QUANTIFYING THE BUSINESS VALUE OF INFORMATION TECHNOLOGY: AN ILLUSTRATION OF THE 'BUSINESS VALUE LINKAGE' FRAMEWORK

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ABSTRACT

Senior management's ability to gauge the business value of investments in information technology (IT) has been seriously hampered by a lack of analytic tools to conduct sound performance assessment. In this paper, we present a conceptual framework called a "business value linkage" that is used to represent 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 to increase market share. Utilizing appropriate modeling and econometric methods, we illustrate our approach by analyzing several hard-to-measure aspects of the business value of automated teller machines (ATMs) in retail electronic banking. The results show that the hardest to measure impacts in some cases can have the greatest business value.

1. INTRODUCTION

1.1. Research Problem

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 (NPV) and discounted cash flow (DCF) analysis are often used to estimate the return on IT investments, however, they fail in effectively capturing the less tangible impacts of IT that can turn an seemingly unprofitable investment into a highly beneficial 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. This hampers the analytic process and often renders the resulting estimates unusable by management. 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.

These problems were underscored by a recent editorial published in *Computerworld* that commented on an Index Group survey:

> *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? .... 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 (COMP88, p.20).*

In this paper, we present a framework that represents a step toward achieving this goal. We propose a generalized "business value linkage" for IT (PARK88, KAUF88) in order to capture the processes by which the direct outputs are transformed within the firm and its operating environment into enhanced revenues, reduced costs and increased market share. We define "business value" as the economic contribution that IT can make to management's goal of profit maximization in the firm. IT can create business value in 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 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 using a new evaluative framework and supporting econometric tests.

1.2. General Approaches to Measuring 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 (PORT80). It relates aspects such as barriers to entry, power in the buyer-supplier relationship, and switching costs to the strategic position of a firm. Porter later extended the framework to identify *where* value-added is generated in a firm, as a product is created and delivered. McFarlan (MCFA84) later recognized the relevance of IT's leverage on specific portions of a firm's value chain. 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, and foster innovation which results in new products. McFarlan also 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) would only restrict the perspective that a visionary senior manager might bring to his firm. And, this reduces the likelihood that "softer" 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 (KAPL86) expanded on this argument, by launching a broad attack on the basics of financial analysis and managerial accounting methods as they are applied to high-tech businesses. He argued that DCF analysis can lead to underinvestment in computer-integrated manufacturing, especially where non-tangible benefits including increased flexibility, faster response to market shifts, and greatly increased throughput and reduced lead times are involved.

Clemons' (CLEM90A, CLEM91) recent work on evaluating strategic investments in IT is suggestive of how much conceptual progress has been made in this area of Information Systems (IS) research in the last several years. He presented a series of case studies and seven lessons on IT valuation that bring the non-quantifiable aspects of IT investments, as well as the mechanisms that are appropriate to justify them, into clearer focus. One example was Merrill Lynch's decision to allow Bloomberg Financial -- a company in which Merrill held a stake as a minority shareholder -- to sell its bond and fixed income analytics to investment banking and brokerage industry competitors. Instead, the problem was *whether* and *how much* selling this service to the competition would change the basis of competition and the operation of the market. The lesson that Clemons drew from this example was that it was inappropriate (if not impossible) to "work with the numbers," because the decision scenario was so complex. This led him to argue in favor of ranking "ranking alternatives" and choosing among them, even in the face of negative NPV outcomes.

In our present research, we suggest a method that will enable management to follow up on the second of Clemons' seven lessons for strategic IT evaluation: "to work with the numbers." Our general approach builds on a growing body of research that was recently reviewed by Kauffman and Weill (KAUF89). They concluded that substantial progress has been achieved through research that applies survey and organizational research methods (WEIL90A, WEIL90B), qualitative and empirical case or field study methods (CLEM89, CLEM90B), and quantitative analysis using concepts from economics and management science (ALPA90, BANK90, BANK91, BARU89, KAUF90). But still the central question remains: do investments in computers pay off (ICIT88, LOMA87, STRA85, WEIL90C)?

2. A FRAMEWORK FOR MEASURING DIMENSIONS OF IT VALUE

2.1. A Business Value Linkage for IT

A common shortcoming of most analytic methods for IT evaluation is that they lack 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 ROI of an IT investment. Our approach enables fuller (though perhaps still not an exhaustive) identification of the potential business value impacts of IT. We formalize the links between investment and value 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 production processes* -- inside or outside the firm -- that are influenced by IT;

* the set of *business value 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 link an IT investment to strategic or operational benefits for the firm.

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

* strategic and operational costs for existing operations;

* direct and potential revenue gains from existing and new products, respectively;

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[1]Our classification also builds on the recent work of two authors: Berger (BERG88) and Weill (WEIL90C). Berger advocated classifying IT impacts into three groups according to their internal/operational, strategic/competitive, and product/service impacts. Weill classifies IT investment according to their purpose, rather than their impacts, however the categories are similar. They include including strategic, operational and infrastructural impacts.

