Association for Information Systems
AIS Electronic Library (AISeL)

ICIS 2010 Proceedings

International Conference on Information Systems (ICIS)

2010

COMPLEMENTARITY OF THE IMPACT OF ALTERNATIVE SERVICE CHANNELS ON BANK PERFORMANCE

Rajiv Banker
Temple University, banker@temple.edu

Pei-Yu Chen
Temple University, pychen@templ.edu

Fang-Chun Liu
Temple University, fangchun@temple.edu

Chin-Shyh Ou
National Chung Cheng University, actcso@ccu.edu.tw

COMPLEMENTARITY OF THE IMPACT OF ALTERNATIVE SERVICE CHANNELS ON BANK PERFORMANCE

Completed Research Paper

Rajiv Banker
Department of Accounting,
The Fox School of Business and
Management, Temple University
Philadelphia, PA 19122 U. S. A.
banker@temple.edu

Pei-Yu Chen
Department of Management Information
Systems, The Fox School of Business and
Management, Temple University
Philadelphia, PA 19122 U.S. A.
pychen@templ.edu

Fang-Chun Liu
Department of Accounting,
The Fox School of Business and
Management, Temple University
Philadelphia, PA 19122 U. S. A.
fangchun@temple.edu

Chin-Shyh Ou
Department of Accounting and
Information Technology, College of
Management, National Chung Cheng
University, Chia-Yi 621 Taiwan
actcso@ccu.edu.tw

Abstract

Faced with intense competition, banks have deployed information technology (IT) to serve customers more efficiently and effectively in diverse ways. The challenge bank managers face is in utilizing alternative service channels to win customers and retain competitive advantages. This study investigates the impact of banks' use of channel mix strategy. We show strong complementarities between traditional branch channel and IT-based self-service channels on performance. The value provided by a channel depends both on its own level of investment and investments in other channels. It can be misleading to examine channels independently or simply view each channel as a substitute for other channels. Even though different channels do substitute each other to some extent, migration of transactions from traditional channels to the IT-based channels may change customers' overall demand such that it increases demand for all channels by transforming traditional channels to perform more value-added services or serve more profitable customers.

Keywords: IT investment, service channels, competitive advantage, banking industry

Introduction

Intense competition and constant change in the banking industry has enhanced banks' incentives to develop alternative service channels for retaining the existing customers as well as attracting new ones (Calisir and Gumussory 2008). In addition to offering traditional branch service channel, banks nowadays have deployed different information technology (IT) to offer multiple service channels, such as automated teller machines (ATMs) and Internet banking, to serve customers and satisfy their needs. Initially, the introduction of IT-based self-service channels was motivated by the need to cut costs because IT-based channels allowed banks to significantly lower operating costs by reducing costly human staff to perform bank transactions. Internet banking, for example, allows customers to perform many simple banking functions anytime and anywhere, while ATMs provide some services not possible by Internet banking, such as depositing checks and withdrawing money around the clock. Although banks may wish their customers migrate most of their transactions to the lower-cost IT-based channels, customers often mix their use of multiple channels in a way not necessarily in line with what the banks may want. Indeed, customers do not view each channel independently. Instead, depending on what is offered by the bank, they mix the use of these different channels to maximize value from banking.[1] This suggests that a bank's channel mix strategy may influence a customer's decision of whom to bank with and which alternative channel to choose from. Consultants recommend that the best strategy for a service company is to enable its customers to interact with it via multiple channels, instead of only through physical channels (Hughes and Kaplan, 2009). Several previous studies show that new service channels or different channel mix change consumers' behaviors. For example, Xue et al. (forthcoming) has shown that consumers' adoption of Internet banking motivates them to open more accounts and increase their overall demand for banking services, suggesting that there exists some strategic synergy among different channels that banks can explore further to obtain a competitive advantage.

IT-based channels do not only simply serve as substitutes for other channels, but may also transform the service performed by other channels. Anecdotal evidence suggests that the traditional branch channel still plays an important role in delivering banking services and is in fact also growing together with alternative IT-based channels. The reason is that shift to IT-based channels enables the branch channel to transform its focus to serving targeted segments of customers with more value-added services, which in turn makes it a critical revenue-generating channel. Even between IT-based channels, one may expect to see ATMs replaced by Internet banking, which lowers operating costs significantly and provides more real-time, interactive services to customers. However, ATM investment today has also grown consistently. Banks are expanding ATM functionalities to provide more diversified services through this channel. This again suggests that one channel can potentially change the value provided by other channels. For example, observing customers' desire to manage their transaction activities more actively, Wells Fargo, the third-largest bank owner of ATMs in U.S., offers the option of emailing ATM receipts to customers who are also the bank's Internet banking users. This strategy not only satisfies customers' needs in a timely fashion but also significantly reduces paper use which contributes to lower operating costs of ATMs.[2] Thus, it may be incorrect to assume that a bank can make investments in different service channels independently. It is important that banks take a holistic view of their channel strategies with the goal to improve customers' banking experience such as by personalizing their experience in order to compete successfully.

The main challenge for banks today is to choose the right mix of service channels to deliver products and services profitably to customers with different needs. This requires a comprehensive understanding of how each channel individually and jointly impacts bank performance while taking into account competitors' channel strategies. As IT plays a pervasive role in banks' business operations, it not only transforms the banks' operations but also substantially changes customer behavior. Anecdotal evidence indicates that bank executives adopt a cross-channel strategy because of the synergy generated by such action. The value-generating and transformative roles of IT are widely appreciated, but how IT should be used together with other traditional means of serving customers has still not been fully understood by either practitioners or academia. The goal of this research is to get a deeper understanding of how different channels of serving customers interact with each other and impact firm performance. This research will provide insights useful for the design of optimal mixed channel strategy.

---

[1] "Open sesame," The Economist print edition issued on May 18, 2000.
[2] "Wells Fargo tests ATM receipt E-Mail," American Banker, available on http://www.americanbanker.com/issues/175_41/wells-tests-atm-receipt-email-1015362-1.html

Much IS research in the banking industry has focused on examining the determinants of IT adoption from the customer perspective (e.g. Curran and Meuter 2005; Lee 2002; Meuter et al. 2005). Some research has explored IT value in the banking industry using case study or survey methods (e.g. Banker and Kauffman 1988; Dos Santos and Peffers 1995; Litchtenstein and Williamson 2006; Tan and Teo 2000). Although prior studies provide empirical evidence on the impact of individual IT-based channels on bank performance, how different service channels interact and affect bank performance jointly has not been examined in previous research. We examine complementarity between traditional and IT-based service channels at the firm efficiency level as well as on their market share competition capability, while simultaneously taking into account competitors' channel strategies.

Our results indicate that even in the presence of IT-based service channels, the traditional branch channel has a positive impact on bank performance in terms of cost-benefit efficiency. Although branches are costly to operate and maintain, we find that higher level of branch intensity is associated with higher bank efficiency and greater market share. This implies that it may not be a wise decision for banks to simply eliminate branches when banks are under severe operating pressure. In addition, we show that ATMs impact bank efficiency positively while Internet banking is significantly and negatively associated with bank efficiency. Even though banks can cut transaction costs performed by customers on the Internet, the direct return associated with investment in Internet banking does not cover its costs. This may be because transactions processed through Internet banking are of low value-added services for which banks may not be able to charge a premium price. On the other hand, we find that both ATMs and Internet banking have a positive and significant impact on bank market share competition. Most importantly, the significant complementarities across traditional branch channel and two IT-based channels are found to drive both bank efficiency and market share competition, providing strategic insights on how efficient utilization of a channel mix strategy contributes to the improvement of a bank's performance.

