The Effects of Early Adoption of Information Technology: An Empirical Study

BRIAN L. DOS SANTOS
PURDUE UNIVERSITY

AND

KEN PEFFERS
RUTGERS UNIVERSITY

ABSTRACT

Few studies have attempted to measure the effects of investments in information technology (IT) applications using measures that are familiar to managers. In general, the vast literature suggesting that information technology investments can provide firms with competitive advantages is unsupported by strong empirical evidence. This paper reports on an empirical study of the effects of early adoption of automated teller machine (ATM) technology by banks, on demand deposit market share and employee efficiency. The results suggest that for some banks, ATM adoption increased employee efficiency and early adoption resulted in market share gains. Efficiency gains were greater for larger banks and banks that grew rapidly, while early adoption resulted in market share gains in states with certain banking regulations. The results support assertions that attributes of the technology, the firm and the industry determine whether competitive advantages result from IT investments.

INTRODUCTION

Dramatic developments in information technologies (ITs) over the last four decades have had tremendous impacts on organizations; affecting products, services and business processes. In many industries, firms have found opportunities to use information technology (IT) to reduce costs, improve quality and increase value to customers. Recently, there have been many claims that investments in information technology can improve a firm's competitive position or allow a firm to become more vulnerable to competitive forces [3, 16, 20]. Based largely upon individual case studies, this literature claims that IT investments have enabled some firms to perform better than their competitors [5, 9]. However, these claims are unsupported by strong empirical evidence [18].[1] In the absence of strong evidence, it may be argued that in competitive markets, the value created by investments in IT will be appropriated by a firm's customers or suppliers [25] and therefore, there is little incentive for firms to aggressively invest in IT. Besides, managers now are concerned that very large and risky investments in IT are being made without adequate evidence that these investments provide value for the firm and many managers doubt that IT investments convey any real competitive advantage [4]. Hence, rigorous studies aimed at determining the effects of IT investments on competition within industries are necessary to test claims that IT investments create competitive advantage.

It is a well-accepted notion in economics that one way for a firm to earn higher returns is for it to seize new lucrative opportunities early [28]. As far as IT investments are concerned, it is claimed that only "early movers" obtain competitive advantages from IT adoption [9, 27]. However, there is no empirical evidence that early investments in new IT applications can provide a firm with competitive advantages. It is particularly important to provide such evidence since new applications of IT are inherently risky; the costs tend to be high and unpredictable and the benefits of new technology applications are difficult to determine in advance. Since the cost of IT adoption tends to decrease over time, followers are likely to be able to implement applictions at lower costs. Hence, the benefits of early adoption must be substantial for

[1] Kauffman and Weill [18] provide a relatively recent review of these studies. They concluded that there was little persuasive evidence that IT investments creates value for the firm. Furthermore, most of the previous studies have attempted to determine how aggregate investments in IT are related to firm performance. Banker and Kauffman [2] is a notable exception.

it to be worthwhile for firms to take the lead in developing new IT applications. Although higher returns may be obtained by seizing new lucrative opportunities early, these higher returns are likely to disappear over time unless the firm earns a decided advantage by going first, or the firm can prevent others from imitating the investment [10]. If these investments can provide firms with sustainable competitive advantages, the risks may be worth taking.

In this paper, we present the results of a study of the effects of early bank investments in automated teller machines (ATM). We attempt to answer the question: did banks that were early adopters of ATM technology gain competitive advantages and if so, were these advantages sustained? ATM systems are believed to have improved operational efficiency and customer service [2, 12, 21]. As a result, early adopters may have been able to gain at least a short term advantage in operating efficiency and a short term gain in market share. Operating efficiency gains may have been short-lived, until competing banks adopted ATMs. However, market share gains could have been sustained if customers did not switch back as other banks also adopted ATMs.

The impact of ATMs on bank branch market share, as measured by demand deposits, was investigated by Banker and Kauffman [2]. Banker and Kauffman sought to determine whether the presence of ATMs at bank branches enabled branches to improve demand deposit market share. Their study was conducted using data from a small region in the southeastern part of Pennsylvania. They concluded that branch ATMs did not affect branch market share. However, one need not conclude from these results that customers did not perceive value in the availability of these ATM facilities. Customers are thought to value the increased availability of services that results from being able to use ATMs at a variety of locations [12]. As a result, the presence of ATMs in bank branches may not affect deposit market share for those particular branches. If customers value the service provided by ATMs, early ATM adoption may well have affected market share for the whole bank. The Banker and Kauffman [2] study was conducted using ATM deployment data for 1986, by which time, a majority of banks had provided their customers with ATM services [1]. As a result, their study does not shed light on the effects of early ATM investments.

We study the effects of investments in ATMs between 1971 and 1979, before most banks had installed ATMs. By 1979, less than 20% of all banks provided ATM services. We hope to determine whether these early investors were able to increase market share, thereby gaining a competitive advantage. In addition, we study the effects of ATMs on employee efficiency. ATM adoption is likely to reduce employment because ATMs can reduce the need for human tellers and new branch banks. Finally, we seek to determine whether the impacts of these early ATM investments were sustained. Our study involves over 3,000 banks, operating nationwide.

In section two, we briefly discuss the relationship between IT and competitive advantage as it relates to ex post analysis of IT investments. In section three, we discuss the characteristics of ATMs, and bank and ATMs regulations that formed the bases for our research questions. In section four, we describe the data. The analysis and results are presented in section five. In section six, we discuss the results. Finally, a summary, limitations and conclusions are presented.