* market segment and market share improvements, due to changes in a firm's competitiveness or to the effects that IT has in changing the basis of the market competition.

This classification is useful because it identifies the major components of IT value that *flow through* to the bottom line. It also offers the opportunity to examine "intermediate production" at points along a firm's value chain where IT has the greatest effects. This can help management to address such important concerns as business risk reduction, organizational learning, increased response flexibility, and the "vanishing status quo" discussed by Clemons (CLEM91), as intermediate levers on the major classes of business value impacts. Figure 1 presents a general representation of these business value impacts and a simplified "value path."

INSERT FIGURE 1 ABOUT HERE

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. Thus, 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 first automation efforts a firm undertakes and they lead to obvious cost reductions.

The primary resources that management targets for operating cost reductions include labor, materials, capital, energy and IT. However, among this set of inputs IT is special: it gives management leverage to reduce other costs through substitution. For example, financial services IT investments promote savings in labor and capital (ALPA90, GOTT89, KAUF88), while manufacturing IT investments help to cut waste in materials and energy, while improving inventory management, quality and overall firm performance (KEKR90, WEIL90C). The airlines' deployment of computerized reservation systems (**CRS**) 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 (COPE88). 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. But, when IT affects the consumption of operating resources in a more complex fashion, it becomes more difficult to measure the impacts. We explored this kind of problem in a recent paper on the use of IT in fast food restaurants (BANK90), and found that IT can significantly influence the productivity of existing resource use.

Business value from IT investments also is derived from increasing revenues from existing products and by creating new products that lead to revenue flows. This occurs when firms realize that a special combination of organizational ingredients is present to enable "piggy-backing" off some existing or new IT investment. Airline CRS offers a good illustration here also. Initially direct revenues did not cover costs. It took increases in airline market shares to finally make a solid business case for the IT investments in CRS. Today though, American and United are able to levy membership fees for Sabre and Apollo because access is now a competitive necessity for travel agents.

The final category of value is most difficult to predict and quantify. IT is normally an indirect factor affecting a firm's competitive position, and this often involves changes in market share. Managers are challenged to identify the extent to which the presence or absence of IT in a firm's service configuration affects the competitive balance, because it is so hard to control for other factors in a firm's marketing mix. Citibank's prowess in capturing retail deposit market share through ATM deployment is a good example here. Glaser reported that after 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 (GLAS88). This provides evidence that the value of ATMs lies in the services that they provide to customers, and that customers are willing to pay for it (STEG88).

3. A CONCEPTUAL MODEL FOR ATM VALUATION IN RETAIL BANKING[2]

Current methods evaluate the benefits from ATMs deployed in retail banking rely heavily on rules-of-thumb to assess performance. These rules have typically been based on transactions or usage volume. For example, up until recently network managers used 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 (BMA86, LIBB86A). For individual ATMs, an aggregate period usage criterion is often used to distinguish between acceptable and unacceptable performance (LIBB86B). 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 (MESH86, LIBB86C). (Interchange fees are paid by banks to one another when their customers use another bank's ATMs.)

3.1. Valuation Problems in Electronic Banking

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 *indirect* impacts.

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

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[2]For an overview of the basics of electronic banking, including ATMs, debit and credit cards, and wholesale funds transfer in the U.S., the interested reader should refer to LIPI85.

electronic banking operations:

* What impacts do branch ATMs create that justify the current high levels of investment (COAT84, HAYN87)?

* Are there impacts on the branch workflow so that teller labor costs are reduced or tellers are replaced (HAYN86B)?

* Do ATMs provide a higher overall level of service to retail banking customers that distinguishes a bank from its competitors and enable it to achieve a higher level of profitability and market share (GLAS88, HAYN86A, WALK77A, WALK77B)?

* How can any these and other impacts be quantified (BOND89)?

3.2. A Conceptual Model for ATM Business Value Measurement

Our approach involves the identification of input resources and the process by which they are transformed into service and other outputs, representing economic benefits derived by the bank. 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 on other segments of a bank's value chain to determine where value is created. Figure 2 below presents a business value linkage for ATMs.

INSERT FIGURE 2 ABOUT HERE

A key aspect of our conceptual model for ATM valuation is that the primary economic impacts only become evident when intra-firm production and inter-firm competition are included. Intermediate production processes *link* the direct (local) outputs of ATMs to their economic or business value impacts. 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 by 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.

Thus, 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.

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 site, 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. Consumption of these site-specific inputs enables the production of direct, local outputs including a reliable level of machine availability and a number 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.

Intermediate Production Processes and Business Value Outputs. ATM business value also is derived from the contribution that an ATM can make 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 that may not be economically justifiable 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 transactions.

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 dependent on the location of the ATM.

