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The Introduction of Financial Technologies and Bank Performance

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Abstract

This study examines the effect the implementation of financial technologies has on bank performance in terms of return on equity and return on assets. Furthermore it is analyzed whether it might have been advantageous to be an early adopter of either internet banking or mobile banking. This study looks at 54 of the largest commercial banks in both developed and developing countries distributed all over the world. An event study is used to indicate whether the implementation of both internet banking and mobile banking has an effect on a bank's performance, taking into account multiple periods including lags. Results show no significant results within five years of implementation for either technology on both ROE and ROA. Furthermore, a panel data method is applied to examine the timing of adoption, while controlling for multiple bank specific as well as macroeconomic variables. Results show no indication that adopting financial technologies at an early stage increases performance in terms of ROE and ROA.

Keywords: Financial Technologies, Internet banking, mobile banking, bank performance.

Contents

Introduction

In this day and age it is impossible to imagine a world without financial technologies. This began when the internet started to become an integral part of our lives at the beginning of this century. As internet usage started to spread it attracted the attention for alternatives to classical banking. This technology gave birth to quite a few new possibilities. Among other things, banks were able to reduce costs and enhance performance, but also increase customer convenience and introduce an innovative payment method (Arnaboldy & Claeys, 2008). For banks this fundamentally changed the rules of the game. This is especially the case for online banking, which offers a customer the possibility to access his or her bank account and conduct different bank operations via the internet. In the early days there were uncertainties whether online banking would be a supplement rather than a substitute product. But due to the increase usage of computers to service transfers and the ability to manage banking affairs wherever and whenever you want online banking became very popular very fast (Halili, 2014).

Another reason for the rapid growth of online banking is that financial services are mainly data-intensive and that no material delivery is involved (Zekos, 2004). This makes the service a lot easier. In addition, online banking also reduces the transaction costs of banking services, both for customers and for the banks themselves. According to Abaenewe et al. (2013) using information technologies in banks has become a necessity due to the huge amounts of information being handled on a daily basis. They add to that by stating that the success of e-banking depends upon sufficient and reliable data communication infrastructure. It is therefore not surprising that banks are one of the largest investors in information systems (Van Buynder, 2016).

Yet, not everyone uses the online alternative to banking. In 2018, according to the European Commission the European average percentage of people between the age of 16 and 74 years old that use online banking is only at 51%. This share has constantly been increasing since the beginning, but still a long way from completion, making it interesting for banks to understand how to penetrate certain population groups to use their online services to further increase performance. The obvious explanation for this fact would be the access to internet but this does not have to be that case. The study of Gorbacheva et al. (2011) state, security concerns within online banking as one important factor for people not to use it. Consequently, solving the issue regarding fraudulent practices online has been one of the greatest challenges to the banking industry (Abaenewe et al. 2013).

As a number of studies indicate, the acceptance of online banking had a significant positive effect on the growth of competition in the banking sector. As a result, the adaptation of online banking has led banks to actively look for further technological innovations (Sullivan, 2000, Arnaboldy & Claeys, 2008, Akhisar et al. 2015,). One of these innovations is targeting the mobile device technology. The mobile banking scene has undergone a lot of changes over the past decades. In the beginning mobile banking consisted only of using SMS to contact the bank for certain actions. With the introduction of

the smartphone this development took a major step towards what it is today (Rahmani et al. 2012). This means that financial operations like viewing account balance or paying bills are conducted by using an application on a mobile device (Ajayi & Enitilo, 2016). At this point the landscape is evolving in such a way that financial transactions are no longer limited to banks. Because non-traditional players enter the mobile banking landscape, banks have to make sure that they match those enhanced service levels as well to stay competitive. Seeing that mobile banking becomes more and more widespread, according to Oracle (2013) it has the potential to become the primary source of banking. Therefore it may safely be said that providing the right mobile banking solutions has become essential to success in the banking world.

Thus online banking and mobile banking, both categorized as e-banking, contribute to a banks success or performance in their own way. Generally, bank performance implies whether a bank has done well to realize its objectives within a trading period (Abaenewe et al. 2013). There are a lot of different ways one can measure bank performance, ranging from stock price behavior, volume of deposits or its profitability. For the purpose of this study, performance indicators, like the return on assets (ROA) and the return on equity (ROE) are used to evaluate a bank's performance. These ratios are good indicators for rate of return and management efficiency. According to Kieso et al. (2019) using the level of net income relative to both total assets and total equity gives an indication on the ability of a company and its management to generate income by using all its resources as well as taking debt levels into account.

The literature regarding the impact of financial technologies like online and mobile banking applications on bank performance show different results. In terms of online banking, this especially holds for the early stages. As Siam (2006) points out there are high costs of implementing online banking in the short run due to infrastructure costs and the training of employees. The consequence of this finding is that online banking has a negative impact on bank performance in the short run. Hernando and Nieto (2007) support these findings and indicate that there is a lag period of up to three years after adoption for online banking to have a significant positive impact on both ROA and ROE. However, Sullivan (2000) compared banks in the United States that adopted online banking to those that did not and found that their performance was similar. In addition to that, Khrawish and Al-Sai'di (2011) support these findings by finding no effect on ROE and ROA of applying online services for either less than or more than two years.

On the other hand, with respect to mobile banking on bank performance there are fewer studies exploring the direct relationship between the two. The study of Cleveland (2016) poses that when mobile banking becomes the primary channel banks have the opportunity to save a lot of costs, partly due to the fact that mobile deposits are much cheaper to process than branch deposits. This issue lies with customer retention, once that is solved banks can thoroughly develop integrated products and services which results in performance indicators that better reflect the success. On the other hand, if

mobile banking is merely added without removing something else, the costs saving capabilities disappear. According to Cleveland (2016) mobile banking is necessary channel to enter the game but not the alpha and the omega route to better financial performance. Though, Kithaka (2014) did find evidence that mobile banking positively contributed to financial performance, measured in ROA and ROE, but this only holds for commercial banks in Kenya.

For academic research it is interesting to investigate the effect both online and mobile banking applications on bank performance for various reasons. Although there is a lot of research published on the subject of online banking, results are contradicting. Regarding mobile banking the literature can certainly benefit from specifically focusing on bank performance. But the results of this research would be particularly interesting for banks themselves. For example, there is a difference in the order of implementation for a specific technology between banks. Investigating the order of implementation on the magnitude of performance of a technology shows whether it can be advantageous to be an early adopter or to wait for further development or consumer adoption. Therefore this study may provide viable information for building a strategy around new financial technologies introduced in the future. This will be realized for a sample of 50 banks consisting of both developed and developing countries, making it possible to compare results based on a country's degree of development.

As a result, this thesis will enhance the existing literature by focusing on the difference in the effect of implementing financial technologies like online and mobile banking applications on bank performance. To accomplish this, this study is divided as follows. Section two discusses previous literature regarding financial technologies and subsequently their effect on bank performance. Section three explains the data and methodology used for the analysis. In section four the results are presented and discussed with existing literature. Section five concludes.

Literature review

This chapter provides an overview of the existing literature dealing with the adoption of financial technologies and its effect on bank performance. First off, the literature with respect to e-banking is introduced to create a foundation for subsequent financial technologies. To then discuss both internet and mobile banking and their effect on bank performance.

E-banking

The banking industry and financial technologies have had a longstanding relationship for many ages, and probably will have for many ages to come. Common days these technologies mostly relate to the use of the internet, though earlier possibilities existed with use of leading technologies of their own time period. For example the introduction of paper during the 17th century or the introduction of punch cards during the 20th century were major innovations. But not all technologies were evident progress in advance. Management often hesitated with the implementation of technologies. Aside from high costs, the main reason is that if business processes are changed, they have to at least match the previous performance. Therefore Lamberti and Büger (2009) called technology in the banking industry rather a question of management than of the technology itself. At a certain point in the late 20th century the matter of scalability, that is the possibility of processing the growing amount of data, played a crucial role in management decisions for implementing different technologies. This, of course, considering the major driver of development was the fact that growing volumes could not be handled without technological advancement (Lamberti & Büger, 2009).

With the introduction of e-banking the growing volumes are no longer an issue. While most banks were already using computerized technology in the 1970s to handle internal processes, it took till the second half of the 1990s with the start of internet banking for banks to transfer its customer-facing processes from the traditional methods to the more modernized methods (Alt & Puschmann, 2012). As Ajayi and Enitilo (2016) state, e-banking caused a new age in the banking system. That is a banking system which includes enabling financial institution customers, businesses or individuals to access accounts or make transactions using a private or public network. This is a development that nowadays can be categorized into many different groups like internet banking, mobile banking, Debit Card and ATM's.