The remainder of this paper is organized into four sections. In Section 2, we describe current use of alternative service channels in the banking industry, review the relevant literature and develop our hypotheses. We discuss the research model, estimation methods, and sample data in Section 3. In Section 4, we present the main tests and results of our hypotheses and conduct additional analyses to check the robustness of our main results. Section 5 concludes the paper with a summary of our findings and provides managerial implications based on our empirical findings.

Hypotheses Development

Alternative Service Channels in the Banking Industry

With the increased demand for banking services, many simple services traditionally performed by branch tellers can be processed electronically through IT-based self-service channels such as ATMs and Internet banking, enabling bank tellers focus on more complex transactions. With the expansion of ATM functionality, ATMs maintain their importance in banks' channel mix strategy and the investment in ATMs is still growing. Internet banking is also becoming a popular channel today but has long been viewed more as a cost saver whose value is predominantly in improving customer satisfaction at a lower delivery cost.

The popularity of ATMs and Internet banking seems to suggest that fewer transactions are done at the counter. Does this mean that a bank can cut or reduce investment in traditional branch channel? On the contrary, despite the presence of IT-based channels, bank executives still value traditional branch channel because some of its functionality cannot be replaced with IT-based channels. The investment in branch channel keeps growing steadily over time (Hirtle 2007). Banks invest in technology to free staff from processing routine and lower value-added activities so that they can concentrate more on selling new services to customers. Recognizing the unique characteristics of each service channel, bank executives are aiming at maximizing the value of integrating alternative service channels to compete successfully[3].

To comprehensively understand the impact of a channel mix strategy, the effect of other banks' strategy needs to be considered simultaneously. We evaluate two dimensions of bank performance. First, we consider how efficiently a bank can transform its input (costs) into output (revenues) relative to its competitors. Given a fixed level of inputs, such as number of employees and fixed assets, banks seek to generate the highest level of output (like deposits and

[3] "Taking steps to mesh ATMs with other channels," American Banker, available on http://www.americanbanker.com/issues/175_43/steps-to-mesh-atms-with-other-channels-1015440-1.html

loans in the context of bank operations). Second, we consider market competition capability of a bank. Market share is critical for banks not only because large market share allows banks to amortize the predominantly high fixed costs in this industry but it is also associated with a bank's long term value and competitive advantage. We are interested in knowing how a channel mix strategy contributes to retain current customers and attract new ones, after incorporating the impact of channel mix strategies pursued by other banks.

Impact of Traditional Branch Channel on Firm Performance

Branch banking is the traditional service channel in the banking industry. The establishment of more branches improves access convenience for customers and contributes to retaining the loyalty of customers. However, the establishment of a branch also increases bank operating costs significantly, including equipment costs, personnel expenditures, and support expenses. In addition, coordination costs tend to be higher for banks with more branch offices (Lin et al. 2005). Therefore, higher reliance on branches will be associated with higher costs and potentially lower cost efficiency. With the rapid development of IT, banks now have multiple IT-based channels, such as ATMs and Internet banking, to provide bank services that are traditionally delivered by branches (Calisir and Gumussory 2008). Prior studies show that banks utilize innovative IT applications as substitutes for the existing branch network (Corrocher 2002; Ingham and Thompson 1993), suggesting that IT may have reduced the importance of branches in the banking industry. However, branches are still the major component of a bank's service delivery system because more complex financial transactions and many customized services, such as personalized financial consulting, that enable banks to charge a premium price are still better delivered through branches. Continued growth of branch network seems to be consistent with banks' beliefs that branch banking will continue to be an effective channel for generating revenues despite the lower costs of alternative IT-based channels (Hirtle 2007). In other words, utilizing IT to perform simpler and routine transactions enables banks to reallocate their branch resources to focus on their core business of generating revenue and serving more profitable customers with more value-added transactions. As a result, revenue is likely to be higher with more branches, even though more branches are associated with higher costs. Therefore, we propose our hypotheses on the relationship between the level of branch intensity and firm performance as follows.

H1a: The level of branch investment is positively associated with bank efficiency

H1b: The level of branch investment is positively associated with market share

Impact of IT-Based Service Channels on Firm Performance

Banking industry is well known for its aggressive and extensive use of IT (Gopalakrishnan et al. 2003)[4]. Whether banks invest IT to improve operating efficiency or enhance strategic positioning is an empirical question that has drawn research interest for over two decades (e.g. Banker and Kauffman 1988; Dos Santos and Peffers 1995; Hannan and McDowell 1984; Peffers and Dos Santos 1996). Prior research indicates that IT spending accounted for approximately 6% of annual revenue for the financial industry (Kauffman and Weber 2002). The principal incentive for banks to invest in IT is that IT can link them with their customers in a competitive environment (Kauffman and Lally 1994). Another important reason for banks to invest heavily in IT is to enhance operating efficiency to sustain competitive advantage (Bauer and Hein 2006).

IT-based services enable firms to react quickly in providing customers timely off-site support for their initiatives and convenient service delivery without time or location constraints. Utilizing alternative IT-based service channels not only relieves the pressure on branches but also enables banks to perform diverse financial transactions more efficiently and to attract high-end customers by providing more personalized services. As such, IT-based channels may support either an operating efficiency or a premium provider strategic positioning. Although IT-based service channels are expected to change bank operations and business model, there is still relative dearth of empirical research examining how alternative IT-based channels impact bank performance individually and jointly (DeYoung et al. 2007; Hernando and Nieto 2007).

Operating in a competitive business environment, banks' marketing strategies seek to expand their markets by introducing lower cost delivery channels. ATMs, a technology employed now for a long time in the banking industry, can efficiently perform frequent, routine tasks that are traditionally processed though tellers and may

[4] "Banking on the technology cycle," The Economist printed edition issued on September 4, 2003.

improve cost efficiency. On the other hand, banks also incur significant costs for investing in ATMs, such as renting space for offsite ATMs, hiring security to guard ATMs, upgrading and maintaining of ATMs, and support staff to integrate ATMs with commercial banking. However, one of the main advantages of ATMs is that it expands banks' physical services and provides multifunctional products and services to efficiently satisfy diverse service needs of its most discerning customers in a cheaper way (Saloner and Shepard 1995). ATM networks first seek to geographically cover the needs of bank customers (Kauffman and Kumar 2008). Banks adopt ATMs to increase their market share or to retain current market share against competitors' threat (Hannan and McDowell 1990). ATMs may not only potentially contribute to cost savings but also extend banks' brands beyond what is possible with the more expensive bank branch system. We, therefore, expect that ATM investment is positively associated with both bank efficiency and market share. Accordingly, we hypothesize the following:

H2a: The level of ATM investment is positively associated with bank efficiency

H2b: The level of ATM investment is positively associated with market share

With the ascent of Internet technology, Internet banking was introduced to the banking industry about 15 years ago[5]. Several studies have examined the determinants of Internet banking adoption from customer perspective (Gopalakrishnan et al. 2003; Litchtenstein and Williamson 2006; Suh and Han 2002; Tan and Teo 2000). From a cost perspective, Internet banking provides greater economies of scale to process transactions, compared to branches or ATMs since Internet banking is mostly a fixed-cost technology. With less staff and fewer physical branch requirements, the average transaction cost through Internet banking is much lower than at a branch (Cheng et al. 2006; Yakhlef 2001). Consistent with the objective of improving cost efficiency, Internet banking is found to be a substitute for physical channels such as traditional brick-and-mortar branches and ATMs (Hernando and Nieto 2007).