IT INVESTMENTS AND COMPETITIVE ADVANTAGE

The literature on IT and competitive advantage has grown rapidly over the last decade. Numerous frameworks have been proposed to aid managers in identifying applications that can provide firms with a competitive advantage [15, 26, 27, 30]. These frameworks suggest, either explicitly or implicitly, that competitive advantage can be gained from being the first to exploit new technologies or finding new ways to use existing technologies. However, these gains could be short-lived if competitors can easily imitate the investment. Sustaining a competitive advantage requires one or more of the following situations: (a) competitors are unable to respond quickly because it takes time to develop and implement a system; (b) differences among competing firms make it difficult for competitors to respond; and (c) competitors can be preempted from retaliating [10].

Each IT innovation may provide a firm with new opportunities to make value-enhancing IT investments. Whether a new technology presents an opportunity for a firm to gain a competitive advantage depends upon the "new capabilities" provided by the technology and the characteristics of the firm and industry. A new technology may provide a firm with an opportunity to gain a competitive advantage because it significantly reduces the cost of performing some function or because it makes entirely new capabilities possible. For example, a new IT that significantly reduces communication costs and increases communication speeds (e.g., Integrated Services Digital Networks) could provide some firms within an industry with a competitive advantage. A large, decentralized firm is likely to incur relatively higher communication costs than a smaller, centralized firm in the same industry. A new IT that greatly reduces communication costs may be of much greater value to the large firm than it is to a smaller competitor. In addition, fast, reasonably priced communication links may

enable the large firm to redesign processes to reduce coordination costs [24]. For example, such an IT might enable the firm to implement "concurrent engineering"; allowing geographically dispersed design, development and manufacturing engineers to concurrently work on a problem, without physically meeting to do so.

Thus, it may be that the characteristics of the technology, the firm, and the industry determine whether a new IT can provide a firm with a competitive advantage and whether these advantages can be sustained. As a result, ex post analysis aimed at determining whether firms were able to gain a competitive advantage by investing in IT, requires that expectations regarding the impact of the investment be determined by the "new capabilities" provided by the technology and, firm and industry characteristics. In the next section, we discuss characteristics of ATM technology and the banking industry that form the basis for our expectations regarding the impact of early investments in ATMs.

ATMS AND COMPETITIVE ADVANTAGE

ATM systems are interorganizational systems that link banks and other financial institutions to retail banking customers for several types of routine banking transactions, including: deposits inquiries, withdrawals, transfers and payments. It is believed that ATMs have affected both production costs and customer value. Therefore, early adopters of ATMs may have been able to gain competitive advantages because of relative improvements in operating efficiency and market share increases. The expectations relevant to gains in each of these areas are discussed in the next two subsections.

Efficiency Gains

An important reason for ATM adoption by banks is the expected impact on operating costs. ATMs have lower variable transaction processing costs than processing by human tellers [17, 21]. Consequently, ATMs could be substituted for employees that provide services on demand deposit accounts, reducing the number of transactions processed by human tellers and allowing banks to reduce direct customer service employment [17]. In addition, ATMs, because they provide many routine services, could also reduce the need to expand branch banking facilities by serving as inexpensive substitutes for new branch buildings. This would also allow banks to reduce employment levels [21]. Hence, early investments in ATMs should have enabled banks to become more efficient in their use of human resources (at least temporarily) than banks that deployed this technology at a later date.

However, because ATMs have large economies of scale, the substitution of ATMs for human tellers is likely to be more extensive in large banks, where transaction processing volume would make them most economical. Hence, we expect that larger banks are likely to be able to reduce their labor force more (relative to size), as a result of ATM deployment and therefore, efficiency gains resulting from early ATM investments will be greater for larger banks.

All banks may not be able to take full advantage of ATM related efficiency gains. Banks may be reluctant to discharge employees to take advantage of improved economies of scale. In addition, they may hesitate to close or reduce branch banking facilities because of sunk plant and equipment cost fallacies and because customers may be displeased by closed branches. However, fast growing banks can take advantage of efficiency improvements without taking these steps. Hence, fast growing banks may be able to reduce their human resource needs to a greater extent by providing ATM services, than banks that grow slowly. We therefore expect efficiency gains resulting from early ATM investments will be greater for faster growing banks.

Market Share Gains

Another important reason for ATM adoption is its impact on the quality of service provided to customers. ATMs provide customers with increased availability, convenient locations, and the ability to make transactions at greater distances from the branch at which they normally conduct their business. Typically, ATMs allow customers 24 hour access to frequently used demand deposit services, such as deposits and withdrawals, inquiries regarding account balances and transfer of funds among accounts. Customers are believed to value this service [21]. Banker and Kauffman [2] indicate that customers cite ATM availability as a reason for choosing a bank. This improvement in service may have permitted banks that were early providers of ATM services to increase market share. For example, early ATM adoption by Citicorp is believed to have helped it to increase market share in New York City from 4% in 1977 to 13.4% in 1988 [12]. Hence, early investments in ATMs should have enabled banks to gain market share.

As other banks follow with their own ATM services, however, iis not known whether the market share gains by early providers of ATM services are sustained for some time, or whether they are quickly lost. Hence, market share gains for early adopters may or may not be sustained for several years.

Regulatory differences could have determined, however, the extent to which ATM deployment improved service and consequently, whether early investment provided gains in market share. Banks operate in 50 different regulatory environments because state laws control important activities. For example, states control branch banking laws for all banks. Unit banking states do not allow any branch banking, while statewide branching states allow banks to

locate branches anywhere in the state, and limited branching states place some geographic restrictions on branching.

In unit banking states, without ATMs, banks are able to provide demand deposit services only to customers located within short distances of the banks. Because ATMs can substitute for many of the routine services provided by branches, banks in unit banking states can greatly improve customer service by providing ATM services. In statewide branching states, on the other hand, banks are able to provide easy access to demand deposit services by the judicious placement of branches, even without ATMs. Hence, while ATM technology allows banks to provide better access to services, the value to the customer may not be as great in statewide branching states as it is in unit banking states. As a result, branching regulations may have an effect on whether and to what extent ATM investment affects market share.

