QUANTIFYING THE BUSINESS VALUE OF INFORMATION TECHNOLOGY: A CONCEPTUAL FRAMEWORK AND APPLICATION TO ELECTRONIC BANKING

by

Rajiv D. Banker
Carlson School of Management
University of Minnesota
Minneapolis, MN 55455

and

Robert J. Kauffman
Leonard N. Stern School of Business
New York University
New York, NY 10006

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Center for Research on Information Systems
Information Systems Department
Leonard N. Stern School of Business
New York University

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1. Introduction

1.1. Research Problem

> Can you imagine growing your information systems budget by nearly twice the projected rate of inflation without having the ability to adequately measure the business value of projects being funded? ([6], p. 20.)

These were the startling words of the editor of *Computerworld*, in a recent commentary on a '988 study by the Index Group of continued growth in IS spending among large corporations in the United States. The editor went on to remind readers:

> To approve such spending increases, the perspective of CEOs on the IS function is presumably growing in the right direction, in which systems strategies are increasingly tied to the overall performance of the company and its bottom line. ... However, it is unsettling that only one in ten executives polled claim to be able to adequately assess the business value of technology investments.([6], p.20)

Senior management's ability to gauge the return on investments in information technology (IT) has been seriously hampered by a lack of analytic tools to conduct sound performance assessment. Net present value and discounted cash flow analysis are often used to identify the return on IT investments, however, they fail to effectively capturing the "second order" impacts of IT that can turn an unprofitable investment into a profitable one. Instead, managers are forced to make their "best guesses" about the size of the cash flows associated with the benefits that an IT investment creates for the firm. The result is an analytic process for evaluating IT investments that no longer rests on firm ground. Paralleling the importance of improved analytic tools for IT value measurement is the need for a practical means to identify the range of possible impacts that IT can create. Managers require a comprehensive framework that helps to ensure that they are including the "right" elements in their evaluations. This is extremely important in conducting *ex post* evaluation, where the focus is on comparing expectations and targets to actual achieved performance.

In this paper, we present a framework that represents a step toward achieving this goal. We propose a generalized "business value linkage" for IT [27, 15] in order to capture the processes by which the direct outputs of an IT are transformed within the firm and its operating environment into enhanced revenues, reduced costs and new strategic opportunities. We define the "business value" of IT as the quantifiable economic contribution it can make to management's goal of profit maximization in the firm. ITs can create business value in a many ways; however, the difficulties lie in measuring and validating those impacts, as the Index study results made clear. In order to illustrate our approach, we report on an empirical study of the business value of automated teller machines (ATMs) that captures and quantifies a range of impacts that may be missed in more traditional approaches to performance evaluation. We also suggest ways to answer a variety of valuation questions likely to be raised by managers via econometric tests.

1.2. Previous Research on IT Value

A number of prior research efforts guided us in developing a framework to identify the range of impacts that IT can have. Porter's framework for strategic analysis of industries and firms provided a useful starting point [30]. His framework relates aspects such as barriers to entry, power in the buyer-supplier relationship, and switching costs to the strategic position of a firm. He later extended the framework to identify *where* value-added is generated in a firm, as a product is created and delivered. McFarlan [21] was first to recognize the relevance of this framework to IT value. He recognized that IT investments have the potential to:

- transform the basis of competition in a product area;
- change the balance of power in the relationships a firm has with its suppliers;
- foster innovation which results in new products.

He argued that "the end products of information systems planning [should] clearly communicate the true competitive impact of the expenditures involved." Thus, reliance on "measurable" return on investment (**ROI**) only would restrict the perspective that a visionary senior manager might bring to his firm. And, this would reduce the likelihood that long run impacts of IT investments would get built into a firm's project evaluation procedures. Spending to achieve competitive parity is even more difficult to cost justify since it is so difficult to measure what "remaining competitive" means in concrete terms.

Kaplan [14] expanded on this argument. He stated that discounted cash flow (**DCF**) analysis can lead to underinvestment in computer-integrated manufacturing, where non-tangible benefits including increased flexibility, faster response to market shifts, and greatly reduced throughput and lead times may be much harder to identify. Part of the problem here is that these impacts are not traditional cost savings; instead, they may enhance the firm's revenue-generating ability.

Strassmann has stressed the importance of the value-added that IT investments can provide, especially in improving the effectiveness of management activities [32]. He proposed a new measure which he termed "return on management capital." IT investment as a percentage of management costs in the business unit being analyzed is used to supplement other measures of the productivity of the organization's management. Then, incremental changes in management productivity are associated with the IT investments.

Norton suggested that IT valuation should be considered in the context of the "strategic interlock" between IT investments and the strategic goals of the firm [26]. He supported using comparative measures across business units, such as IT investment per employee, in evaluating key strategic outputs. These include return on assets, market share and profitability. To complete this analysis would require associating the level of IT investment with environmental moderating variables in order to identify the circumstances under which IT value is maximized.

1.3. Organization of the Paper

In Section 2, we present a generalized framework for evaluating the dimensions of value created by information technology. Section 3 illustrates the use of this framework in the context of evaluating the business value of ATM technology. It also describes the extensive data set we built to carry out the the analysis. Thereafter, we develop and estimate econometric models to validate the business value linkage for ATMs. Section 4 discusses the contribution of branch ATMs to operating cost reduction in local bank branches by considering whether they influence teller labor consumption. It also lays out a model for ATM transaction estimation, which is used to estimate the number of transactions that a branch ATM processes that represent an additional service component not provided by branch tellers. Section 5 examines the direct revenue effects of ATMs which are created by offering services to the branch's competitors' customers. Section 6 focuses on capturing the deposit market share effects of ATM deployment. It presents a model which captures the impacts of a branch ATM on the local market for demand and saving deposits. We conclude by summarizing the results of the illustrate by estimating the composite business value of an ATM. We also discuss the managerial implications of the framework we propose and provide some thoughts about how this analysis can be made operational in other IT evaluation contexts.