Although transaction costs incurred for Internet banking are much lower than for alternative channels, previous literature finds mixed results about the impact of Internet banking on bank profitability (Hernando and Nieto 2007). We argue that transactions currently processed through Internet banking are for non value-added services for which banks cannot command premium prices. Therefore, Internet banking does not lead to higher revenue and it is mostly a cost-driven investment. Unlike customized value-added advisory services where branch staff interact with customers intimately, Internet banking is found to be ineffective in influencing bank customers' buying decisions, which in turn reducing the chance of selling new products to customers (Calisir and Gumussory 2008; Yakhlef 2001). Xue et al.(forthcoming) further documents that Internet banking is negatively associated with a short-term drop in customer profitability. We therefore expect that Internet banking is negatively associated with operating efficiency since the increase of cost efficiency is not enough to offset the loss of revenue efficiency.

However, Internet banking provides a more convenient way to deliver banking services and impose few access, location or time constraints on customers (Calisir and Gumussory 2008). These service characteristics may attract customers who value convenience and timely services. We argue that competitive pressure is the main driving force behind the increased use of Internet banking, ranking ahead of cost reduction and revenue enhancement. Banks keep promoting the use of Internet banking channel in order to increase customers' loyalty (Xue et al. forthcoming) and prevent customers' switches because of the flexibility and availability of channel choices. As a result, we expect that Internet banking positively impacts a bank's market share. The hypothesized relationship between Internet banking and firm performance are as follows.

H3a: Internet banking investment is negatively associated with bank efficiency

H3b: Internet banking investment is positively associated with market share

Complementarity between Alternative Service Channels

The adoption of IT-based channels enables banks to expand their market share in a more cost efficient way and protect their market against their competitors that offer the same IT channel options (Kauffman and Kumar 2008; Hannan and McDowell 1990). A banking transaction conducted over ATMs costs a quarter as much as the same

[5] In the US banking industry, Wells Fargo was the first bank to offer its customers online access to their account statements in 1995, and Security First Network Bank was the first Internet-only bank in the same year.

transaction conducted over a counter in a traditional branch, but it costs mere 1% of an over-the-counter transaction if conducting over the internet[6]. To enjoy the benefits of cost advantage of IT-based channels, one may expect to see the migration of bank activities between branch channel and IT-based channels in banks' operations. By moving routine activities to IT-based platform, branch channel can focus on delivering high value-added services to customers by improving their branch banking experience and selling them new products. The rationale behinds this decision is that bank executives commonly believe that IT provides an opportunity to move lower value-added transactions to IT-based channels, leaving branches with more capacity to devote to higher value-added activities (Calisir and Gumussory 2008). Consequently, all alternative service channels are commonly seen today, suggesting IT-based self-service channels may help increase branches' marginal return on investment.

Previous IT investment studies, however, focus on examining value impact of one type of IT-based channels on bank performance. IT-based channels are generally found to be positively associated with market share competition. The benefits are found to be larger for early adopters but diminish over time because competitors mimic the same strategy later. However, considering only the individual effect of one channel on bank performance constrains the examination of IT value and limits the investigation of strategic use of IT. We expect that the synergy created by combining multiple channels will contribute to higher profitability, greater competitive advantage, and more importantly, generating barriers for followers to imitate.

By extending service coverage, higher level of ATM investment increases customer need for branch resources because certain bank transactions and services can only be provided through branch channel. Customers' adoption of Internet banking is also found to be associated with increased use of branch services, suggesting that investments in branches and Internet banking are complements (Xue et al. forthcoming). We, therefore, expect that the lower costs and higher convenience of IT-based channels create resource slack for customers and increase their demand for services of branch channel. Similarly, we can expect that the more Internet banking users there are, the higher is the transaction demand for ATM services, such as cash withdrawals. As a result, we expect that, even between IT-based channels, the increased use of one IT channel such as ATMs will also increase the demand for the other IT channel such as Internet banking, because there exist unique channel characteristics that are not replaceable by the other channel. We hypothesize the complementarities across alternative service channels as follows.

H4a: There exists strong complementarity between branch investment and ATM investment on bank performance

H4b: There exists strong complementarity between branch investment and Internet banking investment on bank performance

H4c: There exists strong complementarity between Internet banking investment and ATM investment on bank performance

Research Model, Estimation Method, and Sample Data

Empirical Model

Our empirical model is demonstrated in Figure 1. First, we examine the direct impact of alternative service channels on two levels of bank performance: operating efficiency and market competition capability. Second, we examine whether there exists complementarity between alternative service channels and how it affects bank performance.

[6] "E-Commerce," The Economist Online, October 9, 2009.

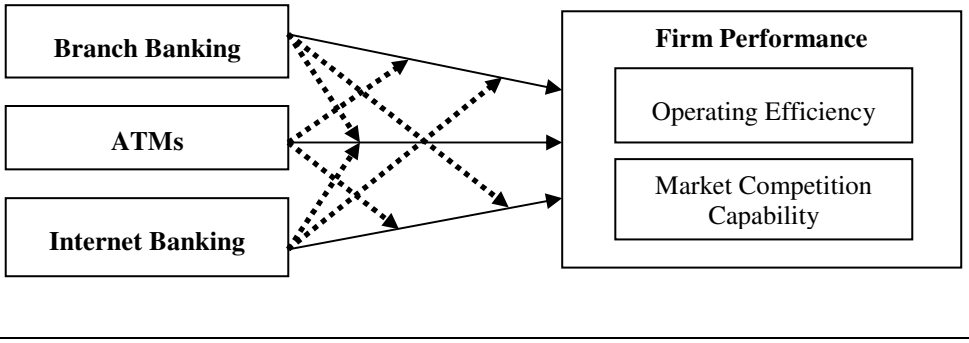

Figure 1. Research Model

Estimation Methods

Two-stage Data Envelopment Analysis

A review of prior research indicates that there are a number of alternative methods available to measure bank efficiency (Berger and Humphrey 1992; Berger and Humphrey 1997; Berger and Mester 1997). Parametric functions to evaluate firm efficiency are restrictive in specifying the structure of production functions. Data Envelopment Analysis (DEA), on the other hand, imposes no explicit specification of the form of the underlying production relationship (Berger and Humphrey 1997). As a non-parametric linear programming method, DEA requires no specific input or output prices in order for a best practice production frontier to be identified (Sturm and Williams 2004). The stochastic DEA model incorporates not only a one-sided inefficiency deviation but also a two-sided random noise deviation which may be caused by measurement errors (Banker and Natarajan 2008).

The banking literature has documented three advantages of employing DEA in evaluating firm efficiency: (1) it provides consistent estimators for the true efficiencies, (2) the DEA estimators can be interpreted as maximum likelihood estimators, and (3) the asymptotic empirical distribution reveals the true distribution under the maintained assumptions of DEA model (Berger and Humphrey 1997). In addition, using the two-stage DEA-based procedure performs significantly better than parametric methods that rely on commonly used parametric functional forms such as Cobb-Douglas and translog to specify the production correspondence. Banker and Natarajan (2008) provide theoretical and simulation-based justification for the two-stage DEA method that uses DEA in the first stage and OLS regression in the second stage to evaluate the impact of contextual variables on efficiency. We, therefore, employ a two-stage DEA method to examine how alternative service channels impact bank efficiency.