An ATM can be thought of as a design characteristic of a branch's local service delivery capability. Its impact on the bank's overall ability to improve its deposit share in a market -- thus lowering its overall funding costs, since retail deposits are relatively cheap -- must be evaluated in terms of how the ATM helps the bank to configure its service delivery capability to effectively participate in 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 provide enough extra service to customers to enable the branch to improve its market share for 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 and market levels.

3.3. Research Site

The research site for this research was Meridian Bancorp, a large commercial bank in southeastern Pennsylvania. 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, and number one in terms of bank-to-bank interchange volume (KUTL88), suggesting the relative importance that customers place on electronic banking facilities deployed by banks in the region. Meridian also participated in a shared network of national scope.[3] In our 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

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 by management 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 automated branch 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

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[3]For an introduction to shared networks in electronic banking, the reader should see the following references: BAKE85, FELG86, GIFF85.

affiliation.

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. 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 (DRSI87). 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 (BOT)

To illustrate our approach, we will apply the results of the models we estimate in the following sections to gauge the business value of one of the bank's ATMs. This ATM is located at a branch in a suburban BOT which has six competing branch banks. Five are commercial banks and one is a mutual savings bank. Nearly all of the branches are able to compete for demand and saving deposits on a relatively equal footing. Collectively, the branches had accumulated nearly $22 million in demand deposits and over $93 million in saving deposits by 1986. The market is a fairly mature one; five of the branches are older than twelve years. Several of the branches have deployed ATMs. We defined two kinds of BOTs based on the balance of competing ATMs that were deployed. A *MAC-dominated* BOT must have greater than two-thirds of the total number of ATM machines as MAC ATMs. By this definition, the BOT under study is *not MAC-dominated.* This distinction will be important when we report the deposit market share contribution results later in the paper.

4. THE ROLE OF ATMS IN REDUCING BANK BRANCH LABOR COSTS

Our analysis begins by estimating a model for branch teller labor consumption. It 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, including whether the ATM is located at a branch. Since ATMs are believed 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 in order to avoid "double counting." 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 represents the presence of the ATM at a branch and will be used to identify the number of transactions processed due to the 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 and the following section, we present the branch transaction and teller labor estimation forecasting models, and then apply their results to one of the bank's branch ATMs.

4.1. The Branch Teller Labor Estimation Model

Our model was estimated using data for 87 branches for three months in 1986, aggregated to one quarterly observation for each branch.[4] 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 and withdrawals, we collapsed these transaction types into just two categories, with all other transactions aggregated with withdrawals.

A simple, linear model to determine whether the presence of an ATM at a branch has an influence on teller labor consumed in the production of teller transactions is shown below.[5]

$$TELLER\_HRS = \beta_1 * DEP\_ATM + \beta_2 * DEP\_NOATM + \beta_3 * OTHER\_ATM + \beta_4 * OTHER\_NOATM + \epsilon$$

where

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;*

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[4]Previous work in this area has been done by Mabert and Raedels (MABE77), Deutsch and Mabert (DEUT80), and Moondrea (MOON78), who applied queueing theory and linear programming to schedule teller labor. More recently, Matta, Daschbach and Wood (MATT87) 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 by the unavailability of 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.

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

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 varied substantially in size and number of teller transactions processed, we found that this linear model was susceptible to heteroskedastic error.[6] To ensure that our variance estimates were not biased by heteroskedasticity, 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 (BELS80).

The reader should recognize the shift in 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 variation in the *productivity of teller labor*. The dependent variable now is expressed as "teller hours per transaction" (TELTRN), the ratio of teller labor hours to number of teller transactions. The revised form of our linear model is shown below.[7]

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[6]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 (GOLD65).

[7]An alternative 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 alternative 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.

$$TELTRN = \beta_1 * DEP\%\_ATM + \beta_2 * DEP\%\_NOATM + \beta_3 * WDL\%\_ATM + \beta_4 * WDL\%\_NOATM + \epsilon$$

where

DEP%_ATM	=	*percent of total branch transactions that were deposits, for branches with ATMs only;*
DEP%_NOATM	=	*percent of total branch transactions that were deposits, for branches without ATMs;*
WDL%_ATM	=	*percent of total branch transactions, including withdrawals and other transactions not involving deposits, for branches with ATMs only;*
WDL%_NOATM	=	*percent of total branch transactions, including withdrawals and other transactions not involving deposits, for branches without ATMs;*
TELTRN	=	*the number of branch teller hours consumed at a branch divided by the total number of transactions processed during the period.*

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.

INSERT TABLE 1 ABOUT HERE

Both the DEP%_ATM and DEP%_NOATM variables were significant. We then 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.[8] Our interpretation of this result is that tellers may be processing more complicated deposit transactions, while customers handle simpler deposit transactions at ATMs.

