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BUSINESS VALUE OF IT IN COMMERCIAL BANKS

Research-in-Progress

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Abstract

Many banks have deployed information technology (IT) to serve customers more efficiency in diverse ways. In a competitive business environment, bank managers must simultaneously use multiple service channels to win customers and increase profit. Most prior research on IT investment in the banking industry has focused on the adoption of innovative IT-based service channels such as Internet banking, from customers' perspective. In this research, we adopt the banks' perspective to analyze the impact of IT on performance by simultaneously considering the traditional physical channel and alternative IT-based service channels. Our initial findings reveal contrasting strategic rationale supporting the use of ATM-based channel versus more recent Internet-based banking.

Keywords: IT investment, business value, service channels, banking industry

Introduction

Facing continuously changing and highly competitive business environment, banks have invested heavily in IT to enhance operating efficiency and sustain competitive advantage. Banks have deployed different IT to offer multiple service channels to serve customers and satisfy their needs. Accordingly, the increasing use of IT has changed the traditional way of understanding and undertaking banking activities (Portela nad Thanassoulis 2007). Strategically utilizing IT to optimize operating performance, banks have continued some functions with traditional branch-based channel, and enhanced their functionality by introducing alternative IT-based service channels, such as automated teller machines (ATMs) and Internet banking. Relieving the pressure on branches enables banks to perform diverse financial transactions more efficiently and also attract high-end customers by providing more personalized services. As such, IT-based channels may support a cost efficiency or a premium provider strategic positioning. Consultants also suggest 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).

IT-based service channel may significantly lower costs of serving customers by offering services without increasing costs of physical facilities. Internet banking also allows customers to perform many banking functions anytime and anywhere, while ATMs provide some services not possible by Internet banking, such as withdrawing money around the clock. This suggests that a bank's channel mix strategy may influence a customer's decision of who to bank with and how to use alternative channels, but in turn also impact the bank's financial performance. In addition, even among IT-based service channels, one channel may compete with the other channel[1]. Thus, examining the impact of multiple service channels can shed light on how banks can strategically utilize IT as a weapon in a competitive setting.

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). There is very little empirical research that examines how multiple service channels (traditional service channels vs. IT-based service channels) impact banks' operating performance in different ways. In this paper, we examine the impact of traditional and IT-based service channels on both cost and revenue dimensions of profitability at the firm level. In addition, we examine how alternative service channels impact on market share of competing banks by considering rivals' channel strategies simultaneously.

With the aforementioned motivation, we propose our research questions as follows:

1. What is the impact of traditional and IT-based service channels on banks' financial performance?
2. Considering competitors' channel strategies, what is the role of traditional and IT-based service channels on market shares?

Our initial results indicate that, in spite of the presence of IT-based service channels, the traditional branch-based channel has a positive impact on profitability. Although branches are costly to operate and maintain, our results show that the negative impact of branch operation on cost efficiency is offset by a stronger positive impact on revenue efficiency possibly by attracting and retaining more profitable customers. Similarly, ATMs are also utilized as a revenue-driven channel by banks. The negative impact of ATMs on cost efficiency is more than offset by their positive impact on revenue efficiency. Internet banking on the other hand is found to be a cost-reduction technology employed by banks. This channel has a positive impact on cost efficiency, but by focusing on the more price-sensitive customers, it also has a negative impact on revenue efficiency. Examining the competitive impact of multiple service channels, we find that all three service channels have a positive and significant impact on improving bank market share. Our study contributes to the research literature on the business value of IT by simultaneously examining the impact of both traditional and IT-based service channels on firm performance for all firms in an industry, and how these relationships are captured in different dimensions of performance in a competitive setting.

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[1]http://news.penki.lt/news.aspx?Element=News&TopicID=123&ArticleID=182725&IMAction=ViewArticle&Lang=EN

The remainder of this paper is organized into four sections. In Section 2, we review the previous literature and develop our hypotheses. The research method is described in Section 3 and the findings in Section 4. A summary in Section 5 concludes the paper.