2. A Conceptual Framework for Identifying Dimensions of IT Value

2.1. A Generalized Business Value Linkage for IT

A common shortcoming of the methods discussed in Section 1 is that they lack robust mechanisms for quantifying the *total value* (tangible and intangible) of IT investments. As a result, it is very hard to determine the components of the business value or ROIof an IT investment. Our approach enables exhaustive identification of the potential business value impacts of IT. The links between investment and value are formalized in a *business value linkage* which can be defined by managers. As a conceptual framework for understanding IT impacts, a business value linkage has several important features:

- an indication of the inputs (e.g., labor, materials, capital, energy and IT) employed in the local production environment;
- a sketch of the intermediate processes -- inside or outside the firm -- influenced by IT;
- the set of outputs modified by or attributable to the IT investment.

A major advantage of our approach, as we will shortly demonstrate, is that it can be employed to identify evidence that links strategic benefits to an IT investment.

We characterize IT investments in terms of three categories of impacts which provide a systematic framework for identifying the potential benefits:[1]

- reductions in costs for existing operations;
- direct revenue gains from existing and new products;
- market segment and market share improvements.

This classification is useful because it identifies the ways in which IT value flows through to the bottom line. It also enables business risk reduction and organizational learning to be taken into account through each of the primary classes of impacts. Figure 1 presents a generalized representation of these business value impacts, which can be adapted by managers for use in many specific IT investment situations.

[1]Our classification also builds on the recent work of Berger [4]. He advocated classifying IT impacts into three groups according to their internal/operational, strategic/competitive, and product/service impacts.

Figure 1: A Business Value Linkage for Identifying IT Impacts

```
                                      Internal/External
                                      Intermediate
                                      Processes
Inputs                                Influenced by IT          Outputs
-------------                         --------------------      ---------

                                          _____________
                                         |             |
                                         | Day-to-Day  |        Operating
                                      -> |    Firm     |-----> Cost
                                     |   | Operations  |        Impacts
                                     |   |_____________|
                                     |
                        ____________ _|
Labor      ------> |            |
Materials  ------> |   Local    |                               Direct
Capital    ------> | Production |-------------------------> Revenue
Energy     ------> |  Process   |                               Impacts
IT         ------> |____________|_
                                     |
                                     |    _____________
                                     |   |             |
                                     |   |Firm-to-Firm|        Market Share
                                      -> |   Market    |-----> and Segment
                                         | Competition |        Impacts
                                         |_____________|
```

2.2. Outputs

The output categories we identified reflect the progressive difficulty managers experience when trying to justify IT investments. They also mesh well with Nolan's observation that as firms get more experienced, they tend to invest in IT projects that are progressively more difficult to justify in terms of direct tangible benefits. Initial corporate investments in IT are justified in terms of their potential to reduce operating costs. Payroll and accounting system investments, for example, are often the the first automation efforts a firm undertakes and they lead to obvious cost reductions. This is because rather substitution of IT for other more costly resources has occurred. When more complex substitution of IT for operating resources occurs, this tends to result in harder to measure impacts. We explored this kind of problem in a recent paper on the use of IT in fast food restaurants [2], and found that IT changes the productivity of existing resource use.

Following efficiency gains achieved via computerization, managers tend to look for ways to improve the firm's effectiveness. Investments are made in IT to achieve strategic goals, but it is even more difficult to identify the extent to which they are responsible, for example, for marginal increases in market share and other more diffuse benefits.

The primary resources of interest for operating cost reductions, in addition to IT, are labor, materials, capital and energy. Financial services IT investments often promote savings in labor and capital, while manufacturing IT investments offer opportunities to cut waste in materials and energy, as well. The airlines' deployment of computerized reservation systems enabled the industry as a whole to save on reservation and sales labor, as travel agents answered their own inquiries on-line and booked tickets directly with a computer [7]. Airline reservation system automation substitutes for the manpower needed to keep track of the many details related to ticket booking, load factors, and flight schedules. There is also an efficiency gain in the use of existing resources, as employees take less time per reservation transaction.

Business value from IT investments also is created by increasing revenues from existing products and by creating new products. In fact, revenue flows often arise which were not initially envisioned when an IT investment was made. This occurs when firms realize that that a special combination of organizational ingredients is present to enable "piggy-backing" off some existing or new IT investment. Airline reservation systems also are a good example of this. American and United are able to levy membership fees to Sabre and Appollo because access is now a competitive necessity for travel agents. Thus, IT deployment has resulted in direct revenues for the airlines that were not the primary reason why they were initially deployed.

The final category is most difficult to predict and quantify. IT is normally a second order factor affecting a firm's competitive position, and so it may also have an effect on market share. Managers are increasingly challenged to identify the extent to which the presence or absence of IT in a firm's service configuration affects the competitive balance after controlling for other factors. Citibank's prowess in capturing retail deposit market share through ATM deployment is also a good example of a less easily quantified impact. Glaser reported that following the initial phases of the bank's ATM and retail banking marketing strategy were in place, the bank achieved a major gain in deposit market share: from 4% of New York City retail deposits in 1977 to 13.4% in 1988 [10].

3. A Conceptual Model for ATM Valuation in Retail Banking

3.1. Valuation Problems in Electronic Banking

Current evaluation methods for the benefits of ATMs deployed in retail banking rely heavily on rules-of-thumb to assess performance. For example, up until recently network managers tried to overcome the "33% wall", a well-known industry target that involved more than one-third of a bank's ATM card holders performing several transactions at an ATM each month [5, 16]. For individual ATMs, an aggregate period usage criterion is often used to distinguish between acceptable and unacceptable performance [17]. For supermarkets and other locations where a bank may be required to initially pay the host for ATM installation, the creation of an "acceptable level" of interchange fees may be most important [22, 18]. (Interchange fees are paid by banks to one another when their customers use another bank's ATMs.)

In contrast to operating environments which are characterized by tangible, direct outputs, special care must be taken to capture elements of the production process which relate the investment in IT to the key dimensions of performance in retail banking. Since a bank branch's performance is influenced by a number of factors, it is important to recognize that management faces an evaluation problem for ATM technology in which nearly all of the business justification has to be based on *second order* impacts.