Since the emergence of computerized technology in the banking industry, the development and adoption of these technologies has gone extremely fast. One major element in this process is the consumer's perspective on adopting new technologies from the banking industry. A well-known model of diffusion of innovations is from Rogers (2010). The model is based on several product or service characteristics that influence its acceptance by consumers, namely relative advantage, observability, compatibility, trialability and complexity. Numerous studies that examined financial technologies in the banking industry incorporated Rogers' model in their explanations (Tan & Teo,

2000), (Kolodinsky et al, 2004), (Abaenewe et al, 2013). First of all, in this model, relative advantage is the extent to which a product or service is perceived better than its substitute by the consumer (Rogers, 2010). In the case of internet banking there are several aspects that can indisputably be classified as relative advantages, which is the ability for customers to access their bank accounts from any location, at any time, provides a huge convenience, saves time and money as provide opportunities for greater financial management (Kolodinsky et al, 2004). Secondly, observability is explained as the degree to which a product or service is visible to its potential users (Rogers, 2010). By way of illustration is difference in observability between ATMs in the street and internet banking conducted at home that can influence the rate of adoption. Thirdly, compatibility is the degree to which a new product or service is consistent with customers past experiences, existing habits and needs (Rogers, 2010). In the case of e-banking, the technological innovations presented to the consumer required a change in behavior for some because of issues such as the diminishing ability to visit the bank (Kolodinsky et al, 2004). Though for the internet-generation in terms of compatibility, e-banking fits right into the lifestyle. Fourthly, Trialability is the extent to which a customer is able to experiment with a new product or service to assess its benefits, like an introduction program. Lastly, complexity refers to the ability of customers to understand a new product or service (Rogers, 2010). The adoption of new banking technologies may be hindered for people with less digital affinity. The studies from Tan and Teo (2000) and Kolodinsky et al. (2004) both found significant results for relative advantage and compatibility on the adoption of e- banking technologies, additionally Tan and Teo (2010) also found significant results for the trialability characteristic.

After discussing the consumer adoption of financial technologies, there are a number of factors that have to do with the change in a bank's internal processes due to the use of new technologies. Since incorporating technology creates opportunities for significant cost advantages, facilitate lower risk and increasing profitability comparing to traditional banking (Akhisar et al. 2015). More specifically, according to DeYoung (2001) e-banking can significantly reduce average operational costs as well as physical expenses within banks. Simply because using technologies is more efficient than manually conducting transactions on a physical location. However, with most technological innovations in the banking system it is a consideration whether the investment will bring enough profit over time to compensate for its high initial costs. Research shows that if there is sufficient customer demand for a technology-based product then a positive return on investment can often be achieved in the short run (Akhisar et al. 2015). Beccalli (2007) states that the effective use of e-banking creates a lot of dynamic capabilities with regards to timely responsiveness, rapid and flexible product innovation causing e-banking to be a strategic necessity rather than a variable to create competitive advantages. This means that technological innovation in the banking industry is essential both in terms of performance as well as competitiveness (Chaarani & Abiad, 2019).

Then there is the matter of adopting e-banking technologies at its early stages. In regards to this, some initial research has been conducted. Most of the research is focused on adopters versus non-adopters of internet banking. In the beginning, new products or services often bring considerable uncertainty with regards to consumer demand. Courchane et al. (2000) argues that this uncertainty causes banks that are strategically large compared to their rivals to probably be one of the first to introduce certain technologies. These banks are more capable of absorbing introduction and developing costs related to the product or service, and are more likely to be able to sustain damages as a result of a possible failed product launch (Sullivan, 2000). Ultimately, an early adopter commits to the sunk costs with the prospect of increased future profits, while a late adopter foregoes the potential profits in favor of less uncertainty by delaying the investment until the true consumer demand for such technology can be observed (Courchane et al. 2000). Furthermore, research as presented in DeYoung et al. (2007) indicates that banks who adopted technologies relatively early might indeed have seen significant profit increases from e-banking technologies, thereby giving cause for other banks to follow as soon as possible. But whether these late adopters experienced comparable profit improvements, or that their combined entry competed temporary profits away, remains unanswered in their research.

Nevertheless, according to Abaenewe et al. (2013), the introduction of e-banking technologies does not come without cost. Their study states that e-banking increases a bank's exposure to traditional risks like compliance, reputation and transaction risk. This is mostly due to the fact that technological systems are more connected and interdependent and thereby increasing the risk of computer intrusion. Banks with inadequate security compared to the level of sophistication of their e-banking operations significantly increase their exposure to an abundance of risks, which could lead to a collapse. Also, as results from Gorbacheva et al. (2011) show, the security concerns connected to internet banking have a large significant impact on the desire to adopt this technology for consumers. Solving the issue of fraudulent practices for both increased security and reassurance of the customer has been a great challenge to the banking industry. Due to the continuous developing nature of the technologies involved, this challenge resembles a never-ending battle. Therefore it is essential that all the risks presented by e-banking activities are incorporated into a bank's overall risk management process and that residual risks should be consistent with a bank's risk tolerance. Not its ability to control and manage risk (Abaenewe et al. 2013).

Internet banking

E-banking can be classified into many different categories. This study focuses on the two most widely accepted e-banking services, namely internet banking and the more recently introduced technology of mobile banking. Subsequently, both of these technologies are compared in respect to their relative effect on bank performance.

Internet banking is the technology where customers use the internet as a remote delivery channel to conduct banking operations. It provides customers with the opportunity to conduct a variety of operations from the comfort of their own home. Customers can, among other things, open accounts, transfer funds and make payments in the growing virtual environment (Halili, 2014). According to Tan and Teo (2000) internet banking is a "one stop service and information unit" and it very much has been for almost two decades. The technology has served as a foundation for a lot of subsequent products and services. As numerous studies conclude, internet banking is used as a complementary way of transacting rather than a substitute for physical branches/ATMs (Hernando & Nieto, 2007), (Halili, 2014).

The fact that the mechanization of the bank/customer relation has not completely substituted physical branches is a blessing for traditional banks. The rise of pure play internet banks started around the year 2000, likely instigated due to high potential cost savings which could provide them with a competitive advantage when compared to traditional banks (Deyoung, 2001). The model used by internet banks is based on reducing overhead costs mainly by eliminating physical locations and corresponding additional labor costs. These banks then use these savings to attract more customers by paying higher interest rates on deposits or charging lower interest rates on loans, thereby increasing their market share (Deyoung, 2001). Due to the low variable costs associated with the internet as a delivery channel, banks can offer lower prices, which in turn often result in faster market growth by acquiring new customers. Consequently this might aid significantly in obtaining considerable economies of scale, increasing a banks' competitive advantage even more. While due to these competitive advantages initial opinions were that traditional banks are dinosaurs that the internet would force to extinction, this opinion is no longer widely shared, for two main reasons. First and foremost because public trust is vital to banking. Traditional banks often have an established brand which is important to customers (Sato & Hawkins, 2001). Secondly, according to Lamberti and Büger (2009), complete mechanization only appeals to a limited amount of customers and good physical counseling still has its value and will likely continue do so in the future, regardless of the increase in counseling functions of intelligent systems. Eventually this results in the failure to materialize the expected reduction in overhead costs as well as failure to reach that much desired sufficient scale in operations to reduce profits. According to DeYoung (2005) the model used by internet banks, while potentially viable, is likely to be limited. Nevertheless, it is not possible for banks to survive in this technological age without offering technical solutions like internet banking (Lamberti & Büger 2009). Additionally, the internet has almost eliminated asymmetric information, by easily providing comparisons between different institutions, thereby causing financial institutions to compete with each other over the quality of technological solutions in an unprecedented manner (Lamberti & Büger (2009).

As technology further developed, more opportunities presented itself. The opportunity of online peer-to-peer lending could question the function of banks as financial intermediary. This way of financing

allows debtors to directly obtain loans from creditors, without a financial institution as middleman. Xu (2015) confirms in her study that P2P lending and bank borrowing are possible substitutes in providing finance. By eliminating the bank as financial intermediary and using the collective intelligence of the crowd, P2P lending has the ability to reduce costs and increase efficiency in the financial market (Guo et al. 2016). As a result, P2P lending should be seen as a potential threat to a traditional banks customer base.