Many states have tried to protect small banks from the effects of ATMs deployed by large banks. ATMs have fairly high fixed costs and low variable costs. If unregulated, large banks were expected to cover the state with ATMs and attract demand deposits away from the smaller banks. Alternatively, they might be able to charge high fees for the use of their networks. In order to insure that financial institutions of all sizes are able to obtain access to ATM networks, 23 states had, by 1983, enacted mandatory sharing regulations, requiring ATM networks to admit any in-state financial institution upon payment of reasonable, non-discriminatory fees [8].

Mandatory sharing regulations require that banks share their ATMs with other banks, allowing other bank's customers to use their machines. Hence, in states with mandatory sharing, banks that provide ATM services to their customers are able to provide even better service because their customers are able to use the ATMs installed by other banks, not just the ATMs installed by the customer's bank. In states without mandatory sharing, many customers were able to use only the ATMs installed by their own banks. Hence, ATM sharing regulations may have determined whether and to what extent early ATM investments affected market share.

Thus, both bank branching regulations and ATM sharing regulations may have determined whether early providers of ATM services were able to gain market share. We are interested in determining whether early adopters in each of these different competitive environments are able to gain market share and if not, in which environments are competitive advantages gained. We expect greater market share effects in mandatory sharing environments and in unit branching states.

THE DATA

To determine the effects of early investments in ATMs, we gathered data on ATM adoption, banking regulations and bank performance. ATMs were first introduced in 1971. The adoption data used in the study was gathered by the Federal Deposit Insurance Corporation (FDIC) for the period 1971-1979. A sample of 3,838 banks was surveyed to determine whether they provided customers with ATM services in each year. By 1979, less than 20% of the sample banks had adopted ATMs. Hence, banks that provided ATM services during this period, may have been able to appropriate much of the value to be gained from early adoption of this technology [22, 23]. The sample included banks from 49 states and three territories.

The bank performance data used in this study (e.g., demand deposits, number of employees, assets, etc.) were obtained from the "Report of Condition/Report of Income" (RCRI) provided by insured banks to the FDIC at the end of each quarter. We obtained annual data from these reports for 1972, 1980, 1982 and 1984. In this study, we were interested in determining whether banks that invested in ATMs between 1971 and 1979 were able to gain competitive advantages. It is unlikely that any effects of ATM adoption would be observed by 1972. Hence, market share and employee efficiency data from 1972 were used as measures of bank performance prior to the deployment of ATMs. In the sample, approximately 20% of the banks had adopted ATMs before 1980.[2] Hence, gains in employee efficiency and market share resulting from ATM adoption may be observed after 1979. Performance data for 1980, 1982 and 1984 were used to measure market share and employee efficiency after the early adoption period. By comparing market share and employee efficiency measures for 1980, 1982 and 1984, to those in 1972, we were able to measure changes in market share and employee efficiency over those periods and thereby, to determine whether early ATM investments had an effect on market share and employee efficiency. By studying these effects over a number of years, we were able to determine whether competitive advantages resulting from early ATM adoption were sustained over that period.

Finally, information on state regulations related to mandatory sharing and bank branching were obtained from the Profile of State Chartered Banking [8]. The data from these four sources were used in our analysis.

Frequency distributions of variables of interest to the study, for banks in the sample, are presented in Table 1. Panel A presents a frequency distribution of banks, categorized by the size of their assets in 1972 and the bank branch-

[2] It should be noted that many banks that are considered non-adopters in our study, may have actually adopted ATMs during the performance measurement period, i.e., between 1980 and 1984. By 1984, approximately 40% of all banks had adopted ATMs. In this study, we only used data for 1980, 1982 and 1984 because this data is difficult to obtain and hard to work with.

Table 1
Sample Characteristics

Panel A
Distribution of Banks by Size,
in States with Different Banking Regulations

Asset Size in Millions	Statewide Branching	Limited Branching	Unit Banking
< 25	315	692	1116
25 – 75	221	359	513
75 – 300	117	168	161
> 300	77	65	34

Panel B
ATM Adoption
in States with Different Bank Branching Regulations

Regulations	Statewide Branching	Limited Branching
Statewide Branching	115	615
Limited Branching	254	1030
Unit Banking	367	1457

Panel C
ATM Adoption
in States with Different ATM Sharing Regulations

ATM Regulations	Adopting Banks	Non-adopting Banks
Mandatory Sharing	338	1328
No-mandatory Sharing	398	1774

Panel D
ATM adoption by Banks of Different Sizes

Asset Size in Millions	Adopting Banks	Non-adopting Banks
< 25	191	1932
25 – 75	286	807
75 – 300	166	280
> 300	93	83

ing rules for the state in which the bank does business. For example, Panel A indicates that in 1972, there were 315 banks with assets under $25 million, from limited branching states. The data indicates that a much larger proportion of small banks and relatively few large ones were from unit banking states. Relative to unit banking states, there were more large banks and fewer small banks from statewide branching states. Panel B presents a frequency distribution of adopters of ATM technology versus non-adopters, for each of the three different types of bank branching regulations. It indicates that the percentage of banks adopting ATMs in states with different branching rules ranged from 16% to 20%. Panel C presents a frequency distribution of adopters of ATM technology versus non-adopters, in states with and without mandatory sharing. Among the banks in states without mandatory sharing, 18% had adopted ATMs, while 20% of the banks in mandatory sharing states had done so.

Panel D presents a frequency distribution of adopters of ATM technology versus non-adopters, broken down by bank size. The data show that 9% of the banks with assets less than $25 million had adopted ATMs while 53% of the banks with assets above $300 million had done so. It should be noted that although more than half the banks with assets greater than $300 million had adopted ATMs by 1979,

competing banks typically are of different sizes and only a small percentage of banks in each state had adopted ATMs by that date.