Despite this problem, senior managers in banking tend to ask the same questions over and over about their electronic banking operations:

- What impacts do branch ATMs create that justify the current high levels of investment?
- Are there impacts on the branch workflow so that teller labor costs are reduced or tellers are replaced?
- Do ATMs provide a higher overall level of service to retail banking customers that distinguishes a bank from its competitors?
- Do branch ATMs create business value in the competitive marketplace for deposits by helping a branch to increase market share?
- How can any these impacts be quantified?

3.2. A Conceptual Model for ATM Value Measurement

Our approach involves recognizing input resources and the process by which they are transformed into service and other outputs, representing economic benefits derived by the bank. Based on our study of the ATM operations of a large commercial bank in the southeastern Pennsylvania, we have identified several kinds of potential impacts that ATMs can have. However, none is adequately measured by reliance on transaction or usage volumes alone. Although transactions and ATM usage rates are tangible at the local ATM level, it is necessary to examine the linkages between individual ATMs and their impacts in other segments of the bank. Figure 2 below presents a business value linkage for ATMs.

A key aspect of our conceptual model for ATM valuation is that the primary economic impacts only become evident when firm-level production processes are included. Intermediate production processes *link* the direct (local) outputs of ATMs to their economic impacts, and thus, our conceptual model recognizes that ATMs may help banks to achieve several important goals. First, they may promote the retention of a retail deposit base by providing customers with convenient access to their account balances. Second, when they are well-located, ATMs enable banks to earn revenues for serving their competitors' clients. Third, ATMs provide banks with value in terms of the extra product delivery service capabilities that accrue without the corresponding increase in staff expenses. In addition, in certain situations ATMs may displace teller labor directly.

The process which creates business value involves four separate elements: inputs which are specific to individual ATMs, direct outputs which are tangible at an ATM, intermediate production processes which ATMs influence and, finally, the indirect, economic outputs. We now consider each of these elements in greater detail.

Figure 2: A Conceptual Model for ATM Value Measurement

```
                                         Intermediate                  Indirect,
Site-specific         Direct             Production Processes          Economic
Inputs                Outputs            Influenced by ATMs            Outputs
-------------         -------            --------------------          ---------
                                              ____________
                                             |            |
                                             |  Regional  |            Retail
                                          -> |  Deposit   |-----> Deposits
                                         |   | Competition|            (interest
                                         |   |____________|             earned net)
                                         |
Fixed   (capital)      ____________     _|
Costs ----------->  |            |        ____________
                    |   Local    |       |            |
Variable            |    ATM     |--->   |  Regional  |            Net Value of
Costs ----------->  | Production |       | Transaction|-----> Interchange
   (maintenance)    |____________|_      | Competition|
                                    |    |____________|
                                    |                              Labor Value
                                    |     ____________             of Extra
                                    |    |            |            Service
                                    |    |   Local    |            Capability
                                    ->   |   Branch   |-----> (estimated
                                         | Operations |            labor cost
                                         |____________|            contribution)
```

3.2.1. Site Specific Inputs and Direct Outputs

At the local ATM level, a bank incurs a set of fixed and variable costs to locate ATMs in its networks. The fixed costs are threefold: initial capital costs to set up a new ATM, and period costs to provide security and a connection to the network. The latter two fixed cost components are actually determined by network level cost considerations, since network design and management policy make it likely that each ATM will have similar security and telecommunication expenses. ATM installation costs, however, vary markedly based on whether an ATM is located through the wall of a branch, in a supermarket or other protected area or in an isolated, stand-alone location. Variable input costs include interest on working capital representing the stock of cash on hand at an ATM, and normal machine maintenance and cash stocking expenses.

Consumption of these site-specific inputs enables the production of direct, local outputs including a reliable level of machine availability and some volume of transactions processed for the bank's and its competitors' customers. The direct outputs acquire business value, however, only through the intermediate production processes that link them to economic outputs.

3.2.2. Intermediate Production Processes and Business Value Outputs

ATM business value is derived from the contribution that it makes to a local branch production process. ATMs enable a branch to increase its service capabilities without increasing teller labor costs. They allow 24-hour retail banking by substituting for labor, something which could not be justified if labor were required. Since bank branches within a network are likely to exhibit varying levels of labor expenses and transaction processing demand, it is appropriate to attribute differential value to ATMs based on the branch production processes to which they contribute. Thus, identifying business value here requires models which identify the influence of ATMs on teller productivity and teller transaction reduction.

The second aspect of ATM business value which we consider is based on their use by a bank's competitors' customers. Their use results in the production of interchange revenues, which in some cases are quite substantial. Compared to the previous two business value outputs, interchange revenues are relatively direct outputs. They deserve special recognition, however, since the extent to which a given ATM is able to produce interchange revenue is linked to the competitors' ATM location decisions. Banks often measure the value of 'net interchange' in an area, placing emphasis on the total interchange fees earned in an area versus those paid to other banks.

An ATM can be thought of as a design characteristic of a branch's local service delivery capability. Its impact on the bank's ability to improve its deposit share in a market must be evaluated in terms of the intensity of regional deposit competition among banks. In areas where a bank has invested early in ATMs, it is possible that placing an ATM at a branch may have provided enough extra service to customers to enable it to improve its market share of deposits. In markets where two networks compete with one another, network choice may play a role in protecting deposit market share. As a result, the search for evidence that ATMs have a beneficial impact must begin by evaluating competition at the branch level.

3.3. Research Site

The research site for this work was a large commercial bank in southeastern Pennsylvania. The bank participated in a shared network of national scope. The regional network it belonged to is known as "MAC" and the major competing network at the time we collected the data was "CashStream." MAC is among the top ten regional networks in the U.S. in terms of monthly transactions. In our preliminary field study, we interviewed many of the bank's staff members involved with branch and ATM operations. This included senior managers involved in charting the future course of the bank's networks, as well as those responsible for carrying out many of the day-to-day tasks crucial to smooth operations. In order to estimate the IT business value models we will soon present, data for 54 "branch operating territories" (**BOTs**), which contain 78 ATMs and 87 branches owned by the bank, were obtained. We defined the BOTs to include interacting ATMs and branches. Since some of the bank's branches compete with one another directly, several of the BOTs have more than one branch owned by the bank. We also identified all the nearby branches and ATMs owned by the bank's competitors, and assigned them to the appropriate BOTs. Since the bank had recently undergone a merger, we took special care to ensure that only those BOTs for which the bank had accurate data were included in this study.