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[8]We utilized the following statistic to test if the difference between β_1 and β_2 was equal to zero:

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

By contrast, the variables representing the other aggregated transaction types, WDL%_ATM and WDL%_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.

5. FORECASTING BRANCH ATM TRANSACTION DEMAND: ENHANCED SERVICE LEVELS

5.1. The ATM Transaction Demand Forecasting Model and Data

In this section we estimate a model for transactions at an ATM using data for 78 MAC ATMs owned by the bank.[9] 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.[10]

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[9]Three prior studies also reported on ATM transaction forecasting models. Pool (POOL76) showed that a large portion of the variance in transactions at a ATM can be explained by the local population demographics. Murphy (MURP83) 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. More recently, Sassone (SASS87) used nine demographic factors to explain greater than 75% of the variance in ATM transactions.

[10]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 used as the base case in our estimation.

INSERT TABLE 2 ABOUT HERE

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

$$
\begin{aligned}
\log ATMTRANS \;=\; & CONSTANT + \alpha_{PCINC} * \log PCINC + \alpha_{POP} * \log POP \\
& + \alpha_{POPHH} * \log POPHH + \alpha_{ATMPOP} * \log ATMPOP + \alpha_{FOOT} * \log FOOT \\
& + \alpha_{AUTO} * \log AUTO + \alpha_{COMMUNITY} * COMMUNITY \\
& + \alpha_{URBAN} * URBAN + \alpha_{VISIB} * \log VISIB + \alpha_{HOURS} * HOURS \\
& + \alpha_{UPTIME} * UPTIME + \alpha_{BRANCH\_ATM} * BRANCH\_ATM + \epsilon
\end{aligned}
$$

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. Raw data on potential independent variables were examined and a number of diagnostic tests were applied to check for the presence of collinearity (BELS80).

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 (related to the BRANCH_ATM variable) 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 transaction processing productivity in the presence of branch ATMs.

INSERT TABLE 3 ABOUT HERE

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. It turns out that 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 normal operating hours. Uptime plays a small role at best due to the bank's ability to provide greater than 97% uptime at most ATMs each month, with rare instances of uptime performance below 95%.

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

We now discuss how the results of the transaction estimation model may be used 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 the *teller labor value* of this branch ATM is shown in Table 4 below. We begin by applying the α_{BRANCH_ATM} coefficient from the regression to the actual number of transactions processed at an ATM. The coefficient of the branch ATM variable 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 per transaction[11], then the estimated value of the labor replaced by the ATM is $16,873.

INSERT TABLE 4 ABOUT HERE

[11]The figure of $.90 for an average teller transaction is net of transaction costs accruing to the bank when a customer's interaction with the bank teller is completed. Source: Meridian Bancorp.

6. 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 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 it can earn a steady, dependable income stream for the bank.

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). IPCT is a metric that is useful to portray how well an ATM does at capturing revenue-generating interchange transactions. 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. The MEAN_IPCT ratio measures overall interchange rates across the entire set of ATMs. 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% maximum absolute deviation from MEAN_IPCT, the average interchange percent level observed across all ATMs.[12]

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:

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

Table 5 shows our calculation of the business value of annual interchange revenue for the branch ATM that we examined above. It amounted to approximately $6,896.

INSERT TABLE 5 ABOUT HERE

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[12]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.

7. 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 (including 42 owned by the bank) 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 (JAIN79, NAKA74) 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 exert competitive leverage within the BOT. A similar application to bank branches can be found in Hansen and Weinberg (HANS79). We have extended their research to incorporate ATM variables in our analysis.[13]

7.1. 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 (COOP88):

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

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

[13]The MCI modeling approach is especially useful in situations where times-series data for market shares and competitive features are not available, by simulating competition among firms which do and do not deploy a specific competitive feature. It allows inferences to be made about the impact of a variable such as IT on market share without requiring pre-deployment and post-deployment data.

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.[14]

INSERT TABLE 6 ABOUT HERE

7.2. Results of the Bank Branch Market Share Estimation

In Table 7 below we present the coefficient estimates and t-statistics of the variables included in the MCI model for BOTs that are not dominated by MAC. The coefficient estimates for the non-information technology variables are similar in nature to the kinds of results reported in similar research on bank branch competition. (For example, see Hansen and Weinberg's work on bank branch competition (HANS79).) Our results showed that bank type (savings and loan, mutual savings or commercial bank), branch age, bank name and the presence of walkup teller counters and platform positions were all correlated with deposit market share. Diagnostic tests that we performed indicated that collinearity among independent variables and heteroskedasticity in residuals were not problematic (BELS80, GOLD65).

Our most important result is that branch ATMs and their association with the MAC shared ATM network may have a positive influence on market shares for both demand and savings deposits markets, though this effect is significant at conventional levels (at least 5% significance) only in the latter case. The usefulness of these results, especially a positive and significant coefficient estimate for the branch ATM variable, will become apparent in a moment, when we use it to obtain an estimate of a branch ATM's deposit market share protection capabilities.