As Lamberti and Büger (2009) stated, offering the service of internet banking is essential in a bank's survival. This study focuses on the effect on performance in a certain timeframe. Generally speaking, performance implies whether a bank has done well within a certain period compared to its objectives (Abaenewe et al. 2013). Thus, any fair evaluation of a bank's performance should always start by checking if the goals set by management and the bank's shareholders are met. Obviously, each bank has its own objectives. Some prefer minimizing risk and carry the image of a healthy bank, often accompanied by offering less rewards to its shareholders. Others might aim to grow faster than everyone else. Normally, the performance of a firm is reflected by the stock price and its behavior. But according to Abaenewe et al. (2013), such a market indicator may not always be reliable, as opposed to the volume of deposits, the size of the bank and its profitability which are internal performance indicators and can be considered more reliable. Most studies use Return on Equity (ROE) and Return on Assets (ROA), which are great indicators of management efficiency and rate of returns, to measure bank performance (Abaenewe et al. 2013).

There is already a great body of literature on the effect of internet banking on performance indicators like ROE and ROA. These studies can be split into groups based on the development of the countries. For developed countries, the research done by Hernando and Nieto (2007), Arnaboldy and Claeys (2008) and Ciciretti et al. (2009) show for different European banks that the adoption of the internet as a delivery channel has a positive impact not only on a bank's performance in terms of ROE and ROA, but also on the development of competition in the banking sector. According to Anaboldy and Claeys (2008), internet banking caused banks to drive their technological innovations up in order to stay competitive. Furthermore, the effect internet banking has on performance is essentially caused by higher commission income and through gradually reducing overhead expenses as a result of lower staff and IT costs (Hernando & Nieto, 2007). In the findings from Hernando and Nieto (2007), it is visible that the cost reduction results in improved profitability, which seems to become significant after one and a half year and after three years in terms of ROA and ROE respectively. Other studies do not find immediate significant positive results in respect to performance for internet banking in developed countries, which suggest a gradual process that contains delayed effects (Onay et al. 2008). The main explanation, according to Hernando and Nieto (2007), is an increase in IT costs in the first two years, which makes an immediate positive return more difficult to achieve. Especially since such a radical technological change needs time to be able to run smooth and efficient. As Ciciretti et al.

(2009) found, adopting internet technology increased performance significantly in an almost linear fashion, thereby suggesting that gaining experience in internet intermediation increases the likelihood of improving performance. But it can also be argued that in some cases it has to do with the intensity in the usage of internet on the consumer side. Banks implementing internet banking in countries where the access to internet is higher have the ability to reach positive returns on their assets at a faster rate through better economies of scale (Anaboldy and Claeys 2008).

On the other hand in the case of developing countries, the literature is optimistic but generally shows more mixed results. For example, the study of Van Dinh (2015) found that the implementation of internet banking causes performance to increase and operational costs to decrease. Under the condition that the bank's customer base increases, they found that only a relatively short period is needed to exceed initial costs and subsequently increase performance. In addition, Ngari and Muiruri (2014) established that internet banking increases the efficiency, accuracy, reliability and speed which lead to a competitive advantage over other banks. These results are consistent with those found in developed countries. However, contradicting findings from Khrawish and Al-Sa'di (2011), Tunay et al. (2015) and Akhisar et al. (2015) show a negative impact from internet banking on performance. Studies that indicate a negative impact generally come to the same conclusion, namely that the lack of electronic infrastructure may cause a substantial increase in overall infrastructure costs that adversely affect performance in most developing countries (Gutu, 2014), (Tunay et al. 2015), (Akhisar et al. 2015). In addition, Gutu (2014) shows that customers in these countries prefer traditional banking services in such a way that even additional advertising makes little difference for performance. It is quite clear that there has been a shift towards research interest in the adoption of digital banking in lesser developed countries, because less developed countries are usually later in implementing such technologies. This means that research on financial technologies in developed countries can especially be of interest as knowledge acquired in practice can be applied upon the development of these systems in developing countries.

In general, for developed countries the research is mostly convinced on the fact that internet banking eventually positively affects a bank's performance. Whether it is through a reduction in operating expenses, an increase in non-interest income or a growing customer base, in the end the results show positive effects on ROE and ROA (Hernando & Nieto, 2007). Studies that did not find a positive relationship in developed countries, like Sullivan (2000) and Halili (2014), have an explanation for doing so. Some studies are conducted in the early stages of internet banking, in hindsight maybe too early to obtain significant results (Sullivan, 2000). Since later research concluded that significant positive impacts on profitability can contain a lag of up to three years due to high initial costs (Hernando & Nieto, 2007). Other studies, like Halili (2014) believed that their negative findings in developed countries are caused by external factors such as the 11 September attacks or the 2008 global financial crisis.

Mobile banking

Mobile banking entails the business of conducting banking operations through a mobile device. It was first introduced in the early 2000s during the upcoming of internet banking. The first mobile services were extremely basic and far from interactive. Main reason for not offering services beyond read-only applications were the security concerns that entail moving key service offerings to a mobile environment (Cleveland, 2016). Customers could contact the bank via SMS for certain automated information, like viewing account balances. In the beginning, it was unclear as to what the development would lead to and many thought it had limited potential (Cleveland, 2016). Hence, mobile banking did not break ground until the introduction of the smartphone. This development provided on the one hand the opportunity to provide services in a similar way as on a computer, and on the other hand it increased the demand for mobile banking services (Shaikh & Karjaluoto, 2015).

Since mobile banking has several different phases and comparable technologies, it is important to clearly state what comprises to the topic and what does not. This study focuses on mobile banking from the moment applications are introduced that enabled customers to access their bank accounts and conduct more complicated financial operations such as loan applications on their mobile device. The fact that a bank is directly involved separates it from mobile payment systems (Shaikh & Karjaluoto, 2015).

The arrival of the smartphone actually caused a re-launch in the mobile banking industry. Banks had to decide to what extent they would offer mobile services. According to Cleveland (2016) it quickly became clear that in order to compete for the business of consumers, banks had to offer more advanced services. Since non-traditional online/mobile-only banks started to join the field, traditional banks had to match those service levels in order to stay competitive. Also, the mobile banking industry is massively growing and, according to Oracle (2013), it has the potential to become the primary source of banking. This means that providing the right mobile banking solution might become essential to survival in the banking world.

The research conducted on the relationship between mobile banking and the financial performance of banks is quite limited, especially in the case of developed countries. The studies that do investigate this relationship are focused on developing countries, mainly in Africa. For example, Kithaka (2014) found that mobile banking contributes positively to the performance of Kenyan banks in terms of ROA and ROE. Although mobile deposits are cheaper to process than branch deposits the significant results are mostly caused by the trend in the number of users and can be explained by the ability of mobile banking to bring banking services to those who live in remote areas without access to banks. The case of mobile banking in developed countries is completely different. This is due to the fact that providing mobile services will not have the same effect on the number of users in these countries, seeing that banks are more accessible to everyone. As stated by Cleveland (2016), in developing

countries banks have to offer mobile services to stay competitive. Furthermore, if mobile banking is merely added without removing something else, there are not a lot of cost cutting opportunities that would lead to improved financial performance. Considering that since the emergence of mobile banking, branch visits have dropped drastically, the reduction of costs related to physical branches provides the biggest opportunity. However, research shows that eliminating physical branches is not necessary beneficial to a bank's performance (Lamberti and Büger 2009). Thus, the bank that is able to minimize the so called "brick and mortar" costs while keeping this channel operable while at the same time develop advanced mobile services to attract customers, will be the winners according to Cleveland (2016).

Methodology

This section provides justification for the methodology used in the analyses. First and foremost, the following hypotheses are formulated to find an answer to the research question:

H1: The implementation of internet banking positively affects a bank's performance level in the long run.

This study hypotheseizes that a financial technology like online banking positively affects a bank's return on assets and return on equity, when controlled for certain bank specific and macroeconomic variables. The literature shows that, compared to traditional banking, online banking creates opportunities for significant cost advantages and increased profitability through increased effciency (Akhisar et al. 2015). To be able to find positive results, studies indicate is important to take into account the high initial costs associated with the implementation of online banking in the short run (Siam, 2006 and Hernando & Nieto, 2007, Onay et al. 2008). These costs can cause possible positive effects on ROA and ROE to contain a lag of two to three years and therefore it is essential to examine multiple windows for both the long run and the short run.

H2: The implementation of mobile banking positively affects a bank's performance level in the long run.