Hypotheses

Impact of traditional service 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. Greater branch intensity, therefore, not only provides customer more service coverage but is often used as an indicator of a bank's market share measure. However, the establishment of a branch also increases bank operating costs, including essential equipment costs, personnel expenditures, and support expense. 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 lower cost efficiency. With the rapid development of IT, banks now have multiple channels, such as ATMs and Internet banking, to deliver their services. Prior studies show that banks utilize innovative IT applications as substitutes for the existing branch network (Corrocher 2002; Ingham and Thompson 1993). Although IT may have reduced the importance of branches in the banking industry, 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 at branches. Continued growth of branch network seems to be consistent with banks' beliefs that branch will continue to be an effective channel for generating revenues despite the costs and the development of alternative IT-based channels (Hirtle 2007). The reason behind the belief is that bank managers commonly believe that utilizing IT provide an opportunity to move non-value-added transactions to IT-based channels, leaving branches with more time to devote to value-added activities (Calisir and Gumussory 2008). Utilizing IT to perform simpler and routine transactions enables banks to reallocate their branch resources to focus on serving high-end customers who are more profitable to banks. Therefore, we propose our hypotheses on the relationship between the level of branch intensity and firm performance as follows.

H1a: Branch intensity is negatively associated with cost efficiency in banks
H1b: Branch intensity is positively associated with revenue efficiency in banks
H1c: Branch intensity is positively associated with higher profitability in banks
H1d: Branch intensity is positively associated with a higher market share in banks

Impact of IT-based service channels on firm performance

Whether banks invest in IT to obtain a competitive advantage is a question that has drawn research interests for over two decades (Banker and Kauffman 1988; Dos Santos and Peffers 1995; Hannan and McDowell 1984; Peffers and Dos Santos 1996). In addition to the motivation of cost reduction, banks hope to maintain or improve their competitiveness by offering IT-based channels to their customers to access firms' services (Daniel et al. 1973; Humphrey and Pulley 1997; Kauffman and Lally 1994; Krishnan et al. 1999). Although IT-based service channels are expected to change bank business operation and business model, there is still relative dearth of empirical research examine how innovative IT-based channels, such as Internet banking, impact bank performance (DeYoung et al. 2007; Hernando and Nieto 2007).

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 improve cost efficiency. However, 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. We, therefore, expect that ATM intensity is positively associated with operating costs. Considering from revenue perspective, ATMs is also a revenue-driven technology because banks can generate revenue from certain transactions processed through ATMs such as ATM surcharge. Therefore, we expect that the revenue generalization ability of ATMs should offset negative impact on cost side, and thus, lead to net profitability. Furthermore, 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 (Saloner and Shepard 1995). That is,

ATMs extend banks' brands beyond what is possible with the more expensive bank branch system. Prior research has shown that banks adopt ATMs to expand their market share or protect their market against their competitors that offer ATMs (Hannan and McDowell 1990). Therefore, we hypothesize:

H2a: The level of ATM intensity is negatively associated with cost efficiency
H2b: The level of ATM intensity is positively associated with revenue efficiency
H2c: The level of ATM intensity is positively associated with higher profitability
H2d: The level of ATM intensity is positively associated with higher market share

With the ascent of Internet technology, several studies have examined the determinants of Internet banking adoption from customer perspective (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. The cost advantage generated by Internet banking may increase bank profits. In addition, Internet banking provides a more convenient way to deliver banking services and imposes few access, location or time constraints on customers (Calisir and Gumussory 2008). These characteristics of bank service may attract customers who value convenience and rapid services. Internet banking, therefore, is expected to increase customers' loyalty. As a result, we expect that Internet banking positively impacts a bank's market share. However, the transaction services currently processed through Internet banking are of low-end services for which banks cannot command premium prices. Unlike customized high-end advisory services where branch staff can interact with customers intimately, Internet banking is found to be ineffective in influencing bank customers' buying decisions (Calisir and Gumussory 2008). Therefore, we expect that Internet banking increases cost efficiency but not revenue efficiency. We measure this variable as the number of years after Internet banking adoption because being further down the learning curve implies that a bank with longer history of Internet banking is more likely to proactively satisfy customer preference for convenient services and realize opportunities for cost reduction. The hypothesized relationship between Internet banking and firm performance are as follows.

H3a: Years after Internet banking adoption are positively associated with cost efficiency
H3b: Years after Internet banking adoption are negatively associated with revenue efficiency
H3c: Years after Internet banking adoption are positively associated with higher profitability
H3d: Years after Internet banking adoption are positively associated with higher market share

Research Model

Empirical Model

Our empirical model is shown below in Figure 1.

