Retail				
BDO Uni	PH	L	BDO Deals	2012	Retail/Info only				
Bangkok Bank	TH	L	Bualuang mBanking	2013	Retail/Investment	YES	YES		
Bank of Ayudhya	TH	L	KMA Krungsri	2012	Retail/Investment	YES			
Bank of Ayudhya	TH	L	Krungsri Biz Mobile	2015	Business			YES	
Kasikornbank	TH	L	K PLUS	2010	Retail/Investment	YES		YES	YES
Kasikornbank	TH	L	K PLUS SME	2017	Business				
Kasikornbank	TH	L	K+ Wallet	2016	Retail				
Kasikornbank	TH	L	K-Corporate	2016	Business				
Kasikornbank	TH	L	K-Cyber Trade	2013	Investment	YES	YES		
Kasikornbank	TH	L	KLeasing	2014	Retail				YES
Kasikornbank	TH	L	KS Super Stock	2015	Investment		YES		
Kasikornbank	TH	L	KS Stock Plus	2017	Investment		YES		
Krung Thai Bank	TH	L	Krungthai NEXT	2011	Retail/Investment	YES		YES	
Thanachart	TH	L	Thanachart Connect	2014	Retail/Investment	YES			
Siam Commercial Bank	TH	L	SCB Easy	2011	Retail/Investment	YES	YES		YES
Siam Commercial Bank	TH	L	SCB Business Net	2016	Business				
Siam Commercial Bank	TH	L	SCBS Stock Advisor	2014	Investment		YES		
Siam Commercial Bank	TH	L	SCB MyProvident	2017	Retail				

7.7 Large Banks in PH and TH – Loan related services

Bank Name	Cty	Size	Mobile App Name	App Release Year	App Types	Car Loans	Mortgages	Credit Cards	Business Loans
BDO Uni	PH	L	BDO Personal Banking	2013	Retail				
BDO Uni	PH	L	BDO Deals	2012	Retail/Info only				
Bangkok Bank	TH	L	Bualuang mBanking	2013	Retail/Investment			YES	
Bank of Ayudhya	TH	L	KMA Krungsri	2012	Retail/Investment	YES		YES	
Bank of Ayudhya	TH	L	Krungsri Biz Mobile	2015	Business				
Kasikornbank	TH	L	K PLUS	2010	Retail/Investment			YES	
Kasikornbank	TH	L	K PLUS SME	2017	Business				
Kasikornbank	TH	L	K+ Wallet	2016	Retail				
Kasikornbank	TH	L	K-Corporate	2016	Business				
Kasikornbank	TH	L	K-Cyber Trade	2013	Investment				
Kasikornbank	TH	L	KLeasing	2014	Retail	YES			
Kasikornbank	TH	L	KS Super Stock	2015	Investment				
Kasikornbank	TH	L	KS Stock Plus	2017	Investment				
Krung Thai Bank	TH	L	Krungthai NEXT	2011	Retail/Investment				
Thanachart	TH	L	Thanachart Connect	2014	Retail/Investment				
Siam Commercial Bank	TH	L	SCB Easy	2011	Retail/Investment			YES	YES
Siam Commercial Bank	TH	L	SCB Business Net	2016	Business				
Siam Commercial Bank	TH	L	SCBS Stock Advisor	2014	Investment				
Siam Commercial Bank	TH	L	SCB MyProvident	2017	Retail				

7.8 Large Banks in PH and TH – Payment related services

Bank Name	Cty	Size	Mobile App Name	App Release Year	App Types	Bills/TT Payment	Real-Time Payment	QR	Apple Watch/ ApplePay
BDO Uni	PH	L	BDO Personal Banking	2013	Retail	YES			YES
BDO Uni	PH	L	BDO Deals	2012	Retail/Info only				
Bangkok Bank	TH	L	Bualuang mBanking	2013	Retail/Investment	YES	YES	YES	
Bank of Ayudhya	TH	L	KMA Krungsri	2012	Retail/Investment	YES	YES	YES	
Bank of Ayudhya	TH	L	Krungsri Biz Mobile	2015	Business	YES	YES	YES	
Kasikornbank	TH	L	K PLUS	2010	Retail/Investment	YES	YES	YES	
Kasikornbank	TH	L	K PLUS SME	2017	Business	YES			
Kasikornbank	TH	L	K+ Wallet	2016	Retail	YES	YES	YES	
Kasikornbank	TH	L	K-Corporate	2016	Business	YES			
Kasikornbank	TH	L	K-Cyber Trade	2013	Investment				
Kasikornbank	TH	L	KLeasing	2014	Retail	YES			
Kasikornbank	TH	L	KS Super Stock	2015	Investment				
Kasikornbank	TH	L	KS Stock Plus	2017	Investment				
Krung Thai Bank	TH	L	Krungthai NEXT	2011	Retail/Investment	YES	YES	YES	
Thanachart	TH	L	Thanachart Connect	2014	Retail/Investment	YES	YES	YES	
Siam Commercial Bank	TH	L	SCB Easy	2011	Retail/Investment	YES	YES	YES	
Siam Commercial Bank	TH	L	SCB Business Net	2016	Business	YES			
Siam Commercial Bank	TH	L	SCBS Stock Advisor	2014	Investment				
Siam Commercial Bank	TH	L	SCB MyProvident	2017	Retail	YES			