3.4. Data Sets

3.4.1. Internal Data: ATM and Branch Operations

The data on the 78 ATMs and 87 branches covered a three month period during 1986. The months chosen were considered to be the three consecutive months least influenced by seasonal activity, and representative of average levels of transaction volumes. We later confirmed this by examining monthly samples of branch and ATM transaction levels. The bank captures nearly all of the transaction and cost data we obtained on a routine basis from its branch automation and ATM systems. What was not available in computerized reports was built up from records kept by a unit of the bank's operations charged with supporting ATM operations. This included technical facts about each ATM, for example, its scheduled hours of availability, average cash on hand, the model and the vendor. We also identified the functions, overall costs, operating hours, purpose and design of individual ATMs. This *factual* background helped us to understand the scope of the bank's ATM business, as well as to capture the values of variables included in our business value assessment models.

Information about important branch design and business policy variables which were believed to affect branch competitiveness for all branches within the bank's BOTs was also obtained within the bank. Examples of these variables included branch age, name recognition of the bank, branch size as measured by the number of service platforms, bank type, presence of an ATM at a branch, and ATM network affiliation.

3.4.2. External Data: Population Demographics and Deposit Market Share

We also gained access to a data base of factual demographic information based on the 1980 U.S. Census.[2] These data described census tracts in terms of characteristics of the population. To use this data we aggregated census tracts to represent the bank's 54 BOTs. Matching census tracts to BOTs required the determination of those census tracts most representative of a branch's account holders' addresses. This resulted in the construction of 54 unique and disjoint sets of demographic data.

Demand and saving deposit market shares were built from raw savings and demand deposit data presented in an annual publication on deposit levels for all financial institutions in the state of Pennsylvania [9]. All market share data and competitive branch BOT assignments were reviewed by bank staff for accuracy.

3.5. A Description of an ATM and its Branch Operating Territory

To illustrate our approach, we will apply the results of the models we estimate in the following sections to gauge the value of one of the bank's ATMs. This ATM is located at the bank's branch in a suburban BOT which has six competing branch banks. Five are commercial banks and one is a mutual savings bank. As a result, all of the branches are able to compete for demand and saving deposits. Collectively, the branches have accumulated nearly $22 million in demand deposits and over $93 million in saving deposits. The market is a fairly mature one; five of the branches are older than twelve years. In addition, several of the branches have deployed ATMs. Based on our definition that a *MAC-dominated* BOT must have

[2]We are indebted to Harry Rivkin, president of Accountline Inc., for assistance in accessing their "Black Box" demographic data base.

greater than two-thirds of the total number of ATM machines be MAC machines, this BOT is *not MAC-dominated*. This distinction will be important in the market share results we employ later in the paper.

4. The Role of ATMs in Reducing Branch Costs

Our analysis begins by estimating a model for branch teller labor consumption, which focuses on how a branch ATM affects teller labor productivity. We next quantify the value of teller labor for which an ATM substitutes by estimating a model which forecasts the number of transactions created at the bank's ATMs. This estimate requires information about the demographic and competitive environment, and a description of the ATM, including whether it is located at a branch. Since ATMs are known to cause bank customers to create more transactions than would otherwise be the case, we are careful to only consider that portion of the transactions that are siphoned off from the normal workflow of the branch. Thus, an important requirement for the model we build is that it enable us to identify this fraction. The estimated coefficient of the qualitative variable which represents the presence of the ATM at a branch will be used to identify the number of transactions processed by the ATM due to its branch location. By applying the bank's average unit cost per teller-processed transaction, we then can calculate the value of teller labor that the ATM replaces. In the remainder of this section, we present the branch teller labor estimation and ATM transaction forecasting models, and then apply their results to one of the bank's ATMs.

4.1. The Branch Labor Estimation Model

Previous work in this area has been done by Mabert and Raedels [19], Deutsch and Mabert [8], and Moondrea [23], who applied queueing theory and linear programming to schedule teller labor. More recently, Matta, Daschbach and Wood [20] predicted the aggregate number of transactions for a branch using customer demand and arrival rates. They also attempted to look at the impact of ATMs on teller scheduling, but were hampered due to unavailable data. The requirements for our model are simpler than those of the models presented in the above references, since we are not attempting to solve a scheduling problem.

Our model was estimated using data for 87 branches for three months in 1986, aggregated to one quarterly observation. It takes into account the mix and volume of transactions handled by branch tellers, with or without the influence of an ATM at the branch. The transaction types include deposits, withdrawals, checks cashed, bill payments, ATM card-related transactions, official checks and miscellaneous transactions. Due to the relatively large number of deposits, we collapsed these transaction types into just two categories: deposits and other transactions.

A simple, linear model to estimate the relationship between teller labor consumed and teller transactions produced is as follows:[3]

$$\text{TELLER\_HRS} = [\beta_1 * \text{DEP\_ATM}] + [\beta_2 * \text{DEP\_NOATM}] + [\beta_3 * \text{OTHER\_ATM}] + [\beta_4 * \text{OTHER\_NOATM}] + \varepsilon$$

where

[3] When we ran a similar linear model, we obtained an R^2 of .82, suggesting the explanatory power of the transaction types.

TELLER_HRS	= the number of branch teller hours consumed at the branch during the period;
DEP_ATM	= total number of branch deposit transactions, for branches with ATMs only;
DEP_NOATM	= total number of branch deposit transactions, for branches without ATMs;
OTHER_ATM	= total number of branch transactions other than deposits, for branches with ATMs only;
OTHER_NOATM	= total number of branch transactions other than deposits, for branches without ATMs.