An output-oriented DEA model of Banker, Charnes and Cooper (BCC) (1984) is employed to estimate the efficiency scores of the different firm-year observations. After calculating efficiency scores for all banks in our sample, we then take the logarithm of efficiency scores and regress on the variables of interest and other control variables to perform the second stage of regression analysis, as expressed in equation (1).

$$\begin{aligned} EFFICIENCY_{it} = {} & \beta_0 + \beta_1 NBRANCH_{it} + \beta_2 ATMINT_{it} + \beta_3 ATMUSE_{it} + \beta_4 EBANKYR_{it} \\ & + \beta_5 EBANKYR*NBRANCH_{it} + \beta_6 EBANKYR*ATMINT_{it} + \beta_7 EBANKYR*ATMUSE_{it} \\ & + \beta_8 ATMINT_{it} *NBRANCH_{it} + \beta_9 ATMUSE_{it} *NBRANCH_{it} + \beta_{10} INVASSET_{it} \\ & + \beta_{11} NACCOUNT_{it} + \beta_{12} DEPOSITDIV_{it} + \beta_{13} LOANDIV_{it} + \varepsilon_{it.} \end{aligned} \quad (1)$$

Multiplicative Competitive Interaction Market Share Analysis

In addition to examining the impact of alternative service channels on bank efficiency, we are also interested in examining the impact of these different service channels on bank market share. We adopt the Multiplicative Competitive Interaction (MCI) models to capture the impact of competitive choices (Hanssens et al. 2001; Nakanishi and Cooper 1974, 1982). The MCI model has been found to be a useful modeling approach in many studies examining a firm's market attraction (Banker and Kauffman 1988; Karnani 1985; Nakanishi and Cooper

1974, 1982). The MCI model represents the relative strengths of competitors' marketing mix choices in achieving market share. It also allows for possible cross-competitive effects between brands (e.g. bank brands) and marketing instruments (e.g. service channels of banks) (Cooper et al. 1996). The market share regression analysis is expressed as the follows.

$$\begin{aligned} MKT\_SH_{it} = {} & \beta_0 + \beta_1 NBRANCH_{it} + \beta_2 ATMINT_{it} + \beta_3 ATMUSE_{it} + \beta_4 EBANKYR_{it} \\ & + \beta_5 EBANKYR*NBRANCH_{it} + \beta_6 EBANKYR*ATMINT_{it} + \beta_7 EBANKYR*ATMUSE_{it} \\ & + \beta_8 ATMINT_{it} *NBRANCH_{it} + \beta_9 ATMUSE_{it} *NBRANCH_{it} + \beta_{10} INVASSET_{it} \\ & + \beta_{11} NACCOUNT_{it} + \beta_{12} DEPOSITDIV_{it} + \beta_{13} LOANDIV_{it} + \varepsilon_{it.} \end{aligned} \quad (2)$$

Variables

To examine impact of service channels on bank efficiency, we measure firm performance in terms of bank efficiency score by using the value-added approach (Berger and Humphrey 1992). The value-added approach identifies both assets and liabilities as outputs that contribute to banks' value added, and recognizes costs associated with the consumption of firm resources to support banks' operating activities as inputs (Berger and Humphrey 1992; Park and Weber 2006a, 2006b). We employ four outputs (total deposits, total loans, total investments, other operating revenue) and two inputs (number of employees, net value of property, plant, and equipments) to calculate bank efficiency score, EFFICIENCY. The higher the efficiency score is, the more efficient the bank is. As for long-term market share competition, we employ the Multiplicative Competitive Interaction (MCI) model to examine how alternative service channels impact the ability of a bank to competitively enhance its market share. Three measures of market share are analyzed in this study: deposit market share (DEPOSIT_MKT_SH), loan market share (LOAN_MKT_SH), and number of customers (CUSTOMER_MKT_SH).

In this study, the principal explanatory variables are the three types of service channels commonly utilized in the banking industry: branches (NBRANCH), ATMs (ATMINT and ATMUSE), and Internet banking (EBANKYR). NBRANCH, measured as the number of branches relative to total assets, reflects branch service intensity. Two variables are used to proxy the level of ATM investment. ATMINT measures ATM intensity as the number of ATMs per branch, and ATMUSE measures the level of ATM utilization as transactions per ATM. ATMINT is used to evaluate the extent of ATM investment from banks' view point while ATMUSE further captures the extent of ATM utilization incorporating the consideration of customers' channel use behaviors. We measure the Internet banking variable (EBANKYR) as the number of years after Internet banking adoption because being further down the learning curve with a longer history of Internet banking makes it more likely that the bank uses this channel proactively to satisfy customer preference for convenient services and realize opportunities for cost reduction.

Following the prior banking industry research literature, we consider two sets of control variables that are commonly associated with bank efficiency. First, we employ two measures of economies of scale: bank size (INVASSET) and account size (NACCOUNT). Second, we control for economies of scope in our model. We employ the commonly used Herfindahl index to calculate two measures of economies of scope: deposit diversity (DEPOSITDIV) and loan diversity (LOANDIV). We employ two kinds of diversity variables to measure how diversified a bank's product lines is. Higher diversity index suggests a bank enjoys a greater level of economies of scope. Table 1 summarizes the definitions of variables and Table 2 provides descriptive statistics on all the variables employed in the study, respectively.

Table 1. Variable Definitions

Dependent Variable	
EFFICIENCY	= the logarithm of efficiency measure for bank i in year t [2 inputs (number of employees and net value of property, plant, and equipments), 4 outputs (total deposits, total loans, total investments, other operating revenue)]
DEPOSIT_MKT_SH	= total deposits of bank i at year t/Total deposits for all banks at year t
LOAN_MKT_SH	= total loans of bank i at year t/Total loans for all banks at year t

CUSTOMER_MKT_SH	= total customer accounts of bank i at year t/Total customer accounts for all banks at year t
Principal Explanatory Variables	
NBRANCH	=(Number of branches/Total assets)*1,000
ATMINT	=(Number of ATMs/Number of branches)/1,000
ATMUSE	=(Number of ATM transactions/Number of ATMs)/1,000,000
EBANKYR	=Years after Internet banking adoption
Control Variables	
INVASSET	=(1/Total assets)*1,000
NACCOUNT	=Number of customer accounts/Total assets
DEPOSITDIV	={1/[(Checking account deposits/Total deposits)^2+(Savings account deposits/Total deposits)^2+(CD/Total deposits)^2]}/1000
LOANDIV	={1/[(Short term secured loans/Total loans)^2+(Short term unsecured loans/Total loans)^2+(Medium term secured loans/Total loans)^2+(Medium term unsecured loans/Total loans)^2+(Long term secured loans/Total loans)^2+(Long term unsecured loans/Total loans)^2]}/1,000

Table 2. Descriptive Statistics

	Mean	Std. dev.	Min.	Max.
EFFICIENCY	0.7253	0.2202	0.0934	1.0000
DEPOSIT_MKT_SH	0.0177	0.0245	0.0001	0.1155
LOAN_MKT_SH	0.0176	0.0247	0.0000	0.1065
CUSTOMER_MKT_SH	0.0177	0.0217	0.0000	0.1043
NBRANCH	0.0001	0.0001	0.00004	0.0010
ATMINT	0.0041	0.0041	0.0000	0.0333
ATMUSE	0.0034	0.0017	0.0001	0.0168
EBANKYR	3.3184	3.4057	0	13
INVASSET	0.0004	0.0004	0.0001	0.0023
NACCOUNT	0.0021	0.0014	0.0000	0.0173
DEPOSITDIV	0.0021	0.0003	0.0011	0.0029
LOANDIV	0.0041	0.0007	0.0018	0.0057

Sample Data

We collect the sample data for this study from the banking industry in Taiwan. The banking industry in Taiwan is ideal for our study because all banks are competing against one another without market segmentation, and there is also little differentiation among banks' services. This allows us to get a cleaner measure of the impact of channel mix without other confounding effects from market segmentation or product differentiation. The rapidly growing number of banks in Taiwan has further increased competition within this sector. Between 1991 and 2002, the number of banks grew from 25 to 52. Hyper-competition may drive banks that fail to sustain their competitive position out of the market. Between 2002 and 2007, the number of banks decreased to 39. Due to severe competition, Taiwanese banks actively invested in IT in order to be competitive by improving operating efficiency and service quality, increasing service flexibility, and expanding service levels. Taiwan is taking a leading position in wealth management and fund automation in Asia. Examining the dynamic, highly competitive banking industry in Taiwan provides insights into how banks strategically utilize multiple service channels to compete.