ANALYSIS AND RESULTS

In the next two sub-sections, we describe our analysis of the efficiency and effectiveness gains from early ATM investments and present the results. Early investment in ATMs should have provided banks at least temporary gains in efficiency and market share. However, because competing banks differ in many ways and because of differences in bank branching and ATM sharing rules, early investments in ATMs may not have provided all banks with these advantages.

Efficiency Gains

As a measure of bank efficiency, we used the ratio of the bank's total assets over its full time equivalent employees. This measure of human resource efficiency (HRE) has intuitive meaning; it is a measure of the assets managed by each employee. We computed 1972 HRE for each bank in the sample as a measure of the bank's efficiency prior to ATM deployment. In 1972, the mean HRE for banks in the sample was $670,428 per employee. We also determined each bank's HRE in 1980, 1982 and 1984. We then determined the change in bank j's HRE between time t and 1972, ΔE_{jt}, as follows:

$$\Delta E_{jt} = \frac{A_{jt}}{E_{jt}} - \frac{A_{jb}}{E_{jb}}$$

where,

A_{jt} = total assets of bank j in thousands of dollars, at the end of year t.

A_{jb} = total assets of bank j in thousands of dollars, at the end of 1972.

E_{jt} = the number of employees in bank j at time t.

E_{jb} = The number of employees in bank j in 1972, the base year.

t = the year in which we measure performance changes, t = 1980, 1982, or 1984.

In order to determine whether early investors in ATMs were able to make more efficient use of their human resources, we formulated the following regression model:

$$\Delta E_{jt} = \beta_o + \beta_i Z_j + \beta_2 S_{jb} + \beta_3 G_{jt} + \beta_4 Z_j S_{jb} + \beta_5 Z_j G_{jt} + \varepsilon \quad (1)$$

where,

Z_j = 1 if bank j adopted ATMs between 1971 and 1979

= 0 otherwise.

S_{jb} = Log 10 of total assets of bank j[3] in millions of dollars, in 1972

G_{jt} = is the growth in total assets of bank j from 1972 to t. It is measured as the ratio of total assets of bank j at time t (t = 1980 or 1982 or 1984) to the total assets of bank j in 1972

$$= \frac{A_{jt}}{A_{jb}}$$

Model (1) allows us to determine whether ATM adoption, bank size and bank growth rates affected HRE between 1972 and year t. Bank size and growth rates are introduced into the model to allow for the possibility that changes in HRE may have been different for banks of different sizes and banks that grew at different rates, regardless of whether or not banks adopted ATMs. The interaction terms involving ATM adoption, bank size and bank growth rates are introduced to determine whether ATM adoption effects were different for banks of different sizes and banks growing at different rates. In the model, the coefficients of variables that include the ATM adoption variable, Z_j, namely β_1, β_4 and β_5, are of particular interest. In this model,

- β_4 is an estimate of the impact of bank size on the effect adoption had on ΔE_{jt}. It determines whether ATM adoption had a different effect on banks of different sizes.
- β_5 is an estimate of the impact of bank growth on the effect adoption had on ΔE_{jt}. It determines whether ATM adoption had a different effect on banks that grew at different rates.
- $(\beta_1 + \beta_4 S_{jb} + \beta_5 G_{jt})$ provides an estimate of the incremental effect of ATM adoption on ΔE_{jt} for a bank of size S_{jb} and growth rate G_{jt},

As per our earlier discussion, β_4, β_5 and $(\beta_1 + \beta_4 S_{jb} + \beta_5 G_{jt})$ should be positive and significant.

In the model, β_2 and β_3 are estimates of the effects of bank size and growth rates on ΔE_{jt}. They are not central to this study, but are introduced to control for possible changes in HRE due to bank size and growth rates, as mentioned earlier.[4]

[3] Operational characteristics of banks are likely to differ across banks of vastly different sizes (e.g., $10, $100, $1,000 million in assets), rather than across banks that are only slightly different in size (e.g., $10, $11 and $12 million in assets). Consequently, we used a log 10 transformation as a measure of bank size. Log transformations have been used in many previous studies of firm performance (e.g., Feigenbaum and Thomas [11]; Hall and Weiss [13]).

[4] $(\beta_0 + \beta_2 S_{jb} + \beta_3 G_{jt})$ is an estimate of the change in HRE for a non-adopting bank of size S_{jb} and growth rate G_{jt}.

Table 2
Estimates of the impact of ATM adoption on human resource efficiency

Whole Sample			
Coefficient of	**1980**	**1982**	**1984**
Constant (βo)	268.197	478.921	649.151
	(0.0001)	(0.0001)	(0.0001)
Adoption ($\beta 1$)	–374.505	–372.960	–276.358
	(0.0001)	(0.0001)	(0.0007)
Size ($\beta 2$)	–17.668	–23.549	2.005
	(0.0344)	(0.0178)	(0.8684)
Growth ($\beta 3$)	67.924	41.887	31.325
	(0.0001)	(0.0001)	(0.0001)
Adoption*Size ($\beta 4$)	138.330	142.073	118.206
	(0.0001)	(0.0001)	(0.0014)
Adoption*Growth ($\beta 5$)	48.761	46.273	21.192
	(0.0001)	(0.0001)	(0.0697)
Sample Size	3601	3523	3321
R^2	0.1004	0.0721	0.0555
F value for Regression	78.890	54.379	38.771
	(0.0001)	(0.0001)	(0.0001)

Note: p-values in parentheses.