Secondly, this study hypotheseizes that a financial technology like mobile banking positvely affects a bank's return on assets and return on equity, when controlled for certain bank specific and macroeconomic variables. The mobile banking industry has grown tremendously in only a couple of years. Cleveland (2016) states that when mobile banking becomes the primary channel, banks have the opportunity to save a lot of costs. For instance, since the emergence of mobile banking, branch visits have dropped dramatically. Furthermore, mobile banking can help strengthen the relationship with customers. According to Cleveland (2016), if the bank fully satisfies the customer with basic services, it can be considerably easier to push for more profitable financial products. These results are not expected to emerge until the long run because it takes time to built a sizeable customer base, for multiple reasons. First of all, most applications at launch are not flawless or offer a complete user-friendly service. Secondly, at the time of the first mobile banking launches the smartphone penetration was even in the most developed countries below the 50 percent. Lastly, security concerns were in the beginning for many people an important reason not to partake (Cleveland 2016).

H3: The early adopters of internet banking do not outperform the late adopters of internet banking.

Thirdly, this study hypotheseizes that the early adopters of internet banking do not outperform late adopters. The complete technological infrastructure that is required for internet banking was in its initial phase in the late 90s when the first banks started their implementation. To use the model

presented by Rogers (2010), although there were clear relative advantages to the internet banking technology, the compatibility issues may have caused the adoption to slow down. Most people, at that time, did not have a computer in their home. Also, switching from traditional banking to internet banking was a big step that required a change in behaviour (Kolodinsky et al, 2004). Combining these factors ensures that this study expects that there were few benefits to be gained from the early implementation of internet banking.

H4: The early adopters of mobile banking outperform the late adopters of mobile banking.

Finally, this study hypotheseizes that the early adopters of mobile banking are experiencing a higher increase in performance compared to the late adopters. First and foremost, according to Cleveland (2016) it quickly became clear that in order to stay competitive, banks have to offer mobile banking services to the best of their ability. The sooner a bank launches an application, the sooner it can start building a cumstomer base. Furthermore, the mobile banking industry had less of an infrastructure problem compared to the internet banking industry. Using the model from Rogers (2010), the main reason for expecting a noticeable increase for early adopters in performance lies with increased compatibility and less complexity. Even though, at the time of introduction most people did not have a smartphone, this number was already rapidly growing (Cleveland, 2016). Furthermore, digital affiniy was less of an issue as opposed to the internet banking age. This resulted in the fact that for most people the switch to mobile banking was a smaller step compared to the switch to internet banking, thereby giving rise to the expectated increased performance for early adopters.

To find the validity of these hypotheses, this study looks at 54 of the largest commercial banks in both developed and developing countries distributed all over the world. The dataset only included banks that at a certain point in time implemented internet banking. The set consists of monthly data ranging from 1990-2015. This sample is chosen because, first and foremost, it comprises data from the first adopters of online banking as well as data from the last adopters of mobile banking. And secondly, it also includes enough data prior to the first adopters of internet banking to be able to generate accurate estimation windows for the event study. The specific range differs per bank depending on the timing of their implementation of internet banking and mobile banking. The timing of the implementation of the two technologies is noted in table 10 in the appendix. The event study excludes three banks from the mobile banking analysis because of incomplete data due to bankruptcy.

The data is collected from multiple sources. All bank specific data comes from the Refinitiv Eikon database, whereas macroeconomic variables are retrieved from the World Bank. As for specific data regarding the timing of online and mobile banking implementation, these are collected mainly from bank balance sheets and news articles. Based on the dates of implementation banks are classified into groups of early adopters and late adopters for both internet banking and mobile banking. Banks that implemented internet banking before January 1st 1999 are considered early adopters while banks

implementing from January 1st 1999 onwards are considered late adopters. For mobile banking, banks that implemented their application before January 1st 2011 are considered early adopters, whereas banks implementing from January 1st 2011 onwards are considered late adopters.

Consequently, a multilevel panel data set consisting of time-series and multilevel cross-sectional data is constructed. The combined data set is an unbalanced panel of around 50000 observations of 54 banks over a twenty five year period starting in 1990. The panel is unbalanced because some banks started or ended their operation between 1990 and 2015. Where the event study uses monthly data, the data for the panel model has been collapsed to yearly. Table 1 below presents the summary statistics regarding the collapsed dataset, after controlling for outliers.

Table 1: *Average summary statistics over 54 banks*

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) max
ROE	1,483	13.24	9.425	-45.27	48.11
ROA	1,449	1.359	2.168	-33.42	35.73
EquitytotalAssetsratio	1,624	7.607	9.342	-14.28	83.47
InternetAccess	1,550	41.22	33.86	0.000111	97.32
Inflation	1,618	3.623	4.998	-1.736	66.01
NPLtoTotalLoans	1,568	3.848	6.636	0.186	62.38
LoanstoAsset	1,596	61.29	10.73	26.41	84.85
Overhead_Ratio	1,596	2.248	2.368	-4.375	42.59
size	1,624	20.44	2.258	14.93	27.46
GDPc	1,596	25,013	19,936	301.2	68,150
Number of id	54	54	54	54	54

Dependent variable

This study tries to explain the effect of e-banking, consisting of internet and mobile banking, on bank performance, the dependent variable. In order to measure bank performance, two proxy variables are being used, namely the return on assets (ROA) and return on equity (ROE). This is a commonly used method when looking at a bank's performance level (Halili, 2014, Abaenewe et al. 2013, Khrawish and Al-Sai'di 2011). ROA compares a bank's profit to its total assets. This ratio gives great information regarding the effectiveness of a bank to generate income by using its available assets. ROE compares the net income of a bank to the total amount of shareholders' equity, which gives an indication of how effectively management uses the funds of its shareholders. Both variables are noted as follows:

$$ROA = \frac{Net\ Income}{Average\ Total\ Assets}$$

$$ROE = \frac{Net\ Income}{Average\ Shareholders' Equity}$$

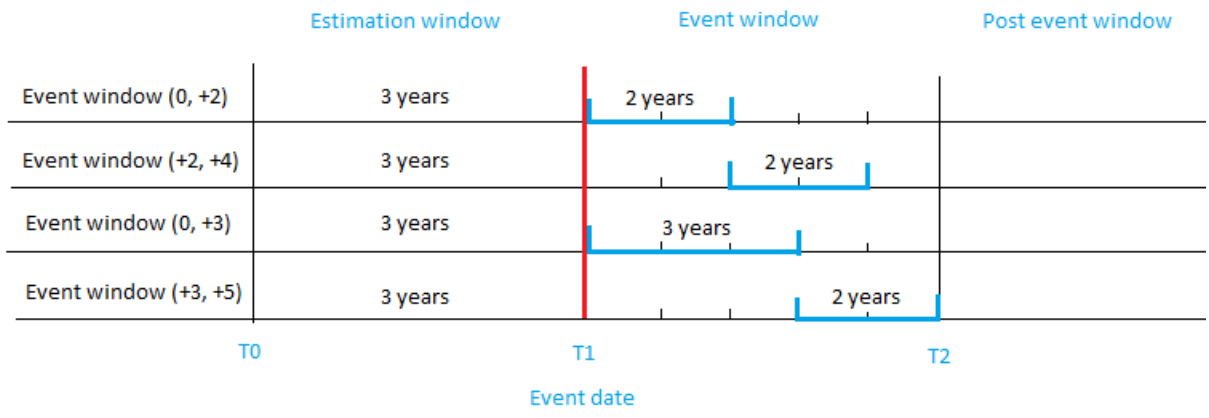
Event study

From existing literature can be inferred that the best way to study the effect of certain event is by adopting an event-study methodology (Smirnov, 2018). Event studies, like the one from Smirnov (2018), analyze the effect of certain events or announcements on stock price behavior. Typically, the idea is to discover the abnormal return attributable to the event in question by adjusting for the return that arises from the price variation of the market as a whole. In this study, the method is applied to provide an initial indication of the effect of implementing a major financial technology on bank performance. Also, by using the event study method, it is possible to examine different time intervals for event windows to figure out if there exists a lag contributed to the implementation of a particular technology. Since the dataset does not include banks without internet banking or mobile banking, it is not possible to use a regression model to examine the effect of a certain technology on bank performance.