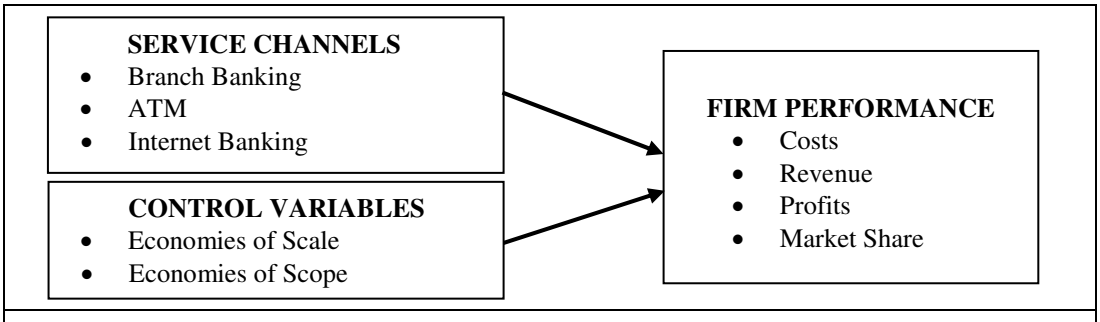

Figure 1. Research Model

We can express this mathematically in form of the following equation:

$$PERFORMANCE_{it} = \beta_0 + \beta_1 NBRANCH_{it} + \beta_2 ATMINT_{it} + \beta_3' ATMUSE_{it} + \beta_4 EBANKYD_{it} + \beta_5 INVASSET_{it} + \beta_6 NACCOUNT_{it} + \beta_7 DEPOSITDIV_{it} + \beta_8 LOANDIV_{it} + \varepsilon_{it}$$

We measure firm performance in terms of bank operating costs (*OPTGCOST*), interest costs (*INTCOST*), operating revenue (*OPTGREV*), interest revenue (*INTREV)*, profits (*PROFIT*), and market share for deposits and loans (*DEPOSIT_MKT_SH* and *LOAN_MKT_SH*). We analyze operating costs into facility costs (*FCLTCOST*), labor costs (*LABORCOST*), and support costs (*SUPPCOST*). All financial variables are normalized by dividing by total assets, except *INTCOST* which is divided by total deposits. Thus, all variables are scale invariant. Normalizing the variables helps alleviate potential multicollinearity problem, which tends to arise when all variables are positively associated with bank size.

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. *ATMINT* measures ATM intensity as the number of ATMs per branch, and *ATMUSE* measures utilization as transactions per ATM. *EBANKYR* measures years after Internet banking adoption. In addition, we borrow from prior banking industry research to 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*). Table 1 summarizes the definitions of variables employed in this study.

Table 1. Variables Definitions

Dependent Variable	
PROFIT	=(Operating revenue-Operating costs)/Total assets
OPTGCOST	=Operating costs/Total assets
INTCOST	=Interest costs/Total deposits
LABORCOST	=Labor costs/Total assets
FCLTCOST	=Property, plant, and equipment/Total assets
SUPPCOST	=(Operating costs-Labor costs-Rent costs-Deprecation costs)/Total assets
OPTGREV	= Operating revenue/Total assets
INTREV	=Interest revenue/Total assets
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
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 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

Sample

We collect the sample data for this study from the banking industry in Taiwan. The rapidly growing number of banks in Taiwan has increased competition within this sector. Between 1991 and 2002, the number of banks grew

from 25 to 52[2]. 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 the 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. After eliminating the missing values in our dataset from 1995 to 2007, the total number of firm-year observations is 225. In our sample, banks spend $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.

Results and Discussion

In this section, we discuss the results of estimating our research models. Fama-MacBeth cross – sectional estimates are provided in Tables 3, 4, and 5. Since our sample has panel data, we use the Fama-Macbeth method to run the regressions and employ the Newey-West method to adjust standard errors (Cochrane 2001; Gujarati 2003). The Fama-Macbeth method is commonly employed in the Finance literature when dealing with cross-sectional financial data (Loughran and Ritter 1996; Skoulakis 2008). This method allows the coefficients of the explanatory variables to vary over time (Chan et al. 1991). We also calculate the Variance Inflation Factors (VIF) to check for collinearity. All the VIF values are less than 5, which rules out any collinearity problem.

In Table 3, *NBRANCH* is significantly negative for operating costs, but is significantly positive for operating revenue and interest revenue. This provides support for hypotheses *H1a* and *H1b*. The coefficient of *NBRANCH* is positive and significant for operating profits, suggesting that branch intensity has a positive impact on profitability. This provides support for hypothesis *H1c*. In addition, *ATMINT* is significantly positive for operating costs, but is positive and significant for both operating revenue and interest revenue. Similarly, *ATMUSE* is significantly positive for both operating costs and interest costs, but is significantly positive for operating revenue. Overall, this supports hypotheses *H2a* and *H2b*. *ATMINT* and *ATMUSE* are both positive and significant for operating profits, which supports *H2c*. Further, *EBANKYR* is positive for operating costs but is negative for operating revenue and interest revenue. Therefore, hypotheses *H3a* and *H3b* are supported. The positive and significant impact of *EBANKYR* on operating profits shows support for hypothesis *H3c*.