This model's coefficients were estimated separately for 1980, 1982 and 1984, to allow us to determine whether efficiency effects were present for a number of years. A summary of the results for each of the three years, obtained by OLS estimation of the model, is presented in Table 2.[5] At the 0.01 level, β_1 and β_4 are significant in each of the three years while β_5 is significant in 1980 and 1982. In each year, $\beta_1$is negative while β_4 and β_5 are positive. A significant, positive β_4 indicates that HRE gains from early ATM adoption were greater for larger banks, while β_5 results indicate that through 1982, HRE gains from early ATM adoption were greater for faster growing banks. However, by 1984, HRE gains were no different for banks with different growth rates.

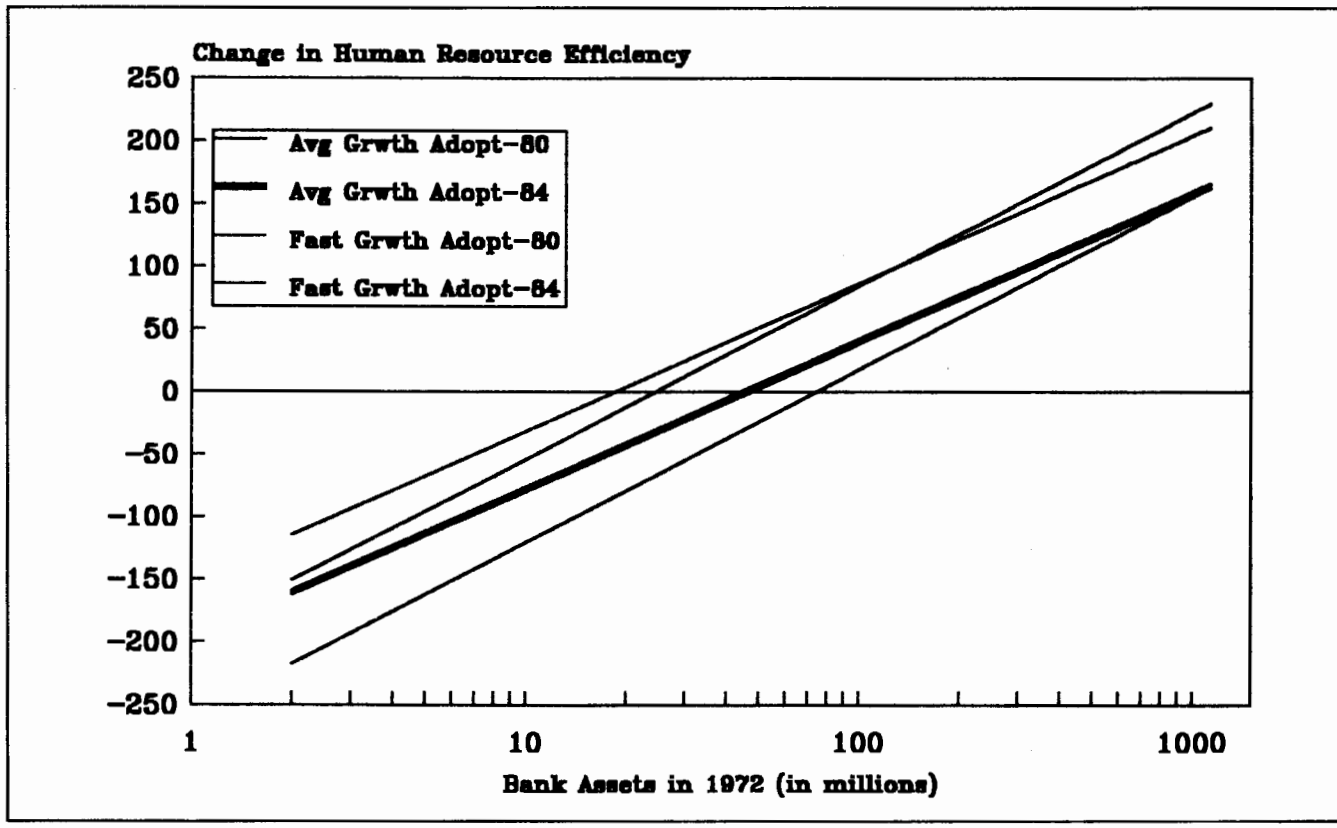
The coefficients β_0, β_2 and β_3 are such that for all values of S_{jb} and G_{jt} in the sample, the change in HRE for non-adopting banks is large and positive. This was expected since, as a result of inflation, the assets of the average sized bank increased substantially between 1972 and the early 1980s. The coefficient β_3 is positive and significant in each year, indicating that fast growing banks were able to improve their efficiency. This is not surprising since faster growing banks are probably better managed [14] and may be expected to achieve greater improvements in efficiency as a result of other environmental changes during this period.

In order to determine the effect of early ATM adoption on changes in HRE for banks with specific characteristics, the estimated model was used to determine the incremental effects of ATM adoption. Figure 1 shows the incremental changes in HRE for banks of different sizes, for specific growth rates. Incremental changes in HRE from 1972 to 1980 and to 1984 are plotted for an average growth bank (i.e., assets growth of 2.37 times from 1972 to 1980 and 3.78 times from 1972 to 1984). In addition, incremental changes in HRE are plotted for a bank that grew very fast (3.74 times from 1972 to 1980 and 5.97 times from 1972 to 1984). The graph shows that except for small banks, ATM adoption resulted in improvements in HRE.

Figure 2 plots the incremental changes in HRE for banks of average and large sizes, that grew at different rates.

[5] The sample size decreases each year because the RCRI data did not include data for some of the banks that were included in the ATM adoption survey. This could have been due to the fact that the missing banks were no longer in business, or they were taken over by other banks.