The event study methodology requires implementing a particular sequence of steps (Smirnov, 2018). The first step is to define the event of interest. Essentially, it is a specific date on which the event study analysis is constructed. In this study, there are two event dates for each bank, namely for the implementation of both internet banking and mobile banking. For example, Wells Fargo is the first bank in the sample to implement internet banking in May of 1995. Subsequently, they launched their mobile application in May 2009. It is crucial that these two dates for each individual bank do not converge within a certain window of each other. This would cause the abnormal returns of internet banking to be afflicted by the implementation of mobile banking. Hence, it has been ensured that they never overlap.

The second step is to establish the research timeline. In an event study two periods have carefully defined, namely the estimation window and the event window. The figure below helps to clarify the procedure.

Firgure 1: Event study timeline



The estimation window (T0, T1) is a period of time before the event date counted in years. Armitage (1995) suggests when conducting an event study with monthly data to use an estimation window of 24 to 60 months. However, due to more missing values at the early stages of internet banking the size of the estimation window is limited. In this case, 36 months generated for both events the most reliable results. This window is used to create an estimation of the expected returns for the event window, as if no event took place. This estimation helps with determining the abnormality of the returns during the event window. The event window (T1, T2) is the number of years for which the abnormal returns are calculated. As seen in figure 1, this study considers four event windows for both internet banking and mobile banking. Namely, two short term windows of less than two and three years, and two long term windows of two to four and three to five years. Research shows that there can be a delay in the profitability of the implementation of for example internet banking of up to three years (Siam, 2006 and Hernando & Nieto, 2007).

The third step is the creation of the index. This study uses the average of both return on assets and return on equity for each individual bank to build an index. This method is preferred over employing the average of all banks because of the differences in date of implementation.

The final step involves defining the predicted return, abnormal return and the cumulative abnormal return. First of all, the predicted return implies the return that is expected in case the event would not occur. Secondly, the abnormal return (AR) consists of the difference between the actual return and the predicted return. And finally the cumulative abnormal return (CAR) is calculated by aggregating the AR values. To determine whether actual cumulative abnormal returns are present the model compares the predicted returns with the actual returns by means of a t-test. The following representation holds for every bank in the sample:

$$AR_{it} = R_{it} - (a_i + \beta_i R_{it})$$

Where:

AR_{it} : Abnormal return

R_{it} : Actual return of the selected event window

$(a_i + \beta_i R_{it})$: Predicted normal return by the index

$$CAR_{t(t_1,\ t_2)} = \sum_{t=t_1}^{t=2} AR_{it}$$

Where $CAR_{t(t_1,\ t_2)}$ resembles the cumulative abnormal return between the boundaries $(t_1,\ t_2)$ of the event window.

Panel data

This study aims to examine the effect of financial technologies on bank performance. Furthermore it tries to analyze whether it might be advantageous to be an early adopter of a specific technology. As already mentioned, the event study is used to provide an initial indication and possibly discover lags contributed to the implementation. However, these results can be influenced by many factors. A panel data model that includes these factors is needed, to disentangle the effect a specific technology has on performance in terms of return on assets and return on equity. Most studies regarding this subject choose to conduct a fixed effects or a random effects model, since the pooled model is not able to measure differences in cross sectional units (Halili, 2014). However, both of these models have their advantages and disadvantages. The fixed effects model can only measure the impact of variables that vary over time, which means it is unable to provide results about the distinction made between adopters of technologies. Then again, the fixed effects model is better suited for measuring bank specific variables that change over time. For that reason, the model is included in the analysis, but more in a minor role. The random effects model is able to incorporate time invariant variables and is therefore crucial to this study. Still, the problem regarding the random effects model arises when the explanatory variables correlate with the individual unobserved heterogeneity. In many applications, the reason for using panel data is to allow the unobserved effect to be correlated with the explanatory variables. However, this would generate biased results. The Hausman test, conducted to test which model should be used, is included in the appendix. Nevertheless, both models are provided in the results.

In order to test hypotheses three and four the model uses an independent dummy variable. This dummy can only be measured in the random effects model because it is time invariant. The dummy differentiates the early and late adopters of financial technologies. The results of this dummy show whether early adopters were able to generate more performance compared to late adopters. The fixed effects model on the other hand includes a dummy variable that considers the third, fourth and fifth year after which banks implemented internet banking and mobile banking. The results of this dummy show whether banks are experiencing an increase in performance for this period.

In addition, several control variables are used in this model in order to disentangle the effect of the implementation of financial technologies on a bank's performance level. Meaning the panel data model uses these variables to control for the effect they have on possible abnormal returns in the event windows. These variables can be split into two sets, either macroeconomic or bank specific variables. For bank specific variables this study uses Liquidity, Credit risk, capital, overhead ratio and size. First off, liquidity reflects the ability of a bank to meet short term obligations. According to Siddik et al (2016) the trade-off between liquidity and profitability is crucial in the sense that liquid assets provide a considerable lower rate of return. Therefore a negative impact is expected. This variable is measured by total loans to total deposits of a bank. Secondly, credit risk is generally accepted as the largest

source of a banks loss, thereby negatively impacting performance (Siddik et al 2016, Khrawish & Al-Sai'di 2011, Halili, 2014). Here, the ratio of non-performing loans to total loans is used to measure credit risk. Thirdly, capital is, according to Naceur and Goaied (2001) an important factor influencing a bank's profitability. They explained that higher capital to asset ratio requires lower expensive external financing, thereby increasing profitability. This variable is measured by the ratio of equity to total assets. Fourthly, overhead ratio sets the costs of doing business against the revenues. Logically, it is every bank's goal to keep the costs as low as possible. However, the implementation of financial technologies might increase these costs. As shown by Halili (2014), who linked significantly negative overhead costs, in terms of IT costs, to the implementation of internet banking. The final specific variable is bank size. According to multiple studies, the size of a bank can have significant impact on the profitability of online banking (Sullivan, 2000). A larger bank is able to obtain more economies of scale and therefore a positive effect is expected. Since biggerillo-Ponce (2013) found bank size to be non-linear, it is measured by taking the natural logarithm of total assets.

The second set includes macroeconomic variables to control for country specific differences and its effect on profitability. This study uses five macroeconomic control variables, namely economic growth, internet access, inflation, economic inequality and Dot-com bubble. The variable economic inequality is excluded in the fixed effects model due to previous mentioned reasons. GDP per capita is used to measure economic growth. Several studies, like Athanasoglou et al. (2008) and Trujillo-Ponce (2013) found a significant positive relationship between economic growth and bank performance. The second macroeconomic variable is internet access. Banks implementing internet banking in countries where the access to internet is higher have the ability to reach positive returns on their assets at a faster rate through better economies of scale (Anaboldy and Claeys 2008). To infer the effect of the intensity in the usage of internet, the model includes internet access per country. Due to the unavailability of data with respect to smartphone penetration, the internet access variable is also used in the mobile banking analysis. The third macroeconomic variable is inflation. Trujillo-Ponce (2013) found a positive relationship between inflation and bank profitability in terms of ROA. Assuming the inflation can be somewhat anticipated, he states that the bank can adjust interest rates appropriately to increase earnings faster than costs. Inflation is measured by through the consumer price index (CPI). The fourth macroeconomic variable is economic inequality. This dummy variable controls for the difference between developed and developing countries. According to the literature, the effect of mobile banking on performance is expected to be stronger in developing countries (Kithaka, 2014).The final macroeconomic variable is the Dot-com bubble. This variable takes into account the effect of the burst of the bubble in early 2000. Such crisis can have enormous impact on the results, as shown by Halili (2014). Table 11 in the appendix gives an overview of all the variables and their correlation. Internet access and GDP per capita are the only variables which can consider to be highly correlated.

Combining the variables produces the following fixed effects model.

$$Y_{ijt} = \mathrm{B}_0 + \mathrm{B}_1 EVENT_i + \sum \mathrm{B}_2 X_{it} + \mathrm{B}_3 GDPc_{jt} + \mathrm{B}_4 INTERNET_{jt} + \mathrm{B}_5 INFLATION_{jt} + \mathrm{B}_6 Dotcom_1 + \varepsilon_{it}$$

And the random effects model:

$$Y_{ijt} = \mathrm{B}_0 + \mathrm{B}_1 EARLY_i + \sum \mathrm{B}_2 X_{it} + \mathrm{B}_3 GDPc_{jt} + \mathrm{B}_4 INTERNET_{jt} + \mathrm{B}_5 INFLATION_{jt} + \mathrm{B}_6 Dotcom_1 + \mathrm{B}_7 INEQUALITY_2 + u_i + \varepsilon_{it}$$

The model consists of:

EVENT_i is the dummy variable for the fixed effects model that takes value 1 in the third, fourth and fifth year after implementing either internet banking or mobile banking.