Since the branches in our data set vary substantially in size and number of teller transactions processed, we found that this linear model was susceptible to heteroscedastic error.[4] As a result, running the regression in this form would have yielded biased parameter estimates; larger branches would have driven the results. To ensure that our parameter estimates were not biased by heteroscedasticity, we divided through on both sides of regression equation by the total number of transactions processed at the branch. One teller transaction type with relatively low volumes was eliminated to avoid perfect collinearity [3]. Notice the shift in the emphasis of our model. In the original equation the focus was on the change in the *number of teller hours consumed* when a branch ATM is present. The revised estimation seeks to identify the shift in the *productivity of teller labor*. The dependent variable now is expressed as "teller hours per transaction" (TELTOT). The revised form of our linear model is shown below.[5]

$$\text{TELTOT} = [\beta_1 * \text{DEP\%\_ATM}] + [\beta_2 * \text{DEP\%\_NOATM}] + [\beta_3 * \text{OTHER\%\_ATM}] + [\beta_4 * \text{OTHER\%\_NOATM}] + \varepsilon$$

[4]We investigated this using the Goldfeld-Quandt test and determined that the variances of the residuals of the smaller branches were smaller than those of the larger branches [11, 28].

[5]An alternate way to do this would be to conduct a direct test for the impact of the presence of a branch ATM on the number of teller transactions at a branch. We utilize a multiplicative model which involves the following variables:

Teller transactions	=	f(competition; demographics; ATM variables)
	=	f(savings deposit dollars, demand deposit market share; per capita income, avg household head age; drive-up window, walk-up window; branch ATM, # of MAC ATMs in BOT, MAC network dominance)

When we estimated this model, we found that the coefficient for the presence of a branch ATM was positive and significant. Discussions with the electronic banking manager at the research site suggested that the bank's policy to "backfill" branches with ATMs which have a large number of teller transactions may be responsible. Therefore, one expects, a positive coefficient for the branch ATM dummy, since this variable is a good proxy for total branch transactions.

A second alternate would have been to look at branch teller labor consumption *before* and *after* a branch ATM was installed. However, we were not able to obtain data to support this kind of an analysis due to the recent restructuring of the bank.

where

DEP%_ATM	=	percent of total branch transactions which were deposits, for branches with ATMs only;
DEP%_NOATM	=	percent of total branch transactions which were deposits, for branches without ATMs;
OTHER%_ATM	=	percent of total branch transactions other than deposits, for branches with ATMs only;
OTHER%_NOATM	=	percent of total branch transactions other than deposits, for branches without ATMs;
TELTOT	=	the number of branch teller hours consumed at branch i divided by the total number of transactions processed during the period.

4.2. Estimation Results and Discussion

The estimation results suggest that more teller labor on average is required to process a deposit when an ATM is present at a branch. Additional detailed results of this estimation are presented in Table 1 below.

Table 1: Results of Branch Teller Labor Estimation

Variable	Coefficient	t-stat (signif.)
DEP%_ATM	0.000533	7.08 ***
DEP%_NOATM	0.000378	6.42 ***
OTHER%_ATM	0.000090	1.67 *
OTHER%_NOATM	0.000104	2.10 **

No. of Observations: 87
R^2 = .30
Significance: *** (.01 level)
** (.05 level)
* (.10 level)

Both the DEP%_ATM and DEP%_NOATM variables were significant. We tested to determine whether their coefficients, β_1 and β_2, were significantly different from one another. DEP%_ATM was identified as being greater than DEP%_NOATM at about the .10 level.[6] Our interpretation of this result is that tellers may be processing more complicated deposit transactions, while customers handle simpler deposit transactions at ATMs.

By contrast, the variables representing the other aggregated transaction types, OTHER_ATM and OTHER_NOATM, were less significant explanatory variables for teller labor productivity and also did not test as significantly different. The coefficients of teller transactions other than deposits were also smaller on average than those for the deposit transactions.

In order to determine whether the decrease in efficiency of tellers at branches with ATMs results from ATMs, we need to investigate whether the overall level of transactions arriving at the tellers' windows is actually affected by ATMs. We next develop a model to estimate the extent to which an ATM captures additional transactions from the branch due to its branch location.

4.3. The ATM Transaction Demand Forecasting Model

In this section we estimate a model for transactions at an ATM using data for 78 MAC ATMs owned by the bank. Three prior studies also reported on ATM transaction forecasting models. Pool [29] showed that a large portion of the variance in transactions at a ATM can be explained by the local population demographics. Murphy [24] found that an ATM's network and its time in place are also important predictors of transaction levels. The network distinction is not relevant for our data set, because all our ATMs are on the same network. Recently, Sassone [31] used nine demographic factors to explain greater than 75% of the variance in ATM transactions.

We included four kinds of variables in our model: *population stock* indicators for the BOT, *population flow* indicators around the ATM, dummies for the *competitive region* where the ATM is located, and *ATM descriptors* for the visibility, hours of availability, uptime and branch location of an ATM. The last variable in this list will enable us to determine the fraction of its total transactions that the branch ATM captures from the teller windows. Since not all of the transactions created at an ATM are due to the branch, we need to separate the fraction from the base level of transactions which result for the set of competitive, demographic and other location-specific factors describing the context of an ATM's production. Since we do not have information on a key indicator -- relative levels of ATM card use among bank customers in the regions covered by our data set -- we also included regional dummies to pick up these and other influences. The variables in the forecasting model are described in detail in Table 2.[7]

The form of the regression model we estimated is as follows:

$$\log \text{ATMTRANS} = \text{CONSTANT} + \alpha_{PCINC} \log \text{PCINC} + \alpha_{POP} \log \text{POP} + \alpha_{POPHH} \log \text{POPHH} +$$

---

[6]We utilized the following test to determine if the difference between β_1 and β_2 was equal to zero [28]:

$$\text{t-stat} = [\beta_1 - \beta_2] \;/\; [\text{VAR}(\beta_1) + \text{VAR}(\beta_2) - 2*\text{COV}(\beta_1, \beta_2)]^{.5} = 1.62$$

[7]The variables FOOT, AUTO and VISIB described in the table represent averages of individual responses by two senior electronic banking managers. They were asked to evaluate the variables on a five-point scale. If their assessments were more than two points different, we asked them to jointly re-evaluate their responses. The three region types we considered were urban, suburban and small town areas. Suburban BOTs were the base case in our estimation.