The data source is the Taiwan Economic Journal (TEJ) database which includes financial statements data and ATM investment data. In addition, we collect Internet banking adoption data by surveying IT departments of banks. We match the observations for all variables employed in the study and delete those with missing values. For banks undergoing merger and acquisition activities, we consolidate sample banks that were merged or acquired in any year within our research period and consider them as a single bank. For instance, if Bank A merged with or acquired Bank B in 1998 then we aggregate the corresponding data values for these two banks in years 1995-1998 and consider them together as a single entity for the entire sample period. After eliminating the missing values in our dataset from 1995 to 2007, the total number of firm-year observations is 260 for 20 banks. In our sample, banks spend between $3.00 and $4.06 in operating costs to manage $1,000 in assets, and between $4.40 and $13.92 to acquire $1,000 in funds. Banks also generate between $16.30 and $100.66 from $1,000 of assets. In Figure 2, we document the change of both traditional branch and two IT-based channels. Despite the increased use of IT-based channels, we can see that traditional branch channel still keeps its importance and grows steadily over time. Compared to 1995, the ratio of employees to ATMs decreases from 15.56% to 5.88% in year 2007. This suggests that ATM-based channel not only becomes a more mature channel utilized by banks, but also a way for banks to reduce heavy labor costs. Figure 2 below shows the investment trend of all three channels over our sample period.

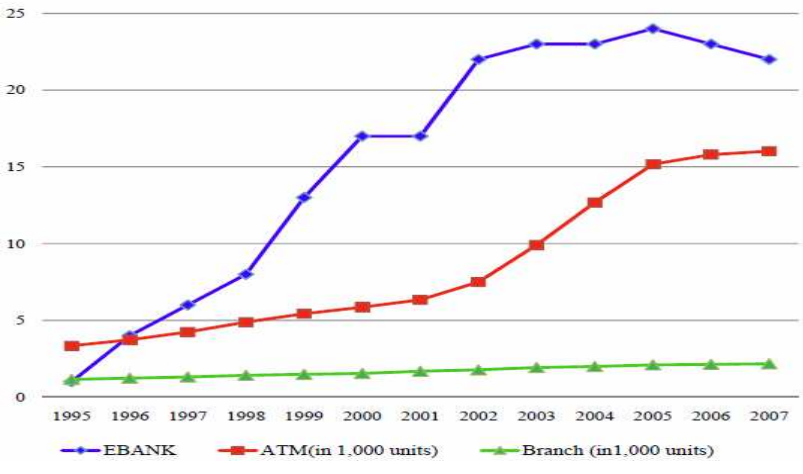

Figure 2. Trend Analysis of Alternative Service Channel Investment

Results and Discussions

Main Results

Following Banker and Natarajin (2008), we employ a two-stage DEA procedure to examine how alternative service channels influence bank efficiency. In the first stage of empirical analysis, we calculate estimates of efficiency score by utilizing value-added approach[7]. We regress the logarithm of efficiency score (EFFICIENCY) on the contextual variables (NBRANCH, ATMINT, ATMUSE, EBANKYR) in the second stage of our analysis. Because pooled cross-sectional and time-series data is used to estimate the impact of contextual variables on bank efficiency, potential serial correlation among sample data may result in biased standard errors of the estimates. We, therefore, address this problem by using a variant of the Prais-Winsten (1954) estimator proposed by Park and Mitchell (1980) to make first-order autocorrelation adjustments to the variables. The generated estimator is consistent and performs especially well for time series and trended data in relation to several other estimates (Doran and Griffiths 1983). It also reduces the extent to which the serial correlation coefficient tends to be underestimated by simpler methods (Kmenta and Gilbert 1970). We also calculate the Variance Inflation Factors (VIF) to check for collinearity. All the VIF values are less than 5, which suggests that collinearity is not a problem in this study.

In the third column of Table 3, we examine the direct impact of alternative service channels on bank performance measured by efficiency score[8]. As documented in Table 3, NBRANCH is significantly positive for bank efficiency, providing support for hypothesis H1a. Both ATMINT and ATMUSE have significant and positive impact on bank efficiency, suggesting that higher level of ATM investment contributes to higher efficiency score. Accordingly, H2a is supported. EBANKYR, on the other hand, is negatively related to bank efficiency, which provides support for H3a[9]. This result is consistent with the expectation that, while Internet banking reduces costs for processing simple, routine transactions, banks are unable to command premium prices for these non value-added activities, and when benefits from cost reductions do not cover investment costs of Internet banking, Internet banking results in a negative impact on bank efficiency.

Next, the examination of the complementarities of alternative service channels on bank efficiency is shown in the last column of Table 3. The interaction terms between branch and two IT-based channels are all positive and significant, supporting hypotheses H4a and H4b. These complementarities come from two sources. First, migration of simple transactions to IT-based channels suggests that branches will have more capacity to process more value-added services. Secondly, since IT-based self-service channels allow customers to perform simple bank transactions more easily and cheaply without the constraint of time and location, customers' overall demand for banking services, including those value-added services that can only be performed through branches, may also increase. As for the interaction between two IT-based channels, our result shows that there is strong and positive complementarity between ATM-based channel and Internet banking channel. This provides support for hypothesis H4c, suggesting that ATMs and Internet banking are also complements.

---

[7] As a further robustness check, we test the robustness of our results in Table 3 by using income-based approach (Leightner and Lovell 1998). Income-based approach specifies net interest income and non-interest income as the two outputs of banks' business units to reflect the final objective of generating revenue from the total cost incurred for banks to run the business (Leightner and Lovell 1998). Accordingly, we measure two banking outputs as interest revenue and other operating revenue, and the five inputs as interest expense, facility costs, support costs, labor costs, and other operating costs, to measure alternative bank efficiency score. For brevity purpose, we don't report the results here but the results are qualitatively same as using value-added approach.

[8] We also consider the impact of alternative services channels on traditional accounting measure, return on assets (ROA), which is commonly employed to evaluate how well a bank performs. Both our findings on individual and joint effect of alternative service channels in Table 3 still hold.

[9] As a sensitivity test, we re-estimate our models by employing Internet banking adoption dummy variable, EBANKYD, to examine the impact of the availability of Internet banking channel on bank performance. Consistent with the findings shown in Table 3 and 4, our results hold.