EARLY_i is the dummy variable for the random effects model that takes value 1 if a bank implemented internet banking before 1999 and for mobile banking before 2011.

X_{it} as a matrix of all bank specific control variables consisting of;

- $Liquidity = \frac{Total\ loans}{Total\ deposits}$
- $Credit\ risk = \frac{Non-performing\ Loans}{Total\ Loans}$
- $Capital = \frac{Total\ equity}{Total\ assets}$
- $Overhead\ ratio = \frac{operating\ expenses}{operating\ income}$
- $Size = \ln(Total\ Assets)$

GDPc_{jt} is the first macroeconomic variable that differs per country over time.

$\mathrm{INTERNET}_{jt}$ is the second macroeconomic variable that differs per country over time.

$\mathrm{INFLATION}_{jt}$ is the third macroeconomic variable that differs per country over time.

$\mathrm{INEQUALITY}_{jt}$ is the fourth macroeconomic dummy variable that divides the sample in two groups, namely developed and developing countries.

DOTCOM_1 is the final macroeconomic dummy variable that takes value 1 in the years 2000, 2001 and 2002.

u_{jt} is the country specific error of the model.

ε_{it} is the bank specific error of the model.

Results

The results are discussed in two parts, starting with the event study followed by the panel data model.

Event study

This study uses an event study to provide an initial indication of the effect that implementing financial technologies has on bank performance in terms of ROA and ROE. The event study also provides the opportunity to discover whether this effect contains a delay. The method is first applied to internet banking and then to mobile banking. Table 2 shows the cumulative abnormal returns for the ROE related to the launch of internet banking. None of the event window offer significant results. According to Siam (2006) and Hernando and Nieto (2007), because of increased costs associated with implementation, the averages for the starting period are expected to be negative and therefore insignificant results are a logical consequence. Furthermore, table 3 shows the cumulative abnormal returns for the ROA related to the launch of internet banking. Again, no significant results are found in any of the event windows. Since the analysis found no indication of increased performance in the long run, it may suggest that the first hypothesis should be rejected.

Table 2: *Cumulative abnormal returns in ROE for internet banking*

Window	Mean	t-statistic
CAR(0,+2)	-12.668	-0.53
CAR(+2,+4)	14.256	0.35
CAR(0,+3)	-6.642	-0.17
CAR(+3,+5)	1.054	0.03

Table 3: *Cumulative abnormal returns in ROA for internet banking*

Window	Mean	t-statistic
CAR(0,+2)	3.771	0.60
CAR(+2,+4)	-0.752	-0.16
CAR(0,+3)	1.534	0.33
CAR(+3,+5)	1.795	0.46

The second part applies the event study to the launch of mobile banking. Table 4 and 5 shows the cumulative abnormal returns for the ROE and ROA respectively. In both instances, no significant results are found. This suggests that the implementation of mobile banking will not considerably increase a banks' performance regardless in both the long and the short run. This may indicate that the second hypothesis should be rejected as well.

Table 4: *Cumulative abnormal returns in ROE for mobile banking*

Window	Mean	t-statistic
CAR(0,+2)	28.64	0.96
CAR(+2,+4)	-27.28	-1.23
CAR(0,+3)	16.489	0.53
CAR(+3,+5)	-22.285	-1.07

Table 5: *Cumulative abnormal returns in ROA for mobile banking*

Window	Mean	t-statistic
CAR(0,+2)	1.743	0.54
CAR(+2,+4)	-0.459	-0.23
CAR(0,+3)	1.173	0.28
CAR(+3,+5)	0.703	0.30

However, the event study in the form conducted in this analysis has some limitations that potentially caused these particular results. First of all, because an event study is not able to control for any factors, these factors may have concealed the effect on performance. Secondly, the event study considers windows consisting of multiple years. This increases the chance that the result of any particular event is diluted by any number of factors. Lastly, the data set consists of both developed and developing countries. Although the literature generally agrees that positive effects can be found in developed countries, the literature for developing countries is more conflicting. Khrawish and Al-Sa'di (2011), Tunay et al. (2015) and Akhisar et al. (2015) all find a negative impact from internet banking. It may be the case that possible positive results are distorted by negative results from developing countries. All things considered, these insignificant results give an indication that the first two hypotheses should be rejected; however this cannot be declared with absolute certainty. Therefore this study aims to provide a deeper understanding of the effect and its influencing factors by way of the following panel data model.

Panel data

Subsequently, the panel data model is used to analyze whether it can be advantageous to implement a financial technology at its early stages. As opposed to the event study, these models are able to take into account factors that influence the effect on performance and thereby provide a deeper understanding of the relationship. The first pair of regressions is for the implementation of internet banking, the second pair is for mobile banking. Results of both the fixed effects model and the random effects model are shown. The results of the hausman test are then considered to provide which of the models should be used. Both models incorporate a set of bank specific and macroeconomic control variables, however only the random effects model includes the dummy for early adopters. The fixed effects model is not able to assess time invariant dummies used to incorporate the effect of early adopters and developing countries on bank performance. Instead, the fixed effects model incorporates an event dummy that considers the period of three to five years after implementation of each technology. The robustness checks belonging to every regression are included in the appendix.

Table 6 shows the first internet banking regression on ROE for both models. Unfortunately, the r-squared is quite low. Because according to the hausman test, the random effects model is only permitted for the regression on ROE. There are no significant results between the early adopters of internet banking and performance in terms of ROE. In contrast, table 7 has a higher r-squared and shows significant positive results in terms of ROA. These results partly acknowledge the findings from Hernando and Nieto (2007) that the effect of internet banking is more present in ROA compared to ROE. This makes sense because internet banking is expected to positively affect loans included in total assets. However, because the hausman test concluded that the random effect parameters are biased, this study accepts the hypothesis that early adopters do not outperform the late adopters of internet banking. Table 7 shows a significantly negative result for the developing country dummy at the 5% level. Although the result is biased, it is consistent with the findings from from (Gutu, 2014), Tunay et al. (2015) and Akhisar et al. (2015). They indicate that the lack of electronic infrastructure may cause a substantial increase in overall infrastructure costs that adversely affect performance in developing countries.

For the overhead ratio both models find significant results. It seems contradicting that the ratio has a negative effect on ROE while it positively affects ROA, but considering the results of the hausman test this could be biased. Keeping this ratio as low as possible is important to a bank, because having high operating expenses compared to the operating income is by no means beneficial to performance (Halili, 2014). Therefore a negative effect is to be expected. The literature is convinced that during the first two to three years of implementation the overhead costs are expected to increase, and thereafter decrease (Hernando and Nieto, 2007). This has to do with the high one-off costs followed by the cost savings through increased efficiency. Additionally, the degree to which people have access to internet

Table 6: *Internet banking regression for ROE*

VARIABLES	(RoE) Fixed Effects	(RoE) Random Effects
Early adopter Internet banking		-0.796
		(1.535)
Inequality		-2.393
		(2.424)
Liquidity	-0.478	-0.565*
	(0.328)	(0.315)
Credit risk	0.135	0.165**
	(0.119)	(0.0829)
Capital	0.00888	0.184
	(0.311)	(0.250)
Overhead_Ratio	-0.495**	-0.481***
	(0.195)	(0.184)
Size	0.159	0.162
	(1.124)	(0.381)
GDP per capita	-1.17e-05	-0.000152
	(0.000150)	(9.79e-05)
Inflation	0.0305	0.0365
	(0.0730)	(0.0705)
InternetAccess	0.0467*	0.0596**
	(0.0270)	(0.0233)
Dotcom	-1.171	-0.901
	(0.923)	(0.876)
Event dummy internet banking	0.803	
	(0.896)	
Constant	12.32	15.09*
	(23.04)	(8.401)
Observations	558	558
R-squared	0.035	0.084
Number of id	54	54
Standard errors in parentheses		
* significant at the 1 percent level		
** significant at the 5 percent level		
*** significant at the 10 percent level		
Internet banking regression for return on equity for the period 1992-2003		

is shown to be significantly positive, which is expected, but results are only found in terms of ROE. Furthermore, this study found strong positive results for the variable capital on ROA. Due to lower costs of financing, capital is expected to have a positive effect on performance.