7.8 Small Banks in MY, PH and BN – Account related services

Bank Name	Cty	Size	Mobile App Name	App Release Year	App Types	A/C Enquiry	FX Rate Enquiry	Open A/C	Open FD
Affin	MY	S	AffinSecure	2017	Retail	YES			
Asia United Bank	PH	S	AUB	2012	Retail	YES			
Bank of the Philippine Islands	PH	S	BPI	2011	Retail	YES			
Bank of the Philippine Islands	PH	S	BPI ExpresssLink Mobile	2011	Business	YES			
Bank of the Philippine Islands	PH	S	BPI BizLink	2017	Business	YES			
China Bank	PH	S	China Bank Corp	2017	Retail	YES			
Metropolitan	PH	S	Metrobank Mobile	2017	Retail	YES			
Philippine National Bank	PH	S	PNB Mobile Banking	2016	Retail	YES			
RCBC	PH	S	RCBC Online Banking	2012	Retail	YES			
RCBC	PH	S	RCBC Online Corporate	2017	Business	YES			
Security Bank Corp	PH	S	Security Bank Mobile	2015	Retail	YES			
Union Bank	PH	S	UnionBank Online	2015	Retail	YES			
Union Bank	PH	S	UnionBank Consumer	2016	Retail	YES			
CIMB Thai	TH	S	CIMB Clicks	2013	Retail/Investment	YES			
Kiatnakin	TH	S	KK e-Banking	2016	Retail/Investment	YES	YES		
Kiatnakin	TH	S	KK Auto	2014	Retail/Investment	YES	YES	YES	YES
LH Financial	TH	S	LH Bank M Choice	2016	Retail/Investment	YES		YES	
TISCO	TH	S	TISCO Mobile Banking	2013	Retail	YES			
TISCO	TH	S	My Car My TISCO	2016	Retail/Investment	YES			
TMB	TH	S	TMB BIZ Touch	2016	Business	YES			
TMB	TH	S	ME by TMB	2016	Retail	YES			
TMB	TH	S	TMB Touch	2014	Retail/Investment	YES	YES	YES	
Baiduri	BN	S	Baiduri Personal	2013	Retail	YES	YES		
Baiduri	BN	S	Baiduri Deals	2013	Retail/Info only				
Baiduri	BN	S	Baiduri Finance	2017	Retail	YES			

7.9 Small Banks in MY, PH and BN – Investment related services

Bank Name	Cty	Size	Mobile App Name	App Release Year	App Types	Mutual Funds	Stocks / Bonds	FX	Insurance
Affin	MY	S	AffinSecure	2017	Retail				
Asia United Bank	PH	S	AUB	2012	Retail				
Bank of the Philippine Islands	PH	S	BPI	2011	Retail				
Bank of the Philippine Islands	PH	S	BPI ExpresssLink Mobile	2011	Business				
Bank of the Philippine Islands	PH	S	BPI BizLink	2017	Business				
China Bank	PH	S	China Bank Corp	2017	Retail				
Metropolitan	PH	S	Metrobank Mobile	2017	Retail				
Philippine National Bank	PH	S	PNB Mobile Banking	2016	Retail				
RCBC	PH	S	RCBC Online Banking	2012	Retail				
RCBC	PH	S	RCBC Online Corporate	2017	Business				
Security Bank Corp	PH	S	Security Bank Mobile	2015	Retail				
Union Bank	PH	S	UnionBank Online	2015	Retail				
Union Bank	PH	S	UnionBank Consumer	2016	Retail				
CIMB Thai	TH	S	CIMB Clicks	2013	Retail/Investment	YES	YES		
Kiatnakin	TH	S	KK e-Banking	2016	Retail/Investment			YES	
Kiatnakin	TH	S	KK Auto	2014	Retail/Investment			YES	YES
LH Financial	TH	S	LH Bank M Choice	2016	Retail/Investment	YES			
TISCO	TH	S	TISCO Mobile Banking	2013	Retail				
TISCO	TH	S	My Car My TISCO	2016	Retail/Investment				YES
TMB	TH	S	TMB BIZ Touch	2016	Business				
TMB	TH	S	ME by TMB	2016	Retail				YES
TMB	TH	S	TMB Touch	2014	Retail/Investment	YES		YES	
Baiduri	BN	S	Baiduri Personal	2013	Retail				
Baiduri	BN	S	Baiduri Deals	2013	Retail/Info only				
Baiduri	BN	S	Baiduri Finance	2017	Retail				YES