Table 3. Impact of Service Channels on Bank Efficiency			
	Pred. Sign	*EFFICIENCY*	
Intercept		0.390** (2.00)	0.695*** (3.71)
NBRANCH	+	4.741*** (11.49)	1.936*** (3.38)
ATMINT	+	0.213* (1.50)	0.045*** (2.99)
ATMUSE	+	1.220** (1.93)	1.333 (0.41)
EBANKYR	-	-0.079** (-1.89)	-0.045*** (-2.53)
EBANKYR * NBRANCH	+		0.282*** (3.46)
EBANKYR * ATMINT	+		0.502*** (2.47)
EBANKYR * ATMUSE	+		0.546** (1.62)
ATMINT * NBRANCH	+		0.489*** (4.71)
ATMUSE * NBRANCH	+		0.132 (0.93)
INVASSET	+	0.450*** (3.62)	0.237*** (3.00)
NACCOUNT	+	1.795** (1.92)	2.911 (0.44)
DEPOSITDIV	+	0.723** (1.79)	0.560** (2.09)
LOANDIV	+	0.080** (2.02)	0.024 (1.13)
Adjusted R^2		0.4282	0.4296

In addition to examining the impact of alternative service channels on bank efficiency, we further examine how each service channel impacts bank's market share competition capability captured by three kinds of market share measures. In addition to examining the impact of alternative services channels on deposit (DEPOSIT_MKT_SH) and loan market share (LOAN_MKT_SH), we also examine whether alternative service channels will increase banks' competitive advantage in attracting more customers, which is captured by the proportional ratio of market share of a banks' customers relative to the customers of all bank (CUSTOMER_MKT_SH). Since a firm's marketing effectiveness is dependent on what its competitors do, we employ the MCI model to simultaneously capture the impact of competitive choices of rivals (Hanssens et al. 2001; Nakanishi and Cooper 1974). In Table 4, NBRANCH is positive and significant in three market share equations, suggesting that higher branch intensity is associated with higher market share, which provides support for hypothesis H1b. Both ATMINT and ATMUSE are also positive and significant in all market share equations, supporting hypothesis H2b. The positive and significant

impact of EBANKYR on three measures of market share provides support for hypothesis H3b, suggesting that Internet banking is utilized to maintain current customers' satisfaction and also an important factor to attract new customers. This finding indicates that even when banks cannot command premium prices on transactions processed through Internet banking, banks can still keep promoting the use of Internet banking because it not only retains existing customers by meeting their service demands but also attract potential customers by offering this alternative channel that the competing banks offer. Overall, the positive impact of all three channels on market share competition suggests that each channel has its own unique functionalities that cannot be replaced by other channels and are needed to attract and meet customers' different demand of bank services. As for the complementary impact of alternative service channels on market share competition, we find positive complementarities across all three channels, consistent with bank executives' rationale of implementing cross-channel strategy. A direct implication of this is that all three channels should be examined together when banks change the investment level of a particular channel. For example, it suggests that for banks that increase investment in Internet banking, investments on other traditional channels should also be increased in order to get the most from the investment in Internet banking.

Table 4 Impact of Service Channels on Market Share Competition

	Pred. Sign	*DEPOSIT_MKT_SH*		*LOAN_MKT_SH*		*CUSTOMER_MKT_SH*	
Intercept		0.111*** (3.44)	0.016*** (2.67)	0.038* (1.44)	0.019* (1.37)	1.239*** (4.62)	1.050** (1.82)
NBRANCH	+	0.214*** (2.38)	0.152 (1.25)	0.356*** (3.36)	0.251** (2.07)	0.170** (1.95)	0.066 (0.21)
ATMINT	+	0.151** (1.72)	0.129 (0.27)	0.026* (1.46)	0.015 (0.87)	0.515*** (3.58)	0.367* (1.53)
ATMUSE	+	0.149*** (2.54)	0.125 (3.05)	0.077* (1.54)	0.010 (1.21)	0.359*** (4.20)	0.183* (1.58)
EBANKYR	+	0.165*** (2.67)	0.114** (1.93)	0.154** (1.87)	0.070** (1.67)	0.308** (2.01)	0.277*** (2.73)
EBANKYR * NBRANCH	+		0.064*** (3.04)		0.055*** (3.28)		0.416** (1.87)
EBANKYR * ATMINT	+		0.022 (1.06)		0.056* (1.34)		0.466** (1.34)
EBANKYR * ATMUSE	+		0.039* (1.39)		0.016 (0.19)		0.274*** (2.49)
ATMINT * NBRANCH	+		0.038 (1.19)		0.013 (0.72)		0.266 (1.11)
ATMUSE * NBRANCH	+		0.030* (1.37)		0.090 (0.63)		0.063 (0.24)
DEPOSITDIV	+	0.447** (2.13)	0.324* (1.50)	0.104 (0.58)	0.093 (0.56)	0.302 (0.99)	0.093 (0.56)
LOANDIV	+	-0.081 (-0.50)	-0.049 (-0.26)	-0.106 (0.76)	0.040 (0.24)	0.104 (0.45)	0.039 (0.24)
Adjusted R^2		0.2077	0.2267	0.1370	0.1686	0.1561	0.1836

Robustness Check

One concern about using the length of offering Internet banking channel may not be able to capture the actual investment value of Internet banking, since two banks may offer Internet banking channel in the same year but with different investment levels. As a further robustness check, we consider alternative Internet banking variable, measured by Internet banking adoption dummy variable, to examine the robustness of our models. The results are robust and qualitatively similar to the ones in Tables 3 and 4. In addition, one may expect that a bank with better performance or higher market share may have advantages in investing IT-based channels much earlier than its competitors. To examine the potential causality problem, we therefore include lagged firm performance measures in our estimated models and re-run the regressions. The results are still hold and consistent with what we have found in Tables 3 and 4.

In Table 3, we show how alternative service channels individually and jointly affect bank performance. However, selection bias may be a concern if banks that choose to invest in innovative IT-based channel are those with certain firm characteristics, such as firm size, product diversity or efficiency, that are highly correlated with the choice of innovative IT-based channels. We construct the two-step Heckman selection model to correct for its impact on our parameter estimates (Heckman 1979; Wooldrige 2001). The standard errors in the second stage regression are corrected for heteroskedasticity and for the fact that Lambda is an estimated regressor (Greene 2002). In the first regression predicting the probability of adopting Internet banking, we examine whether branch investment, ATM investment, the availability of Internet banking offered by competitors, economies of scale and economies of scope affect a bank's decision to adopt Internet banking. To run the second stage regression, we employ the same regression shown in equation (1) after adding inverse Mill's ratio in the regression. The results are reported in Table 5.

$$\begin{aligned} Prob(EBANKYR_{it}) = {} & \beta_0 + \beta_1 NBRANCH_{it} + \beta_2 ATMINT_{it} + \beta_3 ATMUSE_{it} + \beta_4 EBANKYATIO_{it} \\ & + \beta_5 COSTREV_{it} + \beta_6 EMPLOYEE\_COMP_{it} + \beta_7 INVASSET_{it} + \beta_8 NACCOUNT_{it} \\ & + \beta_9 DEPOSITDIV_{it} + \beta_{10} LOANDIV_{it} + \varepsilon_{it.} \end{aligned} \quad (3)$$

$$\begin{aligned} EFFICIENCY_{it} = {} & \beta_0 + \beta_1 NBRANCH_{it} + \beta_2 ATMINT_{it} + \beta_3 ATMUSE_{it} + \beta_4 EBANKYR_{it} \\ & + \beta_5 EBANKYR*NBRANCH_{it} + \beta_6 EBANKYR*ATMINT_{it} + \beta_7 EBANKYR*ATMUSE_{it} \\ & + \beta_8 ATMINT_{it} *NBRANCH_{it} + \beta_9 ATMUSE_{it} *NBRANCH_{it} + \beta_{10} INVASSET_{it} \\ & + \beta_{11} NACCOUNT_{it} + \beta_{12} DEPOSITDIV_{it} + \beta_{13} LOANDIV_{it} + \beta_{13} \lambda_{it} + \varepsilon_{it.} \end{aligned} \quad (4)$$

We find that both branch intensity and ATM investment are positively and significantly associated with Internet banking adoption. This suggests that banks which invest heavily in branches and ATMs tend to invest early in Internet banking. Interestingly, we find that more competitors adopting Internet banking, measured by EBANKRATIO[10], has a positive effect on a bank's Internet banking adoption decision, suggesting that, in a competitive market, bank's own channel mix strategy is influenced by competitors' strategies. If more competitors offer Internet banking, a bank will imitate the same strategy by offering Internet banking to its customers in order to maintain its market share. Our main results on the relationship between alternative service channels and bank efficiency continue to hold after considering sample selection bias in the model.