Table 7: *Internet banking regression for ROA*

VARIABLES	(RoA) Fixed Effects	(RoA) Random Effects
Early adopter internet banking		0.376*
		(0.207)
Inequality		-0.839**
		(0.373)
Liquidity	0.0596	0.116*
	(0.0751)	(0.0697)
Credit risk	0.000703	-0.000504
	(0.0271)	(0.0137)
Capital	0.423***	0.334***
	(0.0728)	(0.0466)
GDP per capita	2.06e-06	-4.13e-05***
	(3.45e-05)	(1.59e-05)
Inflation	-0.185***	-0.150***
	(0.0159)	(0.0151)
Size	0.214	-0.0136
	(0.256)	(0.0587)
Overhead Ratio	0.0965**	0.137***
	(0.0436)	(0.0393)
InternetAccess	-0.00140	0.000835
	(0.00619)	(0.00519)
Dotcom	-0.173	-0.120
	(0.210)	(0.201)
Event dummy internet banking	-0.00144	
	(0.203)	
Constant	-5.289	0.428
	(5.231)	(1.328)
Observations	556	556
R-squared	0.274	0.2325
Number of id	54	54
Standard errors in parentheses		
* significant at the 1 percent level		
** significant at the 5 percent level		
*** significant at the 10 percent level		
Internet banking regression for return on assets for the period 1992-2003		

The second pair of regressions in table 8 and 9 with respect to mobile banking have a comparable r-squared. But the hausman test concludes that the parameters of the random effects model with respect to ROA could be biased. That being said, there are no significant results found for early adopters in both ROE and ROA. The early adopters of mobile banking do not outperform the late adopters. This means hypothesis four can be rejected.

Table 8: *Mobile banking regression for ROE*

VARIABLES	(RoE) Fixed Effects	(RoE) Random Effects
Early adopter mobile banking		2.012
		(1.228)
Inequality		1.843
		(1.811)
Liquidity	1.359	1.423
	(1.082)	(0.907)
Credit risk	0.0374	-0.204***
	(0.0970)	(0.0769)
Capital	-0.148	-0.245
	(0.220)	(0.190)
Overhead_Ratio	0.171	0.0387
	(0.159)	(0.156)
Size	0.443	-0.538*
	(0.729)	(0.295)
GDP per capita	0.000109**	0.000131***
	(4.65e-05)	(3.94e-05)
Inflation	0.294**	0.293**
	(0.135)	(0.133)
InternetAccess	-0.271***	-0.242***
	(0.0243)	(0.0233)
Creditcrisis	-2.318***	-1.666***
	(0.566)	(0.572)
Event dummy mobile banking	-1.877***	
	(0.644)	
Constant	15.58	32.48***
	(15.11)	(6.723)
Observations	774	769
R-squared	0.205	0.1972
Number of id	54	54
Standard errors in parentheses		
* significant at the 1 percent level ** significant at the 5 percent level *** significant at the 10 percent level		
Mobile banking regression for return on equity for the period 2004-2019		

In terms of bank specific variables the random effects model found that credit risk has significant negative impact on both ROE and ROA. Measured as the non-performing loans to total loans this indicates that banks who take on more risk experience a decrease in performance. Additionally, the random effects model for ROE found significant results for size. Contrary to the findings from Sullivan (2000), this suggests that bigger banks are not able to utilize their economies of scale. In relation to the macroeconomic variables considered, the regressions on ROE in table 8 finds positive results for inflation and GDP per capita, and negative results for internet access and the credit crisis dummy. The positive findings for inflation suggest that banks are able to adjust interest rates on loans quicker compared to the rates on deposits, as Trujillo-Ponce (2013) suggested. Both GDP per capita and the credit crisis dummy show their expected findings. The negative findings for internet access, which are also found in both models in table 9, with regards to mobile banking are unexpected. Understandably, the internet access may have less of a direct effect on mobile banking compared to internet banking. However, without access to internet it is impossible to perform mobile banking activities.

Table 9: *Mobile banking regression for ROA*

VARIABLES	(RoA) Fixed Effects	(RoA) Random Effects
Early adopter mobile banking		-0.0738
		(0.0988)
Inequality		0.202
		(0.165)
Liquidity	0.0710	0.280***
	(0.140)	(0.0943)
Credit risk	-0.0113	-0.0348***
	(0.0113)	(0.00740)
Capital	-0.0196	0.0512**
	(0.0277)	(0.0200)
GDP per capita	-7.08e-07	2.55e-06
	(5.96e-06)	(4.32e-06)
Inflation	-0.00167	0.0351**
	(0.0172)	(0.0157)
size	0.0528	0.0159
	(0.0929)	(0.0247)
Overhead_Ratio	-0.00571	-0.0249
	(0.0210)	(0.0191)
InternetAccess	-0.0104***	-0.00793***
	(0.00313)	(0.00280)
Creditcrisis	0.0351	0.00614
	(0.0720)	(0.0718)
Event dummy mobile banking	-0.0194	
	(0.0835)	
Constant	0.927	0.692
	(1.921)	(0.599)
Observations	763	758
R-squared	0.028	0.2292
Number of id	54	54

Standard errors in parentheses

* significant at the 1 percent level
** significant at the 5 percent level
*** significant at the 10 percent level

Mobile banking regression for return on assets for the period 2004-2019

Conclusions

This research aimed to examine the effect the implementation of financial technologies has on bank performance. Furthermore it is analyzed whether it might have been advantageous to be an early adopter of either internet banking or mobile banking. To be able to answer the research question this study used a combination of an event study and a panel data method.

This study first applies the event study method to provide an initial indication of the effect. No significant results were found for both internet banking and mobile banking in any of the event windows considered. This would imply that implementing these technologies may not have been beneficial to performance. These findings are contrary to expectations and generally to the existing literature. However, the results can be caused by some limitations to the way in which the event study method is used. For example, considering multiple years increases the chance of dilution by any number of factors.

To provide a deeper understand of the effect and its influencing factors, this study applies the panel data method to both internet banking and mobile banking. The random effects model has shown that, after controlling for a number of both bank specific and macroeconomic variables, it need not be beneficial to adopt these financial technologies at an early stage. Suggesting that committing to the sunk costs associated with implementing a financial technology at an early stage is unnecessarily risky, because by adopting late one does not foregoes significant profits. Additionally, the fixed effects model showed no signs of an increase in bank performance for the three to five year period following implementation, which corresponds with the results from the event study.

For future research it could be particular interesting to see further analysis with respect to the implementation dates of the technologies collected. This study has managed to collect implementation date specific to the month for over 50 major banks. Also, because the data retrieved from Eikon was not ideal, it could be interesting to see if the results remain the same when improved data with more options for different variables becomes available. Furthermore, the literature with respect to the effect of mobile banking on bank performance is quite thin. This can certainly be expanded in the coming years.

While the limitations to the event study are undeniable, the panel data approach provides new insight for the banking industry. By examining the timing of implementing financial technologies, this study shows that waiting for further technological development or more consumer adoption, will most likely not cause profits to disappear. This may truly be viable information for banks that aim to build a safe strategy around new financial technologies introduced in the future.

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Appendix

Table 10: *Timing of the implementation of each technology*

Banks	Country	Internet banking	Mobile banking
Deutsche Bank	Germany	September 1999	January 2010
Commerzbank	Germany	February 1998	February 2011
HypoVereinsbank	Germany	December 1997	May 2012
Bank of America	USA	December 1995	February 2007
Citibank	USA	November 1997	March 2009
Wells Fargo	USA	May 1995	May 2009
First Union/Wachovia	USA	April 1999	December 2006
Ally Bank	USA	May 2009	May 2012
Bank One Corporation	USA	June 1999	Dissolved
HSBC	UK	July 2000	May 2011
Barclays	UK	1998	July 2012
Lloyds TSB	UK	June 1999	November 2011
Royal Bank of Scotland	UK	January 1997	May 2011
Societe Generale	France	1999	December 2010
Royal bank of Canada	Canada	October 1997	December 2010
Scotiabank	Canada	August 1997	May 2010
Toronto-Dominion bank	Canada	April 1998	April 2010
Dankse bank	Denmark	January 1998	September 2010
Jyske bank	Denmark	July 1998	March 2011
Nordea	Denmark	December 1996	March 2010
ICICI bank	India	June 1998	January 2008
HDFC bank	India	September 1999	August 2010
State Bank of India	India	July 2001	March 2014
Westpac	Australia	June 1998	September 2011
Commonwealth bank of Australia	Australia	February 1997	December 2013
ANZ bank	Australia	April 1999	September 2010
St. George Bank	Australia	1995	Dissolved
National Australian Bank	Australia	1999	December 2010
Industrial & Commercial bank of China	China	December 1999	July 2008
Bank of China	China	June 1999	January 2008