Figure 1
Incremental Change in HRE for Adopting Banks — for Specific Growth Rates



Four curves are plotted, depicting the incremental effects of ATM adoption between 1972 and 1980, and between 1972 and 1984, for banks of average size (e.g., assets of $112 million in 1972) and, between 1972 and 1980 and between 1972 and 1984 for a large size bank ($500 million in 1972). The graph shows that except for average sized banks that grew very slowly (i.e., banks whose assets grew less than 1.7 times from 1972 to 1980), ATM adoption had a positive impact on HRE.

Market Share Gains

ATM adoption is likely to affect a bank's demand deposits since many of the ATM services pertain to a customer's demand deposits. Early adopters of ATMs should have been able to increase their share of demand deposits, as customers selected banks on the basis of ATM services. We therefore used changes in demand deposits to measure market share effects. Specifically, we measured changes in bank j's market share between 1972 and time t (1980, 1982 or 1984), as follows:

$$\Delta M_{jt} = \frac{DD_{jt}}{\sum_{j \epsilon S_k} DD_{jt}} - \frac{DD_{jb}}{\sum_{j \epsilon S_k} DD_{jb}}$$

where,

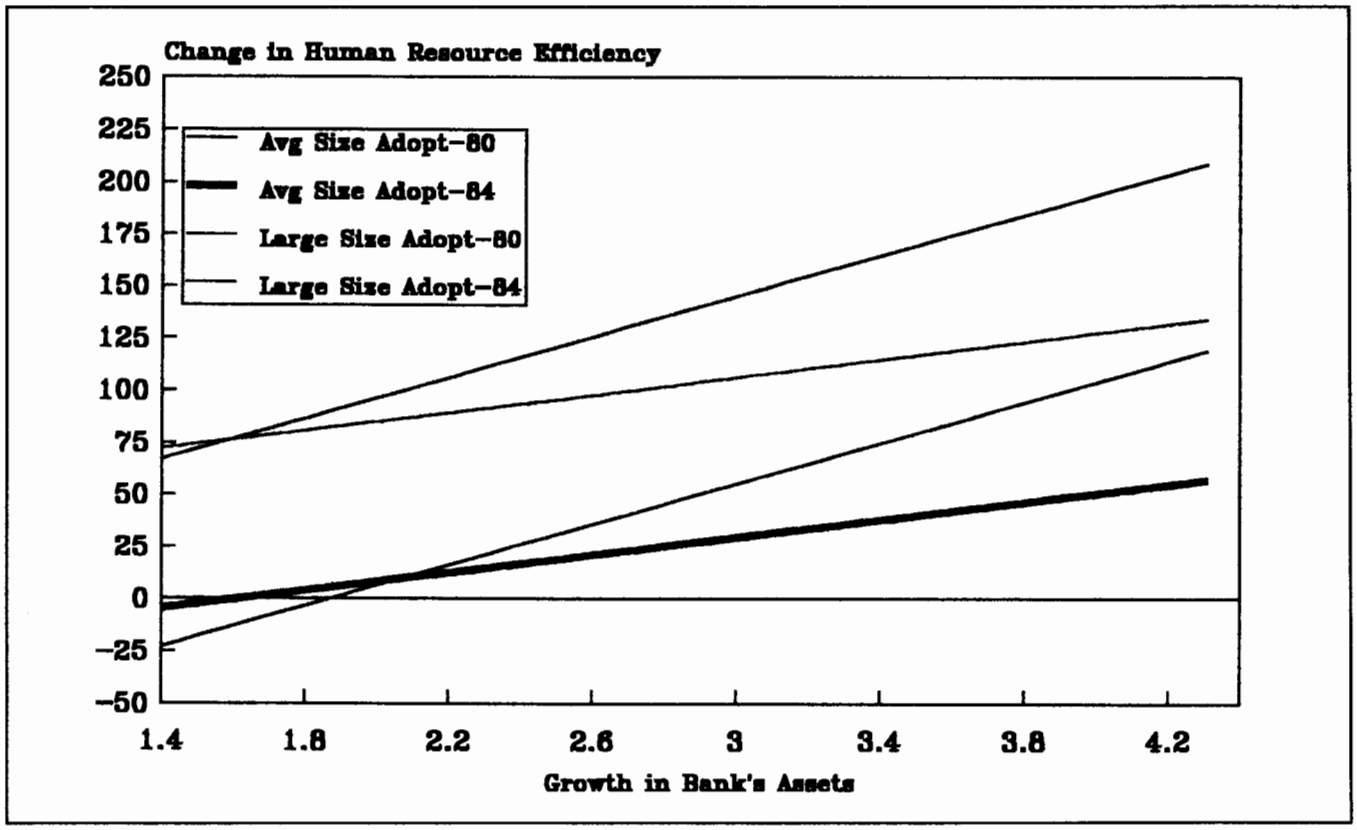
S_k = the set of all banks (including banks not in the adoption sample) that compete for demand deposits in state K.

DD_{jt} = demand deposits of bank j at time t.

DD_{jb} = demand deposits of bank j in 1972.

Our analysis of banking regulations revealed that banks operated in distinctly different retail market environments depending on branching and sharing regulations in their states. Furthermore, as we discussed earlier, there are reasons to expect that the impact of early ATM adoption on market share might be very different in each of these environments. Therefore, we first estimated a regression model with dummy variables for ATM adoption, as well as for bank

Figure 2
Incremental Change in HRE for Adopting Banks — for Specific Bank Sizes



branching and ATM sharing rules. The results indicated that the impact of ATM adoption differed in different regulatory environments (F-tests reject homogeneity). In order to determine in which environments early ATM adoption resulted in market share gains, we partitioned the sample using three types of branching regulations (unit banking, limited branching, statewide branching) and two types of ATM sharing regulations (states with and without mandatory sharing), to create six groups of banks, each of which operated in a relatively homogeneous environment. For each of the six groups, the impact of ATM adoption on market share was determined using the model:

$$\Delta M_{jt} = \beta_0 + \beta_i Z_j + \beta_2 Y_t + \beta_3 Z_j Y_t + \varepsilon \qquad (2)$$

where,

Y_t = the performance measurement year, coded as 0, 1 and 2, for 1980, 1982 and 1984, respectively.[6]