INSERT TABLE 7 ABOUT HERE

[14]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 (BANK88).

7.3. 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 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, derived from the specification of the MCI model presented earlier, is captured by the following relation:

$$MSN_j = \left(1 + e^{\beta_{BRANCH\text{-}ATM}} * \frac{1 - MSA_j}{MSA_j}\right)^{-1}$$

where MSA_j and MSN_j are the branch market shares with and without an ATM, respectively, given identical other characteristics. (Please refer to the Mathematical Appendix for the derivation of this relation.) Since the branch under consideration had an ATM, MSN, the expected value of branch market share when it does not deploy an ATM, is the only unknown in this equation. The incremental value 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 demand and savings deposit market shares increased by 1.49% and 3.15%, 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, on an annual basis.[15] 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. The ATM business value contribution was approximately $11,220 in terms of the time value of demand deposits and $100,343 in terms of the time value of savings deposits.

INSERT TABLE 8 ABOUT HERE

This is a remarkable result for two reasons. *First*, we have quantified one of the least easily estimated business value impacts of a branch ATM and found that it far exceeds the more easily measured impacts, the labor substitution value and the interchange revenues of an ATM. It seems that least tangible among the set of ATM business value outputs to provide the lion's share of ATM's value! *Second*, the business value estimates that we derived grow out of the placement of ATMs for defensive, rather than offensive

[15]We assume that the reduction of one ATM in the BOT would not have resulted in the any reduction of the total market size or amount of deposits.

reasons. Clemons (CLEM86) has argued that ATMs have generally failed to produce competitive advantage for the firms that deployed them. Our results support that view: if anything, our modeling approach measures the *deposit protection value* of deploying branch ATMs, not their ability to help a branch secure competitive advantage.

8. CONCLUSION

We now synthesize our findings for the business value of the branch ATM we have studied throughout this paper to illustrate the magnitude of the various sources of business value.

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

Table 9 presents the business value linkage components and overall business value estimate of $135,332 for a specific branch ATM. In the case of this ATM, the one year benefit is more than sufficient to offset most ATM site installation and operating costs. The striking conclusion is that the business value of this ATM is primarily derived from the competitive leverage it exerts on savings deposit market share in the BOT. In fact, we found the annual value derived from this source is nearly 75% of the ATM's total estimated business value.

INSERT TABLE 9 ABOUT HERE

We should point out at this point that branch ATMs do not create uniform leverage on deposit market share. In fact, the high business value estimate for the branch ATM considered in this study is relatively rare among the bank's ATMs. *First*, not all of the bank's branches were located in BOTs that were "not dominated" by MAC. In prior research (BANK88), we found that ATMs located in territories where MAC ATM deployment was not a distinguishing competitive feature (i.e., "MAC-dominated" territories), did not create business value from incremental market share gains. *Second*, even where a BOT was not dominated by MAC, there were often enough competing branches located in the territory to blunt the market share impact of a branch ATM.

It is also important to point out how rapidly the deposit market share gains that we estimated can be diminished, for example, when other MAC banks choose to locate more ATMs nearby. Small changes in bank configurations have the potential to substantially shift the equilibrium market shares, and other more radical changes are also possible. For example, in 1987, just following the time period that our study covers, a merger occurred between Pennsylvania's two largest ATM networks, Mellon Bank's CashStream and Core States' MAC, giving MAC a monopoly in electronic banking network services in the state. (For additional details, see the case study by Clemons (CLEM89).) This eliminated any incremental deposit market share business value associated with operating an ATM connected to MAC in a BOT that was not already dominated by MAC; MAC now dominates in every branch operating territory in Pennsylvania.

Based on our empirical results, we believe that key benefits can be quantified that would support improved electronic banking performance and investment evaluation, and lead to more optimistic estimates of ATM business value based on their competitive parity effects. While the tests we conducted look at branch competition *ex post*, managers can use such results to develop a baseline of performance that will help them to 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*, if additional data are available, 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 approach to support forecasting ATM business value under changing business and competitive conditions.

8.2. Contributions to IS Research

The primary contribution of our work is our conceptual framework for linking intermediate outputs to business value, and the modeling approaches we demonstrate to quantify the business value of IT. This framework helps to structure a manager's analysis of an IT investment in a way that increases the likelihood that the "right" impacts will be included in cost-benefit analysis. It also supports "working with the numbers" in an instance where management required numbers to distinguish among business value levels for many operating sites.

A second contribution of this research is our illustration of the implementability of the conceptual model for electronic banking operations, and the specific econometric models we suggested to quantify their 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 value-enhancing impacts of changing revenues and market share, and cost-reducing impacts in a firm's operations.

This research has allowed us to build up a significant experience base in doing IT business value assessment with a large and rich data base. Our data set afforded us the opportunity to construct models to evaluate three dimensions of ATM business value, and make comparisons between them. Finally, 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.