Table 3. Impact of Service Channels on Cost and Revenue (Fama-MacBeth Cross-Sectional Estimates from 1995 to 2007)

	Pred. Sign	*PROFIT*	*Pred. Sign*	*OPTGCOST*	*Pred. Sign*	*INTCOST*	*Pred. Sign*	*OPTGREV*	*Pred. Sign*	*INTREV*
Intercept		0.0294*** (3.27)		-0.0035* (-1.61)		0.0374*** (3.00)		0.0235** (2.63)		0.0229*** (3.47)
NBRANCH	+	8.1524** (2.16)	+	9.1982** (2.00)	+	-9.6767 (-1.87)	+	22.6535** (1.91)	+	2.5152** (2.42)
ATMINT	+	1.2815*** (3.45)	+	0.5951*** (5.11)	+	0.1072 (0.45)	+	1.7185*** (3.67)	+	0.6407*** (3.74)
ATMUSE	+	0.2740* (1.57)	+	0.4620** (2.39)	+	0.8573** (2.36)	+	0.4346* (1.56)	+	0.0398 (0.18)
EBANKYR	-	-0.0004** (-2.60)	-	-0.0004** (-1.84)	-	-0.0002 (-0.52)	-	-0.0008** (-2.53)	-	-0.0011*** (-3.16)
INVASSET	+	4.8561** (2.51)	+	5.7405*** (3.40)	+	3.6553 (1.11)	+	9.7845** (1.74)	+	8.5818* (1.69)

[2] Source: Financial Supervisory Commission, Executive Yuan, Taiwan, http://www.fscey.gov.tw/; Taiwan banks to expedite merger efforts as completion hots up, http://www.financialexpress.com/news/taiwan-banks-to-expedite-merger-efforts-as-competition-hots-up/54967/

NACCOUNT	+	2.0102*** (3.42)	+	2.5009*** (2.00)	+	0.2872 (0.40)	+	4.5816*** (3.20)	+	4.8985*** (2.81)
DEPOSITDIV	+	5.4660** (2.19)	+	3.8656*** (4.70)	+	3.3300* (1.45)	+	9.3315** (2.17)	+	5.2981** (2.10)
LOANDIV	+	-1.1471 (-1.04)	+	-1.0099 (-1.73)	+	-0.6882 (-0.98)	+	-2.1570 (-1.30)	+	-1.1012 (-0.99)
Adjusted R^2		0.5560		0.3875		0.5628		0.5560		0.5996
Total Obs.		225		225		225		225		225

Note: ***: significant at 1%; **: significant at 5%; *: significant at 10%.

We further examine components of operating costs to understand the impact of each service channel. In Table 4, *NBRANCH* is positive and significant for *FCLTCOST* and *LABORCOST* equations. In addition, *ATMINT* is significantly positive for *FCLTCOST* and *SUPPCOST*. The positive and significant impact of *ATMUSE* on both *FCLTCOST* and *LABORCOST* suggests greater degree of ATM utilization requires higher level of facility and labor costs. Further, *EBANKYR* is negative and significant for both *LABORCOST* and *SUPPCOST*, suggesting that greater experience with Internet banking adoption increases both labor cost efficiency and support cost efficiency.

Table 4. Impact of Service Channels on Operating Cost Components (Fama-MacBeth Cross-Sectional Estimates from 1995 to 2007)

	Pred. Sign	*FCLTCOST*	*Pred. Sign*	*LABORCOST*	*Pred. Sign*	*SUPPCOST*
Intercept		-0.0188*** (-2.33)		-0.0028* (-1.44)		-0.0024 (-1.26)
NBRANCH	+	34.5367** (1.78)	+	11.2843*** (3.36)	+	2.8127 (0.95)
ATMINT	+	1.0310* (1.51)	+	0.1103 (1.01)	+	0.4170*** (6.69)
ATMUSE	+	1.3403*** (5.89)	+	0.2185*** (3.59)	+	0.2142 (0.93)
EBANKYR	-	-0.0009 (-1.31)	-	-0.0003* (-1.76)	-	-0.0001* (-1.47)
INVASSET	+	-4.8345 (-1.89)	+	-0.0374 (-0.04)	+	4.0673*** (3.31)
NACCOUNT	+	2.3978*** (1.77)	+	0.7790* (1.76)	+	1.5396*** (2.96)
DEPOSITDIV	+	8.1209*** (2.71)	+	1.4610*** (3.12)	+	2.3281*** (3.66)
LOANDIV	+	0.5095 (0.53)	+	0.3429*** (2.69)	+	-1.2619 (-3.07)
Adjusted R^2		0.2834		0.3049		0.3912
Total Obs.		225		225		225

Note: ***: significant at 1%; **: significant at 5%; *: significant at 10%.