Table 5. Estimations of Two Stage Heckman Model

	Pred. Sign	*EFFICIENCY*	*Prob (EBANKYD)*
Intercept		0.146 (0.31)	0.166 (0.34)
NBRANCH	+/+	8.925*** (7.47)	1.491*** (3.88)

[10] EBANKRATIO is the ratio of number of sample banks, excluding bank i, adopting Internet banking in year t to total number of sample banks, excluding bank i, in year t.

ATMINT	+/+	1.431*** (6.33)	2.672*** (3.03)
ATMUSE	+/+	0.172 (0.43)	0.782 (1.03)
EBANKYR	-	-0.026*** (-3.09)	
EBANKYR * NBRANCH	+	4.410*** (2.98)	
EBANKYR * ATMINT	+	0.087** (2.22)	
EBANKYR * ATMUSE	+	0.228** (1.90)	
ATMINT * NBRANCH	+	0.874*** (8.42)	
ATMUSE * NBRANCH	+	0.257*** (4.68)	
EBANKRATIO	+		0.028*** (4.53)
COSTREV	+		0.139*** (2.53)
EMPLOYEE_COMP	+		0.236** (2.20)
INVASSET	+/+	3.264*** (14.75)	0.821** (2.05)
NACCOUNT	+/+	0.591** (2.14)	0.758*** (3.52)
DEPOSITDIV	+/+	0.226* (1.37)	0.133 (0.02)
LOANDIV	+/+	0.089 (0.17)	0.186 (0.87)
Heckman's Lambda	+	0.166** (2.18)	
Adjusted R^2		0.4320	0.3281

Furthermore, one may argue that the level of ATM utilization is correlated with the level of ATM intensity. For example, banks' decision on the level of ATM intensity is partly based on the level of ATM utilization. That is, bank managers decide whether to invest in more or discontinue some of ATMs based on customers' behavior in using ATMs. On the other hand, ATM intensity (more ATMs available) may increase with the level of ATM utilization. We therefore, construct a system of recursive regressions to consider the factors that commonly and individually affect banks' investment choices of all three channels. In addition to the finding of positive correlation between ATM intensity and ATM utilization, we also find that the investment level of one channel is positively associated with the investment levels of the other two channels. This again supports the notion of common use of mixed channel strategy in practice.

Conclusion

As IT becomes more ubiquitous in the banking industry, banks need to adopt alternative IT-based channels to not only improve cost efficiency but also enhance their competitive advantage. IT-based channels change banks' business model by changing the cost structure to serve different customers, reallocating firm resources to higher value-added activities, and reengineering business operations to maximize profitability. While prior research associated business value of IT with firm performance, very few studies examine how traditional and IT-based service channels simultaneously impact performance. This study investigates the impact of multiple service channels on two dimensions of performance, bank efficiency and market competition capability. We examine the Taiwanese banking industry using a panel of data over the period 1995-2007 using two-stage Data Envelopment Analysis (DEA). We compute bank efficiency by utilizing the value-added approach and then regress the logarithm of DEA efficiency score on explanatory variables to consistently estimate their impact on bank efficiency and evaluate their statistical significance. We further employ the Multiplicative Competitive Interaction (MCI) model to assess how alternative channels contribute to banks' competitive advantage in gaining or holding market share while considering competitors' strategies simultaneously.

Our empirical results show that despite the competition from IT-based service channels, branch intensity is positively associated with bank efficiency. We find that ATM intensity and utilization also have a positive impact on bank efficiency. This suggests that ATMs not only extend banks' physical service coverage to more customers, but also enable banks to command premium prices for its services. In contrast, Internet banking adoption is found to be negatively associated with bank efficiency. This finding suggests that even though Internet banking is employed as a technology to increase the cost efficiency of banks, banks are not able to generate revenue from their investment in Internet banking. The gain in cost efficiency is not enough to cover the loss in revenue efficiency, resulting in the negative association with overall bank efficiency.

Further examination of the relationship between service channels and market share shows that both traditional branch service and IT-based services are positively associated with not only deposits and loans market share but also customer base. Both branches and ATMs extend banks' physical services to customers, which helps attract and retain customers. Internet banking, on the other hand, is regarded as a convenient service channel that enables customers to process simpler transactions without time and location constraints. It, therefore, is a critical factor that influences a customer's decision of whom to bank with. The availability of Internet banking channel becomes even more important for customers who value time, convenience and self management of their accounts. Therefore, even though Internet banking does not increase overall bank efficiency, it is important for long term competitive advantage because of its positive impact on market share.

More importantly, our results show that traditional branch channel and IT-based channels are interdependent. Specifically, we find that investment in Internet banking increases marginal benefit of investments in other channels, such as branches and ATMs, even though Internet banking is negatively associated with overall bank efficiency by itself. Continuing branch and ATM investments also reinforce the benefits of Internet banking investment. The positive interdependence of alternative service channels on bank performance suggests that optimal channel mix strategy not only enables banks to compete by improving efficiency but also by strengthening banks' market competition capability. Our findings provide formal empirical support for anecdotal evidence observed in practice. The positive complementarities among alternative service channels indicate the strategic importance of taking a holistic view of optimal design of channels.

This study reveals contrasting strategic rationale supporting the investment in ATMs and more recent Internet-based banking. The examination of alternative service channels also complements prior research in banking industry that primarily focuses on examining the impact of IT investment in ATMs and Internet banking on user acceptance, examined from a customer perspective. Examining from a firm perspective and incorporating firms' strategy considerations, this study contributes to the research stream on value of IT investment. Understanding the complementarities between IT-based and traditional channels is thus essential to evaluate strategic IT investment, particularly in a competitive business environment.

References

Banker, R. D., Charnes, A., and Cooper, W. W. 1984. "Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis," *Management Science* (30:9), pp. 1078-1092.

Banker, R. D., and Kauffman, R. J. 1988. "Strategic contributions of information technology: an empirical study of ATM networks," Proceedings of the Ninth International Conference on Information Systems, pp. 141-150.

Banker, R. D., and Natarajan, R. 2008. "Evaluating Contextual Variables Affecting Productivity Using Data Envelopment Analysis," *Operations Research* (56:1), pp. 48-58.

Bauer, K., and Hein, S. E. 2006. "The Effect of Heterogeneous Risk on the Early Adoption of Internet Banking Technologies," *Journal of Banking & Finance* (30:6), pp. 1713-1725.

Berger, A. N., and Humphrey, D. B. 1992. "Measurement and Efficiency Issues in Commercial Banking," *Output Measurement in the Service Sectors* (56), pp. 245-279.

Berger, A. N., and Humphrey, D. B. 1997. "Efficiency of Financial Institutions: International Survey and Directions for Future Research," *European Journal of Operational Research* (98:2), pp. 175-212.

Berger, A. N., and Mester, L. J. 1997. "Inside the Black Box: What Explains Differences in the Efficiencies of Financial Institutions?," *Journal of Banking & Finance* (21:7), pp. 895-947.

Calisir, F., and Gumussory, C. A. 2008. "Internet Banking versus Other Banking Channels: Young Consumers'View," *International Journal of Information Management* (28:3), pp. 215-221.

Cheng, T. C. E., Lam, D. Y. C., and Yeung, A. C. L. 2006. "Adoption of Internet Banking: An Empirical Study in Hong Kong," *Decision Support Systems* (42:3), pp. 1558-1572.

Cooper, L. G., Klapper, D., and Inoue, A. 1996. "Competitive-Component Analysis: A New Approach to Calibrating Asymmetric Market-Share Models," *Journal of Marketing Research* (33:2), pp. 224-238.