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Mathematical Appendix. **Derivation of Incremental Deposit Market Share for Branch ATM**

The variables MSA and MSN indicate the market shares of a bank branch with and without an ATM, given that all other branch characteristics are fixed. Since MSN is not directly observable at a branch that deploys an ATM, it is necessary to derive a mathematical expression for MSN to enable calculation of the marginal market share gain for a branch which deploys an ATM.

To derive an expression for MSN, we begin by defining the following variables:

MSA_j	=	branch j's market share of deposits when it deploys an ATM;
MSN_j	=	branch j's market share of deposits when it does not deploy an ATM;
x_{jc}	=	the cth design characteristic of branch j, not including a branch ATM;
$x_{j,BRANCHATM}$	=	the presence of an ATM at branch j (x is coded with the value e);
$x_{j,NOBRANCHATM}$	=	the absence of an ATM at branch j (x is coded with a 1);
β_c	=	an estimated "intensity" exponent for a branch characteristic c, not including a branch ATM;
$\beta_{BRANCHATM}$	=	an estimated "intensity" exponent for a branch characteristic, branch ATM;
C-	=	the set of branch characteristics c, excluding a branch ATM;
J-	=	the set of branches, excluding branch j for which incremental market share due to the presence of a branch ATM is being evaluated.

Using these definitions, we can write an expanded form of the MCI model. This model distinguishes among branch characteristics more carefully, by breaking out a term for the multiplicative effect of the categorical variables associated with the presence or absence of an ATM.

$$MSA_j = \frac{\left(\prod_{c\in C-} x_{jc}^{\beta_c}\right) x_{j,BRANCHATM}^{\beta_{BRANCHATM}}}{\sum_{j\in J-}\left(\prod_{c\in C-} x_{jc}^{\beta_c}\right) x_{j,BRANCHATM}^{\beta_{BRANCHATM}} + \left(\prod_{c\in C-} x_{jc}^{\beta_c}\right) x_{j,BRANCHATM}^{\beta_{BRANCHATM}}} \;\text{--->}\; \frac{MSA_j}{1-MSA_j} = \frac{\left(\prod_{c\in C-} x_{jc}^{\beta_c}\right) x_{j,BRANCHATM}^{\beta_{BRANCHATM}}}{\sum_{j\in J-}\left(\prod_{c\in C-} x_{jc}^{\beta_c}\right) x_{j,BRANCHATM}^{\beta_{BRANCHATM}}}$$

$$MSN_j = \frac{\left(\prod_{c\in C-} x_{jc}^{\beta_c}\right) x_{j,NOBRANCHATM}^{\beta_{BRANCHATM}}}{\sum_{j\in J-}\left(\prod_{c\in C-} x_{jc}^{\beta_c}\right) x_{j,NOBRANCHATM}^{\beta_{BRANCHATM}} + \left(\prod_{c\in C-} x_{jc}^{\beta_c}\right) x_{j,NOBRANCHATM}^{\beta_{BRANCHATM}}} \;\text{->}\; \frac{MSN_j}{1-MSN_j} = \frac{\left(\prod_{c\in C-} x_{jc}^{\beta_c}\right) x_{j,NOATM}^{\beta_{BRANCHATM}}}{\sum_{j\in J-}\left(\prod_{c\in C-} x_{jc}^{\beta_c}\right) x_{j,NOBRANCHATM}^{\beta_{BRANCHATM}}}$$

Note that the denominators in MSA and MSN are equal to 1, since the sum of competitors' market shares in a given market will always sum to 1. By subtracting MSA and MSN from the respective denominators we obtained the terms to the right of the arrows above. Dividing MSA/(1-MSA) by MSN/(1-MSN) and then simplifying the resulting expression and rearranging terms yields the following ratio:

$$\therefore \qquad \frac{MSA_j}{MSN_j} \cdot \frac{1-MSN_j}{1-MSA_j} = \left(\frac{x_{j,BRANCHATM}}{x_{j,NOBRANCHATM}}\right)^{\beta_{BRANCHATM}}$$

Rearranging terms, we have:

$$\frac{1}{MSN_j} - 1 = \left(\frac{x_{j,ATM}}{x_{j,NOATM}}\right)^{\beta_{BRANCHATM}} \cdot \frac{1-MSA_j}{MSA_j} = e^{\beta_{BRANCHATM}} \cdot \left(\frac{1-MSA_j}{MSA_j}\right) = e^{\beta_{BRANCHATM}}\left(\frac{1}{MSA_j}-1\right)$$

The value of branch deposit market share for a branch without an ATM, MSN, is now given by:

$$\text{---->} \qquad MSN_j = \left(1 + e^{\beta_{BRANCHATM}} \cdot \frac{1-MSA_j}{MSA_j}\right)^{-1}$$

This enables us to calculate the incremental market share for a branch (given by MSA_j - MSN_j) that deploys an ATM.