Table 2: Variables in the ATM Transaction Prediction Regression

Variable Name	Definition
Dependent Variable	
ATMTRANS	Actual number of transactions at an ATM, excluding inquiries and failed transactions.
Independent Variables	
Population Stock Demographics	
PCINC	Per capita income in BOT.
POP	Population size in BOT.
POPHH	Population per household in BOT.
ATMPOP	Number of ATMs divided by population in BOT.
Population Flow Indicators	
FOOT	Scaled rating of the amount of foot traffic in the vicinity of the ATM (1 to 5 scale).
AUTO	Scaled rating of the amount of auto traffic in the vicinity of the ATM.
Competitive Region Dummies	
COMMUNITY	Qualitative variable for region type: 1 if BOT is in a small town, 0 otherwise.
URBAN	Qualitative variable for region type: 1 if BOT is urban, 0 otherwise.
ATM Descriptors	
VISIB	Scaled rating of the relative visibility of an ATM in comparison to others operated by bank (1 to 5 scale).
HOURS	Qualitative variable for planned weekly hours: 1 if planned hours = 168, 0 if planned hours < 168.
UPTIME	Qualitative variable for machine uptime during "prime time" banking hours, 10:00 AM to 9:00 PM: 1 if actual uptime meets or exceeds the 97% uptime criterion, 0 otherwise.
ATM	Qualitative variable for ATM location: 1 if the ATM is at a branch, 0 otherwise.

$$\alpha_{ATMPOP} \log ATMPOP + \alpha_{FOOT} \log FOOT + \alpha_{AUTO} \log AUTO +$$
$$\alpha_{COMMUNITY}\ COMMUNITY + \alpha_{URBAN}\ URBAN + \alpha_{VISIB} \log VISIB +$$
$$\alpha_{HOURS}\ HOURS + \alpha_{UPTIME}\ UPTIME + \alpha_{ATM}\ ATM + \varepsilon$$

Prior to obtaining the final results presented below, variants of this model were evaluated. An initial concern we had was choosing an efficient subset of demographic and other variables from a larger database of nearly forty variables so as to avoid biased parameter estimates due to collinearity. The raw data for potential independent variables that were highly correlated were further examined, and a number of diagnostic tests for the presence of collinearity were carried out [3].

4.4. Estimation Results and Discussion

Similar to results from previous research, the results we present in Table 3 below suggest that a combination of stock and flow demographics, and ATM site descriptors are useful predictors of ATM transactions. The key result for our present analysis, however, is that the coefficient for the presence of an ATM at a branch (ATM) is positive, and highly significant. This provides evidence that a branch location is conducive to higher ATM transaction volumes. It is also an initial indication that branch ATMs capture transactions that would otherwise have been processed by tellers. Since an ATM cannot handle as complicated transactions as branch tellers can (split deposits, for example), any additional ATM transaction volume which results from its branch location would come from the set of less labor-intensive transactions a teller processes. Thus, the results we report in this section support our conclusion about the decline in average teller productivity in the presence of branch ATMs.

A second interesting finding was that the hours of availability of an ATM and its uptime play a small role at best in predicting the resulting transactions. Discussions with bank managers suggested some likely explanations for the latter results. First, scheduled hours of availability are usually related to the kind of ATM site. In a supermarket, for example, where no consumers can use ATMs after closing hours, transactions will not be created. However, these lost transactions may be recouped by extra flows and concentrations of people during the supermarket's operating hours. This may be smoothing out the transaction volumes. Uptime may play a small role due to the bank's to ability to provide greater than 97% uptime at most ATMs each month, with rare instances of uptime performance below 95%.

4.5. A Business Value Estimate for Teller Labor Replaced by an ATM

We now illustrate how to use the results of the ATM transaction estimation model to calculate the fraction of total transactions that are processed by the branch ATM, instead of at the teller window. We will use one branch ATM owned by the bank in the suburban BOT we described above. This MAC ATM processed a total of 18,507 deposit, withdrawal and transfer transactions during the three months for which we obtained data in 1986.

The estimate we calculated for this branch ATM is shown in Table 4 below. We begin by applying the β_{ATM} coefficient from the regression to the actual number of transactions processed at an ATM. The coefficient of the branch ATM variable

Table 3: Results of ATM Transaction Estimation Regression

Variable Name	Coefficient	t-stat (signif.)	
CONSTANT	3.93	1.73	*
PCINC	0.42	2.00	**
POP	0.04	0.39	
POPHH	-0.45	-0.89	
ATMPOP	0.02	0.24	
FOOT	0.41	3.35	***
AUTO	0.43	3.07	***
COMMUNITY	-0.32	-1.68	*
URBAN	-0.37	-2.64	***
VISIB	0.64	3.60	***
HOURS	0.08	0.46	
UPTIME	0.06	0.48	
ATM	0.29	2.40	**
R-squared	.51		
Adj. R-squared	.42		
Significance:	*** (.01 level)		
	** (.05 level)		
	* (.01 level)		

in our regression is .292, indicating the incremental transactions at the ATM due to its proximity to the teller windows. This enables us to identify the difference between the base and ATM-influenced transaction levels. Assuming the cost of processing a cash-related transaction at the teller's window is $.90 on average, then the estimated value of the labor replaced by the ATM is $4218.

Table 4: Value of Teller Transactions Replaced by a Branch ATM

Actual ATM Trans	Estimated Transactions if the ATM Were Not at a Branch	Estimated Number of Teller Transactions Replaced by ATM	Estimated ATM Business Value
18507	18507/e^.292 = 13820	18507-13820 = 4687	$.90 * 4687 = $4218

5. Interchange Revenue Evaluation

Another aspect of an ATM's outputs deserves recognition for the business value that can potentially be created. ***Interchange transactions*** within the network we investigated involved fees charged among banks; no customers were charged. As a result a consideration of how pricing may change customers' search strategies for ATMs, the resulting impacts on interchange revenues and overall usage is beyond the scope of our current work. However, usage of an ATM by a bank's competitors' customers is a means by which a bank can earn a steady, dependable income stream.