Model (2) enables us to determine whether ATM adoption affected a bank's market share. The terms involving Y_t were introduced to determine whether there was a pattern to the changes in market share over time. The sign and significance of β_3 is of interest since it can indicate whether the effects on market share are increasing or decreasing over the four year period. In this model,

- β_0 is an estimate of the change in market share for non-adopters between 1972 and 1980, while ($\beta_0 + \beta_2 Y_t$) estimates this change from 1972 to 1982 and 1984.
- ($\beta_0 + \beta_1$) is an estimate of the change in market share for adopters, between 1972 to 1980. A positive and significant value for β_1 indicates that the

[6] Modelling the year of performance measurement as we do here imposes a linear restriction on the coefficients involving Analysis of the error terms indicated that this is not a bad model:

$\Delta M_{jt} = \beta_0 + \beta_1 Z_j + \beta_2 Y_1 + \beta_3 Y_2 + \beta_4 Z_j Y_1 + \beta_5 Z_j Y_2 + \varepsilon$

where Y_1 and Y_2 are year-dummy variables. The results were unchanged. Model (2), however, is easier to interpret.

mean change in market shares for adopters exceeded the mean change in market share for non-adopters, between 1972 and 1980. For later years, the incremental change in market share for adopters is ($\beta_1 + \beta_3 Y_t$).

Model (2) was estimated for each of the six groups. A summary of results for banks in mandatory sharing states, is presented in Table 3, Panel A. We find that β_1 is positive and significant in each of the three bank branching environments, indicating that in states with mandatory sharing, early adopters gained demand deposit market share between 1972 and 1980. Also in panel A, β_3 is negative and significant, at least at the 0.1 level, indicating that initial market share gains were gradually lost over the four year time period. Except for limited branching states, β_0 and β_2 are insignificant, indicat-

Table 3

Estimates of the impact of ATM adoption on demand deposit market share

Panel A **States with Mandatory Sharing**			
Coefficient of	**Unit Banking**	**Limited Branching**	**Statewide Branching**
Constant (β_0)	–0.007836 (0.6595)	–0.061097 (0.0011)	0.190522 (0.2351)
Adoption (β_1)	0.165832 (0.0001)	0.615467 (0.0001)	2.540213 (0.0001)
Year (β_2)	0.012839 (0.03423)	0.036792 (0.0113)	0.127842 (0.3220)
Adoption * Year (β_3)	–0.058928 (0.0839)	–0.256803 (0.0001)	–1.262853 (0.0232)
Sample Size	3237	1242	307
R^2	0.0066	0.1444	0.722
F value for Regression	7.152 (0.0001)	69.706 (0.0001)	7.881 (0.0001)

Panel B **States without Mandatory Sharing**			
Coefficient of	**Unit Banking**	**Limited Branching**	**Statewide Branching**
Constant (β_0)	0.011893 (0.3604)	0.065057 (0.0162)	–0.017191 (0.7880)
Adoption (β_1)	0.071662 (0.0306)	0.404762 (0.0001)	0.329367 (0.0486)
Year (β_2)	–0.006556 (0.5122)	0.007699 (0.7156)	0.114447 (0.0278)
Adoption * Year (β_2)	–0.049594 (0.0901)	–0.075471 (0.1747)	–0.227550 (0.1601)
Sample Size	2081	2264	1544
R^2	0.0033	0.0282	0.0044
F value for Regression	2.272 (0.0783)	21.857 (0.0001)	2.285 (0.00771)

Note: p-values in parentheses.

ing that changes in market share for non-adopters were not different from zero in those states. In limited branching states, β_0 is negative and significant, indicating that the market share of non-adopters decreased between 1972 and 1980.

A summary of results obtained from estimating model (2) for banks in states without mandatory sharing, are presented in Table 3, Panel B. The results allow us to conclude that ATM adoption enabled banks in limited branching states to gain market share. In unit banking and statewide branching states the results are weak; so that no conclusions can be drawn regarding the effects of adoption in these environments.

The results in Table 3 indicate the β_3 coefficient is negative in every case, suggesting that any market share gains for adopters were gradually lost. Also, most of the β_0 and β_2 coefficients are not significant, indicating that the changes in market share for non-adopters were not significantly different from zero.

DISCUSSION

The results suggest that not all adopters of ATMs were able to improve human resource efficiency as a result of ATM adoption. Small banks and slow growth banks were not able to improve their HRE. In fact, early adoption by some banks may have resulted in a decrease in efficiency. However, the average bank was able to improve its HRE by adopting ATMs and this operating efficiency gain was still present in 1984,[7] even though many of the non-adopters in the sample may have adopted ATMs by 1984. For small banks and banks that grew very slowly,[8] the additional personnel required to adopt ATM technology may not have been offset by a decrease in the number of personnel involved in handling transactions that were shifted to ATMs. Hence, for these banks, HRE may actually have decreased as a result of ATM adoption.

Since many of the non-adopters are likely to have adopted ATMs by 1984, the fact that early adopters still maintained a relative improvement in HRE could indicate that improvements in HRE lagged adoption by a few years. Although ATMs can allow banks to transfer processing of routine demand deposit transactions from branch employees to machines, work force reductions may not immediately follow ATM deployment. ATM substitution for branch banks are only likely as the need for new branch banking services are felt, since managers are more likely not to build new branch banks as a result of ATMs, rather than shut down existing branch banks.