Figure 1. A Business Value Linkage for Identifying IT Impacts

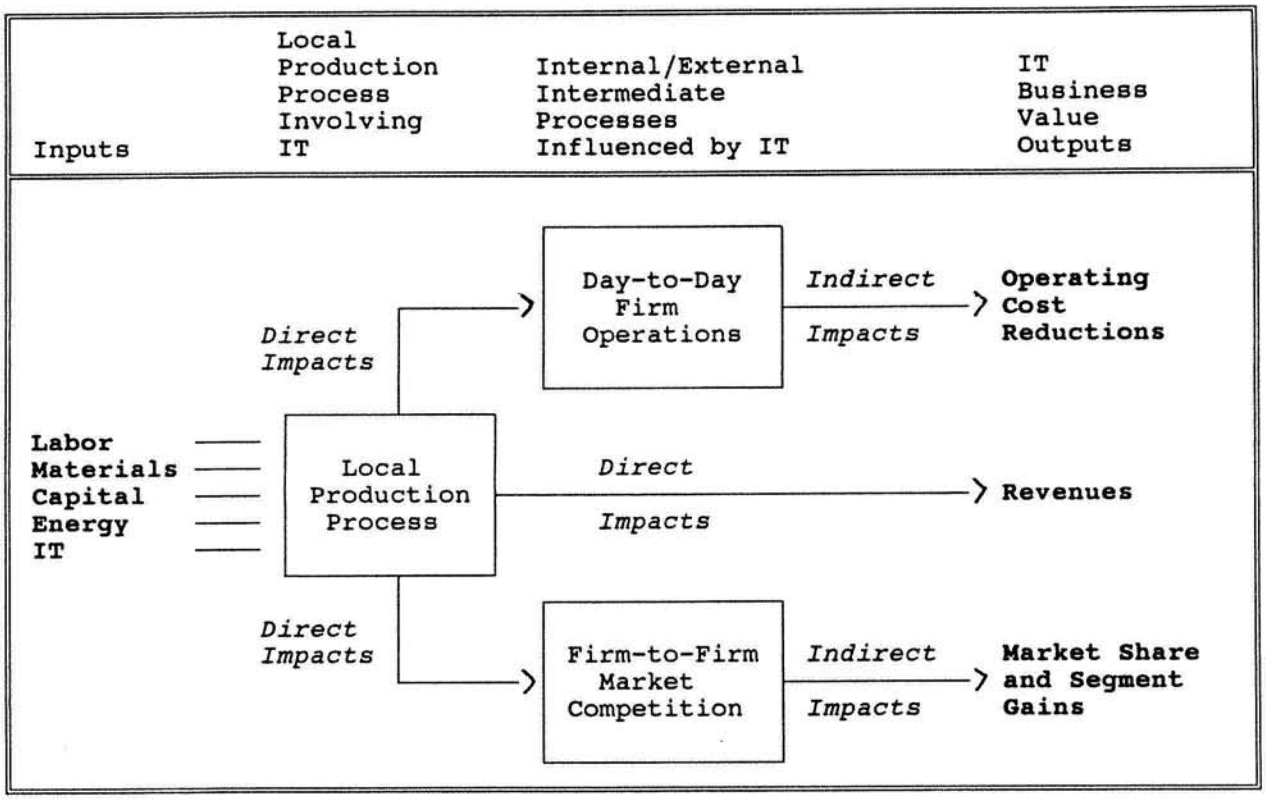

Figure 2. A Conceptual Model for ATM Value Measurement

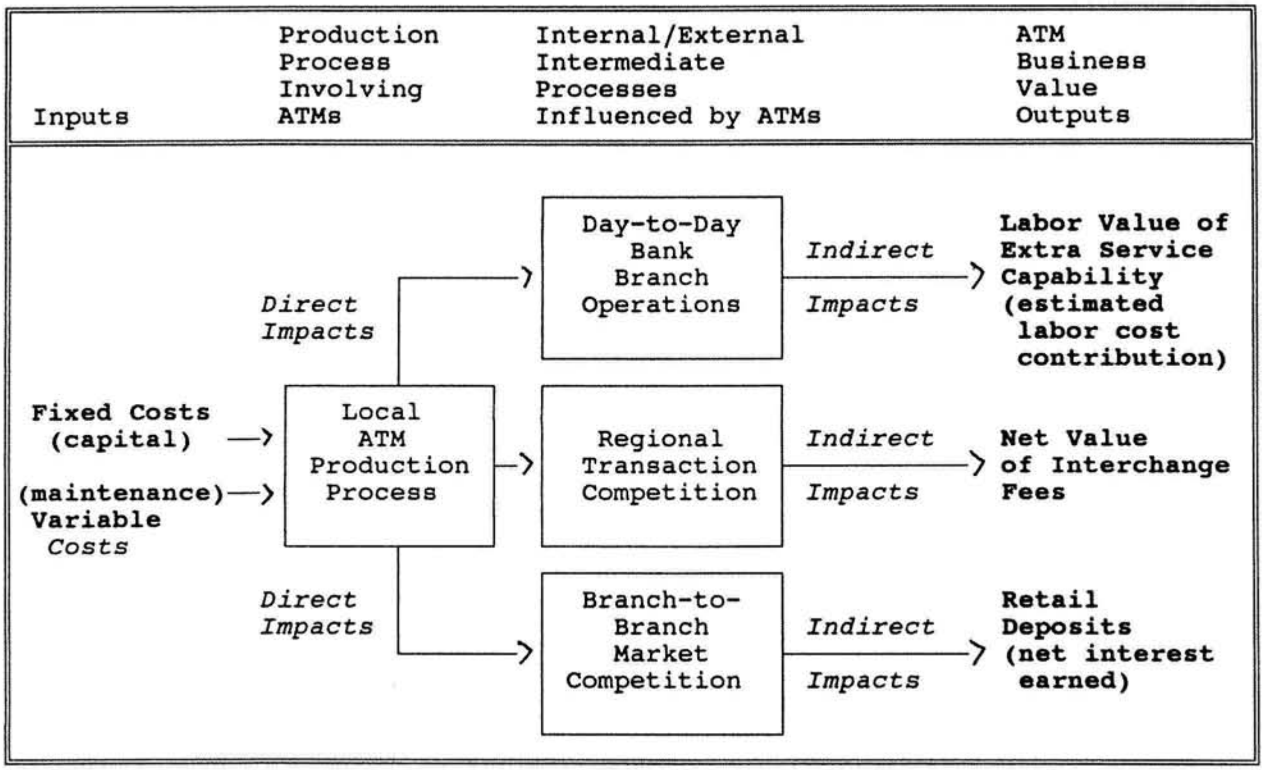

Table 1. Results of Branch Teller Labor Estimation

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

No. of Observations: 87
R-SQUARED = .30
Significance: *** .01 level; ** .05 level; * .10 level

Table 2. Variables in the ATM Transaction Prediction Regression

VARIABLE NAME	VARIABLE 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 hours = 168, 0 if 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.

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	
BRANCH_ATM	0.29	2.40	**

R-squared: .51
Adjusted R-squared: .42
Significance: *** .01 level; ** .05 level; * .01 level

Table 4. **Annual Value of Teller Transactions Replaced by a Branch ATM**

Actual ATM Transactions	Estimated Transactions if ATM Not Located at Branch	Estimated Teller Transactions Replaced by ATM	Estimated ATM Business Value
74028	74028/e^.292 = 55280	74028-55280 = 18748	$.90*18748 = $16873

Note: The figure for per transaction teller costs of $.90 is net of additional processing that occurs behind the banking counter once a customer's interaction with a bank teller is complete. Source: Meridian Bancorp, LIPI85.

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

MONTH #	ATM Transactions			Interchange	
	WDL	DEP	TFR	IPCT	IREV
1	4932	1050	320	.253	$584.00
2	4683	1099	319	.249	$565.00
3	4719	1070	315	.255	$575.00