Using three representative months of data for 78 bank-owned MAC ATMs, we checked the stability of the ratio of interchange transactions to total transactions (IPCT). The distribution of the ratio of the absolute value of the maximum deviation of the three monthly IPCTs from the mean IPCT for each ATM indicated that the value at the 25% quartile was 0.011, the median was 0.026, and the value at the 75% quartile was 0.035. This ratio had a maximum of 0.192 and a minimum of zero for the 78 ATMs. Thus, more than 75% of the ATMs exhibited less than a 4% absolute maximum deviation from MEAN_IPCT.[8]

For the network we examined, three kinds of transactions involved interchange fees: cash withdrawals, deposits and transfers of cash between accounts. Inquiry, bill payment and denied transactions did not involve interchange fees. The prices of withdrawals (WDL) and cash transfers between accounts (TFR) are \$.30, while the price of a deposit (DEP) is \$.70. Interchange revenues (IREV) for an ATM are calculated as follows:

$$IREV = (P_{WDL} * WDL + P_{DEP} * DEP + P_{TFR} * TFR) * IPCT$$

Table 5 shows the value of quarterly interchange revenue for the branch ATM that we examined above.

[8]IPCTs were found to be in only the 10-20% range for branch ATMs in our data set, suggesting that the creation of interchange revenues at branch ATMs probably is not the sole reason the bank deploys ATMs.

Table 5: The Value of Interchange Revenues at a Branch ATM

MONTH #	ATM Transactions			Interchange		TOTAL REVENUE
	WDL	DEP	TFR	IPCT	IREV	
1	4932	1050	320	.253	$584.00	
2	4683	1099	319	.249	$565.00	$1724
3	4719	1070	315	.255	$575.00	

6. Branch ATMs and Deposit Market Share Protection

The third aspect of business value we measured for ATMs is their impact on deposit market shares. In this section we employ data which describe 191 branches that competed for demand deposits and 255 that competed for saving deposits in BOTs that were not dominated by the MAC network. The number of observations in each group differs due to regulatory constraints imposed on certain kinds of banking organizations, which prevent all banks from competing for demand deposits. We estimated a *multiplicative competitive interaction* (MCI) model [13, 25] to identify the importance of ATM-related variables versus other branch design and business policy variables in branch-to-branch competition for demand and savings deposits. The MCI model is a "gravitational model" of market share, in which a competitor's attractive features act to exert competitive leverage within the BOT. A similar application to bank branches can be found in Hansen and Weinberg [12]. We have extended their research to incorporate ATM variables in our analysis.[9]

6.1. The Bank Branch Market Share Model

The general form of the mathematical model for the market share of branch j in territory k for demand or savings deposits is given below.

[9]The MCI modeling approach is especially useful in situations where times-series data for market shares and competitive features are not available. It allows inferences to be made about the impact of a variable such as IT on market share based without requiring pre-deployment and post-deployment data.

$$MS_{jk} = \frac{\prod_{c\varepsilon C} X_{jck}^{\beta_c}}{\sum_{j\varepsilon J_k} \prod_{c\varepsilon C} X_{jck}^{\beta_c}}$$

where

MS_{jk} = *branch j's deposit share in territory k*

X_{jck} = *the cth design characteristic of branch j in territory k*

J_k = *the set of branches in territory k*

β_c = *estimated 'intensity' exponent for characteristic c*

This model states that the market share of a bank branch is a function of the design decisions of its competitors, as well as those of its own management. The multiplicative specification enables us to capture the interactions of the design choices of the branch competitors in their local markets. We do not need to include variables in the model which describe the demographic environment that the branches compete in, since all competing branches in a BOT face the same set of conditions. Instead, the design choices alone distinguish the competitive capability of each branch. The design variables included in the demand and saving deposit market share models are shown in Table 6.[10]

6.2. Results of the Bank Branch Market Share Estimation

In Table 7 below we present results for BOTs which are not dominated by MAC. The most important result of the MCI models is that we found that branch ATMs have positive coefficients when they are located in BOTs which are not dominated by the MAC network. Since BOTs which are not dominated by MAC tend to have fewer ATMs in our sample, the value of a branch ATM is correspondingly higher. Diagnostic tests indicated that collinearity among independent variables, and heteroscedasticity in residuals, di not bias our results [3, 11].

6.3. Quantifying the Deposit Protection Value of a Branch ATM

We next apply the results of our MCI model to estimate business value for the market share gain associated with the branch ATM in the suburban BOT discussed above. Direct estimates of the incremental impact of an ATM can be made with the relevant coefficients from the MCI models, assuming that other branches maintain their current design and business policy choices. This result is captured by the following relation, derived from the specification of the MCI model presented above.

$$MSN / MSA = (XN / XA)^{\beta_{ATM}}$$

MSN, the value of the branch market share without an ATM, is the only unknown in this equation. The incremental value

[10] Note that qualitative variables in this model are coded with 'e' for the presence of an attribute and '1' for the absence of the attribute. These values become '1' and '0' in the log linear estimation form of the model. Additional mathematical details are presented in Banker and Kauffman [1].

Table 6: Variables in the Branch Market Share Models

BRANCH DESIGN VARIABLE	DEMAND SHARE MODEL	SAVING SHARE MODEL	VARIABLE DESCRIPTION
Dependent Variables			
DEMSHARE	X		Branch demand deposits divided by the sum of all deposits in BOT.
SAVSHARE		X	Branch saving deposits divided by the sum of all deposits in BOT.
Independent Variables			
COMMBK	X		Qualitative variable for commercial bank type.
MUTSAVBK		X	Qualitative variable for mutual savings bank type.
S&L		X	Qualitative variable for savings and loan bank type.
HIRATE	X	X	Qualitative variable for higher than avg bank interest rate, as judged by sponsoring branch managers surveyed.
AGE	X	X	Continuous with branches > 12 years old coded as 12 years.
NAME	X	X	5-point scale; based on evaluations made by branch bank managers.
WALKUP	X	X	Qualitative variable for presence of walk-up window at branch.
DRIVEUP	X	X	Qualitative variable for presence of drive-up window at branch.
PLATFORM	X	X	Number of human, non-teller service locations.
ATM	X	X	Qualitative variable for branch ATM.
MAC	X	X	Qualitative variable for MAC member.