Corrocher, N. 2002. "Does Internet Banking Substitute Traditional Banking? Empirical Evidence from Italy," in: *CESPRI Working Papers*, Centre for Research on Innovation and Internationalisation Processes, Universita' Bocconi, Milano, Italy.

Curran, J. M., and Meuter, M. L. 2005. "Self-Service Technology Adoption: Comparing Three Technologies," *Journal of Services Marketing* (19:2), pp. 103-113.

DeYoung, R., Lang, W. W., and Nolle, D. L. 2007. "How the Internet Affects Output and Performance at Community Banks," *Journal of Banking & Finance* (31:4), pp. 1033-1060.

Doran, H. E., and Griffiths, W. E. 1983. "On the Relative Efficiency of Estimators Which Include the Initial Observations in the Estimation of Seemingly Unrelated Regressions with First-Order Autoregressive Disturbances," *Journal of Econometrics* (23:2), pp. 165-191.

Dos Santos, B. L., and Peffers, K. 1995. "Rewards to Investors in Innovative Information Technology Applications: First Movers and Early Followers in ATMs," *Organization Science* (6:3), pp. 241-259.

Gopalakrishnan, S., Wischnevsky, J. D., and Damanpour, F. 2003. "A Multilevel Analysis of Factors Influencing the Adoption of Internet Banking," *IEEE Transactions on Engineering Management* (50:4), pp. 413-426.

Green, W.H. 2002. *Econometric Analysis*, (Fifth ed.) Prentice-Hall, New Jersey.

Hannan, T. H., and McDowell, J. M. 1984. "The Determinants of Technology Adoption: The Case of the Banking Firm," *The RAND Journal of Economics* (15:3), pp. 328-335.

Hannan, T. H., and McDowell, J. M. 1990. "The Impact of Technology Adoption on Market Structure," *The Review of Economics and Statistics* (72:1), pp. 205-218.

Hanssens, D. M., Parsons, L. J., and Schultz, R. L. 2001. *Response Models: Econometric and Time Series Analysis*, (Second ed.) Kluwer Academic Publishers, Boston.

Heckman, J. 1979. "Sample Selection Bias as a Specification Error," *Econometrica* (47), pp. 153-161.

Hernando, I., and Nieto, M. J. 2007. "Is the Internet Delivery Channel Changing Banks'Performance? The Case of Spanish Banks," *Journal of Banking & Finance* (31:4), pp. 1083-1099.

Hirtle, B. 2007. "The Impact of Network Size on Bank Branch Performance," *Journal of Banking & Finance* (31:12), pp. 3782-3805.

Hughes, J., and Kaplan, J. 2009. "Where IT Infrastructure and Business Strategy Meet," *The McKinsey Quarterly*.

Humphrey, D. B., and Pulley, L. B. 1997. "Banks' Responses to Deregulation: Profits, Technology, and Efficiency," *Journal of Money, Credit & Banking* (29:1), pp. 73-93.

Ingham, H., and Thompson, S. 1993. "The Adoption of New Technology in Financial Services: The Case of Building Societies," *Economics of Innovation and New Technology* (2:4), pp. 263-274.

Karnani, A. 1985. "Strategic Implications of Market Share Attraction Models," *Management Science* (31:5), pp. 536-547.

Kauffman, R. J., and Kumar, A. 2008. "Understanding State and National Growth Co-movement: A Study of Shared ATM Networks in the United States," *Electronic Commerce Research and Applications* (7:1), pp. 21-43.

Kauffman, R. J., and Lally, L. 1994. "A Value Platform Analysis Perspective on Customer Access Information Technology," *Decision Sciences* (25:5-6), pp. 767-794.

Kauffman, R. J., and Weber, B. W. 2002. "Introduction to the Special Issue on Advances in Research on

Information Technologies in the Financial Services Industry," *Journal of Organizational Computing and Electronic Commerce* (12:1), pp. 1-4.

Kmenta, J., and Gilbert, R. F. 1970. "Estimation of Seemingly Unrelated Regressions with Autoregressive Disturbances," *Journal of the American Statistical Association* (65:329), pp. 186-197.

Lee, J. 2002. "A Key to Marketing Financial Services: The Right Mix of Products, Services, Channels and Customers," *Journal of Services Marketing* (16:3), pp. 238-258.

Leightner, J. E., and Lovell, C. A. K. 1998. "The Impact of Financial Liberalization on the Performance of Thai Banks," *Journal of Economics and Business* (50:2), pp. 115-131.

Lichtenstein, S., and Williamson, K. 2006. "Understanding Consumer Adoption of Internet Banking: An Interpretive Study in the Australian Banking Context," *Journal of Electronic Commerce Research* (7:2), pp. 50-66.

Lin, J. C., Hu, J. L., and Sung, K. L. 2005. "The Effect of Electronic Banking on the Cost Efficiency of Commercial Banks: An Empirical Study," *International Journal of Management* (22:4), pp. 605-611.

Meuter, M. L., Bitner, M. J., Ostrom, A. L., and Brown, S. W. 2005. "Choosing among Alternative Service Delivery Modes: An Investigation of Customer Trial of Self-Service Technologies," *Journal of Marketing* (69:2), pp. 61-83.

Nakanishi, M., and Cooper, L. G. 1974. "Parameter Estimation for A Multiplicative Competitive Interaction Model: Least Squares Approach," *Journal of Marketing Research* (11:3), pp. 303-311.

Nakanishi, M., and Cooper, L. G. 1982. "Simplified Estimation Procedures for MCI Models," *Marketing Science* (1:3), pp. 314-322.

Park, K. H., and Weber, W. L. 2006. "A Note of Efficiency and Productivity Growth in the Korean Banking Industry, 1992-2002," *Journal of Banking & Finance* (30:8), pp. 2371-2386.

Park, K. H., and Weber, W. L. 2006. "Profitability of Korean Banks: Test of Market Structure versus Efficient Structure," *Journal of Banking & Finance* (58:3), pp. 222-239.

Park, R. E., and Mitchell, B. M. 1980. "Estimating the Autocorrelated Error Model with Trended Data," *Journal of Econometrics* (13:2), pp. 185-201.

Peffers, K., and Dos Santos, B. L. 1996. "Performance Effects of Innovative IT Applications over Time," *IEEE Transactions on Engineering Management* (43:4), pp. 381-392.

Prais, S. J., and Winsten, C. B. 1954. "Trend Estimators and Serial Correlation," Cowles Commission discussion paper.

Saloner, G., and Shepard, A. 1995. "Adoption of Technologies with Network Effects: An Empirical Examination of the Adoption of Automated Teller Machines," *The RAND Journal of Economics* (26:3), pp. 479-501.

Sturm, J. E., and Williams, B. 2004. "Foreign Bank Entry, Deregulation and Bank Efficiency: Lessons from the Australian Experience," *Journal of Banking & Finance* (28:7), pp. 1775-1799.

Suh, B., and Ham, I. 2002. "Effect of Trust on Customer Acceptance of Internet Banking," *Electronic Commerce Research and Applications* (1:3-4), pp. 247-263.

Tan, M., and Teo, T. S. H. 2000. "Factors influencing the adoption of Internet banking," *Journal of Association for Information Systems* (1:5), http://jais.isworld.org/articles/1-5.

Wooldridge, J. M. 2001. *Econometric Analysis of Cross Section and Panel Data* MIT Press, Boston, MA.

Xue, M., Hitt, L. M., and Chen, P. Y. 2010"The Determinants and Outcomes of Internet Banking Adoption," *Management Science* (Forthcoming).

Yakhlef, A. 2001. "Does the Internet Compete with or Complement Bricks-and-Mortar Bank Branches?," *International Journal of Retail & Distribution Management* (29:6), pp. 272-282.