China Everbright Bank	China	December 1999	December 2016
Shanghai Pudong Development Bank	China	June 2001	April 2009
China Minsheng Bank	China	June 2001	July 2012
Hua Xia Bank	China	October 2000	October 2016
Sumitomo Mitsui Financial Group	Japan	January 1997	May 2018
Branco de Brasil	Brazil	May 2000	January 2011
Banco Bradesco	Brazil	1996	July 2013
Standard Bank	South Africa	May 1997	June 2012
Absa Bank	South Africa	Late 1996	April 2013
Nedbank	South Africa	May 1997	August 2012
Hana Financial Group	South Korea	August 1999	April 2010
CHB Bank	South Korea	Beginning 1998	Dissolved
Commercial Internation Bank	Egypt	December 2003	February 2014
DBS Bank	Singapore	1997	April 2010
United Overseas Bank	Singapore	Late 1997	December 2011
OCBC Bank	Singapore	1998	March 2011
Maybank	Malaysia	June 2000	January 2010
Skandinaviska Enskilda Banken	Sweden	December 1996	September 2010
Handelsbanken	Sweden	December 1997	June 2010
Swedbank	Sweden	March 1997	June 2010
Pireaeus Bank	Greece	April 2000	May 2012
Alpha Bank	Greece	November 1998	June 2012
Eurobank Ergasias	Greece	February 2000	December 2013
HSBC	Hong Kong	2000	May 2011
Bank Internasional Indonesia	Indonesia	2002	June 2011
Bank Mandiri	Indonesia	2002	June 2012
Bank Mega	Indonesia	2001	July 2013
Bank Negara Indonesia	Indonesia	2007	January 2016

Table 11: *Correlation matrix*

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) ROE	1.000									
(2) ROA	0.310	1.000								
(3) Loantodeposits	-0.116	0.061	1.000							
(4) NPLtoTotalLoans	-0.001	-0.064	-0.023	1.000						
(5) EquitytotalAssets	-0.038	0.355	-0.201	0.101	1.000					
(6) Overhead_Ratio	-0.166	-0.016	0.139	0.047	-0.187	1.000				
(7) Size	-0.032	-0.120	-0.101	-0.282	-0.251	0.083	1.000			
(8) GDPc	-0.227	-0.121	0.216	-0.153	-0.202	0.064	-0.239	1.000		
(9) InternetAccess	-0.225	-0.089	0.133	-0.122	-0.134	0.076	-0.097	0.788	1.000	
(10) Inflation	0.178	-0.088	-0.137	0.073	0.065	-0.033	0.156	-0.394	-0.349	1.000

Table 12: *Hausman test*

Dependent variable	**Regression**	**Hausman statistic**
ROE	Internet banking	0.6982
ROA	Internet banking	0.0000***
ROE	Mobile banking	0.8831
ROA	Mobile banking	0.0000***

Table 13: *Robust internet banking regression for ROE*

VARIABLES	(RoE) Fixed Effects	(RoE) Random Effects
Early adopter internet banking		-0.796
		(1.624)
Inequality		-2.393
		(2.060)
Liquidity	-0.478***	-0.565***
	(0.130)	(0.138)
Credit risk	0.135	0.165
	(0.152)	(0.128)
Capital	0.00888	0.184
	(0.260)	(0.184)
Overhead Ratio	-0.495	-0.481
	(0.404)	(0.385)
Size	0.159	0.162
	(0.942)	(0.353)
GDP per capita	-1.17e-05	-0.000152
	(0.000194)	(0.000111)
Inflation	0.0305	0.0365
	(0.0868)	(0.0800)
InternetAccess	0.0467	0.0596*
	(0.0417)	(0.0346)
Dotcom	-1.171	-0.901
	(0.913)	(0.845)
Event dummy internet banking	0.803	
	(0.953)	
Constant	12.32	15.09*
	(20.20)	(8.116)
Observations	558	558
R-squared	0.035	
Number of id	54	54
R2 overall	0.0562	0.0838
Standard errors in parentheses		
* significant at the 1 percent level		
** significant at the 5 percent level		
*** significant at the 10 percent level		
Robust Internet banking regression for return on equity for the period 1992-2003		

Table 14: *Robust internet banking regression for ROA*

VARIABLES	(RoA) Fixed Effects	(RoA) Random Effects
Early adopter internet banking		0.376*
		(0.218)
Inequality		-0.839*
		(0.451)
Liquidity	0.0596**	0.116
	(0.0248)	(0.0906)
Credit risk	0.000703	-0.000504
	(0.0318)	(0.0160)
Capital	0.423***	0.334***
	(0.0588)	(0.0630)
GDP per capita	2.06e-06	-4.13e-05*
	(3.03e-05)	(2.27e-05)
Inflation	-0.185	-0.150
	(0.116)	(0.107)
Size	0.214	-0.0136
	(0.232)	(0.0808)
Overhead Ratio	0.0965***	0.137***
	(0.0177)	(0.0373)
InternetAccess	-0.00140	0.000835
	(0.00625)	(0.00320)
Dotcom	-0.173	-0.120
	(0.169)	(0.197)
Event dummy internet banking	-0.00144	
	(0.209)	
Constant	-5.289	0.428
	(4.916)	(1.493)
Observations	556	556
R-squared	0.274	
Number of id	54	54
R2 overall	0.169	0.233

Standard errors in parentheses

* significant at the 1 percent level
** significant at the 5 percent level
*** significant at the 10 percent level

Robust internet banking regression for return on assets for the period 1992-2003

Table 15: *Robust mobile banking regression for ROE*

VARIABLES	(RoE) Fixed Effects	(RoE) Random Effects
Early adopter mobile banking		2.012
		(1.614)
Inequality		1.843
		(1.826)
Liquidity	1.359	1.423
	(1.079)	(0.976)
Credit risk	0.0374	-0.204***
	(0.0929)	(0.0693)
Capital	-0.148	-0.245
	(0.156)	(0.190)
Overhead_Ratio	0.171	0.0387
	(0.186)	(0.176)
size	0.443	-0.538*
	(0.804)	(0.326)
GDP per capita	0.000109*	0.000131**
	(6.31e-05)	(6.60e-05)
Inflation1	0.294	0.293
	(0.214)	(0.206)
InternetAccess1	-0.271***	-0.242***
	(0.0517)	(0.0471)
Creditcrisis	-2.318***	-1.666**
	(0.760)	(0.709)
Event dummy mobile banking	-1.877***	
	(0.591)	
Constant	15.58	32.48***
	(16.45)	(7.722)
Observations	774	769
R-squared	0.205	
Number of id	54	54
R2 overall	0.133	0.197

Standard errors in parentheses

* significant at the 1 percent level
** significant at the 5 percent level
*** significant at the 10 percent level

Robust mobile banking regression for return on equity for the period 2004-2019

Table 16: *Robust mobile banking regression for ROA*

VARIABLES	(RoA) Fixed Effects	(RoA) Random Effects
Early adopter mobile banking		-0.0738
		(0.116)
Inequality		0.202
		(0.194)
Liquidity	0.0710	0.280**
	(0.225)	(0.124)
Credit risk	-0.0113	-0.0348**
	(0.0309)	(0.0151)
Capital	-0.0196	0.0512
	(0.0267)	(0.0389)
GDP per capita	-7.08e-07	2.55e-06
	(5.32e-06)	(6.11e-06)
Inflation1	-0.00167	0.0351*
	(0.0191)	(0.0190)
size	0.0528	0.0159
	(0.141)	(0.0320)
Overhead_Ratio	-0.00571	-0.0249
	(0.0175)	(0.0222)
InternetAccess1	-0.0104*	-0.00793*
	(0.00561)	(0.00441)
Creditcrisis	0.0351	0.00614
	(0.0613)	(0.0632)
Event dummy mobile banking	-0.0194	
	(0.0521)	
Constant	0.927	0.692
	(3.039)	(0.820)
Observations	763	758
R-squared	0.028	
Number of id	54	54
R2 overall	0.103	0.229
Standard errors in parentheses		
* significant at the 1 percent level ** significant at the 5 percent level *** significant at the 10 percent level		
Robust mobile banking regression for return on assets for the period 2004-2019		