Table 7: Deposit Market Share Results -- Not MAC-Dominated BOTs

Independent Variables	Demand Deposits Coef	Demand Deposits t-stat (signif.)		Saving Deposits Coef	Saving Deposits t-stat (signif.)	
COMMBK	2.09	6.91	***	----	----	
MUTSAVBK	----	----		0.98	3.50	***
S&L	----	----		0.47	2.91	***
HIRATE	1.66	2.64	***	0.12	0.72	
AGE	0.76	3.96	***	0.63	4.55	***
NAME	1.44	2.57	***	0.79	4.47	***
WALKUP	1.22	2.57	***	0.28	1.78	**
DRIVEUP	-0.38	-0.97		-0.18	-1.52	
PLATFORM	0.53	3.41	***	0.56	4.62	***
ATM	0.14	0.92		0.27	2.32	**
MAC	0.35	2.24		0.46	3.93	***
R-squared		.41			.33	
Adj R-squared		.38			.30	

Significance: *** (.01 level) ** (.05 level) * (.10 level)

of an ATM in terms of market share gain is then given by $\Delta\_MS = MSA - MSN$. Solving for MSN, we found that branch ATMs increased branch shares by 1.68% and 3.57%, respectively. The business value associated with these increases can be calculated directly by applying the difference between the bank's marginal cost of funds and the lower cost of retail deposits, during the three-month study period. At that time, the bank's marginal cost of funds was 8.7% and the market rate on retail deposits was 5.25%. Table 8 presents the variables involved in this calculation and the results for incremental demand and savings deposit value.

Table 8: Incremental Market Share Calculation: Variables and Results

	Demand Deposit Model	Saving Deposit Model	Definition of Variable
DEPOSITS	\$21,827M	\$92,333M	Actual observed level of deposits in the BOT.
β_{ATM}	.143	.272	Coefficient of the branch ATM variable.
XA	e	e	Qualitative variable to represent ATM at branch.
XN	1	1	Qualitative variable to represent no branch ATM.
MSA	.1259	.1498	Actual market share of branch with ATM.
MSN	.1091	.1141	Estimated market share of branch without ATM.
Δ_MS	.0168	.0357	Estimated incremental market share attributed to branch ATM.
Δ_DEPOSITS	\$366,694	\$3,296,300	Estimated change in retail deposit volume.
Δ_\$	\$3,163	\$28,430	Business value of Δ_MS (assuming spread of 345 basis points between marginal cost of funds and deposit interest cost).

7. Conclusion

7.1. Managerial Analysis: A Business Value Estimate for a Branch ATM

It is now possible to summarize our findings for the business value of the branch ATM we have studied throughout this paper. Table 9 presents the components of total estimated business value. The striking conclusion is that the primary business value of this ATM is derived from the competitive leverage it exerts on savings deposit market share in the BOT. The quarterly value of the market share gain in savings deposits is the largest single component of the ATM's total estimated business value.

Our results also suggested that branch ATMs do not create uniform leverage on deposit market share. This provided

Table 9: A Summary of the Business Value of a Branch ATM per Quarter

Source of Business Value	Business Value Estimate for a Branch ATM in a non-MAC-dominated BOT
Costs of Branch Labor Replaced	$ 4,218
Creation of Interchange Transaction Revenues	$ 1,724
Incremental Value of Market Share for:	
* Demand Deposits	$ 3,163
* Saving Deposits	$28,430
Total Estimated Business Value	$37,535

significant information for managers interested in fine-tuning the bank's ATM deployment strategy, and also pointed out the extent to which over-capacity in ATMs makes it difficult for them to create a significant economic contribution. The high business value estimate for the ATM evaluated in this study is relatively rare among the bank's ATMs; most are unlikely to show incremental deposit market share gains, because they were located in territories where MAC ATM deployment was not a distinguishing competitive feature. It is also important to recognize how rapidly the ATM value we estimated could be diminished, especially by other MAC banks choosing to locate more ATMs nearby.

In practice, many ATM location proposals often carry negative NPV returns. But based on our empirical results, we believe that key benefits can be quantified that would support improved performance and investment evaluation, and lead to more optimistic returns. While the tests we conducted look at branch competition *ex post*, managers can use the results to develop a baseline of performance that will help them make more refined *ex ante* estimates for the performance of newly deployed ATMs.

Several extensions of our current ATM value results are appropriate. First, it makes sense to attempt to develop even more refined measures for the market share and branch labor effects of ATMs. We are currently investigating how demographic and other descriptive features of the competitive environments tend to enhance or suppress ATM value. Second, provided we can obtain additional data, it would be useful to carry out a time-series analysis to determine how business value changes over time as competitors respond to one another's ATM deployment decisions. A third extension would involve recasting our modeling approaches to explicitly support forecasting ATM business value under changing business and competitive conditions.

7.2. Summary: Contributions to IS Research

Parker and Benson, in a recent *Datamation* cover story on the new economics of information technology, suggested the need for tools to assist managers in looking beyond traditional "cost-benefit analysis to deal with projects that previously have been difficult or impossible to assess, such as those that have strategic impact on a company" ([27], p. 96). The primary contribution of this work is to provide a new analytic alternative: the conceptual framework we illustrated for identifying the range of potential IT impacts. This framework can help to structure a manager's analysis of an IT investment in a way that increases the likelihood that the "right" impacts will be include in cost-benefit analysis.

A second contribution of this research is our illustration of the conceptual model for electronic banking operations, and the econometric models we suggested to quantify their second order impacts. We believe that an empirical approach is appropriate to provide evidence to link intangible impacts to an IT investment. For other IT valuation problems, different evaluative models will be required which are specialized to capturing *primal*, value-enhancing impacts of changing revenues and market share, and *dual*, cost-reducing impacts in a firm's operations.

A final contribution of this work is the experience base it builds in IS research for doing business value assessment with a large data base. The size of our data set afforded us the opportunity to construct very rich models to evaluate three dimensions of ATM business value. An important implication of our findings at the research site was that electronic banking managers needed to reconsider what should be included in a strategic database for ATM valuation. Generalizing from this experience, we believe that data availability will continue to constrain the kinds of results that can be achieved by IS managers in practice.

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