7.10 Small Banks in MY, PH and BN – Loan related services

Bank Name	Cty	Size	Mobile App Name	App Release Year	App Types	Car Loans	Mortgages	Credit Cards	Business Loans
Affin	MY	S	AffinSecure	2017	Retail				
Asia United Bank	PH	S	AUB	2012	Retail				
Bank of the Philippine Islands	PH	S	BPI	2011	Retail				
Bank of the Philippine Islands	PH	S	BPI ExpresssLink Mobile	2011	Business				
Bank of the Philippine Islands	PH	S	BPI BizLink	2017	Business				
China Bank	PH	S	China Bank Corp	2017	Retail				
Metropolitan	PH	S	Metrobank Mobile	2017	Retail				
Philippine National Bank	PH	S	PNB Mobile Banking	2016	Retail				
RCBC	PH	S	RCBC Online Banking	2012	Retail				
RCBC	PH	S	RCBC Online Corporate	2017	Business				
Security Bank Corp	PH	S	Security Bank Mobile	2015	Retail				
Union Bank	PH	S	UnionBank Online	2015	Retail				
Union Bank	PH	S	UnionBank Consumer	2016	Retail	YES	YES	YES	
CIMB Thai	TH	S	CIMB Clicks	2013	Retail/Investment				
Kiatnakin	TH	S	KK e-Banking	2016	Retail/Investment				
Kiatnakin	TH	S	KK Auto	2014	Retail/Investment	YES			
LH Financial	TH	S	LH Bank M Choice	2016	Retail/Investment				
TISCO	TH	S	TISCO Mobile Banking	2013	Retail				
TISCO	TH	S	My Car My TISCO	2016	Retail/Investment	YES			
TMB	TH	S	TMB BIZ Touch	2016	Business				YES
TMB	TH	S	ME by TMB	2016	Retail				
TMB	TH	S	TMB Touch	2014	Retail/Investment			YES	
Baiduri	BN	S	Baiduri Personal	2013	Retail				
Baiduri	BN	S	Baiduri Deals	2013	Retail/Info only				
Baiduri	BN	S	Baiduri Finance	2017	Retail	YES			

7.11 Small Banks in MY, PH and BN – Payment related services

Bank Name	Cty	Size	Mobile App Name	App Release Year	App Types	Bills/TT Payment	Real-Time Payment	QR	Apple Watch/ ApplePay
Affin	MY	S	AffinSecure	2017	Retail	YES			
Asia United Bank	PH	S	AUB	2012	Retail	YES		YES	
Bank of the Philippine Islands	PH	S	BPI	2011	Retail	YES			
Bank of the Philippine Islands	PH	S	BPI ExpresssLink Mobile	2011	Business				
Bank of the Philippine Islands	PH	S	BPI BizLink	2017	Business	YES			
China Bank	PH	S	China Bank Corp	2017	Retail	YES			
Metropolitan	PH	S	Metrobank Mobile	2017	Retail	YES			
Philippine National Bank	PH	S	PNB Mobile Banking	2016	Retail	YES			
RCBC	PH	S	RCBC Online Banking	2012	Retail	YES			
RCBC	PH	S	RCBC Online Corporate	2017	Business	YES			
Security Bank Corp	PH	S	Security Bank Mobile	2015	Retail	YES			
Union Bank	PH	S	UnionBank Online	2015	Retail	YES			
Union Bank	PH	S	UnionBank Consumer	2016	Retail	YES			
CIMB Thai	TH	S	CIMB Clicks	2013	Retail/Investment	YES	YES		
Kiatnakin	TH	S	KK e-Banking	2016	Retail/Investment	YES	YES	YES	
Kiatnakin	TH	S	KK Auto	2014	Retail/Investment		YES		
LH Financial	TH	S	LH Bank M Choice	2016	Retail/Investment	YES	YES	YES	
TISCO	TH	S	TISCO Mobile Banking	2013	Retail	YES	YES	YES	
TISCO	TH	S	My Car My TISCO	2016	Retail/Investment	YES			
TMB	TH	S	TMB BIZ Touch	2016	Business	YES	YES	YES	
TMB	TH	S	ME by TMB	2016	Retail	YES	YES	YES	
TMB	TH	S	TMB Touch	2014	Retail/Investment	YES	YES	YES	
Baiduri	BN	S	Baiduri Personal	2013	Retail	YES			
Baiduri	BN	S	Baiduri Deals	2013	Retail/Info only				
Baiduri	BN	S	Baiduri Finance	2017	Retail				