Finally, we examine how each service channel impacts deposit market share and loan market share. Since a firm's marketing effectiveness is dependent on what its competitors do, we employ the Multiplicative Competitive Interaction (MCI) model to capture the impact of competitive choices (Hanssens et al. 2001; Nakanishs and Cooper 1974). In Table 5, *NBRANCH* is positive and significant in both deposit and loan market share equations, which provides support for hypothesis *H1d*. Both *ATMINT* and *ATMUSE* are also positive and significant in the two market share equations, providing support for hypothesis *H2d*. *EBANKYR* has positive and significant impact on both market share measures, providing support for hypothesis *H3d*.

Table 5. Impact of Service Channels on Deposit and Loan Market Shares (Fama-MacBeth Cross-Sectional Estimates of MCI Model from 1995 to 2007)

	Pred.	*DEPOSIT_MKT_SH*	*Pred.*	*LOAN_MKT_SH*

	Sign		*Sign*	
Intercept		0.0021** (2.41)		0.0014 (0.32)
NBRANCH	+	7.1600** (2.31)	+	10.2960** (1.87)
ATMINT	+	0.5622** (1.73)	+	0.1923* (1.63)
ATMUSE	+	0.1400*** (2.57)	+	0.1820* (1.58)
EBANKYR	+	0.0004*** (2.70)	+	0.0001* (1.45)
DEPOSITDIV	+	0.7174* (1.57)	+	0.5192 (0.56)
LOANDIV	+	1.7740*** (5.89)	+	1.6780*** (4.79)
Adjusted R^2		0.3848		0.3311
Total Obs.		225		225

Note: ***: significant at 1%; **: significant at 5%; *: significant at 10%.

To the extent that other banks' service channel decisions may impact the relations in our models, we check the robustness of our results by calculating industry-adjusted values for each variable in our equations. The results are qualitatively same as the ones we report above. In addition, customers' adoption of Internet banking is expected to be associated with increased usage of branch services. One possible reason is that the lower costs and higher convenience of Internet banking creates resource slack for customers and increases their demand for banking services. In order to be in a position to service this extra demand, banks need the physical infrastructure in place to realize additional profits. We test whether complementarity between two service channels has positive impact on profitability. The coefficient of the interaction term is negative and insignificant for operating revenue, and is positive and insignificant for operating costs and market share. These findings are consistent with the notion that Internet banking is utilized primarily as a cost-reducing technology, and its customers are mainly low-end customers that do not enable banks to charge premium prices.

Conclusion

This study examines the competing forces between traditional and IT-based service channels at the firm level and their impact on firm performance in the banking industry. While prior research associated business value of IT with firm performance, there are very few studies which compare how traditional and IT-based service channels simultaneously impact firm performance. This also complements prior research in the banking industry that focuses on examining the impact of certain IT investment such as ATM and Internet banking on user acceptance examined from a customer perspective. We show that, in spite of competition from IT-based service channels, the positive impact of branch intensity on operating costs is offset by significantly positive impact on operating revenue, which in turn results in higher operating profits. We find that the impact of IT-based service channels on firm performance is contingent on the IT. Our results show that, although ATM intensity and utilization is negatively associated with operating costs, the significant impact on operating revenue more than offsets the negative impact on costs, resulting in a net positive impact of ATM investment on profit. Thus, ATM investment is revenue-driven enabling banks to command premium prices for services such as ATM interchange. In contrast, Internet banking adoption is positively associated with operating cost efficiency, but not with operating revenue efficiency, suggesting that Internet banking is cost-driven, utilized to reduce transaction costs incurred by low-end customers. By analyzing operating costs into three components, our results provide a more comprehensive understanding of the cost impact of each service channel. Our examination of the relationship between service channels and market share shows that both traditional branch service and IT-based services are positively associated with market shares in deposits as well as loans.

This is research in progress and we plan on several ways to enhance our study for ICIS 2009. First, we plan to obtain more Internet banking data to examine not just the experience with considering the Internet banking, but also increases in its functionality over the years. Second, we plan to indentify the best service channel mix strategy for banks to achieve optimal performance. Finally, we plan to employ alternative production function specifications to verify the robustness of results obtained based on a Leontief technology assumption.

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