The effects of early ATM adoption on market share indicate that only in certain environments did early adoption result in market share gains. Early adopters in states with mandatory sharing were able to gain market share. However, these gains were gradually lost, so that by 1984, most of the gains were lost. Mandatory sharing regulations require banks to cooperate with other banks that provide ATM services, resulting in better service since customers are able to use the facilities of other banks. Hence, cooperation in the deployment of ATMs was beneficial to all cooperating parties. One of the important questions facing early mover firms contemplating development of new interorganizational systems, is whether they should develop cooperative or proprietary systems [6, 29]. Our study provides some support for Clemons' [7] suggestion that firms may gain greater competitive advantages from cooperative use of IT. Our results suggest that it may be advantageous under certain circumstances to cooperate with competing firms, thereby enabling all early movers to gain a greater competitive advantage. It should be noted, however, that early increases in market share were gradually lost, as other banks also began to provide ATM services. In states without mandatory sharing, early adoption resulted in gains in market share only in states with limited branching regulations, and in this case the gains were sustained. In states without mandatory sharing, why the early adopters in limited branching states were the only ones able to gain market share is not clear and deserves further attention. Perhaps, banks with geographically limited branch banking were better prepared to take advantage of opportunities to expand, than were banks in unit banking states, because of their larger size; and they had more to gain from adoption than did banks that were allowed unlimited branching.

The frequency data on ATM adoption presented in Table 1 indicates that the percentage of banks that adopted ATMs through 1979, was not very different in states with different regulations, although the effect on market share was different in states with different regulations. Small, slow growing banks in some states may have had little to show for their early investments in ATMs. Since most of the market share increases, when present, appear to have been lost by 1984, it does not appear that early investments in ATMs allowed banks to sustain gains in market share.

Since this analysis does not make a distinction between adoption from 1972 to 1979, it tends to undervalue early ATM adoption, since adopters in the early 1970s may have benefited from improved efficiency and increased market share before 1980.

[7] An average bank is a bank of average size (assets of $113 million in 1972) and average growth in assets (i.e., increase in assets of 2.37 times between 1972 and 1980; 2.96 times between 1972 and 1982; and 3.78 times between 1972 and 1984).

[8] Here, slow growth actually refers to banks with a negative inflation adjusted growth in assets.

SUMMARY, LIMITATIONS AND CONCLUSIONS

This study sought to determine whether early ATM adopters gained competitive advantages. The results suggest that except for the small banks and banks that grew slowly, early ATM adopters were able to improve their HRE relative to banks that were not early adopters. Very small banks and banks that grew very slowly, may have, by adopting ATMs, actually lowered the efficiency of their human resources.

Early ATM adoption allowed banks in some states to gain market share. The competitive environment, determined by bank branching and ATM sharing laws, determined whether early ATM adopters gained market share. Interestingly, it appears that competitive advantages gained through efficiency improvements were sustained through 1984, while most of the market share gains were lost by 1984.

These results suggest that early investments in IT can provide competitive advantages to firms, but gaining an advantage is dependent upon the competitive environment, attributes of the technology and firm characteristics. There also is some support for the claim that early investors in interorganizational systems may be able to gain a greater advantage by cooperating with other early adopters, although, in this case, cooperation was mandated.

A limitation of this study is that it fails to determine whether early adoption of ATMs increased bank value. While many early adopters were able to gain market share and improve operating efficiency, this study does not determine whether these gains were worth the cost. Besides, by using a measure such as market share, the study tends to underestimate effectiveness gains since banks that become more effective may choose to raise prices (e.g., account service fees) rather than try to gain market share. Both these problems can be overcome by using a business level performance measure, such as profits.

A limitation of longitudinal field studies is that they do not allow one to easily account for other possible explanations for the findings. In this case, for example, it could be that the better managed banks were early adopters and that efficiency improvement and market share gains are the result of generally better management, rather than investments in ATMs.

This is one of the few studies that have attempted to determine how investment in a specific IT application affects firm performance, using measures that are of interest to managers. Such studies are hampered by the difficulty of obtaining the necessary data. Longitudinal data is difficult to obtain; it is difficult for researchers to gather and good secondary data sources are rarely available. In this case, we were fortunate to obtain data on IT adoption for a very large sample of firms over an eight year period. In subsequent research, we hope to extend this work by examining the impacts of adoption for specific time periods within the early adoption period.

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ABOUT THE AUTHORS

Brian Dos Santos *is assistant professor of management at the Krannert Graduate School of Management, Purdue University, West Lafayette, Indiana. His major research interests are in information technology management and in the development of decision support and expert systems. His articles have appeared in* Decision Support Systems, IEEE Transactions on Engineering Management, Journal of Management Information Systems, Journal of Systems Management, Management Science *and many other journals. He has also published papers in the Proceedings of many International Conferences and has contributed chapters to many books. Brief summaries of his work with Ken Peffers on the impact of ATM investments in the banking industry have been reported in numerous National and International business magazines and newsletters.*

Ken Peffers *is assistant professor of management at the School of Business, Rutgers University, Camden NJ. His research interests include the evaluation of information technology (IT) investments, the industrial and organizational impacts of innovative IT investments, and the strategic management of information and IT resources. In 1991, he earned a PHD in management information systems (MIS) from the Krannert Graduate School of Management, Purdue University, where he had been the General Electric Doctoral Fellow in 1988-9 and 1990-1. He participated in the Doctoral Consortium held at the 1990 International Conference on Information Systems (ICIS) in Copenhagen, Denmark and was a Society for Information Management (SIM) Doctoral Fellow in 1990. He has also presented research papers at the 1991 ICIS Conference (New York) and the 1992 EURO/TIMS Joint Conference (Helsinki, Finland). Dr Peffers holds a BA in History from New College, Sarasota FL in 1970. Before entering the doctoral program at Krannert, he was a practicing manager in Michigan.*

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