ESTIMATED ANNUAL REVENUE					$6,896

Table 6. Variables in the Branch Market Share Models

BRANCH DESIGN VARIABLE	DEMAND DEPOSITS SHARE MODEL	SAVINGS DEPOSITS SHARE MODEL	DESCRIPTION OF THE VARIABLES
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 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

Variable Name	*Demand Deposits*			*Saving Deposits*		
	Coefficient	t-stat	(signif.)	Coefficient	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		
Adjusted R-squared:	.38			.30		

Significance: *** .01 level; ** .05 level; * .10 level

Table 8. Incremental Market Share Calculation: Variables and Results

Variable Name	Demand Deposit Model	Savings Deposit Model	Description 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.
MSA	.1259	.1498	Actual market share of branch with ATM.
MSN	.1091	.1141	Estimated market share of branch without ATM.
Δ_MS	.0149	.0315	Estimated incremental market share attributed to branch ATM.
Δ_DEPOSITS	$325,222	$2,908,490	Estimated change in retail deposit volume.
Δ_$	$11,220	$100,343	Business value of Δ_MS (assuming spread of 345 basis points between marginal cost of funds and deposit interest cost).

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	
	Dollar Value of Contribution	Percent of Total Contribution
Costs of Branch Labor Replaced	$ 16,873	12.5%
Creation of Interchange Transaction Revenues	$ 6,896	5.1%
Incremental Value of Market Share for:		
* Demand Deposits	$ 11,220	8.3%
* Savings Deposits	$100,343	74.1%
Total Estimated Business Value	$135,332	100.0%